CALOES/FEMA DRAFT

2025 HAZARDS AND CLIMATE RESILIENCE PLAN

San Francisco's Local Hazard Mitigation Plan

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City and County of San Francisco
Hazards and Climate Resilience Plan

San Francisco's Local Hazard Mitigation Plan

Copies of this document can be found at http://onesanfrancisco.org
or through the Office of Resilience and Capital Planning

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Chapter 01

Introduction

Anyone who spends time in San Francisco quickly recognizes its incredible beauty. Dramatic landscapes and vistas, proximity to water, wonderful hills, mild weather, and rolling fog are all part of what make San Francisco such a great place to live. However, the same geologic and climate forces that create this setting also make us susceptible to natural disasters. Coping with, recovering from, and in many cases thriving after disasters, is not new to San Franciscans.

The Great Earthquake of 1906, when a magnitude 7.9 earthquake and subsequent fires destroyed 80% of the city, as well as the impacts of the Loma Prieta Earthquake of 1989 are present in peoples' minds. In recent years, new and unprecedented hazards have challenged San Francisco, including extreme heat in 2017 and 2020, unhealthy air quality in 2018 and 2019, and a string of atmospheric river events in 2023. Climate science tell us that these and other climate-related hazards, such as coastal flooding and drought, will be on the rise as greenhouse gas emissions drive higher temperatures, higher sea levels, and more extreme precipitation patterns.

The Hazards and Climate Resilience Plan (HCR) captures our latest understanding of how hazards are intensifying along with the climate crisis and what we can expect in the years to come. It presents a strategy with goals, objectives, and actions for how San Francisco can become a safer and more resilient place by mitigating the impacts of natural hazards to our buildings, communities and infrastructure, and adapting to what we cannot mitigate. This chapter describes the purpose, scope, and key updates to the HCR.

1.1 Purpose and Scope

Purpose

The City and County of San Francisco's HCR is a combined hazard mitigation and climate adaptation plan. It serves as the City's action plan for reducing the impacts of hazards that have long been a part of life in San Francisco, such as earthquakes and landslides, as well as hazards that are becoming more frequent and severe due to climate change, including flooding, drought, and extreme heat.

The HCR includes an assessment of the current and increasing risks facing San Franciscans today and in the years and decades to come. The Plan includes goals, objectives, and actions to increase the resilience of San Francisco's infrastructure, buildings, and communities. In so doing, it serves as a guide for decision makers as they commit resources to reduce the impacts of natural hazards and climate change.

The HCR also serves as a resource for the broader community to better understand how the City and partners are working together to mitigate and adapt to natural hazards. It builds awareness of the projects and programs that increase the resilience capabilities of departments, non-profits, community groups, individuals, and other partners. Finally, the HCR seeks to encourage deeper levels of participation and collaboration on hazards and climate resilience planning.

Resilience Vision

The vision of the HCR is to make San Francisco resilient to immediate and long-term threats of climate change and natural hazards through actions to mitigate risks, adapt built and natural assets, and build a more equitable and sustainable city. This includes ensuring systems are in place so that individuals, communities, institutions and businesses survive, adapt, and thrive no matter the kinds of chronic stresses and acute shocks they experience. The HCR also coordinates with and supports the City's Climate Action Plan, which outlines urgent strategies needed to achieve net-zero greenhouse gas emissions by 2040 and minimize the severity of climate change and its associated impacts.

Guiding Principles

The following principles guided the development of the HCR, from scoping the assessment to evaluating and refining strategies.

- Equity & Health: Proactively work to eliminate racial or social disparities in the impacts of all hazards and/or the distribution of resilience benefits.
- Community Cohesion: Empower people to reduce vulnerability and promote resilience at the building, block, and neighborhood level.
- Affordability & Economic Viability: Help residents and business stay and thrive in San Francisco.
- Climate Mitigation: Pursue hazard mitigation and climate adaptation strategies in ways that also help eliminate the greenhouse gas emissions, which drive climate change and worsen climate-related hazards.
- Biodiversity & Connection to Nature: Restore and leverage local ecosystems to help mitigate hazards and support climate adaptation, while ensuring all residents can access green spaces, parks, and natural habitats and experience nature every day.
- Science-Grounded Innovation: Closely monitor evolving climate and hazard-related science and modify approaches appropriately to maintain maximum effectiveness.
- Good Governance: Provide dependable and actionable information to foster transparency and openness.

Scope

Hazard Mitigation Planning

The 2025 HCR serves as San Francisco's 2025 Local Hazard Mitigation Plan (LHMP) update. It builds and expands on previous LHMPs (including the 2020 HCR). Hazard mitigation is a process in which a jurisdiction identifies and profiles hazards that affect the area, analyzes the people and facilities at risk from those hazards, and develops mitigation actions to lessen or reduce the impact of profiled hazards. The jurisdiction's implementation of mitigation actions, which include long-term strategies that may involve planning, policy changes, programs, projects, and other activities, is the primary objective of this process.

Local hazard mitigation planning is governed by the Stafford Act, as amended by Disaster Management Act of 2000 (DMA 2000), and by federal regulations implementing the Stafford Act. As revised by DMA 2000, the Stafford Act requires state, local, and tribal governments to develop and submit for approval a mitigation plan that outlines processes for identifying the natural hazards, risks, and vulnerabilities of the jurisdiction. Federal Emergency Management Agency (FEMA) approval of such plans is a prerequisite to receiving federal pre- and post-disaster hazard mitigation assistance funding.

Climate Adaptation Planning

Climate adaptation planning strives to reduce the unavoidable impacts of climate change. Climate change is already affecting San Francisco and is projected to continue into the foreseeable future. Reducing global greenhouse gas (GHG) emissions is critical to avoiding the most severe, costly, and disruptive impacts. Given the amount of emissions already in the atmosphere, San Francisco will continue to see higher temperatures, sea level rise, and altered precipitation patterns regardless of future global emissions trajectories. The longer-term severity of those changes and related climate hazards will depend on how successfully society (i.e. cities, states, and nations) can bring down emissions globally. Chapter 03 provides more information on climate change projections and the implications for local hazards.

Local climate adaptation planning in California is governed by Senate Bill 379 (2016) which states that when a local jurisdiction updates its Hazard Mitigation Plan (HMP), it must also update the Safety Element of its General Plan to address climate adaptation and resilience strategies. The bill requires the update to include goals, policies, and objectives based on a climate change and vulnerability assessment. The State provides guidance and resources to undertake this type of planning through the online Cal-Adapt tool and the California Adaptation Planning Guide. The HCR builds on these tools and uses previous and ongoing climate adaptation planning in San Francisco, including the Sea Level Rise Action Plan, Sea Level Rise Vulnerability & Consequences Assessment, and Heat and Air Quality Resilience Plan. Linking the HMP to the Safety Element also makes the City and County eligible to be considered for part, or all, of its local-share costs on eligible Public Assistance funding to be provided by the State per Assembly Bill 2140.

Climate adaptation planning in San Francisco is also driven by the City's commitment to implement our Climate Action Plan to reach net-zero carbon emissions by 2040. The HCR is San Francisco's commitment to increase resilience to the impacts of climate change and is a companion document to the Climate Action Plan.

Resilience Planning

Resilience describes the capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow, no matter what kinds of chronic stresses and acute shocks they experience. Approaching challenges with a resilience lens calls for bridging the gaps between social justice, sustainability, disaster recovery, and other areas.

The HCR builds on San Francisco's 2016 resilience strategy, *Resilient SF*, which was produced in partnership with 100 Resilient Cities initiative funded through the Rockefeller Foundation. As over 90% of the strategies from Resilient SF are complete or underway, the HCR provides new direction for the City's resilience efforts. The HCR takes a more in-depth focus on the shocks of natural hazards and climate change impacts, while continuing to develop solutions that also address the chronic stresses San Franciscans face day to day.

The City of San Francisco continues to be a part of efforts to support and promote resilience in the region, the State, and across the globe. San Francisco is a member of the Global Resilience Cities Network (GRCN) to foster resilience in cities across the world by sharing best practices, training resilience officers, and bringing cities together. In 2023, the Chief Resilience Officers from San Francisco, Berkeley, and Oakland hosted resilience officers from across North America to learn from each other and see first-hand a range of resilience efforts in the Bay Area.

In San Francisco, the term climate resilience is used to coordinate synergistic efforts that benefit greenhouse gas mitigation and climate adaptation (see Figure 1-1). While the scope of this plan is more aligned with climate adaptation, the plan strives to maximize connections to climate mitigation through the goals, objectives, and actions in Chapter 7.

FIGURE 1-1: CLIMATE RESILIENCE VENN DIAGRAM

Planning Area

The Planning Area covered by the HCR includes the City and County of San Francisco, as shown on Figure 1-1. San Francisco is the only consolidated city-county in California; the City of San Francisco is the sole municipality located within the county. San Francisco County encompasses approximately 47 square miles of land and 185 square miles of water, and has nearly 30 miles of shoreline. Included within county boundaries are Treasure Island and the Farallon Islands. Unlike Treasure Island, the Farallon Islands are uninhabited, except for the Southeast Farallon Islands where research residents stay.

Natural Geography

Before the peninsula was developed, San Francisco featured numerous rocky hills cutting through miles of sand dunes to the north and west, and marshes and mudflats to the east along the Mission Creek and Islais Creek watersheds. San Francisco's sand dune ecosystem was the largest in the western hemisphere, stretching seven miles from Ocean Beach to the Financial District.[1] Mission Creek and Islais Creek fed the two largest creek and marsh watershed systems. Today, these creeks are largely capped, with landfill developed over what was once large swaths of wetland at the mouth of both creeks.[2] Despite the extensive infill and development of land and port area along the City's northern and eastern shorelines, there still exists important saltwater wetland habitat, including Heron's Head Park, Crissy Field, Yosemite Slough, and edges of the Mission Creek and Islais Creek channels, which protect the coastline from severe weather, help to filter water pollutants, and provide habitat for hundreds of plant, bird, and fish species.[3] To further explore, the past, present, and future of watersheds, please visit the Discover Your Watershed webpage.

[1] Ecosystems, https://www.sfenvironment.org/ecosystems?repaired
[2] San Francisco History Creek Map, https://explore.museumca.org/creeks/SFTopoCreeks.html
[3] SF Environment, "Ecosystems," Accessed July 1, 2024. Retrieved from: https://www.sfenvironment.org/ecosystems?repaired

FIGURE 1-2: HCR PLANNING AREA

Built Geography

San Francisco has been inhabited for more than 10,000 years, and was inhabited by the Ohlone people since about 740 AD. The Ohlone people in what is now San Francisco had dozens of village sites and practiced regular burning of the landscape to promote a plant and animal ecology that provided a regular food supply.[4] More drastic changes in the built landscape began to occur in the late 1700s when the Spanish came to occupy the peninsula, and developed settlements, missions, and military outposts.

In 1848, San Francisco became a part of California, and through the late 1800s San Francisco grew into a major city, overlaying a grid system on the city's hills, and developing further westward toward the ocean. During this time, the waterfront was developed, and the seawall was built, creating hundreds of acres of real estate on the

[4] National Park Service, "Indigenous Period," Accessed July 1, 2024: https://www.nps.gov/prsf/learn/historyculture/indigenous-period.htm

northern and eastern shoreline. The Sunset District was developed in the middle of the 20th century, setting the overall city building footprint we see today.[5]

The western and southern districts continue to be primarily residential, while the financial district and civic center in the northeastern quadrant form the economic engine of the city. The southeast quadrant contains the majority of the city's industrial use, including many assets that support critical infrastructure operations, such as wastewater and mobility.

San Francisco is the 2nd densest large city in the U.S. after New York City, with a population of more than 808,000 on less than 50 square miles of land.[6] The city's population has seen a nearly 8% decrease since 2020 and the population is projected to reach around 845,000 by 2060.[7]

1.2 Key Updates in the 2025 HCR

Below is a summary of the key updates made from the 2020 HCR and where you can read more about them in the Plan.

New Climate Change Research and Planning

- For a summary of new climate change research integrated into the Plan update, please see Chapter 02, Section 2.3.
- The Port and Army Corps released the San Francisco Waterfront Flood Study in February 2024. Please see Chapter 02, Section 2.3.
- The Heat and Air Quality Resilience Project (HAQR) was launched in 2021 and is described Chapter 02, Section 2.3.

[5] Found SF, "The Sunset District: From Dunes to Cityscape, "Accessed July 1, 2024. https://www.foundsf.org/index.php?title=The_Sunset_District:_From_Dunes_to_Cityscape
[6] American Community Survey. 1-Year Estimates Total Population: B01003. For 2022, accessed July 1st, 2024. Retrieved from: https://data.census.gov/table/ACSDT1Y2022.B01003?t=Population%20Total&g=050XX00US06075
[7] State of California Department of Finance (2022). "Projections: P-2 County Population Projections (2020-2060). Accessed July 7th, 2024. Retrieved from: https://dof.ca.gov/forecasting/demographics/projections/

- The Department of Emergency Management (DEM) launched the Extreme Weather Resilience Program in 2023 and is described further in section Chapter 06, section 6.1.
- San Francisco adopted an update Climate Action Plan in 2021. Please see Chapter 02, section 2.3.

New Seismic Safety Programs

- Given the completion and success of the of the Mandatory Soft Story Retrofit Program, which has a compliance rate of 93% at the time of writing, the City is turning towards other priority buildings types. This includes concrete buildings, pre-Northridge steel moment frame buildings, and soft story buildings with less than 5 units. These priorities are reflected in Chapter 07, Action B-1.2.

Communities Engagement Priorities

- Priorities from the community engagement process include energy resilience, seismic safety, multi-modal mobility, waterfront resilience, and neighborhood capacity building. For a more detailed discussion, please see Chapter 02, section 2.3.

Housing and Development Changes

- The 2025 HCR integrates resilience efforts related to major development projects, the development of a new community on Treasure Island and Yerba Buena Island, and proposed zoning changes related to the 2022 Housing Element Update and Expanding Housing Choice Project. For more detail please see Chapter 03, section 3.2.

Lessons from the COVID-19 Pandemic and Economic Recovery

- The COVID-19 pandemic has been the most significant hazard event in San Francisco since the 2020 HCR. For many months, staff from across City departments served as Disaster Service Workers, putting their normal responsibilities on hold to respond to the public health emergency. The pandemic has changed how the City approaches prioritizing communities that face increased risk, whether because of economic precarity or preexisting health conditions. These changes are reflected in a new objective in Chapter 07: C-4: "Support robust emergency response planning in partnership with communities most adversely impacted by hazards."

- Small businesses and workers in hospitality industries were especially hard hit by economic impacts and the economic recovery of Downtown continues to be a high priority for numerous stakeholders. This is reflected in a new objective C-5: "Prepare small businesses and workers to bounce back faster after a hazard."

Plan Organizational Changes

- The actions in Chapter 07 have been reorganized under objectives rather than hazard groups to better reflect the multi-hazard nature of resilience work in San Francisco. Summary Table 7-3 still provides a summary of which strategies address which specific hazards.
- The criteria used for prioritizing HCR actions has also been added with an emphasis on feasibility (including cost) and maximizing co-benefits.
- By reducing redundancies and focusing on higher priority actions, the 2025 HCR has 22% fewer actions than the 2020 HCR, which will help improve Plan communications, monitoring, and maintenance. Despite having fewer actions than 2020, the 2025 HCR includes 20 new actions that reflect new and emerging priorities.

1.3 Document Overview

The HCR is organized into the following chapters and appendices:

Chapter 02: Planning Process provides an overview of the methodology, approach, and community and stakeholder engagement used to develop this plan.

Chapter 03: San Francisco Risk Landscape summarizes climate change projections and their implications on the hazards we experience in San Francisco, the asset sectors used in the Vulnerability & Consequences Assessment, and changes in development.

Chapter 04: Hazard Analysis provides a hazards-based assessment, which includes information on the history, impacts, location, and probability of future events for the hazards identified.

Chapter 05: Vulnerability and Consequence Analysis includes an overview of the exposure assessment and summaries the results of the Vulnerability & Consequence Assessment from Appendix A into 10 Key Planning Issues.

Chapter 06: Capabilities and Existing Action documents the abilities within the City and County of San Francisco to undertake future hazard mitigation and climate adaptation actions, existing actions underway, and the status of 2014 HMP actions.

Chapter 07: Strategy includes San Francisco's HCR goals and the complete set of actions proposed to increase the resilience of buildings, infrastructure, and communities.

Chapter 08: Plan Maintenance describes how the City will maintain the HCR over the next five years.

Appendix A contains Vulnerability & Consequence Profiles for each asset class.

Appendix B lists out-of-county assets and primary out-of-county hazards.

Appendix C provides details on the city's hazard mitigation capabilities as a companion to Chapter 06.

Appendix D provides the City's responses to comments received during the public comment period.

Appendix E is a placeholder for documentation of the local adoption process.

1.4 Key Concepts and Terms

- Adaptive Capacity: The ability to adjust as conditions change, including from things like climate change.
- Asset: a resource with economic value. This plan deals primarily with fixed assets, such as buildings.
- Asset Class: A categorization of multiple assets that are of similar type, or serve similar functional purposes
- Baseline/Reference: The baseline (or reference) is the state against which the change is being measured. It might be 'current baseline', in which case it represents observable, present day conditions. It might also be a 'future baseline', which is the projected future set of conditions excluding the driving factor of interest. Alternative interpretations of the reference conditions can give rise to multiple baselines.
- Climate Adaptation: Ways of reducing the impacts of climate change on people and the environment
- Climate Change: Long-term shifts in global temperatures and weather patterns caused by human activities, like burning fossil fuels that release gases trapping more heat in the Earth's atmosphere.
- Climate Equity: Understanding, recognizing, and addressing the impacts of climate change fairly and justly
- Climate projections: The modelled change in climate variability.
- Climate Mitigation: Ways of reducing the amount of heat-trapping gasses in the atmosphere in order to reduce harms caused by climate change
- Climate Resilience: Seeking a healthier and safer future by acting together to reduce both the causes and impacts of climate change.
- Climate Variability: Variations in the mean state and other statistics (such as standard deviations, statistics of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability) or to variations in natural or anthropogenic external forcing (external variability).

- Co-benefits: All the additional good things that happen when we address climate change, like planting trees to cool an area also improves air quality and provides nesting for birds.
- Communities at Increased Risk: Groups of people who have historically had fewer resources, opportunities, or support compared to others, making it more difficult for them to deal with challenges like climate change.
- Consequence: The impacts to people, ecology, and economy if vulnerable assets are exposed to a hazard.
- Critical Facility: A building that supports important services to the community, such as a school, fire station, or hospital.
- Emissions scenario: A plausible representation of future greenhouse gas (GHG) emissions, based on a coherent and internally consistent set of assumptions about driving forces (demographic, socio-economic development, technological change, etc.) and their key relationships.
- Environmental Justice: Supporting the rights of people, particularly those with historically fewer resources, opportunities, or support compared to others, to a clean and safe environment.
- Exposure: The extent to which an asset is situated in a place or setting that could be adversely affected by hazards.
- Geographic Information Systems (GIS): A technological system designed to capture, store, manipulate, analyze, manage, and present spatial or geographic data. In the HCR, GIS is used to analyze the exposure of assets using layers of hazard data.
- Hazard: A source of potential danger or an adverse condition that could harm people, socioeconomic systems, or built and natural environments.
- Hazard Mitigation: Taking steps to reduce or prevent damage and danger from natural disasters, like building stronger houses to withstand earthquakes.
- Natural hazard: A hazard that results from conditions in the natural environment, such as flooding. Humans may contribute to or exacerbate the hazard but cannot directly cause it.
- Preparedness: Actions that strengthen the City's capability to respond to disasters.
- Resilience: The capability of preparing for, responding to, and recovering from difficult conditions; the ability to bounce back after change or adversity. The HCR

uses the term resilience actions, which encompass both hazard mitigation and climate adaptation.

- Risk: The chance that a given hazard could occur multiplied by the understood consequences of an impact on people, socioeconomic systems, or the built and natural environment.
- Risk Management: Regulatory controls, plans, policies, programs, projects, initiatives, and anything else employed to cost-effectively eliminate, avoid, or minimize risks.
- Sea Level Rise Vulnerability Zone: Waterfront or coastal areas that face increased flood risk as a result of climate change.
- Vulnerability: Being more likely to be affected, damaged, or injured by a hazardous event.

1.5 Acronym Glossary

ADM	Office of the City Administrator
BOS	San Francisco Board of Supervisors
CBOs	Community Based Organizations
DAAS	Department of Disability and Aging Services
DBI	Department of Building Inspection
DEM	Department of Emergency Management
DPH	Department of Public Health
HCR	Hazards and Climate Resilience Plan
DPH	Department of Public Health
FEMA	Federal Emergency Management Agency
FLEET	City Administrator Fleet Management
HSA	Human Services Agency of San Francisco
LHMP	Local Hazard Mitigation Plan
MOD	Mayor's Office on Disability
MOHCD	Mayor's Office of Housing and Community Development
OEWD	Office of Economic and Workforce Development
ORCP	Office of Resilience and Capital Planning
Planning	San Francisco Planning Department
Port	Port of San Francisco
Public Works	San Francisco Public Works
RPD	San Francisco Recreation & Parks Department
SF CARD	San Francisco Community Agencies Responding to Disaster
SFDT	San Francisco Department of Technology
SFE	San Francisco Department of Environment
SFFD	San Francisco Fire Department
SFMTA	San Francisco Municipal Transportation Agency
SFPL	San Francisco Public Library
SFO	San Francisco International Airport
SFPUC	San Francisco Public Utilities Commission

Chapter 02

Planning Process

Breakout groups discussions at Lifelines Council

This chapter describes the process of updating the Hazards and Climate Resilience Plan (HCR) for 2025. The scope of the update was "right-sized" to reflect the comprehensive nature of the 2020 HCR assessment, limited changes in risk and development since 2020, and the resources available. This approach included working across departments to determine the essential information that has changed since 2020 and the most efficient way to update the plan. The update process was informed by specific feedback received during the 2020 HCR development from community stakeholders and FEMA reviewers.

2.1 Planning Process Overview

The planning process detailed below was designed to create an updated 2025 combined hazard mitigation plan (HMP) and climate adaptation plan in compliance with State and federal requirements and provide a centralized local community resource and roadmap for natural hazard and climate resilience work in San Francisco.

The HCR planning process sought to achieve the outcomes:

- Build greater understanding of San Francisco's hazard and climate risks among City leaders, staff, and community stakeholders.
- Learn from community members, especially in Environmental Justice Communities, about their experiences with and concerns about hazards and incorporate their priorities for resilience into the Plan update.
- Provide strategic policy guidance and direction for ongoing and future citywide multi-hazard risk reduction efforts.
- Build the capacity of City staff and partners to develop hazard and climate resilience projects and programs.

2.2 City Agency Engagement

Project Management and Planning Team

The Office of Resilience and Capital Planning (ORCP) managed the HCR update process through a small Project Team. The regular contact that the Project Team has had with departments in producing the 2021-2023 Annual Progress Reports (as a part of the plan maintenance process) built a strong foundation for the 2025 HCR update. The Project Team convened and engaged a larger citywide Planning Team over the course of six meetings summarized in Table 2-1 below. These Planning Team meetings were convened as opportunities for members to be engaged stakeholders in the process of charting the update process as well as contributing to the final report. The Project Team also held numerous small meetings at the beginning of the update process to hear directly from departments on the progress and relevancy of existing 2020 HCR strategies as well as any emerging issues and priorities that should be captured in the 2025 HCR. Departments that participated in the Planning Team include the following:

- City Administrator (ADM)
    - Director and Chief Resilience Officer
    - Emergency Response Manager
    - Resilience Program Manager
    - Resilience GIS Analyst
    - Deputy Director; Treasure Island Development Authority
    - ClimateSF Program Manager
- Controller's Office (CON)
    - Deputy Director; Administrative Services
- Department of Building Inspection (DBI)
    - Deputy Director
- Department of Disability and Aging Services (DAS)
    - Deputy Director of Community Services
    - Nurse Manager
    - Program Support Analyst
- Department of Emergency Management (DEM)
    - Deputy Director; Emergency Services Division
    - Assistant Deputy Director; Emergency Services Division
- Department of Homelessness and Supportive Housing (HSH)
    - Disaster Planning Manager
- Department of Public Health (DPH)
    - Director; Emergency Preparedness
    - Manager; Climate Health Program
    - Epidemiologist; Climate Health Program
    - Deputy Director; Emergency Response and Preparedness and Response
    - Healthcare Planning Lead; Emergency Response and Preparedness
    - Health Disparities Program Director
    - Agency Preparedness Manger
    - Community Health Resilience Manager
- Department of Technology (DT)
    - Technology Risk and Resilience Manager
    - Manager; SFGIS Program
- Department of the Environment (SFE)
    - Head of Climate Programs
    - Climate Program Assistant Coordinator
- Mayor's Office of Housing and Community Development (MOHCD)
    - Director of Construction Services
- Office of Community Investment and Infrastructure (OCII)
    - Senior Project Manager
- Planning Department (Planning)
    - Senior Planner; Resilience and Sustainability
    - Principal Planner
- Port of San Francisco (Port)

- Deputy Program Manager; Waterfront Resilience Program
    - Senior Planner/ Urban Designer; Waterfront Resilience Program
- San Francisco Airport (SFO)
    - Sustainability and Environmental Policy Director
    - Manager; Emergency Operations and Planning
- San Francisco Fire Department (SFFD)
    - Assistant Deputy Chief
- San Francisco Municipal Transportation Agency (SFMTA)
    - Policy and Long-Range Planning Manager
- San Francisco Office of Economic Workforce and Development (OEWD)
    - Legislative and Government Affairs Manager
    - Deputy Director
- San Francisco Public Utilities Commission (SFPUC) (sole local dam owner)
    - Climate Program Director
    - Utility Planning Division Manager
    - Emergency Planning Director
    - Utility Specialist; Regulatory and Legislative Affairs
    - Project Manager; Ocean Beach Climate Change Adaptation Project
    - Regulatory Specialist
- San Francisco Public Works (Public Works)
    - City Architect and Manager; Bureau of Architecture
    - Manager; Bureau of Landscape Architecture
    - Regulatory Affairs Section Manager; Bureau of Engineering
- San Francisco Recreation and Parks (REC)
    - Planner

TABLE 2-1:
HCR 2025 UPDATE PLANNING TEAM MEETINGS

Meeting #	Topics	Date
1	Kick-off: Plan update overview and requirements Planning Team roles and responsibilities Hazard profile updates	July 2023
2	Vulnerabilities and Consequences update Capabilities update including existing actions Stakeholder engagement process	September 2023
3	Updated key planning issues Strategy development updates Introduce prioritization process	January 2024
4	Strategy prioritization results Preliminary stakeholder engagement findings Strategy review process	April 2024
5	Review feedback on Public Review Draft Revisions for submission to CalOES/FEMA	October 2024

City Leadership Engagement

ClimateSF

ClimateSF is a governance body for interagency projects and plans related to climate change in San Francisco. The Project team engaged with the ClimateSF Directors' and Deputy Directors' Committees through presentations and feedback sessions. This allowed the project team to solicit high-level feedback to ensure that there was leadership buy-in on proposed approaches and priorities during the update process. ClimateSF includes the following departments:

- Mayor's Office
- Office of Resilience and Capital Planning (ORCP)
- Planning Department (Planning)
- Department of the Environment (SFE)
- Port of San Francisco (Port)
- Public Utilities Commission (SFPUC)
- Municipal Transportation Authority (SFMTA)
- San Francisco Airport (SFO)
- Public Works

The Project Team also presented twice at the Sea Level Rise and Flood Hazards Coordinating Committee, which brings together flood experts from across City departments. The Team shared two drafts of flood hazard-related actions to identify gaps and incorporate feedback.

Concrete and Tall Buildings Executive Panel

ORCP convenes an Executive Panel to oversee current seismic programs, including the Concrete Building Safety Program and Tall Building Safety Strategy. The Project Team presented seismic and housing-related related actions for their feedback. This panel is composed of the following agencies:

- City Administrator
- Department of Building Inspection (Director)
- Department of Emergency Management (Director)
- Mayor's Office of Housing and Community Development (Director)
- Office of Economic and Workforce Development (Director)
- Office of Assessor-Recorder (Assessor-Recorder)

- Public Works (City Engineer)

2.3 Community Engagement

This section describes opportunities for the broader San Francisco community to provide feedback during the plan update process and drafting, including engagement with community stakeholders such as:

- Non-profits and community-based organizations (CBOs)
- Interest organizations
- Large institutions and employers
- Neighboring jurisdictions
- Regional, State, and federal agencies

Community Engagement Goals and Strategies

The goals of HCR community engagement were to:

1) Better understand and how community members experience hazard events and reflect their top concerns for current or future hazards in the Plan update.
2) Better understand and reflect community member's resilience priorities in the Plan update.
3) Build relationships that may support future partnerships on resilience projects and programs.
4) Share information about:
    a. Purpose and contents of the HCR
    b. Natural hazards and climate change impacts for San Francisco
    c. The range of existing resilience actions
    d. Additional requested resources

To achieve those goals, the Project Team used the following engagement strategies:

First, the Project Team reviewed community feedback from climate and resilience efforts since 2020, such as the Waterfront Resilience Program, Islais Creek Southeast Mobility and Adaptation Strategy, Climate Action Plan, Safety and Resilient Element, and Environmental Justice Framework. These resources are described further in section 2.4. The Project Team worked to align the updated HCR objectives and actions with those plans and their associated community feedback.

Second, in response to the feedback received during the 2020 HCR engagement, which involved convening and recruiting participants for five thematic workshops, the 2025 HCR focused on meeting the community where they already are. Specifically, this meant the Project Team attended existing convenings hosted by community organizations rather than creating standalone workshops that community members would have to carve out capacity to participate in.

This approach involved outreach to community organizations to inquire whether they were interested in hosting the Project Team at an existing meeting for a short presentation and discussion. The team used other engagement formats as requested, such as interviews with organization leadership or poster sessions at larger convenings. This outreach focused on organizations in Environmental Justice (EJ) Communities and organizations that were partners on the 2020 HCR. This included organizations representing Mission District, Chinatown, Bayview-Hunters Point, Japantown, and Treasure Island among others.

Lastly, in addition to the concerted outreach to organizations in EJ Communities, the Project Team leveraged other opportunities for engagement, such as meetings with organizations by request, leveraging the Port and Army Corps' Flood Study Public Workshops, and hosting a workshop at the San Francisco Lifelines Council. Table 2-2 below provides a summary of all events.

TABLE 2-2: SUMMARY OF STAKEHOLDER EVENTS

Date	Event/ Organization	Stakeholder Type	Notable Concerns or Priorities
Sep 2023	Meeting with California Native Plant Society, Yerba Buena Branch	Biodiversity and conservation non-profit	• Drought tolerance and fire prevention • More education on biodiversity benefits
Dec 2023	Bayview Climate Summit	Community-based organizations, EJ Community	• Importance of energy resilience • Information resources to support the safety of workers and renters • Contamination and illegal dumping • Flooding on roadways
Dec 2023	Lifelines Council	Infrastructure and utility agencies	• Resilience of Treasure Island • More coordination across sectors to shorten transit disruptions.

Date	Event/ Organization	Stakeholder Type	Notable Concerns or Priorities
			• Ensure that energy resilience projects are used to leverage other resilience priorities (i.e, seismic, flooding, etc.).
Feb 2024	Meeting with Residents Supporting Community on Treasure Island	Community-based organization, EJ community	• Power outages are very disruptive to Treasure Island residents • Leverage new battery technologies
Feb 2024	Waterfront Resilience Program Workshops (4)	Members of the public interested in the waterfront, EJ Community (1, Bayview)	• Earthquakes are a high priority • Contaminated lands and how they related to sea level rise • Transportation network resilience
Mar 2024	Japanese American Religious Federation	Faith-based organization	• Urban fires • Centering seniors in resilience • High wind is challenging for seniors and mobility
Mar 2024	Japantown Task Force, Land Use/Transportation Committee	Community-based organization	• Small business relief • Neighborhood-based planning • Resilience of new development and strengthening codes • Energy resilience including battery storage and microgrids
Apr 2024	Richmond Senior Center	Members of the public, Seniors, Access and Functional Needs	• Ensuring community centers are resilient and able to provide services during/after hazard events
Apr 2024	BAR Architects, Sustainability Education & Environmental Design	Design professionals	• Regional collaboration especially around transportation • More current seismic risk data • Post-earthquake housing recovery
Apr 2024	Meeting with PODER leadership	Community-based organizations, EJ Community	• Low-income access to energy, heating, cooling, and support with weatherization. • Establishing a Resilience Hub in the Mission
May 2024	Chinatown Disaster Preparedness Committee	Community-based organizations, EJ Community	• Seismic resilience a historic focus for the committee • Cool spaces within SRO's because respite centers can be too far

Date	Event/ Organization	Stakeholder Type	Notable Concerns or Priorities
			• Increasing weatherization rates for buildings is a priority
July 2024	Urban Forestry Council	Advisory body on urban forestry and tree management	• Update of CAL FIRE's wildfire hazard severity map • Wildfire risk from eucalyptus trees • Storm impacts from downed trees

Community engagement at the Richmond Senior Center

Community engagement a SF Waterfront Flood Study public workshop

External Agency Engagement

Agencies external to the City and County were also engaged to ensure that information regarding their assets and vulnerabilities was accurate and their resilience priorities also reflected. These included BART, Caltrain, Golden Gate National Recreational Area (GGNRA), PG&E, San Francisco Unified School District, and University of California San Francisco. This engagement occurred through the San Francisco Lifelines Council, smaller meetings, and sharing the Draft Plan for review and feedback.

Themes from Stakeholder Engagement

The Project Team reviewed the data collected from stakeholder engagement events and found six high level themes that were most prevalent in stakeholder feedback. This section describes the themes and identifies how themes are reflected in the actions found in Chapter 07, including where new actions were added in this update.

Energy resilience: Many stakeholders expressed interest in improved energy resilience and energy access for low-income communities. Stakeholders expressed concerns about power outages (such as on Treasure Island), increased stress on the power grid due to extreme weather events, and the shift of equipment, appliances, and vehicles from fossil fuels to electric power. Stakeholders were interested in a range of actions, from grid-scale improvements, to microgrids, battery backup, to household level support with electrification. Examples of actions where this theme has been incorporated include:

- IN-1.1: Enhance energy resilience at Critical Community Institutions.
- IN-1.2: Improve and expand power distribution infrastructure and advanced energy systems to support new development and increase resiliency.
- IN-1.4: Develop a roadmap for disaster resilient EV charging infrastructure. *(New)*
- B-2.5: Support increased building electrification (fuel switching), mechanical upgrade, and weatherization.

Earthquake resilience: Residents across a wide range of neighborhoods and representing different constituencies all noted the need for resilience actions that support mitigation, preparedness response, and recovery for earthquakes. Stakeholders expressed interest in more robust planning at the neighborhood level and advance staging of essential resources. Many stakeholders expressed concern about smaller soft-story buildings that were not retrofitted under the 5+unit mandatory soft story program and fire-following earthquake. Examples of actions where this theme has been incorporated include:

- B-1.1: Assess and seismically retrofit municipal buildings or secure new resilient facilities as needed.
- B-1.2: Implement priority tasks of the Earthquake Safety Implementation Program, such as addressing concrete and steel buildings.
- B-1.3: Implement the recommendations of the Tall Building Safety Strategy.
- B-1.4: Address seismic retrofit needs within San Francisco's affordable housing stock.
- IN-7.4: Complete studies and capital projects to improve and expand the Emergency Firefighting Water System (EFWS).

Waterfront resilience: The waterfront was identified as an essential resource to residents and its resilience was noted as a priority, particularly from seismic and flooding risks. This was particularly notable in the engagement that occurred in waterfront neighborhoods but also was expressed by residents in more inland neighborhoods. Concerns were noted around the prevalence of contaminated sites in relation to sea level rise and this was expressed most notably in the Bayview-Hunter's Point and Embarcadero areas. All of the actions under objective IN-5 and IN-6 relate to this theme and the list below highlights actions that were added during this update:

- Develop a subregional shoreline resiliency plan by 2034 per SB 272 *(New)*
- Develop the Yosemite Slough Neighborhood Adaptation Plan *(New)*
- Advance the Adaptive Management Strategy from the Treasure Island Infrastructure Plan to ensure continual protection to changing conditions. *(New)*
- Develop and support major development projects and public/private partnerships that deliver resilient waterfront infrastructure. *(New)*
- Protect human health and the environmental through close involvement in the framework of property controls and mitigations at the Hunters Point Shipyard. *(New)*

Transportation: Many residents noted the importance of keeping the city's infrastructure in a functional state day-to-day, to be better prepared for when disaster events occur. Community members focused on the public realm, including sidewalks, streets, and bridges. Transit was noted as priority system for residents, and especially ensuring that these assets and services remain dependable during and after hazard events. Examples of actions where this theme has been incorporated include:

- IN-3.1: Incorporate opportunities for hazard mitigation into the planning and design of all SFMTA facility improvements and property re-development.
- IN-3.2: Study, plan, design, and implement improvements to the multimodal transportation system that are vulnerable to coastal flooding.
- IN-3.3: Improve the public right-of-way state-of-good-repair, including retrofitting bridges and other key structures. *(New)*
- IN-3.4: Decrease the geographic vulnerability inherent to the island communities on Treasure Island and Yerba Buena Islands by increasing low-emission, connectivity to San Francisco. *(New)*

Neighborhood capacity building for resilience planning: Many stakeholders emphasized the importance of supporting neighborhood-based organizations to continue to serve residents in the event of a hazard. This includes supporting residents to create networks before an event to ensure those connections are there before they are needed. Stakeholders noted that elderly residents require additional consideration in planning for hazard events. Examples of actions where this theme has been incorporated include:

- C-2.1: Continue to support neighborhood level capacity building.
- C-2.2: Support volunteer emergency preparedness, response, and recovery programs including the Neighborhood Emergency Response Team (NERT).
- C-4.2: Pilot a wellness check program for vulnerable populations including homebound seniors, and people with access and functional needs. *(New)*
- C-4.1: Establish an evacuation strategy for people with Access and Functional Needs, including vertical evacuation and large-building refuges.

Public Feedback

The HCR update process offered several opportunities for members of the public to provide their feedback during the drafting stage. At the beginning of the drafting process, the webpage for the Hazards and Climate Resilience Plan was updated to include a call out box with information about the 2025 update process as well as a link to sign up for more information.

Public Comment Period

On July 29, 2024 The 2025 Draft HCR was posted on www.onesanfrancisco.org with information on how to submit public comment. The public comment period was open for approximately two months until September 30, 2024. During this period, the channels for feedback included public comment received by e-mail, presentations at public commissions and councils, and briefings with members of the Board of Supervisors.

Public Comment by E-mail

The availability of the Draft Plan for public comment was communicated to anyone who signed up through the website and through several newsletters that reach hundreds of internal and external City stakeholders. These newsletters include ClimateSF, City Administrator, and Board of Supervisors newsletters.

These agencies and jurisdictions were directly notified of the Draft Plan and offered the opportunity to provide comment:

- Neighboring cities/counties: City of Oakland, City of Alameda, City of San Rafael, San Mateo County
- Local institutions: Presidio Trust, University of Californian San Francisco (USSF)
- Regional agencies: Metropolitan Transportation Commission, FEMA Region 9, Golden Gate Bridge Highway and Transportation District, Bay Area Rapid Transit (BART), Golden Gate National Recreation Area (GGNRA)

Appendix D includes the City's detailed responses to all public comments received by e-mail. The most common themes in the public comments received included:

- Biodiversity and open space
- Community involvement and data sharing
- Contaminated lands
- Waterfront and sea level rise
- Wildland-urban-interface fire

Board of Supervisors Briefings

During the public comment period, ORCP staff also provided briefings to Board of Supervisor members for Districts 4, 6, 8, and 10. All other Board members will be briefed after the November 2024 election. The Youth Commission, which advises the Board and Mayor on issues and legislation affecting young children and youth, will also be briefed after the election. The briefings focused on building awareness of the Plan's goals and actions that support resilience in their districts and requesting the Supervisors feedback. The Supervisors expressed interest in:

- Additional community outreach, such as webinars and one-pagers
- Resilient shoreline infrastructure in the Southern waterfront
- Connections to policy work on building electrification
- Seismic safety programs
- Focusing City efforts on the greatest risks

Presentations at Public Commissions and Councils

During the public comment period, City staff presented the 2025 Draft Hazards and Climate Resilience Plan at several public meetings, Table 2-2 highlights the most notable feedback from each meeting.

TABLE 2-3: PRESENTATIONS AT PUBLIC COMMISSIONS AND COUNCILS

Date	Meeting Title	Notable Feedback
9/10/2024	Public Utilities Commission	• Interest in how ecosystem health is reflected in the Plan • Interest in leveraging new technologies
9/17/2024	Port Commission	• Interest in how City will pay for resilience/adaptation work • Interested in how we learn from other cities
9/17/2024	Lifelines Council	• Interest in highlighting connections to emergency response, including fuel, fleets, and mutual aid. • Importance of communications systems redundancies and applying new technologies

Date	Meeting Title	Notable Feedback
9/23/2024	Environment Commission	• N/A
9/26/2024	Planning Commission	• Interest in how City will pay for resilience/adaptation work • Interest in open space • Interest in how we work with neighboring jurisdictions • Interested in community engagement process
9/27/2024	Disaster Council	• Interested in the local adoption process

Revisions to the Draft Plan based on Public Comment

The Office of Resilience and Capital Planning considered the many different avenues for feedback during the Public Comment period, including e-mails received from the public, feedback from Commissions and Councils, and feedback from members of the Board of Supervisors. As a result of the feedback received, several revisions were made to the Draft Plan, including:

- Added comparative risk data from FEMA in Chapter 5
- Highlighted the City's Biodiversity Guidelines in Chapter 6
- Added an action to explore growing food for communities in public open spaces to Table 7.7: Additional Strategies for Consideration in Chapter 7
- Highlight future opportunities for public involvement in planning for sea level rise in Chapter 8.
- Incorporated more information on integration with emergency response planning in Chapter 8.

2.4 Reports, Plans, and Other Resources

A key element of the update process included reviewing new resources published since 2020 regarding hazards, vulnerabilities, risks, and potential actions. The hazard analysis in Chapter 04 and Vulnerability & Consequence Profiles in Appendix A include citations of source material and this section provides an overview of key resources used for this update. Please note that this is not a complete bibliography and footnotes contain additional references.

Local Resources

The following section highlights new reports and studies developed by the City and County of San Francisco since 2020 and used to update the Plan.

San Francisco Waterfront Flood Study – Draft Plan

The San Francisco Waterfront Flood Study analyzes coastal flood risk and sea level rise effects for the 7.5 miles of waterfront within the jurisdiction of the Port, from Aquatic Park to Heron's Head Park. The Draft Plan represents 6 years of community engagement and input with an estimated $13.5 billion dollars of proposed solutions which, if approved by congress, will be cost-shared with the Federal government at 65%. This work is reflected in the action IN-6.2: Advance the Waterfront Resilience Program and Flood Study to reduce flooding and seismic risk along the 7.5 miles of Port jurisdiction. The Flood Study included the following reports that were also integrated into the 2025 HCR Update:

Contaminated Lands: Mission Creek/Mission Bay and Islais Creek/Bayview (2023)

This study provides a comprehensive review of the contaminated sites located within the Flood Study area. This report determines where applicable sites are located, their relationship to the shallow groundwater table, as well as how that relates to expected influence of sea level rise. This report was used to update the hazardous materials release hazard profile (Chapter 04) and the contaminated lands vulnerability and consequences profile (Appendix A).

Multi-Hazard Risk Assessment Northern Waterfront and Embarcadero Seawall Summary Report (2020)

The Port carried out a comprehensive Multi-Hazard Risk Assessment to better understand the conditions across the waterfront as well as the exposure of various critical Port assets to earthquakes and sea level rise. This report considers the risks to these assets from an economic, life-safety, and environmental perspective and provides a planning level study of the implications of these risks. The in-dept understanding of earthquake and flood risks has been integrated into the larger, adaptation focused planning effort being done in partnership with the U.S .Army Corps of Engineers.

Findings from this report were used to update numerous asset profiles in the vulnerability and consequence assessment (Appendix A).

Waterfront Resilience Transportation Assessment (2022)

The SFMTA Waterfront Resilience Transportation Assessment was developed to integrate with the planning and align with potential sea level rise adaptation pathways. Specifically, this assessment looked at different lines of defense for sea level rise defense structures and determined the effect that these different pathways would have on SFMTA facilities as well as the network disruptions that could occur. This assessment then went on to consider how SFMTA may need to adapt their assets based on different scenarios.

This analysis was used to update the Transportation asset class and inform the broader work through the port waterfront resilience program.

Heat and Air Quality Resilience Plan (2023)

The Heat and Air Quality Resilience Plan is San Francisco's first comprehensive approach to identify and address the public health implications of extreme heat and air quality. This plan represents the culmination of a multi-year, multi-sectoral planning process to identify, plan, and implement comprehensive medium to long-term adaptation strategies. This framework addresses multiple domains including existing buildings, green infrastructure, emergency response and research/coordination to effectively increase San Francisco's ability to address future hazard events.

This report was used to update the Extreme Heat and Poor Air Quality Hazard Profiles (Chapter 04) and proposed actions from this report were incorporated into Chapter 07, based on the HCR's prioritization criteria.

- C-1.1: Facilitate the development of priority areas for green infrastructure investment using health-equity data. *(New)*
- C-1.2: Develop public education initiatives to connect benefits of green infrastructure to public health. *(New)*
- C-1.3: Investigate and pilot strategies to cool impervious surfaces. *(New)*
- C-1.4: Enhance monitoring, measurement, and improvement of indoor air quality and temperatures. *(New)*
- B-2.2: Determine the City and community facilities that will comprise a network of respite locations open to the public for a range of emergencies and the services, roles, and responsibilities necessary to facilitate their use.
- B-2.3: *Seek to add resilience scope to affordable housing rehabilitation funding opportunities with support from state/federal funds. (New)*
- B-2.5: Support increased building electrification (fuel switching), mechanical upgrade, and weatherization.

SFO Infrastructure Resilience Framework (2022)

This assessment provides a framework for SFO to invest in its critical infrastructure to provide the essential services required in the case of significant hazard events. This includes determining the ability to provide continuity of service in a way that is flexible, adaptable, and responsive through conceptual planning, design, construction, and operation of key critical facility improvements. The airport is a full campus environment; therefore, these improvements span everything from transit, staff space, aviation, utilities, and emergency response assets.

This information was used to update the Airport vulnerability and consequence profile (Appendix A) and actions from this framework were integrated into Chapter 07 where applicable.

Safety and Resilience Element (2022)

The Safety and Resilience Element of the General Plan is the foremost policy document to ensure that the climate resilience work the city does is fully integrated into land-use and development regulations. This element codifies policies for all hazards, both natural and human-made, with a focus on hazard mitigation, emergency preparedness, response, recovery and reconstruction. The 2022 update included two additional goals on equitable community safety and climate resilience. In order to achieve these goals, policies were developed for racial and social equity, environmental justice, and resilience to multiple hazards that also reduces greenhouse gas emissions.

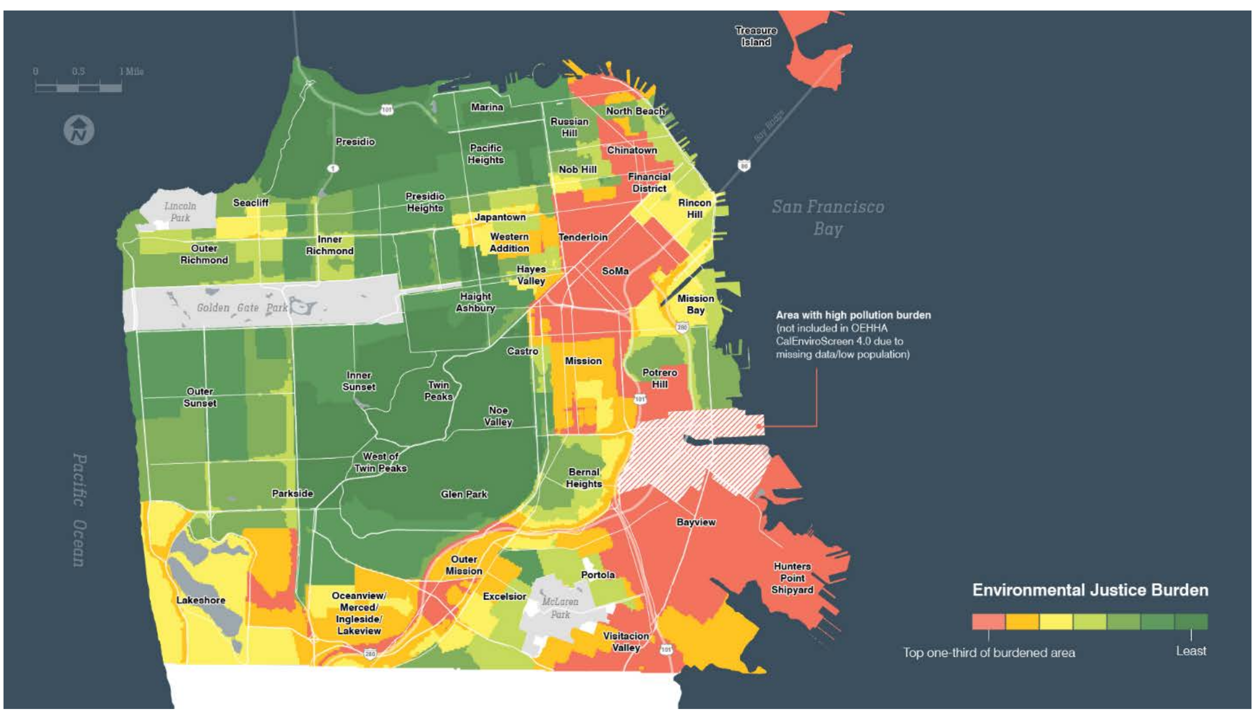
This document was reviewed to ensure alignment of the 2025 HCR objectives and actions (Chapter 07) and informed the drafting of new objectives, such as C-2: Support the growth of community resilience networks to empower all people and Objective B-2: Increase climate and multi-hazard resilience of existing buildings.

Environmental Justice Framework (2023)

The Environmental Justice Framework, adopted into the General Plan in May 2023 serves to recognize the role of historic environmental racism in the conditions of communities today. This has contributed to higher exposure to hazards and a decreased ability to address this exposure in particular geographic communities. The Environmental Justice Framework identified where these communities are in San Francisco and proposes numerous strategies across six policy areas for the city to implement to mitigate the conditions in these communities.

The map highlighting Environmental Justice Communities in San Francisco was integrated into the communities at increased risk asset class and informed the stakeholder engagement strategy. In addition, the EJ Framework particularly informed the creation of Objective C-1: Limit exposure and protect public health against hazards related to environmental health.

FIGURE 2-1:
ENVIRONMENTAL JUSTICE COMMUNITIES MAP



Housing Element Update 2022

The Housing Element 2022 Update is San Francisco's plan for meeting housing needs for the next 8 years and is the City's first housing plan centered on racial and social equity. As part of the update, San Francisco had to analyze how it could accommodate the Regional Housing Need Allocation, which for the 2023-2030 cycle is 82,069 housing units. The update includes a sites inventory and analysis of constraints as well as policies and programs to ensure the city can support the production of this housing.

Climate Action Plan (2021)

Adopted in 2021, the Climate Action Plan (CAP) is the greenhouse gas (GHG) mitigation roadmap for San Francisco and charts a path to the city having net-zero carbon emissions by 2040. The plan was developed with robust community and interdepartmental collaboration and integrates strategies across 7 sectors: Buildings, clean energy, zero waste, transportation, housing, carbon sequestration, and water supply.

Actions from the CAP were integrated into Chapter 07 to address GHG mitigation needs, where there is an overlap with co-benefits to climate adaptation. These are summarized in Table 7-8.

Shallow Groundwater Response to Sea-Level Rise: Alameda, Marin, San Francisco, and San Mateo Counties (2022)

Pathways Climate Institute and San Francisco Estuary Institute collaborated with city and county partners (including San Francisco) to analyze the impact that sea-level rise on the shallow groundwater table and where emergent groundwater can be expected.

This information was used to update the Flooding Hazard Profile (Chapter 04) and inform the Contaminated Lands Vulnerability and Consequence Profile (Appendix A).

San Francisco Precipitation in a Warmer World (2023)

This report details the impacts of climate change on extreme precipitation in San Francisco. This essential study quantifies expected shifts in future precipitation patterns, an essential step in creating the planning tools to address combined flood risk citywide in the coming years. This information will also inform efforts to develop a citywide flood resilience policy.

Growing Resilience: Recommendations for Dune Management at North Ocean Beach (2023)

The San Francisco coast is managed by multiple public agencies with unique jurisdictions and responsibilities. This report details the causes for dune degradation at Ocean Beach and recommends an adaptive management process.

This informed the inclusion of an additional action for Ocean Beach (IN-6.4) in Chapter to ensure that priority actions to implement the Ocean Beach Master Plan are adequately captured.

Concrete Building Safety Program Stakeholder Engagement Report (2024)

The City convened a Working Group of internal and external partners to provide guidance and feedback to City staff on the development of the Concrete Building Safety Program (CBSP). The CBSP Stakeholder Engagement Report details the Working Group's engagement activities, review of technical criteria, and recommendations for the development of the Concrete Building Safety Program. This report informs Action B-1.2: Implement priority tasks of the Earthquake Safety Implementation Program, such as addressing concrete and steel buildings (Chapter 07).

State and Regional Resources

2023 State Hazard Mitigation Plan

This report updates current and historical information on hazards facing the state of California at a time when the state is facing hazard events of unprecedented scale. This update also focuses on integrating the progress made in integrating equity into planning processes over recent years and applies a community resilience approach not seen in previous iterations. This plan also provides key information on the status of previously committed mitigation actions statewide. This report was integrated into the hazard profiles, as appropriate (Chapter 04).

Cal-Adapt

Cal-Adapt provides local jurisdictions across the state with robust information produced by the State of California's scientific and research community. In this way, it is a valuable and essential resource to glean local climate change impacts and facilitate understanding of the latest science and projections as the science advances. For the

HCR, this was most essential for understanding projected changes in extreme heat and precipitation patterns, for integration into relevant hazard profiles. This information was also integrated into the climate projections found in Chapter 03.

Sea Level Rise Guidance to DTSC Project Managers for Cleanup Activities (2023)

This state guidance supports project managers in accounting for the impacts of sea level rise during the hazardous waste cleanup process based on the existing authority granted to the state as regulator. The guidance includes information on how sea level rise can impact traditional remediation processes, identifies the state's role in addressing sea level rise during cleanup, and mandates a potential process for project managers to integrate in considering impacts during the cleanup process. This information was used to update the Contaminated Lands Vulnerability and Consequence Profile (Appendix A) as well as the Hazardous Materials Release Hazard Profile (Chapter 04).

Protecting Californians from Extreme Heat: A State Action Plan to Build Community Resilience (2022)

This report sets the standard of science across the state for extreme heat, including providing projections for areas across the state. This report lays out recommendations and strategies taken at the state level to deal with the increasing impacts of extreme heat in the state with a focus on public health. Actions in the plan are organized across a series of tracks including: Building Public Awareness and Notification, Strengthening Community Services and Response, Increasing Resilience of the Built Environment, and Utilizing Nature-Based Solutions. This roadmap will be integrated into existing and proposed climate adaptation programs to marshal the requisite efforts and funding to implement them. This report was used to update and frame the Extreme Heat Hazard Profile (Chapter 04).

State of California Sea Level Rise Guidance: 2024 Science and Policy Update (Draft 2024)

This report is produced by the California Ocean Protection Council (OPC) and serves as a replacement for the 2018 'State of California Sea-Level Rise Guidance'. This report provides the best available science on sea level rise and its coastal impacts for state and local policy/decision makers to ensure they have the latest information to inform their climate adaptation work. This ensures that jurisdictions and agencies can adequately prepare and align their efforts in the coastal communities around the state. Information from this report was used in Chapter 03 to update the section characterizing sea level rise projections.

Chapter 03

San Francisco Risk Landscape

King Tide Flooding

This chapter describes climate change projections and their implications for hazards in San Francisco, provides an overview of the assets at risk in San Francisco, and describes changes in development and population patterns in hazard-prone areas. This chapter sets the scene for the subsequent hazard analysis, vulnerability and consequences assessment, and strategy chapters.

3.1 Climate Change and Implications for Hazards

This section provides an overview of climate change and how it influences hazards in San Francisco now and into the future.

Overview

Climate change is happening, and its effects are impacting more people every year. The National Ocean and Atmospheric Administration (NOAA) identifies 2023 as the warmest year in recorded history since records began in 1850 and the 10 warmest years on record have all occurred during the last decade from 2014-2023.[1] These extreme temperatures have a significant and cascading impact on global weather patterns. High temperatures melt polar ice caps and contribute to the thermal expansion of the oceans which cause global sea levels to rise. Warm ocean temperatures also increase evaporation, and this increased concentration of water vapor in the atmosphere changes rainfall patterns as storms and droughts both become more extreme. Climate change results in important changes to the global climate system which influence the severity and frequency of local hazards. The following sections discuss the implications that climate change has on current and future hazards in San Francisco.

[1] Annual 2023 Global Climate Report (June 2024). Retrieved from: https://www.ncei.noaa.gov/access/monitoring/monthly-report/global/202313#:~:text=The%20year%202023%20was%20the,decade%20(2014%E2%80%932023).

TABLE 3-1
SUMMARY OF CLIMATE CHANGE IMPLICATIONS FOR HAZARDS

Climate Change:	Increasing Temperatures	Rising Sea Levels	Changing Precipitation Patterns
Implications for Hazards:	More **extreme heat** days, making heatwaves more frequent and longer lasting. **Drought** and **wildland-urban-interface fires** may become more frequent and severe. Wildfires create **poor air quality**.	More frequent, extensive and longer-lasting **coastal flooding**, especially during storm events. **Stormwater flooding** may increase as high bay levels can impede drainage of stormwater runoff. Higher groundwater table may **increase the susceptibility of some soils to liquefaction** during an earthquake.	Concentrated precipitation in discrete storm events may increase **stormwater flooding**, risk of **landslides** and **dam/reservoir** failure. **Droughts** may be more frequent and severe. Reduced snowpack in the Sierras may also exacerbate **drought**.

Climate Modeling and Projections

Representative Concentration Pathways (RCPs)[2]

Global Climate Models are a math-based simplification of four primary interactions driving climate change, namely: The Atmosphere, The Oceans, The Land, and Human Influences. These systems are all interconnected but human influences in these climate models are expressed as Representative Concentration Pathways (RCPs). RCPs assume different levels of human influence on the climate based on potential cumulative anthropogenic CO2 emissions, from the year 2000 as a baseline. This

[2] For more information on RCPs, see Carbon Brief (2019). "Explainer: The high emissions 'RCP8.5' global warming scenario". Retrieved from: https://www.carbonbrief.org/explainer-the-high-emissions-rcp8-5-global-warming-scenario/

approach focused on the amount of radiative forcing[3] at a certain point in the future, rather than explicitly including socioeconomic pathways associated with the scenarios. These were used in the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) in 2014 to contextualize the findings of the report.

TABLE 3-2
SUMMARY OF REPRESENTATIVE CONCENTRATION PATHWAYS

Representative Concentration Pathway (RCP)	Pathway Assumptions
RCP 8.5	Assumes anthropogenic global greenhouse gas emissions continue to rise over the next century (i.e., there are no significant efforts to limit or reduce emissions)
RCP 6.0	Assumes anthropogenic global greenhouse gas emissions peak in 2080 and then decline
RCP 4.5	Assumes anthropogenic global greenhouse gas emissions peak in 2040 and then decline
RCP 2.6	Assumes stringent emissions reductions, with anthropogenic global emissions declining by about 70% between 2015 and 2050, to zero by 2080, and below zero thereafter (i.e., humans would absorb more greenhouse gasses from the atmosphere than they emit).

Shared Socioeconomic Pathways (SSPs)

These pathways were developed to be complementary with the RCP scenarios detailed above. SSPs allow for the modeling of different potential futures of climate mitigation based on the global socioeconomic development of the world and how we approach climate action in the future. This includes modeling different worlds with various degrees of climate policy in addition to considering the differences in future emissions based on the form that takes. These scenarios are being used in the latest iteration of climate models, known as CMIP6, which informs the IPCC AR6 report. There are five SSP scenarios and their full descriptions are as follows:

[3] Carbon Brief (2018). "Q&A: How do climate models work?" Retrieved from: https://www.carbonbrief.org/qa-how-do-climate-models-work/#inout

TABLE 3-3
SUMMARY SHARED SOCIOECONOMIC PATHWAYS (SSOP)

SSP Name	Pathway Summary
SSP1: Sustainability – Taking the Green Road	Low challenges to mitigation and adaptation
SSP2: Middle of the Road	Medium challenges to mitigation and adaptation
SSP3: Regional Rivalry – A Rocky Road	High challenges to mitigation and adaptation
SSP4: Inequality – A Road Divided	Low challenges to mitigation, high challenges to adaptation
SSP5: Fossil-fueled Development – Taking the Highway	High challenges to mitigation, low challenges to adaptation

Understanding these potential model futures is important for understanding the likelihood of impacts from climate change. While climate change may be global in scope, its impacts are local.

Increasing Temperatures

As a result of climate change, we are already experiencing an increase in temperatures. From 1950 through 2005, the Bay Area saw an average annual maximum temperature increase of 1.7° F.[4] San Francisco reached an all-time high temperature of 106° F on September 1, 2017.[5] Scientists project that temperatures will continue to increase in the decades to come. As a result, San Francisco will experience more extreme heat days. In addition, higher temperatures can worsen drought and wildfires.

An extreme heat day in San Francisco is any temperature in the top two percent of all San Francisco temperatures between the years 1961 – 1990. According to this measure, an extreme heat day is any day with temperatures over 85°F.

[4] California National Resources Agency. California's Fourth Climate Change Assessment: San Francisco Bay Area Region Report. Retrieved from: http://www.climateassessment.ca.gov/regions/docs/20180827-SanFranciscoBayArea.pdf (Accessed: 9/10/2018)
[5] http://sanfrancisco.cbslocal.com/2017/09/01/excessive-heat-warning-declared-for-entire-bay-area/

Projections

Average Temperature

- Average yearly temperatures are expected to increase between 1.3°F and 3.1°F by mid-century and 3.3°F and 5.5°F by end-of-century compared to 2010.[6]

Extreme Heat

- Baseline: Between 1960 and 1990, San Francisco averaged about four extreme heat days per year. [7] The warmest years featured as much as 10 extreme heat days.

- Projections (85°F Degrees):

  Mid-Century (2035-2064): San Francisco can expect to have an average of 7 extreme heat days with particularly hot years having a maximum of 24 extreme heat events.[8]

  Late-Century (2070-2099): San Francisco can expect an average of 15 extreme heat events with particularly hot years having a maximum of 51 heat events.[9]

- Projections (95°F Degrees):

  Mid-Century (2035-2064): San Francisco can expect an average of 1 day over 95°F per year with particularly hot years having a maximum of 7 days over 95°F.[10]

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[6] Scrips Institute of Oceanography, Cal-Adapt and California Nevada Applications Program. Temperature: Extreme Heat Tool, http://cal-adapt. org/temperature/heat/

[7] Scrips Institute of Oceanography, Cal-Adapt and California Nevada Applications Program. Temperature: Extreme Heat Tool, http://cal-adapt. org/temperature/heat/

[8] Cal-Adapt. (2018). [Number of Extreme Heat Days for San Francisco County, RCP 8.5, Global Climate Models HadGEM2-ES, CNRM-CM5, CanESM2, MIROC5].

[9] Ibid.

[10] Extreme heat and Health (2023). Retrieved from: https://sf.gov/reports/may-2023/extreme-heat-and-health#extreme-heat-in-san-francisco

Late-Century (2070-2099): San Francisco can expect an average of 2 days over 95°F per year with particularly hot years having a maximum of 10 days over 95°F.[11]

Heat waves are similarly projected to increase in both frequency and severity.

Implications for Future Hazards

Higher temperatures influence several hazards, including:

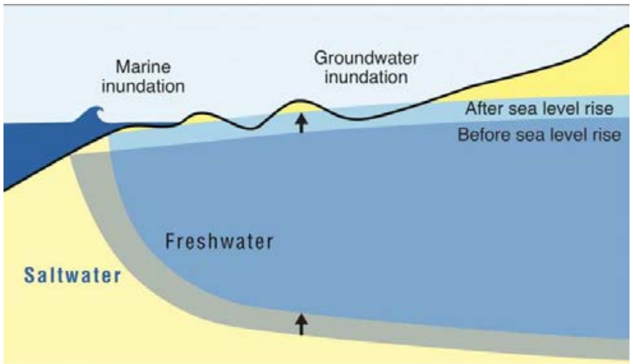
- San Francisco will experience more extreme heat days and heatwaves will be longer. San Franciscans are particularly vulnerable to extreme heat (for additional information see Extreme Heat Hazard Profile).
- Drought and wildfires fires may become more frequent and severe. Higher temperatures increase evaporation, which dries out soils and vegetation, increasing the severity of drought and making the region more prone to wildland-urban-interface fires.[12] In addition, more wildfires can increase the occurrence of poor air quality events (For additional information see Drought Hazard Profile, Wildfire Hazard Profile, and Air Quality Hazard Profile).

Rising Sea Levels

Rising sea levels will have implications for flooding and liquefaction risks. Historically, sea levels have risen by as much as 8 inches according to the Presidio Tide Gauge. The rate of sea level rise for the last century has been approximately 2 millimeters per year but this rate had doubled to roughly 4.8 millimeters per year by 2000. The rate of sea level rise increase is also expected to accelerate over the coming century while the speed of this acceleration is a subject of continued research.

FIGURE 3-1
SEA LEVEL RISE DIAGRAM[13]

[11] Ibid.
[12] Ekstrom, Julia A., and Susanne C. Moser. 2012. Climate Change Impacts, Vulnerabilities, and Adaptation in the San Francisco Bay Area: A Synthesis of PIER Program Reports and Other Relevant Research. California Energy Commission. Publication number: CEC-500-2012-071.
[13] UHM Coastal Geology Group



Projections

Since the 2020 Hazards and Climate Resilience Plan, which referenced the 2017 Rising Seas in California[14] and 2012 National Resource Council[15], scientific understanding of both present and future sea level has evolved based on recent observations and advances in projections. The California Sea Level Scenarios published by Ocean Protection Council in 2024[16] show greater certainty in the amount of sea level rise expected in the next 30 years than previous reports and demonstrates a narrow range across all possible emissions scenarios. Over the long-term (towards 2100 and beyond), the range of sea level rise becomes increasingly large due to uncertainties associated with physical processes, such as earlier than-expected ice sheet loss and resulting future sea level rise. The high-level takeaways are summarized below:

- Statewide, sea levels are most likely to rise 0.8 ft (Intermediate Scenario) by 2050.
- In the mid-term (2050-2100) the range of possible sea level rise expands due to more uncertainty in projected future warming from different emissions pathways and certain physical processes (i.e. rapid ice sheet melt). By 2100, statewide average sea levels are expected to rise between 1.6 ft (Intermediate Low

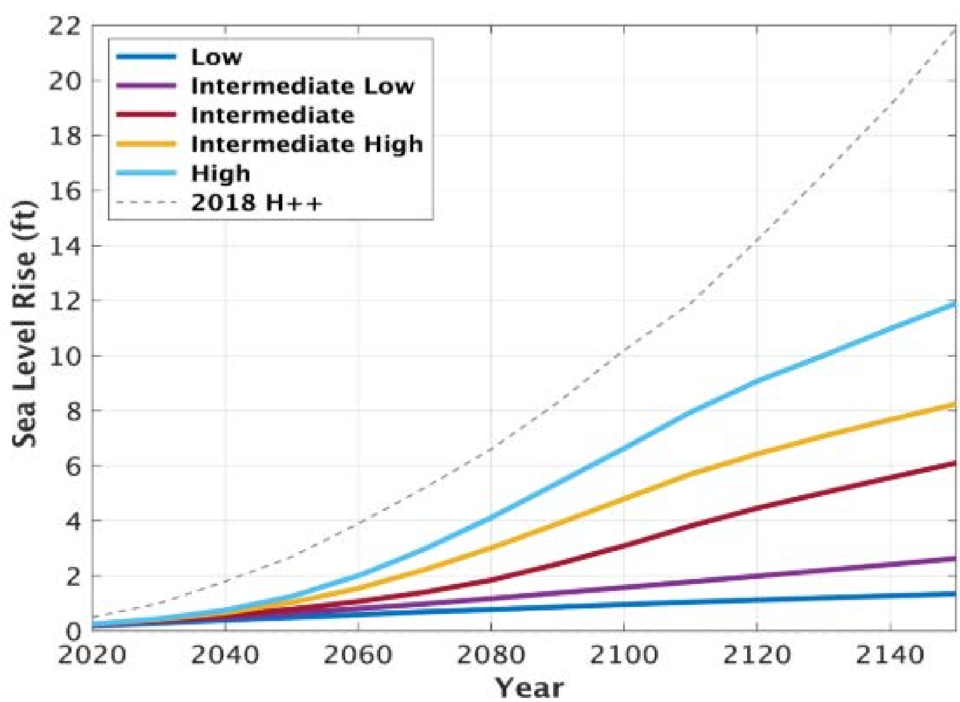
[14] Ocean Protection Council, 2017. Rising Seas in California. An Update on Sea Level Rise Science. https://www.opc.ca.gov/webmaster/ftp/pdf/docs/rising-seas-in-california-an-update-on-sea-level-rise-science.pdf
[15] [15] National Research Council (2012). Sea-Level Rise for the Coasts of California, 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.
[16] California Sea Level Rise Guidance: 2024 Science and Policy Update. 2024. California Sea Level Rise Science Task Force, California Ocean Protection Council, California Ocean Science Trust.

Scenario) and 3.1 ft (Intermediate Scenario), although higher amounts are possible.

- Over the long-term (towards 2100 and beyond), the range of sea level rise becomes increasingly large due to uncertainties associated with physical processes, such as earlier than-expected ice sheet loss and resulting future sea level rise. Sea levels may rise from 2.6 ft to 11.9 ft (Intermediate-Low to High Scenarios) by 2150, and even higher amounts cannot be ruled out.
- The extreme sea level rise scenario (i.e. H++) from Rising Seas 2017 is much higher than best available science suggests and has not been included in the 2024 update.

The 2024 Draft OPC Guidance presents five sea level rise scenarios for California based on target value of global mean sea levels in 2100 and they are shown below. For further detailed discussion of the scenarios, please consult the OPC Guidance.[17]

FIGURE 3-2
SEA LEVEL RISE SCENARIOS FROM 2020 TO 2150 IN FEET



[17] Ibid.

The exposure and vulnerability in this report (Chapter 05 and Appendix A) uses two different sea level rise scenarios:

- 66 inches above MHHW[18], which represents a mid-century upper-end SLR projection plus 100-year extreme tide or a late-century upper-range SLR projection without extreme tide (NRC 2012, OPC 2024).
- 108 inches above MHHW, which represents a later-century upper-end SLR projection plus 100-year extreme tide (NRC 2012, OPC 2024).

For a more detailed treatment of SLR projections and mapping, please see "Chapter 2: Sea Level Rise Climate Science and Scenarios" of the San Francisco's Sea Level Rise Vulnerability and Consequences Assessment.[i]

Implications for Future Hazards

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

- Low-lying areas that are not currently exposed to tides will experience inundation during high tides in the long-term.[19] (For additional information see Flooding Hazard Profile.)
- Coastal flooding will become more frequent as Bay and sea levels occur more often. Coastal flooding will be more extensive and longer-lasting, especially during storm events.[20] (For additional information see Flooding Hazard Profile.)
- Stormwater flooding will increase as high bay levels can impede drainage of stormwater runoff.[21] (For additional information see Flooding Hazard Profile).

[18] MHHW: Mean Higher High Water (MHHW) is the average level of the highest tide for each day computed over a 19-year period
[19]City and County of San Francisco, 2016. "Sea Level Rise Action Plan."
[20] Ibid
[21] Ibid

* Higher sea levels will also increase the elevation of the groundwater table, increasing the susceptibility of some soils to liquefaction during an earthquake.[22] (For additional information see Earthquake and Flooding Hazard Profiles).

Changing Precipitation Patterns

San Francisco precipitation levels have historically fluctuated between wet and dry extremes. Climate change will amplify this trend. As a result, San Francisco is projected to experience an increase in both flooding and drought.

Projections

Baseline: Although San Francisco has historically received on average 21 inches of rainfall annually, Bay Area precipitation levels are prone to large year-to-year variation.[23] California currently receives 35% - 45% of its annual precipitation from discrete storm events. These extreme storms events occur between November and March when atmospheric rivers transport water vapor from Hawaii across the Pacific Ocean towards the west coast of the United States.[24] Compared to other storm systems that originate in Alaska, atmospheric river storms are warm and wet and are associated with many of California's flood events. While 35% - 45% of California's annual precipitation comes from atmospheric river storms, they are responsible for nearly 80% of California's flooding because of both the quantity of precipitation these storms contain, and because these storms are less likely to result in snowfall because they have warmer water and can occur in spring or fall.[25] These storms may carry as much water as seven to fifteen Mississippi Rivers in a single event and often play a pivotal role in ending periods of drought[26].

Projection: Considering RCP4.5 mean projections, most regions of the state can expect to see at least modest increases in mean wet-season precipitation compared to historical amounts. However, the San Francisco Bay area is projected to see potential

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[22] Adapting to Rising Tides, "Climate Impacts and Scenarios." http://www.adaptingtorisingtides.org/portfolio/climate-impacts-and-scenarios/
[23] NOAA National Center for Environmental Information Station ID CHCND:USW000232272
[24] Dettinger, Michael, 2011. "Climate Change, Atmospheric Rivers, and Floods in California – A Multimodel Analysis of Storm Frequency and Magnitude Changes", *Journal of the American Water Resources Association*, Vol. 47, No. 3
[25] https://www.jpl.nasa.gov/news/news.php?feature=5648
[26] California National Resources Agency. California's Fourth Climate Change Assessment: San Francisco Bay Area Region Report. Retrieved from: http://www.climateassessment.ca.gov/regions/docs/20180827-SanFranciscoBayArea.pdf (Accessed: 9/10/2018)

average late-century increases of up to 10.5 percent, the highest in the state, making the region most likely to see changes in future storm events.[27] This trend is also evident in the RCP8.5 projections that point to average wet-season mid-century changes as much as 10.3% and as much as 18.7% by late-century. These indicators represent a general trend towards more intense/frequent storms during the wet season in the coming decades.

FIGURE 3-3
AVERAGE WET-SEASON PRECIPITATION CHANGE ACROSS THE STATE ASSUMING A RCP4.5 SCENARIO[28]

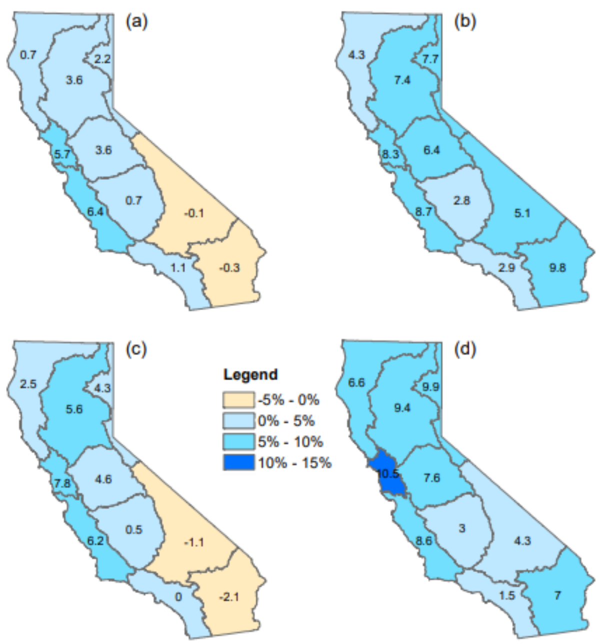

Figure 3: Percent Differences (%) between Historical and Mean RCP 4.5 Projections on (a) Annual Precipitation in Mid-Century, (b) Wet Season Precipitation in Mid-Century, (c) Annual Precipitation in Late-Century, and (d) Wet Season Precipitation in Late-Century.

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[27] He, Minxue, Andrew Schwarz, Elissa Lynn, Michael Anderson (California Department of Water Resources). 2018. Projected Changes in Precipitation, Temperature, and Drought across California's Hydrologic Regions. California's Fourth Climate Change Assessment. Publication number: CCCA4-EXT-2018-002.

[28] He, Minxue, Andrew Schwarz, Elissa Lynn, Michael Anderson (California Department of Water Resources). 2018. Projected Changes in Precipitation, Temperature, and Drought across California's Hydrologic Regions. California's Fourth Climate Change Assessment. Publication number: CCCA4-EXT-2018-002.

Year-to-year precipitation levels are expected to increasingly cluster around wet and dry extremes.[29] Precipitation is expected to become more variable in the future, with more rainfall occurring during extreme events, as higher temperatures can result in more water held in the atmosphere that is able to fall as rain. By the end of the century, atmospheric river storms are expected to provide nearly 50% of California's annual precipitation.[30] Under the RCP8.5 high-emissions scenario, severe storms with a return frequency of once every 200 years (a storm on the magnitude of the Great California Flood of 1862) could potentially occur every 40-50 years in the Bay Area by 2100.[31]

San Francisco gets 85% of its water from the Sierra Nevada.[32] According to a study by the UCLA Center for Climate Science, the snowpack in the year 2100 is expected to be 36 percent of the snowpack in 2000, which presents a major challenge for water management.[33]

Recent modelling by Pathways Climate Institute and Lawrence Berkeley National Laboratory in partnership with SFPUC shows the expected impact of climate change on Atmospheric River (AR) and Extra Tropical Cyclone storm events, the two most common sources of flooding for San Francisco. Across all the storms modelled as a part of the research effort, there were increases in storm duration, increases in total precipitation, and increased rainfall depth for 5-year return occurrence storms.

TABLE 3-4
CHANGE IN MODELLED STORMS BY YEAR

Impact	Projected year	Magnitude of change
Storm Duration	2050	+9% to +24% Increase
	2100	+18% to +55% Increase
Total Precipitation (Atmospheric River	2050	Up to +17% Increase
	2100	Up to +37% Increase

[29] Dettinger, Michael, 2011. "Climate change, atmospheric rivers, and floods in California – A Multimodel Analysis of Storm Frequency and Magnitude Changes", *Journal of the American Water Resources Association*, Vol. 47, No. 3
[30] Dettinger, Michael, 2011. "Climate Change, Atmospheric Rivers, and Floods in California – A Multimodel Analysis of Storm Frequency and Magnitude Changes", *Journal of the American Water Resources Association*, Vol. 47, No. 3
[31] California National Resources Agency. California's Fourth Climate Change Assessment: San Francisco Bay Area Region Report. Retrieved from: http://www.climateassessment.ca.gov/regions/docs/20180827-SanFranciscoBayArea.pdf (Accessed: 9/10/2018)
[32] San Francisco Public Utilities Commission - http://www.sfwater.org/index.aspx?page=355
[33] Reich, KD, N Berg, DB Walton, M Schwartz, F Sun, X Huang, and A Hall, 2018: "Climate Change in the Sierra Nevada: California's Water Future." UCLA Center for Climate Science.

and Extra tropical Cyclone)		
5-year return occurrence storms (Rainfall Depth)	2050	Up to ~+20% Increase
	2100	Up to ~+%56% Increase

This study goes on to provide Intensity-Duration-Frequency curves considering this new information and will be essential in adapting the city's flood policies to address this new scale of impact.

Implications for Future Hazards

Changing precipitation patterns may influence several hazards, including:

- Concentrated precipitation in extreme events may increase stormwater flooding, especially along San Francisco's underground creeks and in San Francisco's natural drainage basins. (For additional information see Flooding Hazard Profile.)
- Concentrated precipitation in extreme events may also increase the risk of landslides. An increase in wildland-urban-interface fires also increases landslide risks. (For additional information see Landslide Hazard Profile.)
- Concentrated precipitation in extreme events may increase the risk of reservoir/dam failure, especially if combined with older infrastructure and deferred maintenance. (For additional information see Dam/Reservoir Failure Hazard Profile)
- In dry years, when coastal high-pressure systems do not dissipate during winter months, California may be subject to frequent and severe droughts. In addition, a reduced snowpack in the Sierras can exacerbate drought and compromise water supply. (For additional information see Drought Hazard Profile).

3.1 Assets

This section describes the asset sectors (key areas) and assets at risk that form the basis of the asset-based vulnerability assessment described in Chapter 05: Vulnerability and Consequences Assessment, i.e., those assets that are evaluated with full results and in-depth analysis presented in Appendix A. These assets span both public and private ownership but share an essential characteristic, they are essential to ensuring the delivery of vital services to the general public. These assets are segmented into different sectors for communication with relevant stakeholders (public stakeholders, City staff and decision makers, etc.).

People

Communities at Increased Risk

Communities at increased risk refer to individuals within the city that are more susceptible to impacts from hazards because they have specific pre-existing conditions. Resilience in the face of hazards, particularly those influenced by climate change, is rooted in an interconnected set of conditions. Many of these are structurally determined, such as socioeconomic status, but others are particular to each individual, such as the prevalence of pre-existing health conditions. It's important to assess and understand the ways that hazards can impact different particular groups in order to create more nuanced programs and strategies that consider the unique needs of different populations within the city.

Emergency Response Facilities

Critical Response Facilities

Critical response facilities are facilities that provide direct life safety, property, and environmental protection services essential to communities during and after an emergency or disaster. These include direct service facilities such as the city's police and fire department buildings as well as facilities responsible for strategic coordination, known as the Emergency Operations Center (EOC) and the Departmental Operations Centers (DOC).

Hospitals

Hospitals provide lifesaving and life-sustaining services to protect the health and well-being of all San Francisco residents. These include several hospital facilities that operate across the city.

Other Emergency Sites

These assets are composed of the numerous public and private locations that are essential in supporting the city's communities during and after an incident. These include indoor/outdoor shelter sites for those displaced during events, the animal care and control facility that will be essential in managing the animal population of the city, as well as resource staging areas to potentially be used following a hazard event.

Public and Community Services

Municipal Buildings and Facilities

This asset class includes municipal offices, correctional facilities, and city-owned cultural centers, museums, and performance halls. These facilities serve the community in many different capacities, and some have unique cultural and economic value while the services rendered out of these buildings and facilities cannot be easily replaced (in some instances).

Municipal Yards

Many departments in the City are responsible for providing numerous sustained services (such as public transit or access to parks). This necessitates unique maintenance and storage needs for vehicles and equipment which the City accommodates through the operation of specialized facilities. The San Francisco Public Works, San Francisco Municipal Transportation Agency, the Port of San Francisco, and the Recreation and Park Department all have yards that fall under this category of facility and are listed under this asset class.

Health Care Facilities

Formal hospitals are not the only facilities in San Francisco that provide lifesaving and life sustaining services, rather there are a wide range of facilities that also provide similar or more specialized services that maintain the health and wellbeing of the city's residents. Primary care clinics, skilled-nursing facilities, pharmacies, and residential care facilities for the elderly all play a critical role in response to hazard events while also often acting as a point of service for some of the most vulnerable people in the city.

Food Distribution

Food distribution is composed of the numerous wholesale suppliers, grocery stores and charitable food distribution facilities that regulate the flow of food to communities throughout the city, provide food services for vulnerable populations, and ensure everyday access to this vital resource.

Educational Institutions

Educational institutions include public and private K-12 schools, as well as public and private colleges and universities spread across the city. K-12 institutions are vital in that they provide education, nutrition, and basic health care to children and youth, including those who may be more vulnerable to climate impacts because of existing disparities. Higher education institutions provide career services, confer degrees, and foster research, in addition to providing nutrition, housing, and health services to many of their students. Education institutions are also major employers, especially large universities.

Community Centers

Community centers provide a location where community members can obtain resources and information, and participate in spiritual, educational, recreational, and/or political activity. These include libraries, recreation centers, senior centers, youth centers, neighborhood centers, and faith-based centers. Community centers are run by the City, NGOs and places of worship, and many are a part of organizational networks, such as the YMCA. Some are large facilities that contain fitness, open space, and kitchen amenities. Others operate in small to medium sized commercial properties or in traditional building types for places of worship. These facilities are essential to community cohesion and often offer vital services to the residents of San Francisco.

Housing

The housing stock of San Francisco ranges from simple older buildings built over a century and a half ago, to complex, modern high-rises. This variety in form supports the wide variety of people that rely on these buildings for their housing needs. Variety is also seen on the quality and affordability of this housing stock which has notable implications for the ability of this housing to withstand hazards.

Business and Industry

Commercial

Commercial buildings make up a significant portion of the city's economy and are notable in contributing to the economic health and well-being of the city. These buildings consist of offices, retail spaces, hotels, and mixed-use properties. They can typically be found broadly across the entire city, however, they are densely concentrated in the Northeastern corner of the city.

Industrial

Industrial buildings are known as production, distribution, and repair building types. These buildings are often used for industrially intensive businesses, such as waste management or Port facilities. These businesses often support low-income workers and are geographically concentrated in the east and southeast neighborhoods of the city. The majority of these are privately owned.

Maritime

The maritime uses of the Port of San Francisco range significantly over the shoreline properties that it leases, manages, or directly operates for commercial and industrial activity. These consist of a series of shoreline piers on parcels along the eastern coast of the city. A variety of fishing, police, recreational, research, cruise shift terminal, cargo, and heavy industrial uses occupy these properties and, due to their proximity to the shoreline, they are particularly vulnerable to many hazards exacerbated by climate change. These assets also play an essential role in disaster response.

Contaminated Lands

Historical land use and development of the city, before the enforcement of modern environmental regulations, has left a legacy of contaminated lands in areas of the cities. Furthermore, these lands can often geographically coincide with vulnerable communities of color, due to patterns of environmental racism historically seen in this country. The City of San Francisco recognizes the need to vet, and ensure, that land slated for development has been adequately evaluate soil condition in advance of development. These lands are subject to a variety of local and federal programs based on previous ownership, contamination type, and remediation needs. Many of these areas can be found on land that was previously federally owned such as areas in Bayview Hunter's Point and Treasure Island.

Hazardous Materials Sites

Hazardous materials facilities are those that generate, store, transport, or treat any of the following kind of materials: radioactive, flammable, explosive, toxic, corrosive, or unsafe in other ways. These are often facilities such as gas stations, paint supply stores, manufacturing facilities, or other businesses that use these materials to provide a variety of goods and services. These facilities can be publicly or privately owned and are strictly regulated through enforcement of state provisions by the San Francisco Department of Public Health Hazardous Materials and Waste Program.

Transportation

Roadways

Roadways facilitate residents, workers, and visitors traveling within and through San Francisco, which supports economic activity, goods movement, and quality of life. The roadway network links people with community facilities and services, jobs, family and friends, recreation, and other destinations within the city and throughout the Bay Area region. Roadways as an asset class includes traditional roads, bicycle and pedestrian infrastructure, on-street parking, and bridges (state and local). Roadways are integral to transportation, access, and connectivity throughout the city even though they are managed by a variety of local, state, and federal agencies.

Parking

Parking garages are multi-story concrete parking structures. Rather than being spread throughout the city, they are concentrated largely in the Northeastern part of the city. This asset refers to the public garages owned by the city but managed by a variety of different departments.

Transit Network

The transit network facilities the movement of residents, workers, and visitors traveling within and through San Francisco, supporting economic activity and quality of life. This is essential to connecting San Francisco's residents with services, jobs, family, recreation opportunities, and other destinations locally and regionally. The transit network includes systems managed by a variety of public entities, these include: SFMTA's Muni system, BART, Caltrain commuter rail, AC Transit, Sam Trans, and Golden Gate Transit and their associated facilities such as bus yards, overhead catenary wires, tunnels, etc.

Water Transportation

Water transportation consists of ferries, water taxis, and facilities for the docking of private vessels and motorized/non-motorized boats. This asset also includes the Ferry terminals, gangways, and external services required for the effective operation of these facilities. Ferry services are provided by the Water Emergency Transportation Authority (WETA), Golden Gate Ferry, Blue and Gold, and many smaller operators and not only are these valuable for everyday operation.

Airport

The San Francisco Airport is the largest of three airports in the Bay Area and provides a significant amount of commercial air travel to the region. The airport is located 11 miles outside of the City and County of San Francisco to the south, in San Bruno. This facility covers a vast area, predominately composed of reclaimed land through the filing of the Bay and has several sophisticated utility systems and a large number of buildings to facilitate its day-to-day operations. These include the airfields, air traffic tower, terminals, utilities, and supporting structures required to process the large volume of air travel handled by the airport daily.

Utilities and Infrastructure

Power

Access to electrical power is essential to the continued operation of the communities of San Francisco. Many of the other assets listed in this chapter are heavily dependent on external services, such as power, for their continued operation and to provide the goods and services that the city relies on. To achieve this provision, a combination of generation sources, substations, transmission lines, transmission poles and distribution lines are networked across the city. While distribution lines span the whole city, a large amount of this infrastructure is concentrated along the eastern edge of the city.

Natural Gas

While the city is committed to moving towards the phase out of natural gas as an energy source, in recognition of its commitments to addressing the climate crisis, many communities rely on natural gas for commercial, industrial, and domestic uses. Natural gas use is facilitated by a network of infrastructure production (originating out of state), interstate transmission lines, intrastate transmission lines, distribution lines, and natural gas stations spread across the city but predominantly located in the Southeast. This infrastructure is managed by Pacific Gas &Electric (PG&E), which is regulated primarily by the California Public Utilities Commission (CPUC).

Potable Water

The potable water system delivers water from a sophisticated, regionally connected collection of resources to meet the needs of San Francisco residents and businesses. Distribution pipelines, storage reservoirs, and groundwater well sites are essential components of the system. The operation of the system involves the use of pumping stations, geographically spread across the city, moving water over a range of elevations to serve a wide range of users. San Francisco's Public Utilities Commission (SFPUC) Water Enterprise is responsible for managing the transmission, treatment, storage and distribution of potable water in the City and County of San Francisco.

Emergency Firefighting Water System

The Emergency Firefighting Water System is a high-pressure firefighting water system was created to safeguard lives and property in the case of future earthquakes. It spans the breadth of the city, covering the east side extensively, with improvements to the Westside and Southern areas currently being identified for implementation. This system is essential to combatting large urban fires that may occur following a significant earthquake hazard event. The system is composed of reservoirs/tanks as the primary supply of water; however, it can also access water from the Bay as a secondary source using pumping stations, manifolds, and drafting points. While the system is operated by the San Francisco Fire Department, it is managed by SFPUC.

Combined Sewer

San Francisco's combined sewer system treats combined wastewater from the stormwater runoff and sewage generated by the city to service the waste produced by the cities communities. Using gravity and an interconnected web of combined sewers, tunnels, and transport/storage boxes to intercept, store, and convey combined sewer flows throughout the City. Where gravity isn't sufficient to move this water around the system, or where weather conditions require the use of different facilities, force mains and pumping stations move wastewater to its eventual destination at one of three treatment facilities. Following treatment to nationally permitted standards, effluent is either discharged to the Pacific Ocean on the Western/Pacific shoreline or discharged to the Bay through outfalls located along the Bayshore. The system has a variety of components essential to in's operation, ranging from sewer pipes and tunnels to the treatment plants that treat the water for discharge.

Shoreline Protection Infrastructure

Shoreline infrastructure provides a critical function to much of the city, including flood protection during storms and extreme tide events, habitat, recreation opportunities, and public access. It also supports key utility and transportation infrastructure, including BART, Muni, the Port maritime facilities and ferry transportation. During an emergency it supports emergency response and recovery operations. Shoreline protection around San Francisco is made up of a variety of shoreline types and conditions, including beaches and bluffs along the western and northern shoreline of San Francisco, which fronts the Pacific Ocean and structural protection in many forms along the eastern and southern shorelines of the city along the San Francisco Bay. The majority of San Francisco's shoreline protection infrastructure is owned by public agencies, including the Port of San Francisco and the Department of Parks and Recreation; and the National Park Service.

Communications

The City's communications asset class transmits voice, video and data communications by fiber infrastructure, cellular and radio communications, and inside wired infrastructure. San Francisco Department of Technology (SFDT) manages a wide array of communications systems including radio, TV, internet, City internal data network, public warning sirens, emergency call boxes, communication path for traffic signals and the Mayor's Emergency Telephone Systems (METS). In some instances, these communication channels leverage private communications operators' fiber networks and internet service. Key City owned systems include the municipal fiber optics network, data centers, and the 800Mhz radio system. Private communications systems are owned by a wide range of operators, including Verizon, AT&T, T-Mobile, also Comcast and these provide redundant access to the Internet for municipal services.

Open Space

Parks and Open Space

Equally as important as the buildings and infrastructure that make up our cities are the recreation facilities and open spaces that connect and strengthen our communities. These spaces enhance the quality of life of city residents and provide a respite from the often-overwhelming elements of urban life by providing opportunities for recreation, social interaction, and mental well-being. In addition, these spaces provide habitat for native species to thrive, contribute to the environmental health of the city, and provide benefits for climate adaptation by delivering various ecosystem services. Distributed around the city, these areas are managed primarily by public agencies including federal, state, and local entities.

3.2 Changes in Development

This section describes changes in development that have occurred since the last plan update in hazard-prone areas and the associated actions in the HCR to increase the community's resilience. Related potential impacts are described in Table 3-5 below.

New Development

Since 2020, there has not been a significant amount of new development due to economic conditions. However, the development that has occurred has been concentrated in major development projects in waterfront communities that could be exposed to hazards such as flooding, tsunami, and liquefaction. In recognition of the vital role that various City departments play in developing new resilient housing, communities, and infrastructure through major development projects, the HCR 2025 includes a new action:

- N-6.6: Develop and support major development projects and public/private partnerships that deliver resilient waterfront infrastructure. For more detail, please see Chapter 07.

Treasure Island and Yerba Buena Island

Treasure Island and Yerba Buena Island have seen significant development progress since the 2020 HCR. The project has completed the first stage of infrastructure, ten acres of new parks and open space, and 1000 units of housing. At approximately, 500 acres when considered together, Treasure Island and Yerba Buena Island will feature San Francisco's newest neighborhood with over 8,000 homes, approximately 27% of which being affordable housing when the development is complete. The neighborhood will also feature an integrated transportation network that prioritizes pedestrians, cyclists, and other low carbon forms of transportation. Open space and natural areas will be integrated into the development that will not only provide recreational opportunities for the residents but also act as climate adaptation assets. The new development will also integrate ground stabilization techniques to mitigate seismic hazards on the island as development continues.

Development of transportation will be key to the success of the new neighborhood and that is reflected in the Treasure Island Transportation Implementation Plan (TTIP). TTIP supports the implementation of a variety of measures that will align transportation priorities with land-use and leverage development agreements to implement these improvements. This includes the new ferry service, bus services, and alternative fuel shuttles, among other measures.

To better reflect the resilience measures being incorporated into the community and infrastructure development at Treasure Island and Yerba Buena Island, the 2025 HCR includes several new actions:

- IN-3.4: Decrease the geographic vulnerability inherent to the island communities on Treasure Island and Yerba Buena Islands by increasing low-emission, connectivity to San Francisco.
- IN-4.4: Continue to develop public private partnerships to conserve and steward biodiversity and habitat on Treasure Island and Yerba Buena Islands.
- IN-5.6: Advance the Adaptive Management Strategy from the Treasure Island Infrastructure Plan to ensure continual protection to changing conditions.
- IN-7.2: Support the completion and handover of new power, water, wastewater distribution infrastructure at Treasure Island and discontinue the use of the legacy navy systems.

- IN-7.3: Complete construction of the Treasure Island Water Resource Recovery Facility to improve water treatment, increase water security, and to connect recycled water to San Francisco's first neighborhood with a complete green infrastructure system.

Central Waterfront

Mission Rock is a mixed-use development at Seawall Lot 337 and Pier 48 on approximately 28-acre Port-owned property. Construction will occur over 4 phases and began in 2019. Of the approximately 1,500 units planned for the site, the first two residential buildings totaling 541 units (of which 133 are affordable) have been completed, along with the first two commercial buildings totaling 575,000 sf of commercial and R&D space. The project has also built substantial horizontal infrastructure, including a new waterfront China Basin Park, that recently opened, designed with sea level rise in mind. The development will feature numerous design elements that relate to mitigating the impacts of climate change and natural hazards, including cool paving to mitigate urban heat island effect, localized stormwater treatment through green infrastructure on site, final grade elevations in waterfront park areas will be based on 2100 sea level rise projections, and plantings will be selected to be drought and saline tolerant.

The Potrero Power Station was a functional power plant providing energy to the city until it was decommissioned in 2011. Following this, the City and the property owner collaborated on a redevelopment proposal and, with a new site owner coming on board, created a masterplan for the site and immediate area that was approved for development in 2020. Of the overall 2,200 units entitled for the site, the first residential building with 105 units (100% affordable) is currently under construction, and permits have been filed for another 348 units. Substantial infrastructure work and clean-up has been done on the site as well.

Upon completion, this project will include 2,601 housing units with 30% below market rate, 6.9 acres of open space, and mixed-use commercial areas. As the site is along the waterfront, considerations of sea level rise have been integrated into the development planning process and will improve resilience for the future community.

Following the approval of the development agreement in 2018, construction of Pier-70 began. The 28-acre site will be developed in phases and include new residential buildings with up to 2,150 units of affordable and market rate housing. Since 2020, utility and street construction has been completed for Phase 1 of the development program, completed renovation of historic building 12, and began implementing the Interim Best Management Practice to address stormwater runoff.

Mission Bay has seen continued development since 2020. This has most notably included the construction of the Sister Lillian Murphy Community (152 affordable housing units), Bayfront Part and additional creek-side open space.

Expanding Housing Choice

The current housing affordability crisis has forced many of the people that keep our city running, like teachers, first responders, and service workers, to leave. Among many actions, the SF Housing Element 2022 Update[34] requires the city to undertake zoning changes to accommodate new housing and provides broad policy directives and concepts for where the zoning changes should occur.

Over the past 20 years, the majority of housing development in San Francisco has occurred in the eastern and southeastern neighborhoods where zoning allows for taller buildings. These areas are more exposed to hazards, such as flooding, liquefaction, tsunami, extreme heat, and toxic materials than other parts of San Francisco.

Zoning changes since 2022 are focused on well-resourced neighborhoods in the northern and western neighborhoods (comprising 52% of the city's residential land). The proposed zoning changes are focused on transit and commercial corridors, which will provide new residents with convenient access to low-carbon transportation options and make it easier for them to meet their daily needs within walking distance. The changes would increase housing capacity and affordability for low- and middle-income households. Focusing these changes in high resourced neighborhoods has been shown to improve economic, educational, and health outcomes for low-income families, particularly children. These areas are also typically less exposed to liquefaction and flooding hazards.[35]

Nevertheless, resilience to seismic, fire-related and combined hazards remain important considerations for all San Francisco neighborhoods.

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[34] SF Planning. SF Housing Element 2022 Update (2022). Retrieved from: https://generalplan.sfplanning.org/I1_Housing.htm#well-resourced-neighborhoods

[35] Some proposed zoning changes are in areas that are more vulnerable to liquefaction and sea level rise, such as parts of the Marina (south of Chestnut) and Fisherman's Wharf (up to Jefferson St.)

This zoning effort has been folded into the existing action from the 2020 HCR:

- C-6.1: Continue to meet housing production goals.

Downtown Recovery and Adaptive Reuse

The COVID-19 pandemic dramatically increased working from home. In July 2023, the "Commercial to Residential Adaptive Reuse and Downtown Economic Revitalization" ordinance was passed to ease the conversion of underutilized office buildings into housing. Ensuring that converted buildings are resilient to hazards is an important consideration specified in Action B-1.2 ("Implement priority tasks of the Earthquake Safety Implementation Program, such as addressing concrete and steel buildings").

3.3 Changes in Population Patterns

Projections for changes in San Francisco's population by 2050 vary among different sources. The Plan Bay Area 2050 report anticipates the city's population will grow from approximately 866,000 in 2015 to over 1 million by 2050, reflecting an increase of about 16%.[36] However, projections from the California Department of Finance predict that San Francisco will lose population from around 870,000 in 2020 to approximately 845,000 by 2060, a reduction of about 2.9%.[37] Population projections are subject to change due to various factors, including economic conditions, housing availability, migration trends, and policy decisions. Recent events, such as the COVID-19 pandemic and the rise of remote work, have influenced migration patterns and could further impact future demographic trends.

In terms of changes in socially vulnerable populations, projections from the California Department of Finance have also indicated a growth in the aging population, especially adults 70 and over.[38] This demographic trend is significant because seniors and older adults are at increased risk of morbidity and mortality from hazard events because they are more likely to have chronic health conditions, mobility constraints, and experience

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[36] Metropolitan Transportation Commission, 2021. "Plan Bay Area 2050: Executive Summary." https://planbayarea.org/sites/default/files/documents/Plan_Bay_Area_2050_Exec_Summary_October_2021.pdf

[37] California Department of Finance, County Population Projects (2020-2070). https://dof.ca.gov/forecasting/demographics/projections/

[38] City College of San Francisco, 2018. "Regional Report: San Francisco Population Projections." Accessed 2/12/2025. https://www.ccsf.edu/sites/default/files/2023/document/regionalreport-sfpopulationprojection-aug2018v2-ada.pdf

social isolation. Additional mitigation resources may need to be targeted to this population.

There has been an increase in the number of people experiencing homelessness. The 2024 Point in Time count indicated a 7% increase to more than 8,300 people compared to 2022.[39] The count also found that while the total number of people experiencing homelessness has increased, the number of "unsheltered homelessness" or people sleeping in tents, cars, and RVs decreased 1% since 2022 and 16% since 2019. Nearly half of the city's unhoused residents are now living in shelters.[40] This trend is significant because unhoused populations are among the most vulnerable San Franciscans. Without stable shelter options, this population is often more exposed to hazard events. During hazard events, this population has limited resources to evacuate, communicate, and shelter in place.

For a detailed demographic analysis by neighborhood, please see Appendix A. Potential impacts by hazard are described in Table 3-5 below.

[39] SF.gov. "Homeless Population: San Francisco's Biennial Point-in-Time (PIT) Count." Accessed 2/12/2025. https://www.sf.gov/data--homeless-population
[40] KQED. "San Francisco Homeless Up 7% Despite Decline in Street Camping." Accessed 2/12/2025. https://www.kqed.org/news/11986620/san-francisco-homelessness-up-7-despite-decline-in-street-camping

TABLE 3-5. SUMMARY OF POTENTIAL IMPACTS DUE TO CHANGES IN DEVELOPMENT AND LAND USE AND POPULATION

	Changes in Development and Land Use	Changes in Population
Earthquake	• Due to advances in building codes, new buildings will generally perform better in an earthquake than older buildings. However, the building code focuses on life safety rather than functional recovery. As a result, even new buildings may be damaged in a major earthquake. • Treasure Island has seen significant development since 2020 and is located in a liquefaction hazard zone. To reduce potential damage to buildings and infrastructure, significant seismic improvements have been made, including ground stabilization of the shoreline and development parcels and bridge retrofits.	• Seniors and older adults are at greater risk for morbidity and mortality in an earthquake due to mobility constraints. • The City is planning retrofits for San Francisco's homeless shelters, which have poor seismic performance ratings, indicating a life safety risk.
Tsunami	• Waterfront developments are in the tsunami hazard zone. In the event of a tsunami, potential impacts include damage to buildings and infrastructure and potential injuries and casualties. However, these major development projects include measures to adapt to sea level rise that also mitigate potential tsunami impacts.	• Seniors and older adults are at greater risk for morbidity and mortality in a tsunami due to mobility constraints and communications challenges. •Unhoused populations are at greater risk for morbidity and mortality in a flood event due to greater exposure from living outdoors or in vehicles in low-lying areas.
Landslide	• There are no recent changes in development and land use that are relevant to this hazard.	• Seniors and older adults are at greater risk for morbidity and mortality in a landslide due to mobility constraints.
Dam or Reservoir Failure	• There are no recent changes in development and land use that are relevant to this hazard.	• Seniors and older adults are at greater risk for morbidity and mortality in a dam or reservoir failure event due to mobility constraints and communication challenges.

Flooding	• Without adaptation, shoreline development could be exposed to flooding due to sea level rise. Potential impacts include temporary damage to buildings and infrastructure during storms or permanent inundation. However, new shoreline development projects are elevating the shoreline to protect to at least 2050-levels of projected sea level rise and include adaptive management strategies to further protect communities to 2100 and beyond. • Some development sites with legacy contamination due to military and/or industrial uses will need to undergo vulnerability and risk analysis to sea-level rise and groundwater rise, and remediation prior to development to avoid potential exposure of hazardous materials to humans and the environment.	• Seniors and older adults are at greater risk for morbidity and mortality in a flood event due to mobility constraints and communication challenges. •Unhoused populations are at greater risk for morbidity and morality in a flood event due to greater exposure from living outdoors or in vehicles in low-lying areas.
High Wind	• There are no recent changes in development and land use that are relevant to this hazard.	• Seniors and older adults are at greater risk for morbidity and mortality in a high wind event due to mobility constraints.
Extreme Heat	•New buildings are more likely to include AC than existing buildings. New development projects include design elements to mitigate urban heat island effects, such as green infrastructure and cool pavements.	• Seniors and older adults are at greater risk for morbidity and mortality during an extreme heat event due to pre-existing health conditions, mobility constraints, and social isolation. •Unhoused populations are at greater risk for morbidity and mortality in an extreme heat event due to pre-existing health conditions and greater exposure from living outdoors or in vehicles.

Drought	• New development may increase demand for water supplies. To mitigate this potential impact, new development is constructed with high efficiency water fixtures, native and drought tolerant plantings, and recycled water systems.	• An increase in overall population may increase demand for water supplies. See mitigations discussed to the left.
Large Urban Fire	• New development may increase the demand for post-earthquake firefighting water supplies. The Emergency Firefighting Water System 2050 Planning Study recommended increasing conveyance capacity and geographic coverage of the EFWS based on 2050 population estimates. New developments are also required to expand or upgrade the EFWS pipe network. This has occurred in Mission Bay, Pier 70, and other locations.	• Seniors and older adults are at greater risk for morbidity and mortality during a large urban fire event due to mobility constraints and communications challenges.
Wildfire	• There are no recent changes in development and land use that are relevant to this hazard.	• Seniors and older adults are at greater risk for morbidity and mortality during a wildfire event due to mobility constraints and communications challenges.
Poor Air Quality	• New buildings are built to modern building codes and feature tighter building envelopes and other features that increase resilience to poor air quality. • Development in certain areas is subject to increased ventilation standards as a part of the Article 38 Air Quality Exposure Zone provisions and therefore have more rigorous air quality protections for residents.	• Seniors and older adults are at greater risk for morbidity and mortality during a poor air quality event due to pre-existing health conditions. • Unhoused populations are at greater risk for morbidity and mortality in a poor air quality event due to pre-existing health conditions and greater exposure from living outdoors or in vehicles.

Chapter 04

Hazards Analysis

The HCR characterizes 13 hazards that impact San Francisco. Each hazard has a profile capturing the impact, the history of past hazard events, the location, severity, and probability of future events. The chapter also includes an overview of climate change science and how climate change influences hazards in San Francisco. The Planning Team (as described in Chapter 02) was responsible for reviewing the hazards assessed in the 2020 HCR as a starting point for the 2025 HCR Update. Based on subject matter expertise, the 2025 HCR update has focused on the same hazards as the 2020 HCR and no additional hazards were identified for inclusion or removal in this update cycle, although groundwater rise was added to the existing flood hazard profile. The factors that went into the broader decision on hazards for the 2025 HCR Update included most principally, previous risk analysis regarding the hazards that could impact San Francisco. This included the continuing presence of seismic risk, increased attention on climate influenced hazards (such as flooding and heat), and stakeholder input on priorities for hazard mitigation.

Hazard Rationale

The following table contains the hazards considered and the rationalization for their inclusion or omission from the plan:

Hazard	Included in 2025 plan	Included in 2020 plan	Comments
Avalanche	No	No	Avalanche is not a concern for San Francisco due to a lack of snow.
Flooding (Coastal)	Yes	Yes	Coastal flooding is a notable concern due to existing conditions and projected sea level rise.
Cold Wave	No	No	San Francisco does not typically experience extreme cold, but cold weather is a concern for some populations, including the unhoused. The Planning Team will continue to monitor trends to determine if this hazard should be added in the future.
Dam/Reservoir Failure	Yes	Yes	Dam/reservoir failure is a notable risk in San Francisco due to its coincidence with other hazard risks such as earthquake.
Drought	Yes	Yes	Drought is a notable concern for San Francisco based on the frequent and increasing occurrence of this hazard across the state.
Earthquake	Yes	Yes	Earthquakes are a top hazard for San Francisco based on the historic occurrence of this hazard as well as the prevalence of numerous faults in the area.
Hail	No	No	While hail occasionally occurs in San Francisco, there have not historically been significant impacts from hail events.
Hazardous Materials Release	Yes	Yes	Hazardous Materials Waste hazards are notable due to their coincidence with other hazard risks such as earthquakes and flooding.
Heat Wave	Yes	Yes	Extreme heat is a notable hazard for San Francisco due to the low

			occurrence of air conditioning and recent heat waves.
Pandemic	Yes	Yes	Pandemic is a notable hazard for San Francisco due to historic impacts from this hazard as well as the increasing likelihood of future impacts.
Poor Air Quality	Yes	Yes	Poor Air Quality is a notable hazard for San Francisco due to the jurisdictions proximity to fire prone areas and the attendant wildfire smoke that coincides with these events.
Hurricane	No	No	Hurricanes have not historically occurred in San Francisco.
Ice storm	No	No	Ice storms have not historically occurred in San Francisco .
Landslide	Yes	Yes	Landslides are a notable concern for San Francisco due to the hilly topography and likelihood of an earthquake.
Lightning	No	No	San Francisco has not experienced significant impacts from lighting.
Flooding (Riverine)	Yes	Yes	Flooding is a notable hazard for San Francisco due to the incidence of atmospheric rivers and increased impervious surfaces.
Strong Wind	Yes	Yes	Strong winds are a notable hazard for San Francisco due to atmospheric rivers and other damaging high wind events.
Tornado	No	No	Hurricanes have not historically occurred in San Francisco.
Tsunami	Yes	Yes	Tsunami is a notable hazard for San Francisco due to the coastal location and risk of local seismic activity or activity in other areas.
Volcanic Activity	No	No	Volcanic activity is not a concern for San Francisco due to a lack of volcanos in proximity.
Wildfire	Yes	Yes	While wildfire risk within San Francisco is low to moderate, it is very high in neighboring jurisdictions and in counties with key water and power infrastructure.
Winter Weather	No	No	Impacts and risks from winter storms are captured in the flooding and high wind hazard profile.

The table below displays the hazard profiles that compose this chapter along with their associated icons.

Earthquake	Tsunami	Landslide	Dam or Reservoir Failure	Flooding	High Wind	Extreme Heat	Drought	Large Urban Fire	Wildfire	Poor Air Quality	Pandemic	Hazardous Materials

Federal and State Disaster Declarations

The following emergency declarations have occurred since the last plan update:

Federal or State	Disaster Declaration Name and ID	Related hazard	Date
State	State of emergency declaration for October Atmospheric Rivers	High Wind, Flooding, Landslide	October 21st, 2021
Federal	California Severe Winter Storms, Flooding, Landslides, and Mudslides (DR-4683-CA)[1]	High Wind, Flooding, Landslide	Jan 14th, 2023
Federal	California Severe Winter Storms, Straight-line Winds, Flooding, Landslides, and Mudslides (DR-4699-CA)[2]	High Wind, Flooding, Landslide	April 3rd, 2023

[1] FEMA (2025). "California Severe Winter Storms, Flooding, Landslides, and Mudslides" Retrieved from: https://www.fema.gov/disaster/4683
[2] FEMA (2025). "California Severe Winter Storms, Straight-line Winds, Flooding, Landslides, and Mudslides. Retrieved from: https://www.fema.gov/disaster/4699

Earthquake Hazard Profile

4.1 Earthquake

Earthquakes present one of the greatest risks to San Francisco's buildings, infrastructure and people. San Francisco has experienced several devastating earthquakes in its history, and there is a high likelihood of a large earthquake in the near future. An earthquake is a sudden slip on a fault in the earth's crust, and the resulting ground shaking and radiated seismic energy caused by the slip.[1] A fault is a fracture in the earth's crust where a block of crust on one side moves relative to the other.[2]

The energy released in earthquakes can produce different types of hazards. Groundshaking and Liquefaction are discussed in greater detail in this profile, while tsunami, earthquake-induced landslides, fire following earthquake (large urban fire), and dam failure are discussed in their own profiles. Each of which are discussed in greater detail in this section:

Ground Shaking

Impact Statement

All of San Francisco is susceptible to very strong to extreme ground shaking during a major earthquake. There is a 72 percent chance that an earthquake of moment magnitude (Mw) 6.7 or greater will strike the San Francisco Bay Region between now and 2043. A Mw 6.7 earthquake or above on one of the seven major faults in the Bay Area could result in very strong to severe shaking in the city, which in turn may result in widespread casualties and infrastructure damage. Though the impact of climate change on earthquakes has not been clearly established,[3] sea level rise may result in higher ground water tables, which may increase the areas of the city susceptible to liquefaction.[4]

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[1] United States Geological Survey (USGS) Earthquake Hazards Program, "Earthquake Glossary - Earthquake," accessed May 17, 2018, https://earthquake.usgs.gov/learn/glossary/?term=earthquake.

[2] USGS Earthquake Hazards Program, "Earthquake Glossary - Fault," accessed May 17, 2018, http://earthquake.usgs.gov/learn/glossary/?term=fault.

[3] Ilan Kelman, "Climate Change and the Sendai Framework for Disaster Risk Reduction," *International Journal of Disaster Risk Science* 6 (2015): 121, accessed May 22, 2018, https://link.springer.com/content/pdf/ 10.1007%2Fs13753-015-0046-5.pdf.

[4] Peter Quilter, Sjoerd van Ballegooy, and Marje Russ, "The Effect of Sea Level Rise on Liquefaction Vulnerability." *6th International Conference on Earthquake Geotechnical Engineering*, 1-4 November 2015, Christchurch, New Zealand.

Nature

The effects of large earthquakes can be felt far beyond the site of their occurrence. Earthquakes occur without warning and can cause significant damage and extensive casualties after just a few seconds. The most common effect of earthquakes is ground shaking. When an earthquake occurs, the energy from the quake radiates outward from the fault in all directions in the form of seismic waves. As seismic waves reach the earth's surface, they shake the ground and anything on it. Strong ground shaking may damage or destroy buildings and may injure or kill occupants. Ground shaking is the primary cause of earthquake damage to buildings and infrastructure.[5]

The severity of ground shaking in an earthquake depends on the magnitude of the quake, the distance from the fault, and local geologic conditions. We can anticipate the amount of shaking that may occur at a given location from a particular fault by knowing how long the fault is (which indicates earthquake magnitude), where the fault is (giving us the distance to any location), and the geological conditions at the site.[6] Soil type is one geological condition that may affect ground shaking. The velocity at which soil or rock transmits shear waves generated by earthquakes contributes to amplification of ground shaking. Shaking is stronger where the shear wave velocity is lower. Because soft soils have lower shear wave velocity, they amplify or increase ground shaking. As a result, earthquake damage is typically more severe in areas with soft soils.[7]

Table 4-1, below, shows soil types in the Bay Area and their shear wave velocity. San Francisco's predominant soil is Type D, but there are locations in the city with Type E soils. Both of these soil types amplify shaking. For a map showing soil types in San Francisco, see Figure 4-1 below.

[5] USGS, Earthquake Hazards Program, "Soil Type and Shaking Hazard in the San Francisco Bay Area," accessed May 17, 2018, https://earthquake.usgs.gov/hazards/urban/sfbay/soiltype/.

[6] Southern California Earthquake Center (SCEC), "Earthquake Shaking - Accounting for "Site Effects," accessed May 17, 2018, http://scecinfo.usc.edu/phase3/overview.html.

[7] USGS, Earthquake Hazards Program, "Soil Type and Shaking Hazard in the San Francisco Bay Area."

FIGURE 4-1
SOIL TYPES IN SAN FRANCISCO

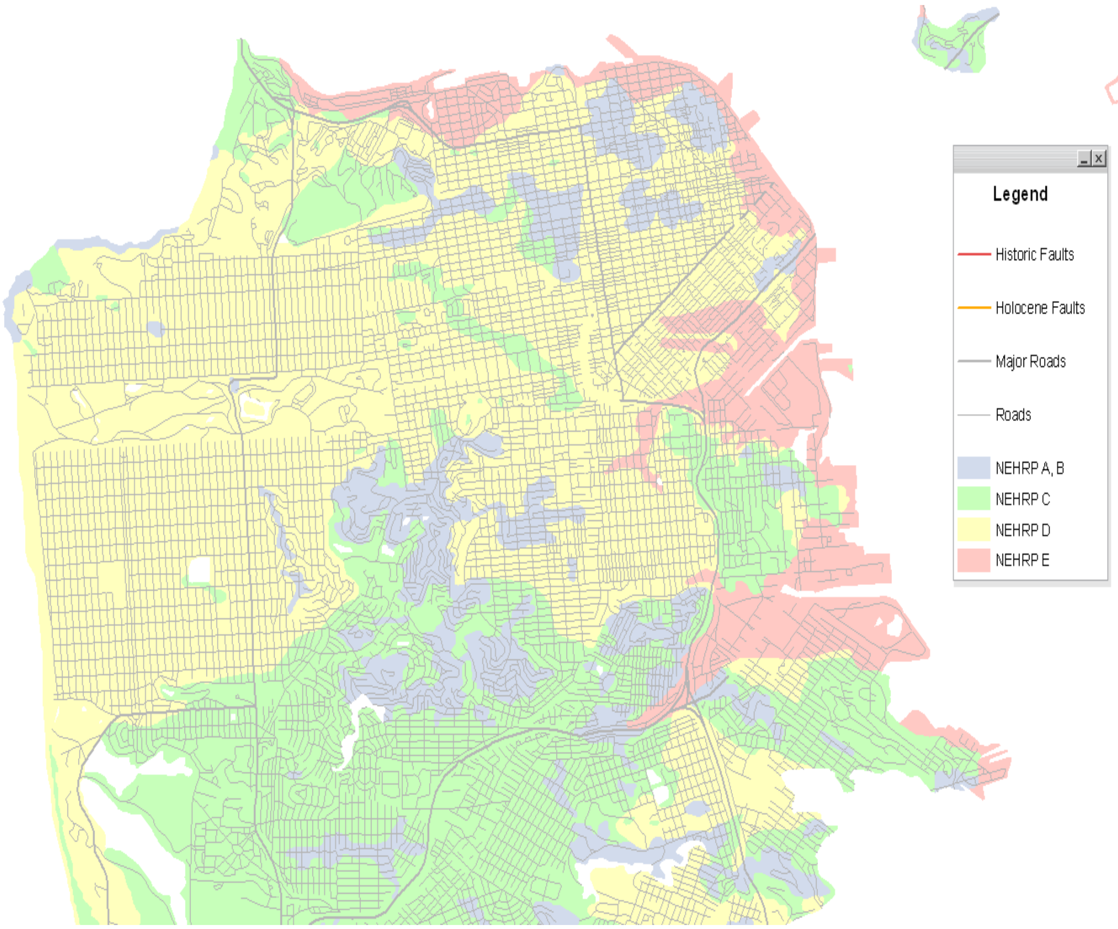


TABLE 4-1
SOIL TYPES AND SHAKING AMPLIFICATION[8]

Soil Type	Shear-Wave Velocity (Vs)	Soil Definitions
Type A	Vs > 1500 m/sec	Includes unweathered intrusive igneous rock. Occurs infrequently in the Bay Area. Soil types A and B do not contribute greatly to shaking amplification.
Type B	1500 m/sec > Vs > 750 m/sec	Includes volcanics, most Mesozoic bedrock, and some Franciscan bedrock. The Franciscan Complex is a Mesozoic unit that is common in the Bay Area.
Type C	750 m/sec > Vs > 350 m/sec	Includes some Quaternary sands, sandstones, and mudstones; Upper Tertiary sandstones, mudstones and limestone; Lower Tertiary mudstones and sandstones; and Franciscan melange and serpentinite.
Type D	350 m/sec > Vs > 200 m/sec	Includes some Quaternary muds, sands, gravels, silts and mud. Significant amplification of shaking by these soils is generally expected.
Type E	200 m/sec > Vs	Includes water-saturated mud and artificial fill. The strongest amplification of shaking is expected for this soil type.

The severity of an earthquake can be described in terms of intensity and magnitude. Intensity is the impact of an earthquake on the Earth's surface. Intensity measures the strength of shaking from an earthquake at a certain location as indicated by its effects on people, structures, and the natural environment. Intensity generally increases with the amount of energy released, which is proportional to the size of the earthquake, and decreases with distance from the quake epicenter.[9]

One scale used in the United States to measure earthquake intensity qualitatively is the Modified Mercalli Intensity (MMI) Scale. The MMI Scale consists of 10 increasing levels of intensity ranging from imperceptible shaking to building destruction.[10] MMI less than 6 does not generally damage buildings. Table 4-2 below shows the expected impacts to

[8] USGS, Earthquake Hazards Program, "Soil Type and Shaking Hazard in the San Francisco Bay Area," accessed May 17, 2018, https://earthquake.usgs.gov/hazards/urban/sfbay/soiltype/
[9] USGS, "The Severity of an Earthquake," *General Interest Publication 1989-288-913*, accessed May 17, 2018, https://pubs.usgs.gov/gip/earthq4/ severitygip.html.
[10] USGS, Earthquake Hazards Program, "The Modified Mercalli Intensity Scale," accessed May 17, 2018, https://earthquake.usgs.gov/learn/topics/mercalli.php.

building contents and common building types. For maps showing MMI for various earthquake scenarios that may impact San Francisco, see Figure 4-2 and Figure 4-3 below.

Ground shaking intensity can also be quantitatively measured in terms of acceleration, velocity, or displacement. Peak ground acceleration (PGA) is a common ground motion parameter used by engineers. PGA measures earthquake intensity by quantifying the rate of acceleration of the ground at a given location. Peak acceleration is the largest increase in velocity recorded by a particular geophysical instrument station during an earthquake.[11] PGA is expressed as a percentage of the acceleration of gravity (g): One g is an acceleration of 9.8 meters per second.[12]

Another means of measuring earthquake severity is Magnitude (M), which measures the size of an earthquake. The first magnitude scale was the Richter Scale, also known as local magnitude (M_L). Because the Richter Scale does not satisfactorily measure the size of larger earthquakes, it is no longer commonly used. The magnitude scale currently used by seismologists is the moment magnitude (Mw) scale.[13] The Mw scale, based on the concept of seismic moment, is uniformly applicable to all sizes of earthquakes.[14] Table 4-3 shows an approximate correlation between the Mw and MMI Scale for intensities typically observed at locations near the epicenter of earthquakes of different magnitudes.

[11] USGS, Earthquake Hazards Program, "Earthquake Glossary - Acceleration," accessed May 17, 2018, https://earthquake.usgs.gov/learn/glossary/?term=acceleration.

[12] USGS, Earthquake Hazards Program, "Earthquake Glossary – G or g," accessed May 17, 2018, https://earthquake.usgs.gov/learn/glossary/?term=G%20or%20g.

[13] USGS, Earthquake Hazards Program, "Measuring the Size of an Earthquake," accessed May 17, 2018, https://earthquake.usgs.gov/learn/topics/measure.php.

[14] USGS, Earthquake Hazards Program, "Earthquake Glossary – Magnitude," accessed May 17, 2018, https://earthquake.usgs.gov/learn/glossary/?term=magnitude.

FIGURE 4-2
PREDICTED GROUND SHAKING INTENSITY: 7.0 HAYWARD FAULT SCENARIO

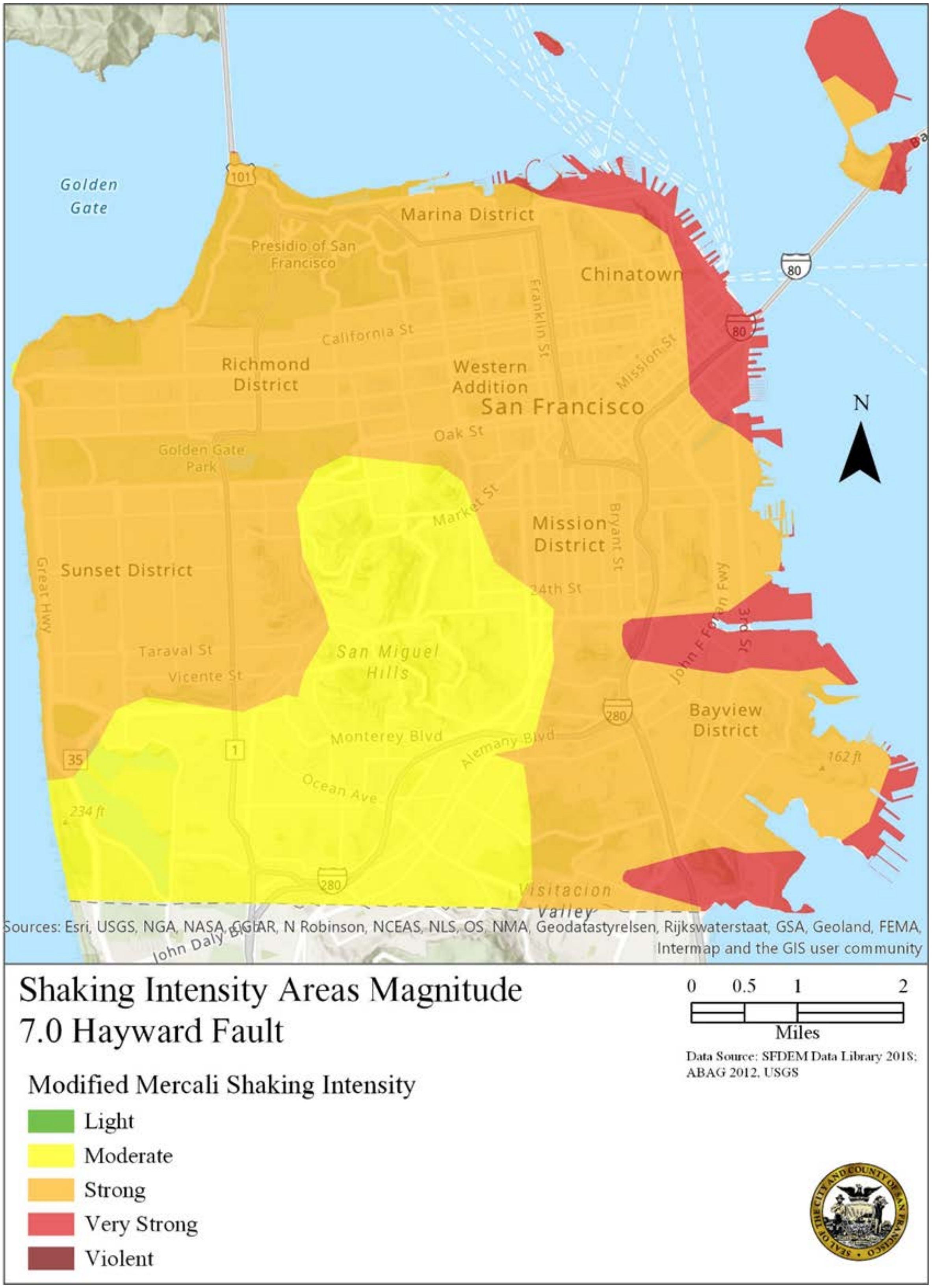


FIGURE 4-3
PREDICTED GROUND SHAKING INTENSITY: 7.8 SAN ANDREAS FAULT SCENARIO

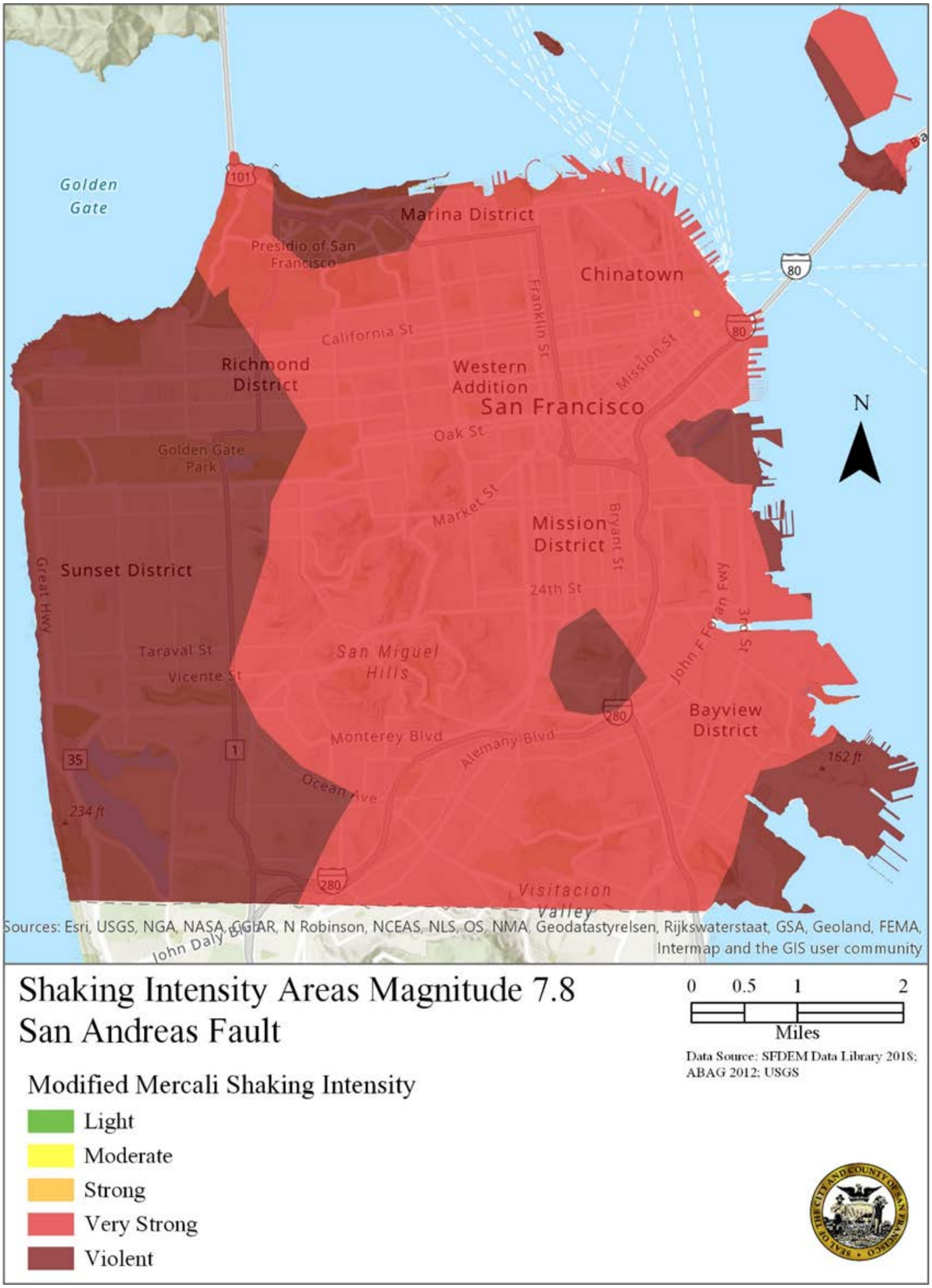


TABLE 4-2
SHAKING INTENSITY IMPACTS[15]

Intensity	Shaking	Intensity Description or Damage
I	Not Felt	Not felt except by a very few under especially favorable conditions.
II	Weak	Felt only by a few persons at rest, especially on upper floors of buildings.
III	Weak	Felt quite noticeably by people indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to passing of a truck. Duration estimated.
IV	Light	Felt indoors by many, outdoors by few during the day. At night, some awaken. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V	Moderate	Felt by nearly everyone; many awaken. Some dishes and windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI	Strong	Some things thrown from shelves, pictures shifted, water thrown from pools. Some walls and parapets of poorly constructed masonry buildings crack. Some drywall cracks. Some chimneys are damaged. Some slab foundations, patios, and garage floors slightly crack.
VII	Very Strong	Many things thrown from walls and shelves. Furniture is shifted. Poorly constructed buildings are damaged and some well- constructed buildings crack. Cornices and unbraced parapets fall. Plaster cracks, particularly at inside corners of buildings. Some unretrofitted soft-story buildings strain at the first-floor level. Some partitions deform. Many chimneys are broken and some collapse, damaging roofs, interiors, and porches. Weak foundations can be damaged.
VIII	Severe	Nearly everything thrown from shelves, cabinets, and walls. Furniture overturned. Poorly-constructed buildings suffer partial or full collapse. Some well-constructed buildings are damaged. Unreinforced walls fall. Unretrofitted soft-story buildings are displaced out of plumb and partially collapse. Loose partition walls are damaged and may fail. Some pipes break. Houses shift if they are not bolted to the foundation or are displaced and partially collapse if cripple walls are not braced. Structural elements such as beams, joists, and foundations are damaged. Some pipes break.
IX	Violent	Only very well anchored contents remain in place. Poorly constructed buildings collapse. Well- constructed buildings are heavily damaged. Retrofitted buildings damaged. Unretrofitted soft-story buildings partially or completely collapse. Some well- constructed buildings are damaged. Poorly constructed buildings are heavily damaged, some partially collapse. Some well- constructed buildings are damaged.
X	Extreme	Only very well anchored contents remain in place. Retrofitted buildings are heavily damaged, and some partially collapse. Many well- constructed buildings are damaged.

[15] US Geological Survey (USGS). https://earthquake.usgs.gov/learn/topics/mercalli.php

TABLE 4-3
MAGNITUDE AND INTENSITY COMPARISON[16]

Moment Magnitude (Mw)	Modified Mercalli Intensity (MMI) Scale
1.0-3.0	I
3.0 - 3.9	II – III
4.0 - 4.9	IV – V
5.0 - 5.9	VI – VII
6.0 - 6.9	VII – IX
7.0 and higher	VIII or higher

History

The San Francisco Bay Area is located within the boundary between the Pacific and the North American tectonic plates, where the Pacific plate is slowly and continually sliding northwest and past the North American plate.[17] Historically, the San Andreas Fault system is the most active system in the Bay Area. This fault system is capable of generating very strong earthquakes of magnitude 7.0 or greater.

The last major earthquake on the northern portion of the fault occurred in 1906. Known as the Great 1906 San Francisco Earthquake, this event was centered off San Francisco's Ocean Beach, and lasted 45 to 60 seconds. The 1906 quake has been estimated at moment magnitude 7.7 to 7.9.[18] The quake was reported at the time to have resulted in 498 deaths in San Francisco and $80 million in earthquake damage to the region.[19] Later research has produced estimates of over 3,000 deaths in San Francisco from the 1906 earthquake.[20]

[16] USGS. http://earthquake.usgs.gov/learning/topics/mag_vs_int.php
[17] USGS, *Earthquake Outlook for the San Francisco Bay Region 2014—2043*, by Brad T. Aagaard, James Luke Blair, John Boatwright, Susan H. Garcia, Ruth A. Harris, Andrew J. Michael, David P. Schwartz, and Jeanne S. DiLeo, Fact Sheet 2016-3020, (Reston, Virginia, 2016), 2, accessed May 21, 2018, https://pubs.usgs.gov/fs/2016/3020/ fs20163020.pdf.
[18] USGS, Earthquake Hazards Program, "1906 Earthquake: What was the magnitude?" accessed May 17, 2018, https://earthquake.usgs.gov/earthquakes/events/1906calif/18april/magnitude.php.
[19] USGS, Earthquake Hazards Program, "Casualties and damage after the 1906 Earthquake," accessed May 17, 2018, https://earthquake.usgs.gov/earthquakes/events/1906calif/18april/casualties.php.
[20] Gladys Hansen and Emmet Condon, *Denial of Disaster* (San Francisco: Cameron and Co., 1989), 14.

On October 17, 1989, San Francisco experienced the Mw 6.9 Loma Prieta Earthquake. The 1989 quake was centered near Loma Prieta peak in the Santa Cruz Mountains, approximately 60 miles south-southeast of San Francisco. The quake lasted only 15 seconds but resulted in severe shaking in the San Francisco and Monterey Bay regions.[21] In San Francisco, Loma Prieta resulted in 12 deaths, 300 people injured, and $2 billion dollars in property damage.[22]

The largest earthquake since Loma Prieta was the August 24, 2014, South Napa Earthquake, a Mw 6.0 earthquake on the West Napa fault, which is part of the Calaveras Fault Zone system. The Napa quake resulted in two deaths and 300 injuries, and caused extensive damage in Napa, Solano, and Sonoma counties. It did not result in significant damage in San Francisco.[23]

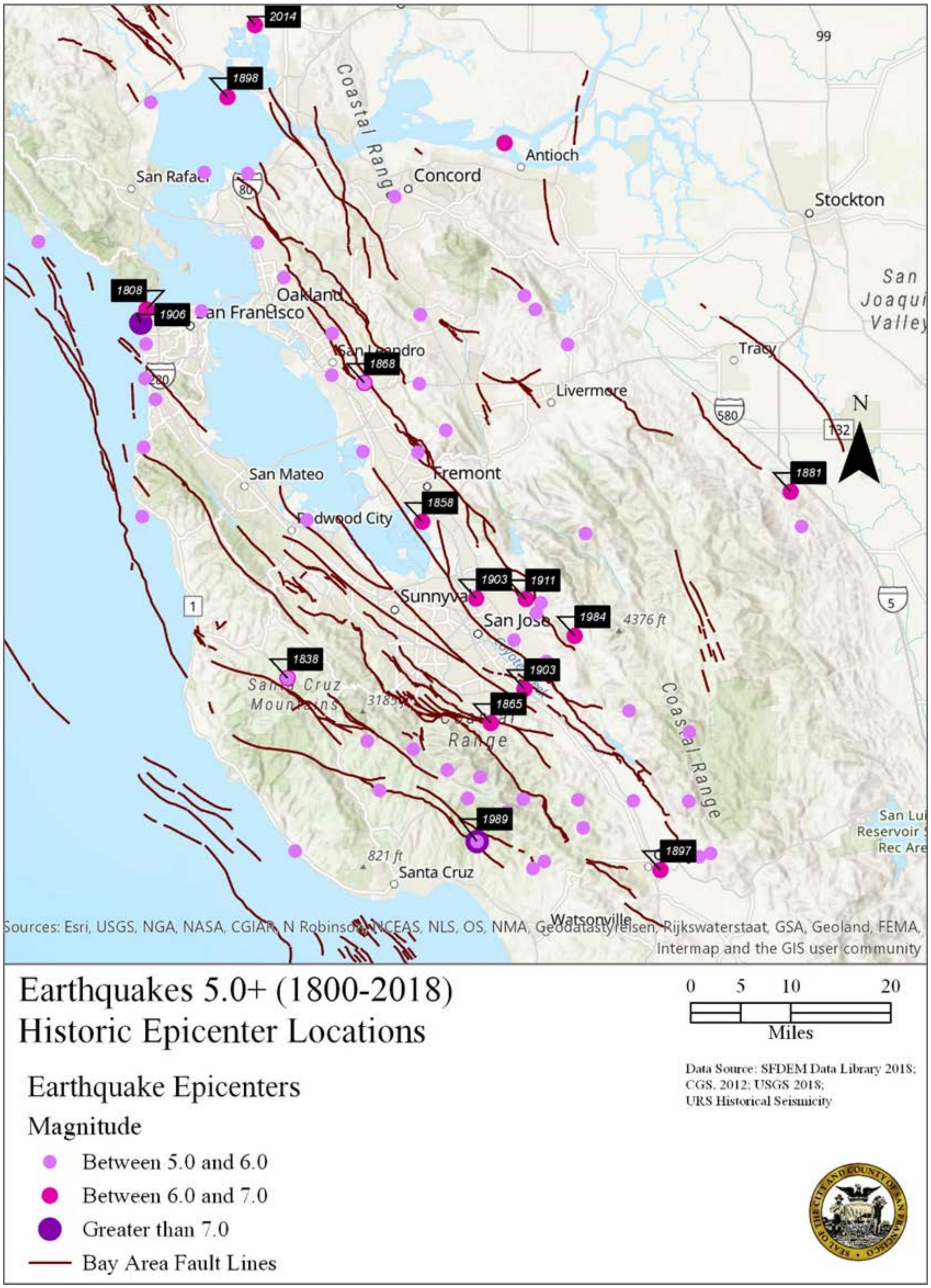
As shown in Figure 4-4 below, the San Andreas and other regional faults, including the Hayward fault, have generated 70 recorded M 5.0 or greater earthquakes since 1800. Of these recorded earthquakes, three (1838, 1906, and 1989) registered at a M_L of 6.8 or greater. For further discussion of measurement of earthquake severity, see Ground Shaking, Nature, above.

[21] USGS, Earthquake Hazards Program, "M 6.9 October 17, 1989, Loma Prieta Earthquake," accessed May 17, 2018, https://earthquake.usgs.gov/earthquakes/events/1989lomaprieta/.

[22] California Senate Committee on Toxics and Public Management, "1989 Northern California Earthquake," California Senate Paper 228 (1989), 2, accessed May 21, 2018, https://digitalcommons.law.ggu.edu/cgi/viewcontent.cgi?referer=https://www.google.com/&httpsredir=1&article=1219&context=caldocs_senate. Dollar figures are in 1989 dollars. In 2018 dollars, this would represent over $4 billion in damage.

[23] See California Seismic Safety Commission and Pacific Earthquake Engineering Research Center, *The Mw 6.0 South Napa Earthquake of August 24, 2014: A Wake-up Call for Renewed Investment in Seismic Resilience Across California*, by Laurie A. Johnson and Stephen A. Mahin, CSSC Publication 16-03, PEER Report No. 2016/04 (2016), 1, accessed May 21, 2018, https://peer.berkeley.edu/publications/peer_reports/reports_2016/CSSC1603-PEER201604_FINAL_7.20.16.pdf.

FIGURE 4-4
EARTHQUAKES 5.0+ (1800-2018) HISTORIC EPICENTER LOCATIONS



Location

Though no known active faults are located within San Francisco County boundaries, San Francisco is susceptible to seismic hazards from numerous known faults in the Bay Area, and from potentially unmapped or undiscovered faults. Most of the known major faults in the Bay Area are strike-slip faults, which are vertical or nearly-vertical fractures where the ground generally moves horizontally.[24] The Bay Area also has several thrust or reverse faults, which are fractures where the ground generally moves vertically with a dip of 45 degrees or less.[25] The most active of the large strike-slip faults in the region are the San Andreas Fault and the Hayward Fault, which has three segments, including the Rodgers Creek Fault. Table 4-4, below, lists major Bay Area faults, their locations, and lengths within the Bay Area.

[24] USGS, Earthquake Hazards Program, "Earthquake Glossary – Strike-slip," accessed May 17, 2018, https://earthquake.usgs.gov/learn/glossary/?term=strike-slip.

[25] USGS, Earthquake Hazards Program, "Earthquake Glossary – Dip slip," accessed May 17, 2018, https://earthquake.usgs.gov/learn/glossary/?term=dip slip.

TABLE 4-4
MAJOR KNOWN FAULTS IN THE SAN FRANCISCO BAY AREA[26]

Fault Source	Location	Fault Type	Length (Miles)
Northern San Andreas	Northern California Coast	Strike-slip	294
Hayward-Rodgers Creek	Alameda, Contra Costa, Marin, Santa Clara, and Sonoma Counties	Strike-slip	118
Calaveras	Alameda, Contra Costa Counties	Strike-slip	81
Concord-Green Valley	Alameda, Contra Costa, Solano, Santa Clara Counties	Strike-slip	81
Greenville Fault	Alameda, Contra Costa, Santa Clara Counties	Strike-slip	34
San Gregorio	Marin, Monterey, San Mateo, Santa Cruz Counties	Strike-slip and reverse thrust	68
Mt. Diablo Thrust	Alameda, Contra Costa Counties	Thrust fault	20

Severity and Probability of Future Events

As noted earlier, the severity of an earthquake at a particular location can be expressed in terms of the MMI Scale. Figure 4-3 shows the shaking intensity for a Mw 7.9 earthquake on the northern segment of the San Andreas Fault, an event similar to the 1906 earthquake. Figure 4-2 shows the shaking intensity for a Mw 6.9 earthquake on the northern segment of the Hayward Fault. Figure 4-3 indicates that all of San Francisco is susceptible to very strong to extreme shaking. Figure 4-2 shows areas subject to very strong shaking in San Francisco including the Lake Merced area, Treasure Island, the Marina District, North Waterfront, Financial District North, Financial District South, South of Market (SOMA), Mission Bay, South Beach, Potrero Hill, Bayview District, and Hunters Point neighborhoods.

[26] USGS, Quaternary Fault and Fold Database of the United States; 2007 WGCEP, 2008, Uniform California Earthquake Rupture Forecast, Version 2 (UCERF 2): USGS Open-File Report 2007-1437 and California Geological Survey Special Report 203, 28, https://pubs.usgs.gov/of/2007/1437/

There is a strong likelihood that San Francisco will experience a significant earthquake from one of the known major faults in the next 30 years. In 2014, the Working Group on California Earthquake Probabilities (WGCEP) issued its Third Uniform California Earthquake Rupture Forecast (UCERF3). UCERF3 indicates there is a 72-percent chance that an earthquake of moment magnitude 6.7 or greater will strike the nine-county San Francisco region over a 30-year period (2014–2043) along one of the Bay Area fault systems identified in the forecast.[27] Figure 4-5 below, shows the earthquake outlook for major faults in the Bay Area as determined by UCERF3. As of 2024, the WGCEP has not issued an updated earthquake rupture forecast.[28]

[27] Edward H. Field and 2014 Working Group on California Earthquake Probabilities (WGCEP), *UCERF3: A New Earthquake Forecast for California's Complex Fault System: Fact Sheet 2015–3009 (2015)*, 4, accessed May 18, 2018, https://dx.doi.org/10.3133/fs20153009.

[28] http://wgcep.org/

FIGURE 4-5
EARTHQUAKE OUTLOOK FOR THE SAN FRANCISCO BAY REGION 2014–2043[29]

[29] USGS, Earthquake Outlook for the San Francisco Bay Region 2014-2043, https://pubs.usgs.gov/fs/2016/3020/fs20163020.pdf

Liquefaction

Impact Statement

Liquefiable soils in San Francisco are generally found in water saturated sandy or silty soils or landfill along the Pacific coast and San Francisco Bay and in inland areas of fill in the Financial District, South of Market Area, the Mission District, Civic Center areas, and on Treasure Island. The area surrounding the San Francisco International Airport (SFO) in San Mateo County is also within the State liquefaction zone. Liquefiable soils must be shaken hard enough and long enough to trigger liquefaction. Given past instances of severe liquefaction during the Great 1906 and 1989 Loma Prieta Earthquakes, it is reasonable to assume that severe liquefaction will again occur in future earthquakes with strong shaking. As groundwater levels rise due to climate change-related sea level rise, liquefaction zones can be expected to increase in size. Conversely, for earthquakes occurring during a multi-year, severe drought, a low water table and dry ground may inhibit liquefaction that might otherwise occur during large earthquakes.

Nature

Earthquake-induced soil liquefaction is a leading cause of earthquake damage worldwide.[30] Liquefaction is a process in which water-saturated soil temporarily loses strength and acts as a fluid. Liquefaction can occur during earthquake shaking,[31] when seismic waves cause water pressure to increase to the extent that sand grains in the sediment lose contact with each other, leading the sediment to lose strength. Soil that has liquefied may lose its ability to support structures, cause it to flow down even very gentle slopes or to erupt to the ground surface in the form of sand boils. The ground surface may also experience settlement as a result of liquefaction; this phenomenon typically occurs in uneven patterns that damage buildings, roads and pipelines.[32]

The effects of liquefaction on buildings and other infrastructure can be extremely damaging, and may include cracking of foundations, damage to support structures, and

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[30] National Academies of Sciences, Engineering, and Medicine, *State of the Art and Practice in the Assessment of Earthquake-Induced Soil Liquefaction and Its Consequences* (Washington, DC, 2016), 1, accessed May 23, 2018, https://doi.org/10.17226/23474.

[31] USGS, Earthquake Hazards Program, "Earthquake Glossary – Liquefaction," accessed May 22, 2018, https://earthquake.usgs.gov/learn/glossary/?term=liquefaction.

[32] USGS, San Francisco Bay Region Geology and Geologic Hazards, "About Liquefaction," accessed May 22, 2018, https://geomaps.wr.usgs.gov/sfgeo/liquefaction/aboutliq.html.

even structural collapse. Such structural damage may in turn cause injuries to people and leave structures unusable.

Three factors are required for liquefaction to occur:[33]

1. Loose, granular sediment.
2. Saturation of the sediment by ground water.
3. Strong shaking.

Many areas of San Francisco have loose, sandy soils, or have been built up over "reclaimed" areas of human-made "fill." In these areas, ground water fills the spaces between sand and silt grains, making liquefaction more probable during strong shaking. All parts of San Francisco Bay have the potential to be shaken hard enough for susceptible sediment to liquefy.[34]

In most of the San Francisco Bay region, ground water is closest to the surface, where it can saturate younger sediment, in the winter and spring, during and following what is typically San Francisco's rainy season. In 1906, the region experienced a relatively dry rainy season. The 1989 Loma Prieta earthquake occurred at the end of the dry season in October, when ground water levels were relatively deep beneath the ground surface. Nevertheless, the city experienced considerable liquefaction-related damage as a result of both these earthquakes.[35]

History

The United States Geological Survey (USGS) has mapped liquefaction occurrences in San Francisco for earthquakes occurring in 1838, 1852, 1865, 1868, 1906, 1954, and 1989.[36] Detailed liquefaction maps for the 1906 earthquake show very high liquefaction susceptibility in areas along the Pacific Ocean and San Francisco Bay, including Treasure Island and small portions of Yerba Buena Island.[37] Detailed liquefaction maps

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[33] USGS, San Francisco Bay Region Geology and Geologic Hazards, "Factors of Liquefaction," accessed May 22, 2018, https://geomaps.wr.usgs.gov/sfgeo/liquefaction/factors.html

[34] USGS, San Francisco Bay Region Geology and Geologic Hazards, "Factors of Liquefaction."

[35] Ibid

[36] USGS, San Francisco Bay Region Geology and Geologic Hazards, "Earthquakes That Have Caused Liquefaction in the San Francisco Bay Area," accessed May 22, 2018, https://geomaps.wr.usgs.gov/sfgeo/liquefaction/ eq_caused.html

[37] USGS, San Francisco Bay Region Geology and Geologic Hazards, "Earthquakes That Have Caused Liquefaction in the San Francisco Bay Area, Locations of liquefaction features produced during the 1906 San Francisco earthquake," accessed May 22, 2018, https://geomaps.wr.usgs.gov/sfgeo/liquefaction/image_pages/ liqmap_16.html

for the 1989 Loma Prieta Earthquake show very high susceptibility to liquefaction in the same areas affected by the 1906 earthquake.[38]

A significant portion of the damage resulting from the 1906 earthquake was directly or indirectly related to liquefaction. Most liquefaction-related damage in the 1906 quake occurred in reclaimed areas that were once bay or marshland.[39] Liquefaction caused great damage to buildings and structures in areas like the Mission District and the Market Street area, including settlement, lateral spreading, and damage to water mains and sewers.[40] In addition, the catastrophic fires following the earthquake, which burned for the better part of three days, were so damaging in part because liquefaction-related damage to the city's water system severely limited the city's ability to fight the fires.[41]

After the 1989 Loma Prieta earthquake, liquefaction in the Marina District caused vertical settlement, lateral displacement of buildings, buckling of sidewalks, cracking of asphalt pavement, and breaking of water pipes and gas lines. Over 70 sand boils were reported in garages and backyards. Some of the sand boils were nearly four feet in depth. Liquefaction during the Loma Prieta quake also impacted the city's Auxiliary Water Supply System (AWSS), which provides San Francisco with water for firefighting purposes.[42] AWSS is currently referred to as the Emergency Firefighting Water System (EFWS).

Location

In both the 1906 and 1989 earthquakes, most liquefaction occurred in areas where significant local amplification of ground motion was caused by underlying soft sediment.[43] As shown on the following page, in Figure 4-6, the USGS and California Geological Survey (CGS) have mapped areas of liquefaction potential. Liquefiable soils in San Francisco are generally found in areas of landfill along the bay front, former bay inlets, and sandy low-lying areas along the ocean front. Locations subject to very high

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[38] USGS, San Francisco Bay Region Geology and Geologic Hazards, "Earthquakes That Have Caused Liquefaction in the San Francisco Bay Area, Locations of liquefaction features produced during the 1989 San Francisco earthquake," accessed May 22, 2018, https://geomaps.wr.usgs.gov/sfgeo/liquefaction/image_pages/ liqmap_17.html

[39] USGS, San Francisco Bay Region Geology and Geologic Hazards, "Liquefaction in Past Earthquakes," accessed May 22, 2018, https://geomaps.wr.usgs.gov/sfgeo/liquefaction/effects.html

[40] USGS, *The Loma Prieta, California Earthquake of October 17, 1989—Liquefaction*, Professional Paper 1551-B (Washington, DC, 1998), B37–B39, accessed May 22, 2018, https://pubs.usgs.gov/pp/1551b/report.pdf.

[41] USGS, San Francisco Bay Region Geology and Geologic Hazards, "Liquefaction in Past Earthquakes," accessed May 22, 2018, https://geomaps.wr.usgs.gov/sfgeo/liquefaction/effects.html.

[42] USGS, *The Loma Prieta, California Earthquake of October 17, 1989—Liquefaction*.

[43] USGS, *The Loma Prieta, California Earthquake of October 17, 1989—Liquefaction*, B3.

liquefaction susceptibility in San Francisco include areas of Ocean Beach in the Sunset and Richmond Districts and portions of the Presidio, Marina District, North Waterfront, the Financial District, South Beach, Mission Bay, the Central Waterfront (Dogpatch), Hunters Point, Candlestick Point, and Treasure Island. Inland portions of the city that also have very high liquefaction susceptibility include the South of Market Area (SOMA), the Stowe Lake area of Golden Gate Park, and Civic Center.

The Ferry Building area has been identified as one of the highest risk areas in the entire waterfront, as seen in the figure below, due to the significant lateral spreading expected in the area in combination with expected settling of the ground in the area post event.

In addition, the area surrounding the San Francisco International Airport (SFO), located in San Mateo County, is within the state's Seismic Hazards liquefaction zone, as mapped by CGS pursuant to the Seismic Hazards Mapping Act of 1990.[44]

[44] California Geological Survey, "Earthquake Zones of Required Investigation, San Mateo Quadrangle" (2015), accessed May 22, 2018, http://gmw.conservation.ca.gov/SHP/EZRIM/Maps/SAN_MATEO_EZRIM.pdf; Cal. Public Resources Code §§ 2690 et seq.

FIGURE 4-6
POTENTIAL LIQUEFACTION AREAS

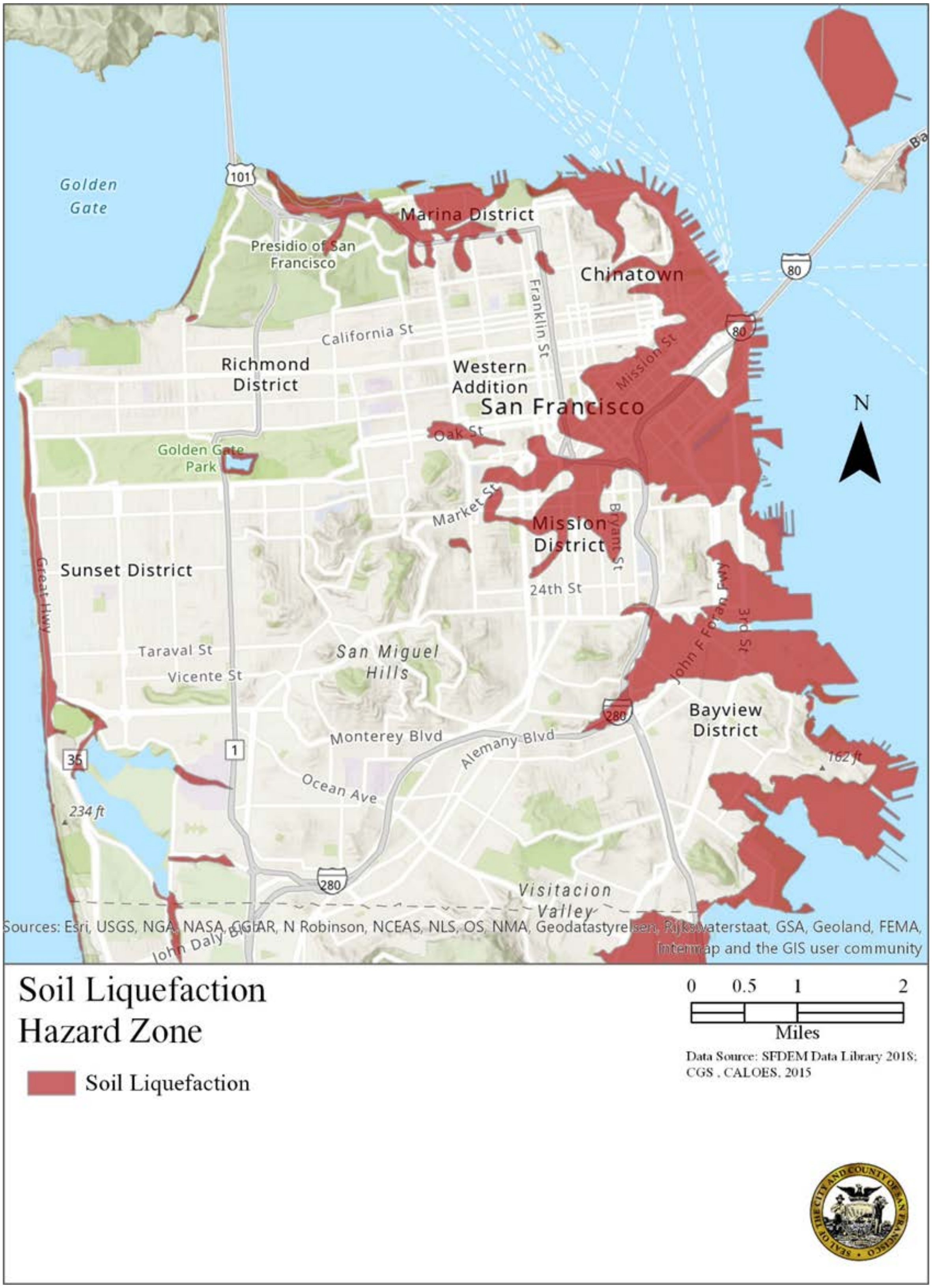
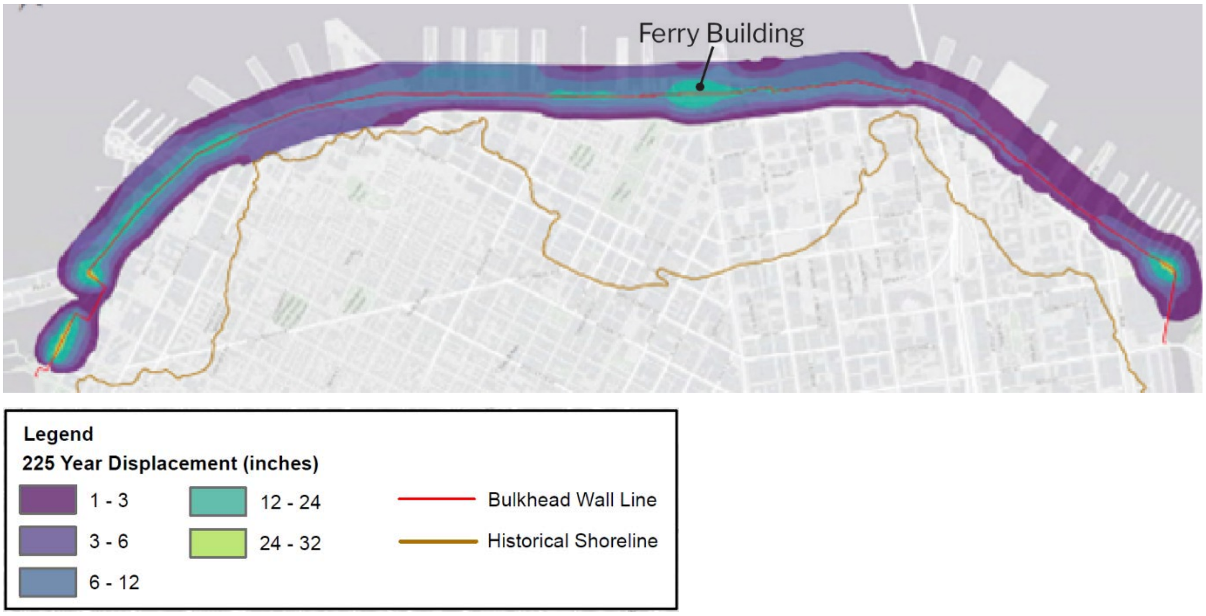


FIGURE 4-7
LATERAL GROUND DISPLACEMENT UNDER THE 225-YEAR EARTHQUAKE



Severity and Probability of Future Events

San Francisco has experienced severe liquefaction, and the attendant impact on infrastructure, in past major earthquakes in 1906 and 1989. As mentioned above, liquefaction can cause ground rupture, sand boils, ground subsidence, and lateral and vertical displacement of the ground. Given the fact that significant portions of the city are located on soft, sandy, liquefiable soils, it is reasonable to assume that severe liquefaction will occur in any future earthquake with strong shaking. SFO is located in another area that is likely to experience liquefaction in a major earthquake. As noted earlier, scientists have determined that there is a 72 percent chance of a Mw 6.7 or greater earthquake along one of the seven Bay Area fault systems in the 30-year period ending in 2043.[45] For further discussion of earthquake severity, probability, and response planning, see the City and County of San Francisco's Earthquake Annex of the Emergency Response Plan.

Climate change can impact liquefaction from earthquakes. As groundwater levels rise due to sea level rise, liquefaction zones are expected to increase in size.[46] Conversely,

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[45] Field and WGCEP, *UCERF3: A New Earthquake Forecast for California's Complex Fault System*, 4.
[46] Poh Poh Wong, et al, 2014: "Coastal Systems and Low-Lying Areas," in Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the *Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, by C.B. Field, et al., (eds.), (New

for earthquakes occurring during a multi-year, severe drought, a drought-induced low water table and dry ground may inhibit landslide and liquefaction that might occur during large earthquakes, resulting in less damage than might otherwise take place.[47]

Related Hazards

Tsunami

A tsunami is a series of ocean waves caused by sudden movement of the sea floor, typically as a result of major earthquakes. Tsunamis also may be caused by undersea landslides or volcanic activity.[48] Earthquakes of Mw 7.5 or greater at plate boundaries located in subduction zones around what is known as the Pacific Ring of Fire may generate ocean-wide tsunamis. For further discussion, please see the Tsunami Hazard Profile.

Earthquake-Induced Landslide

A landslide is the downhill movement of ground typically caused by the action of gravity on weakened soil or rock. Slopes may be weakened by weathering, erosion, saturation, or the addition of weight from artificial fill, structures, or rock. Earthquake-induced landslides typically originate from steep, weakened slopes as a result of strong ground shaking. The most common earthquake-induced landslides include shallow rock falls, rockslides, and slides of earth and debris. For further discussion of landslides, see the Landslide hazard profile.

Reservoir Failure Following Earthquake

York, NY, 2014), 383, accessed May 22, 2018, https://www.ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-Chap5_FINAL.pdf; Capitol Corridor Joint Powers Authority, *Sea Level Rise Vulnerability Assessment*, Executive Summary (2014), ii, accessed May 22, 2018, http://www.adaptingtorisingtides.org/wp-content/uploads/2015/04/CCJPA-SLR-Vulnerability-Assessment_Final.pdf.

[47] USGS, "Science Features: South Napa Earthquake – One Year Later," accessed May 17, 2018, https://www2.usgs.gov/blogs/features/usgs_top_story/south-napa-earthquake-one-year-later/.

[48] National Oceanic and Atmospheric Administration (NOAA), "Tsunami," accessed May 23, 2018, https://www.tsunami.noaa.gov/.

A reservoir failure involves structural collapse of a reservoir resulting in a release of water stored in the reservoir. Reservoir failure may occur as a result of an earthquake. For further discussion of reservoir failure following earthquake, see the Dam or Reservoir Failure hazard profile.

Fire Following Earthquake

While ground shaking may be the predominant agent of damage in most earthquakes, fires following earthquakes can also lead to catastrophic damage depending on the combination of building characteristics and density, meteorological conditions, and other factors. Fires following the 1906 San Francisco Earthquake led to more damage than that due to ground shaking. More recently, fires in the Marina District following the 1989 Loma Prieta Earthquake demonstrate that fires following earthquakes pose a significant hazard in San Francisco. For further discussion of fire following earthquake, see the Large Urban Fire hazard profile.

Tsunami Hazard Profile

4.2 Tsunami

Impact Statement

Tsunami hazards should be considered low frequency but high impact events. While they are very infrequent, due to their relationship to seismic events, depending on the timing of its occurrence in reference to high or king tides, it could have significant impacts to the city and particularly in coastal areas. Damage would be concentrated in low-lying coastal areas and could damage homes and businesses, infrastructure, and vessels and maritime facilities.

Nature

A tsunami is a series of ocean waves caused by sudden movement of the sea floor, typically because of major earthquakes. Tsunamis also may be caused by undersea landslides or volcanic activity.[1] Earthquakes of Mw 7.5 or greater at plate boundaries located in subduction zones around what is known as the Pacific Ring of Fire may generate ocean-wide tsunamis.

San Francisco may experience tsunamis from three possible sources: (1) distant sources, such as large earthquakes near Japan, Alaska, or Chile; (2) regional sources, such as earthquakes in the Cascadia Subduction Zone, which begins off Humboldt County, California and extends north to British Columbia, Canada; and (3) near sources off the coast of Northern California, such as the Point Reyes Thrust Fault. For a list of tsunami types, their classification based on distance from San Francisco, how quickly they may arrive in San Francisco, and the likelihood of occurrence, see Table 4-5, below.

TABLE 4-5
TYPES OF TSUNAMIS THAT MAY BE EXPERIENCED IN SAN FRANCISCO

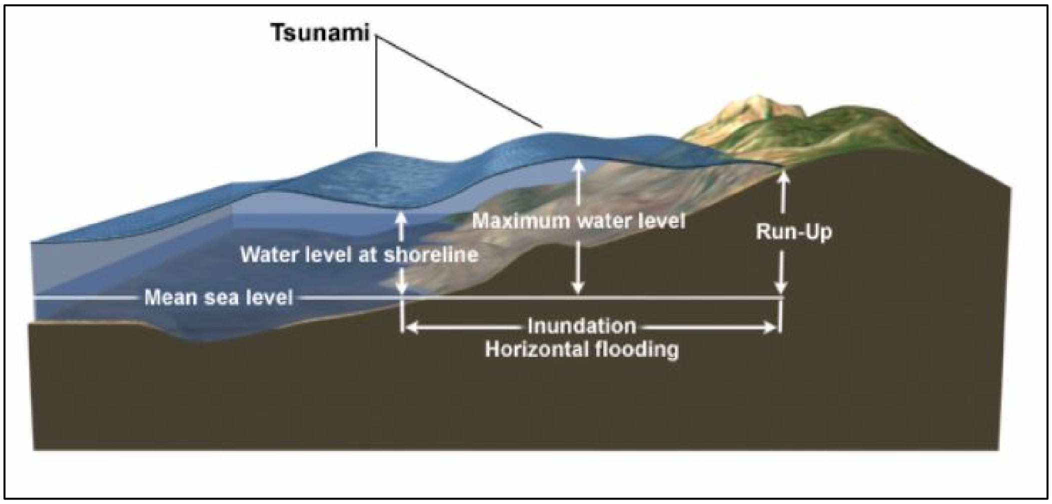
Tsunami Types	Source Event Distance from San Francisco	Time to Reach San Francisco	Likelihood of Occurrence
Distant Source	621 miles or more	4–21 hours	Moderate
Regional Source	Less than 621 miles	1–1½ hours	Moderate
Near Source	62 miles or less	10–15 minutes	Low

In the open ocean, tsunamis can travel over 500 miles per hour (mph)—the speed of a jet—and are barely perceptible to ships at sea. However, as tsunami waves reach shallow water, they slow in speed and grow in height. At the shoreline in San Francisco, tsunami waves may range in height from a few inches to over 30 feet. The first wave is almost never the largest.[2]

Normal, wind-driven ocean waves move only the surface layer of the water. In contrast, tsunami waves are longer in length, and move the entire "column" of water from the ocean floor to the surface. As a result, tsunami waves have increased power to inundate or flood low-lying coastal areas, making tsunami waves more dangerous and destructive than normal ocean waves. In addition, unlike normal ocean waves, the wave period, or time between tsunami waves, may vary from a few minutes to up to two hours. Thus, damaging tsunami waves may last for hours or days,[3] though typically the largest, most damaging tsunami waves occur in the first five hours of a tsunami incident.[4] Tsunamis also can cause powerful, dangerous currents in harbors, ports, and other shoreline areas that may last for several days after the initial tsunami wave.

Tsunami inundation is the maximum horizontal distance reached by tsunami waves on shore. “Runup” is the maximum height and distance of tsunami-related water inundation onshore. Runup is measured vertically from a reference sea level, such as mean sea level. Inundation is measured horizontally from the mean sea level position at the water's edge.[5] For a visual representation of inundation and runup, see Figure 4-8, below.

FIGURE 4-8
TSUNAMI RUN-UP CROSS-SECTION[6]



Tsunamis not only affect beaches open to the ocean, but also may cause damage to bays, ports, harbors, tidal flats, and coastal inlets. Because of their long wavelengths, tsunami waves can wrap around and reflect off land masses. Thus, peninsulas, offshore islands, and human-made breakwaters may not provide protection from tsunamis.[7] In addition, it is important to note that tsunamis can cause damage even when they do not result in inundation. Because tsunamis can generate strong, powerful, currents that may last for many hours, they can result in significant damage to maritime assets, including ports, harbors, marinas, and vessels.[8]

History

Since 1850, at least 59 tsunamis have been recorded or observed in San Francisco Bay. None of these tsunamis resulted in inundation or in significant damage in San Francisco. Eleven of the tsunamis originated off Japan; all were generated by major earthquakes. Ten originated off Alaska; eight of these were caused by an earthquake, two were caused by earthquake and landslide. Eight tsunamis originated off Chile, all generated by earthquakes.[9]

Only one tsunami originating along the Northern California Coast has been recorded. A 4-inch wave run-up was recorded at the Presidio gauge station shortly after the 1906 earthquake.[10] The 1906 earthquake is believed to have caused down dropping of the seafloor north of Lake Merced, between overlapping segments of the San Andreas Fault, generating a small tsunami.[11]

The magnitude 6.8 Hayward Earthquake of October 21, 1868 is reported to have produced a wave at the Cliff House that was 15 to 20 feet higher than usual. The likely cause of this tsunami was an earthquake-triggered submarine landslide.[12] The magnitude 9.2 Great Alaskan Earthquake generated a distant-source tsunami that produced maximum water heights over sea level of 1.13 meters (3.7 feet) as recorded on the tide gauge at the San Francisco Presidio near Crissy Field. However, the largest waves from the Great Alaskan tsunami occurred during low tide. Had these waves arrived at high tide, the absolute water level could have reached over 12 feet above sea level at the Presidio.[13]

Little damage occurred in San Francisco as a result of the tsunami generated by the Japan Tohoku earthquake of March 11, 2011. The Tohoku tsunami produced a maximum measured amplitude of 0.62 meters (two feet) at the San Francisco Marina, and estimated maximum currents of seven knots, or approximately eight miles per hour. Currents in excess of three knots are known to cause damage to fixed piers and structures, as well as present hazards to water navigation. Two piles were broken, and boats keeled over in the San Francisco Marina.[14] Damage from the Tohoku tsunami was minimal in San Francisco because the largest surges occurred during low tide.[15]

In 2022, a large underwater volcanic eruption off the coast of Tonga put many parts of the Bay Area under Tsunami advisory on January 15th. Large waves occurred off Ocean Beach with an individual requiring rescue. Damage was not significant in San Francisco but nearby jurisdictions experienced notable instances of damage or disruption to normal services. This event triggered two types of tsunamis, both a standard tsunami caused by the displacement of water and also a meteotsunami caused by a fast-moving pressure disturbance in the atmosphere[16].

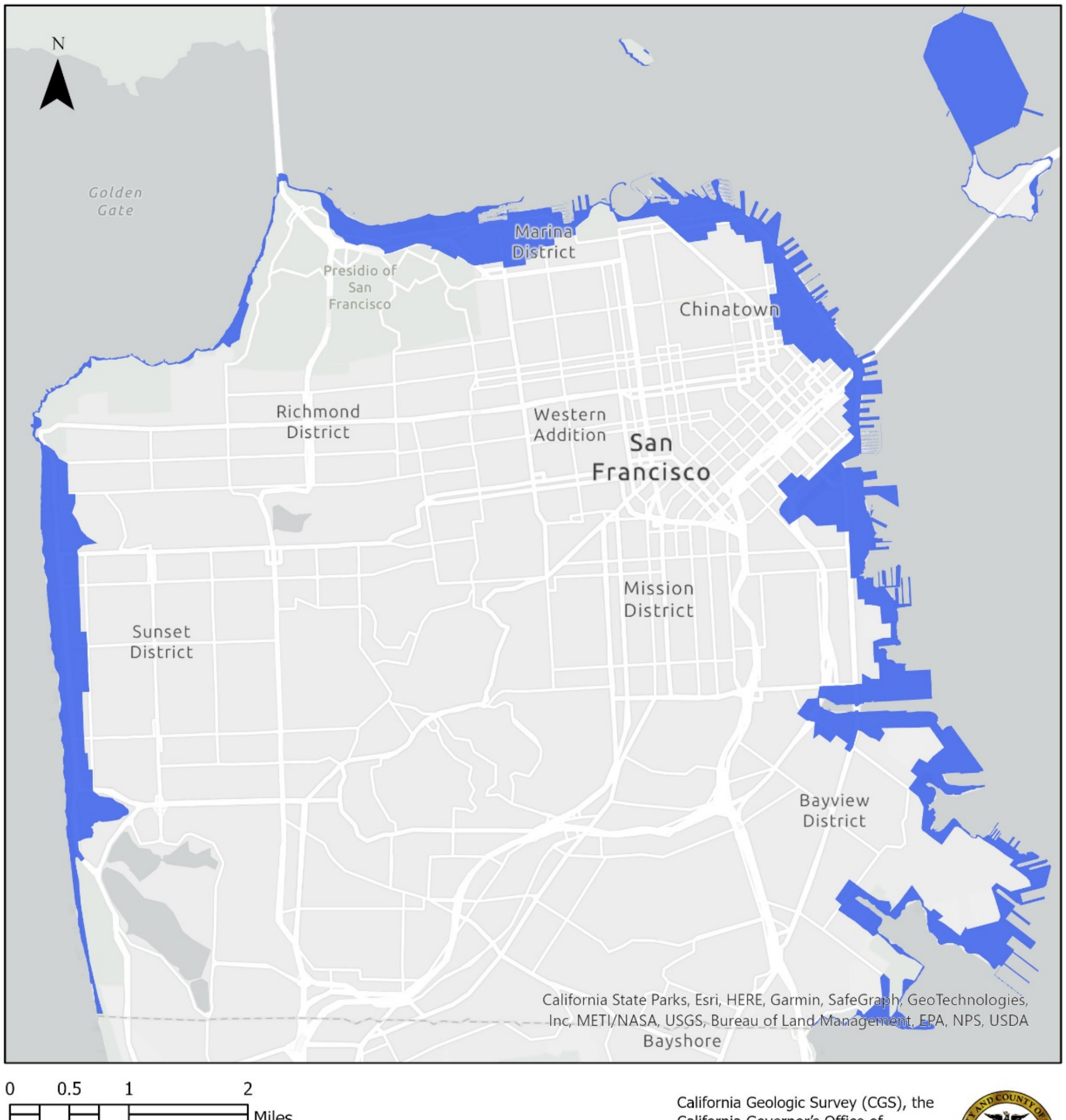
Location

In 2009, the California Geologic Survey (CGS), the California Governor's Office of Emergency Services (Cal OES), and the Tsunami Research Center at the University of Southern California produced the first statewide tsunami inundation maps for coastal areas of California, including San Francisco and San Mateo Counties. The maps indicate coastal areas that could be flooded in an inundating tsunami. The state prepared the tsunami inundation maps to assist coastal communities in identifying tsunami hazards and in creating tsunami evacuation and response plans. The inundation lines shown on the maps represent the maximum considered tsunami runup based on several extreme but realistic tsunami scenarios.[17] These maps were updated in 2021 to incorporate new LiDAR data. This update added areas that were previously not considered susceptible to Tsunami hazards and have been added to the summarization below.

Figure 4-19 shows the tsunami inundation map prepared for the City and County of San Francisco.

Areas within San Francisco susceptible to tsunami inundation include Pacific Coast areas of Lake Merced, the Sunset and Richmond Districts, Sea Cliff, and the Presidio. Areas adjacent to San Francisco Bay are also subject to tsunami inundation, including the Presidio, the Marina District, North Waterfront, Fisherman's Wharf, China Basin, Mission Bay, Financial district (South of Market and Samsone St.), North Beach (from Beach Street to Chestnut Street at Columbus Avenue), Potrero Hill, Bayview, Hunters Point, Treasure Island, and portions of Yerba Buena Island (see Figure 4-9 below).

FIGURE 4-9
CITY AND COUNTY OF SAN FRANCISCO TSUNAMI HAZARD ZONES



California Geologic Survey (CGS), the California Governor's Office of Emergency Services (Cal OES), and the Tsunami Research Center at the University of Southern California (2021)

This map provides general information related to hazard potential, planning areas, and impact severity. It is not intended for permitting, regulatory, or other legal uses. Risk zones are based on model outputs, and site specific conditions may not be fully represented.

Severity and Probability of Future Events

Inundating tsunamis are infrequent, but high impact events that may result in widespread damage and destruction in San Francisco. Injuries and deaths are one of the primary impacts of tsunamis. Drowning is the most common cause of death associated with tsunami.[18] Widespread damage to homes and businesses, and the resulting displacement of people in coastal areas are additional concerns after a destructive tsunami.[19] Damage to infrastructure from a flooding tsunami would be extensive, and could include impacts to roads, public transportation, power systems, and sewage treatment plants.[20] In addition, tsunami waves may damage building foundations, bridges, roads, and other structures.[21] Even a non-inundating tsunami can result in strong currents and rip tides that cause damage to vessels and maritime facilities in or near coastal waters. Currents of three knots (3.5 miles per hour) or more have resulted in damage to fixed piers and structures and may present navigation hazards to vessels in the area.

The primary tsunami threat to San Francisco is a distant-source tsunami generated by an earthquake in the eastern portion of the Aleutian-Alaska Subduction Zone. Data from the California Seismic Safety Commission indicates that since 1872, Alaska earthquakes have produced tsunami run-ups in the Bay Area ten times, for a recurrence interval of 14.6 years. Historically, the runup from these events has been only a few inches. However, the modeling used to create the 2009 state tsunami inundation maps indicates that an Mw 9.2 in the Central Aleutians, San Francisco's "worst-case" tsunami scenario, produced an estimated maximum tsunami wave runup elevation of 22 feet above mean sea level at Ocean Beach. As tsunami waves from this modeled event wrapped around the city and entered the Golden Gate, wave heights diminish to 11 feet above mean sea level at Aquatic Park, 8 feet above mean sea level at Treasure Island, and 6 feet above mean sea level at Candlestick Point.[22]

San Francisco also has a moderate risk of an earthquake-generated tsunami from a regional source. Our most likely regional source is an earthquake and tsunami in the Cascadia Subduction Zone (CMZ), a 600-mile fault approximately 70 to 100 miles off the Pacific coastline that runs from Cape Mendocino in Northern California to British Columbia. There have been 41 earthquakes in the last 10,000 years within the CMZ. The last earthquake in this area was an estimated magnitude 9.0 on January 26, 1700, which resulted in an ocean-wide tsunami. Currently, scientists predict that there is a 40 percent chance of an Mw 9.0 or greater earthquake in this fault zone in the next 50 years.[23]

San Francisco has a low risk of a near-source tsunami, given that the majority of the region's faults are strike-slip faults. The nearby Point Reyes Thrust Fault, San Gregorio Fault, and Hayward-Rodgers Creek Fault are all believed capable of producing a near-source tsunami affecting San Francisco. However, to date, none of these faults have produced local tsunamis. State tsunami modeling shows worst-case inundation from a near-source tsunami generated by the Point Reyes Thrust Fault of six feet above mean sea level at Ocean Beach, 4 feet above mean sea level at Aquatic Park, 3 feet above mean sea level at Treasure Island, and 3 feet above mean sea level at Candlestick Point.[24] A strike-slip fault event could produce a potential localized tsunami threat from an earthquake-induced landslide. However, the gentle topography of near-shore areas of San Francisco Bay and the lack of history of large landslides into the bay indicate that the risk of a landslide-generated tsunami into the Bay is low.[25]

For further discussion of tsunami severity, probability, and response planning see the City and County of San Francisco Tsunami Annex.

Landslide Hazard Profile

4.3 Landslide

Impact Statement

Landslides are most likely to occur on steep slopes on hills and cliffs and intermediate slopes with previous landslide deposits. In addition, weak saturated soils that are bordered by steep or unsupported embankments or slopes are prone to landslide. Given the dense urban nature of San Francisco, landslides can result in many casualties and in serious damage to homes and other infrastructure. Heavy rainfall events and wildland-urban interface fires are anticipated to become more frequent with climate change. Thus, San Francisco may experience an increase in the frequency of landslides in the future.

Nature

Landslide is a general term used to describe the downslope movement of soil, rock, and organic materials under the effects of gravity. It also is used to refer to the landform that results after such movement. Landslides can be classified into different types based on the type of material and the type of movement involved. In general, material in a landslide is either rock or soil, or both. Soil is described as earth if primarily composed of sand-sized or finer particles, and as debris if composed of coarser fragments. Type of movement refers to the actual mechanics of how the landslide is displaced. Movement categories are fall, topple, slide, spread, or flow. Thus, landslides are described using two terms that refer respectively to material and movement, such as rock fall or debris flow. Landslides may also encompass complex failures that involve more than one type of movement, such as rock slide-debris flow.[1]

Landslides are typically caused by the action of gravity on weakened soil or rock. However, most landslides have multiple causes. Slope movement occurs when forces acting down-slope exceed the strength of the materials that make up the slope. Causes include factors that increase the effects of down-slope forces and that contribute to low or reduced strength of slope materials. Landslides can be caused in slopes that are weakened because of rainfall, snowmelt, changes in ground water, erosion, earthquakes, disturbances by human activities, or a combination of these factors. Earthquake shaking

[1] U.S. Geological Survey (USGS), *The Landslide Handbook—A Guide to Understanding Landslides,* by Lynn M. Highland and Peter Bobrowsky. U.S. Geological Survey Circular 1325 (Reston, VA, 2008), 4–5, accessed May 24, 2018, https://pubs.usgs.gov/circ/1325/pdf/C1325_508.pdf.

and other factors also can induce landslides underwater called submarine landslides. Submarine landslides may trigger tsunamis that damage coastal areas.[2]

Slope saturation by water is a primary cause of landslides. This can occur in the form of intense rainfall, snowmelt, changes in ground-water levels, and water-level changes along coastlines, earth dams, and lake banks, reservoirs, canals, and rivers. Earthquakes in steep landslide-prone areas also greatly increase the chances that landslides will occur due to ground shaking or to shaking-caused expansion of soil materials, which allows rapid infiltration of water. Ground shaking due to earthquake can also cause rock falls.[3] San Francisco has experienced landslides, rockslides, and other types of ground failure due to moderate to large earthquakes and winter storms.

History

U.S. Geological Survey (USGS) records show that localized damage in the San Francisco Bay Area due to earthquake-induced landslides has been recorded since 1838 for at least 20 earthquakes. The 1906 earthquake generated more than 10,000 landslides throughout the region, killing 11 people and causing substantial damage to buildings and infrastructure.[4] The most significant landslides caused by the 1989 Loma Prieta earthquake were located in the Santa Cruz Mountains. However, landslides from the Loma Prieta earthquake were reported in in the Lake Merced area of San Francisco in the weakly-cemented sand, silt, and clay of the Merced Formation. These same materials also are believed to have produced several landslides in the 1906 earthquake and in the 1957 Daly City earthquake.[5]

Non-earthquake-induced landslides in San Francisco generally occur during or after prolonged winter rainstorms. On January 3–5, 1982, a catastrophic rainstorm over the Central California coast triggered landslides in San Francisco, which resulted in approximately $399,000 in damages in 1982 dollars ($1 million in 2018 dollars) to public

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[2] USGS, "What is a landslide and what causes one?" Accessed May 24, 2018, https://www.usgs.gov/faqs/what-a-landslide-and-what-causes-one?qt-news_science_products=7#qt-news_science_products.

[3] USGS, Landslide Types and Processes, Fact Sheet 2004-3072 (2004), accessed May 24, 2018, https://pubs.usgs.gov/fs/2004/3072/pdf/fs2004-3072.pdf.

[4] David K. Keefer, "Landslides Synopsis," in *The Loma Prieta, California Earthquake of October 17, 1989: Strong Ground Motion and Ground Failure,* USGS Professional Paper 1551-C (Washington, DC, 1998), C1, accessed May 24, 2018, https://pubs.usgs.gov/pp/pp1551/pp1551c/pp1551c.pdf.

[5] Keefer and Manson, "Regional Distribution and Characteristics of Landslides Generated by the Earthquake," C21.

and private property in San Francisco, predominantly to private residences. Most landslide damage was located in the Twin Peaks, Mount Davidson, and Glen Park areas.[6]

Winter rainstorms in December 1995 contributed to the collapse of a 100-year old sewer line, subsequently creating a landslide and damaging sinkhole. A couple structures were swallowed by the pit, 23 homes were evacuated, and utilities were temporarily disrupted for the entire neighborhood[7].

Landslides also occurred in February 1998, as a result of El Niño storms. El Niño is a disruption of the ocean-atmosphere system in the Tropical Pacific, which has important consequences for weather and climate around the globe. Between February 2, and February 26, 1998, landslides and minor debris flows were reported on steep slopes near Mount Sutro in Forest Knolls, Mount Davidson in the Miraloma Park neighborhood, and in the Twin Peaks, Diamond Heights, Potrero Hill, and Seacliff neighborhoods. These landslides caused an estimated $4.1 million in damages in 1998 dollars ($6.3million in 2018 dollars) to residential properties, and to the Olympic Club golf course.[8]

Nine years later, on February 28, 2007, after three days of rainfall, a 75-foot-wide mass of Telegraph Hill slid down a granite and sandstone slope above Broadway, between Montgomery and Kearny Streets. Approximately 120 people from a 45-unit condominium were evacuated until the property owner stabilized the hillside.[9] Similarly, on January 23, 2012, extensive rainfall resulted in a rockslide on Telegraph Hill, which crushed a car and required the partial evacuation of a condominium complex.[10]

In February 2016, during heavy precipitation associated with the 2015-2016 El Niño, a landslide in the Mount Davidson area of San Francisco destroyed one house, and damaged five others. However, it appears that this slide was due to human-caused

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[6] Stephen D. Ellen, et al., *Landslides, Floods, and Marine Effects of the Storm of January 3-5, 1982, in the San Francisco Bay Region, California* (USGS Professional Paper 1434) (1988), 198–200, accessed May 24, 2018, http://pubs.usgs.gov/pp/1988/1434/.

[7] Carl Nolte: SFgate. (1995) "Sea Cliff Mansion Tumbles into Hole/Aged Sewer Line Collapses under Home". Retrieved from: https://www.sfgate.com/news/article/Sea-Cliff-Mansion-Tumbles-Into-Hole-Aged-sewer-3017549.php

[8] John W. Hillhouse and Jonathan W. Godt, "Map Showing Locations of Damaging Landslides in San Francisco City and County, California, Resulting from 1997-98 El Nino Rainstorms," USGS MF-2325-G (1999), accessed May 24, 2018, https://pubs.usgs.gov/mf/1999/mf-2325-g/mf2325g.pdf.

[9] Robert Selna, et al., "Telegraph Hill Landslide Forces 120 from Homes," *San Francisco Chronicle*, February 28, 2007, accessed May 24, 2018, https://www.sfgate.com/news/article/Telegraph-Hill-landslide-forces-120-from-homes-2614672.php.

[10] CBS SF Bay Area, "Residents Near SF Telegraph Hill Landslide Allowed to Return," January 24, 2013, accessed May 24, 2018, http://sanfrancisco.cbslocal.com/2012/01/24/residents-near-sf-telegraph-hill-landslide-allowed-to-return/.

changes in the area. Public Works crews subsequently discovered and repaired a rupture in an eight-inch water main under a nearby street that is believed to have led to the slide.[11]

A WWII-era bunker slid onto the beach in Fort Funston Park after historic atmospheric river events over saturated the cliffside in early 2023. This has been the only landslide event in our jurisdiction in the last 5 years.[12]

Location

According to the California Geological Survey (CGS), steep slopes on hills and cliffs and intermediate slopes with previous landslide deposits are highly susceptible to landslides. In addition, weak saturated soils that are bordered by steep or unsupported embankments or slopes are prone to lateral spreading, which is a type of landslide.[13] Seismic Hazard Zones, seen in Figure 4-16, show areas susceptible to earthquake-induced landslide in San Francisco. These areas include hills and cliffs in the Outer Richmond, Sea Cliff, Presidio, Lake Shore, Bayview Heights, Midtown Terrace, Twin Peaks, Clarendon Heights, Golden Gate Heights, Forest Hills, Diamond Heights, the Castro, Dolores Heights, Noe Valley, and Yerba Buena Island.

CGS has also developed a landslide susceptibility map that shows the relative likelihood of deep-seated landslides based on the location of past slides and on regional estimates of rock strength and steepness of slopes.[14] Slides are considered deep-seated if the slip occurs on a surface more than 10 to 15 feet below the ground.[15] The San Francisco-portion of this map is included in Figure 4-16. The map shows areas similar to those

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[11] KTVU2, "SF Landslide That Threatened Homes Appears More Man-Made than Natural," February 1, 2016, accessed May 25, 2018, http://www.ktvu.com/news/sf-landslide-that-threatened-homes-appears-more-man-made-than-natural; CBS SF Bay Area, "PG&E Sued Over Landslide That Destroyed San Francisco Home," October 18, 2017, accessed May 25, 2018, http://sanfrancisco.cbslocal.com/2017/10/18/pge-lawsuit-landslide-casitas-miraloma/.

[12] https://www.sfgate.com/bayarea/article/WW-II-structure-falls-200-feet-from-cliff-onto-17721355.php

[13] California Department of Conservation, California Geological Survey (CGS), *Guidelines for Evaluating and Mitigating Seismic Hazards in California*, Special Publication 117 (2008), 19–21, accessed May 25, 2018, http://www.conservation.ca.gov/cgs/Documents/SHZP_Webdocs/SP117.pdf.

[14] C.J. Wills, et al., *Susceptibility to Deep-Seated Landslides in California*, California Geological Survey (CGS) Map Sheet 58 (2011), accessed May 24, 2018, http://www.conservation.ca.gov/cgs/information/publications/ms/Documents/MS58.pdf.

[15] Helen Gibbs, et al., "USGS Monitors Huge Landslides on California's Big Sur Coast, Shares Information with California Department of Transportation," accessed May 24, 2018, https://soundwaves.usgs.gov/2017/10/ fieldwork.html.

noted in the seismic hazard zone map mentioned above as susceptible to deep-seated landslides.[16]

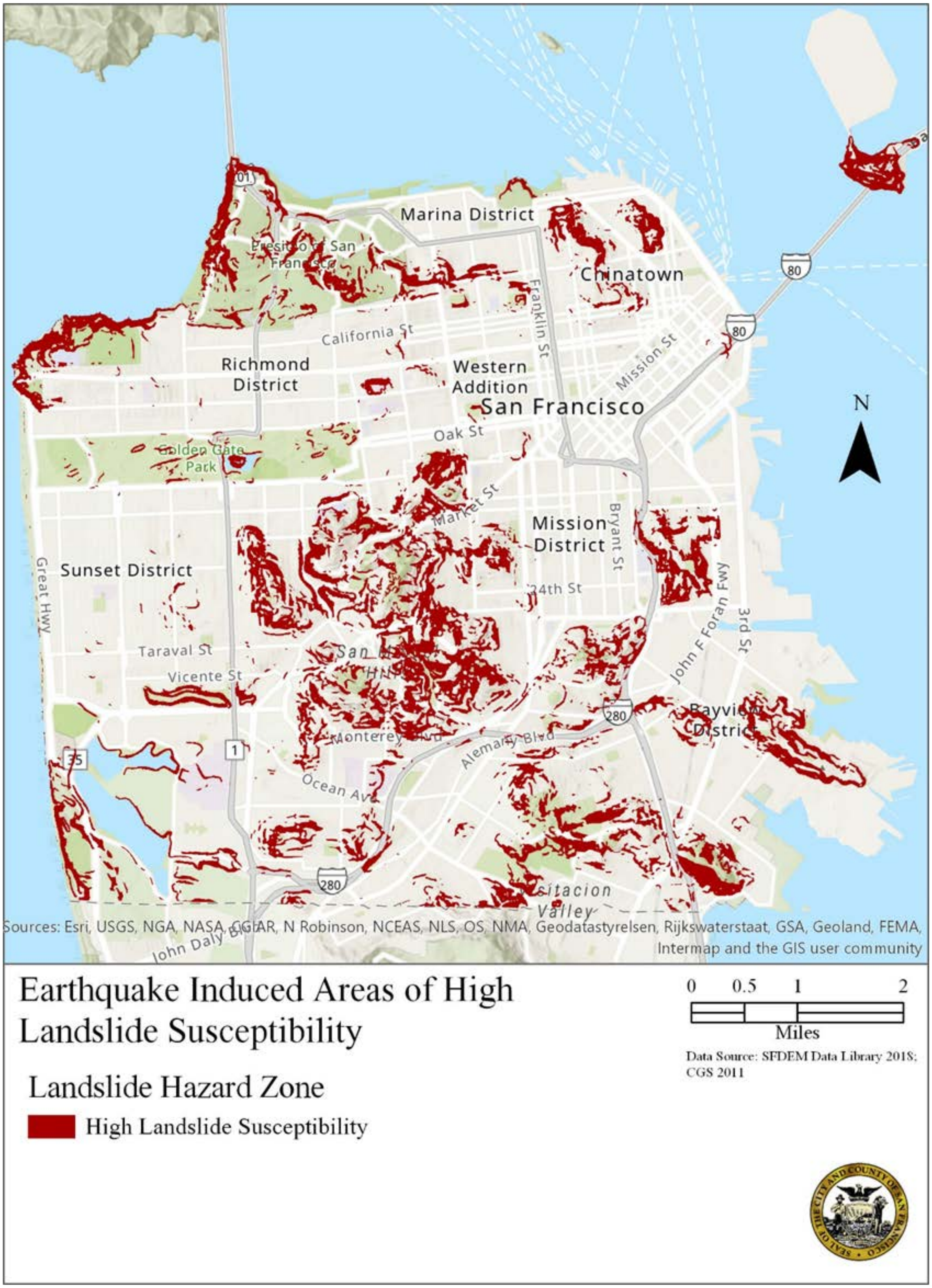
CGS has not prepared maps for San Francisco that identify hazards associated with non-earthquake induced landslides. However, in general, areas that are subject to landslides during earthquakes are also subject to landslides under other conditions. Thus, the earthquake-induced landslide map in Figure 4-10, seen below, is instructive as to the location of steep-sloped areas where landslides may occur due to heavy rainfall or other non-seismic conditions.

In addition, steep, recently burned areas are susceptible to debris flows within the first two years after a fire. Even modest rain storms during non-El Niño years can trigger post-wildfire debris flows.[17] Fire-related debris flows are likely to occur in steep, rural out-of-county areas where some city-owned infrastructure is located. Examples include the area surrounding Hetch Hetchy Reservoir and O'Shaughnessy Dam in Tuolumne County, California, which is part of the system that provides drinking water to city residents. For further discussion of wildland-urban interface fires, see the Wildland-Urban Interface profile.

[16] Wills, *Susceptibility to Deep-Seated Landslides in California*. CGS intends this map to provide a general overview of where landslides are more likely to occur. It does not include information on landslide-triggering events such as rainstorms or earthquake shaking, nor does it address susceptibility to shallow landslides such as debris flows. It is not appropriate for evaluation of landslide potential at any specific site.

[17] See USGS, Landslide Hazard Program, "Rainfall and Landslides in Northern and Central California," accessed May 25, 2018, https://landslides.usgs.gov/research/ca-rainfall/ncal.php; USGS, California Water Science Center, "Post-Fire Debris Flow," accessed May 25, 2018, https://ca.water.usgs.gov/flooding/wildfires-debris-flow.html.

FIGURE 4-10
EARTHQUAKE INDUCED AREAS OF HIGH LANDSIDE SUSCEPTIBILITY



Severity and Probability of Future Events

The severity of an earthquake-induced landslide depends on the landslide characteristics and materials and on the settings in which the landslide occurs. Shallow rock falls disrupted rock slides, and disrupted slides of earth and debris are the most common types of earthquake-induced landslides. Earth flows, debris flows, and avalanches of rock, earth, or debris typically transport material the farthest.[18] The USGS reports that landslides in San Francisco are typically narrower than 1,500 feet, or about one quarter of a mile.[19] Given the dense urban nature of the city, slides of this size could cause many casualties and serious damage to homes and other infrastructure.

USGS studies show that earthquakes as small as magnitude 4.0 may trigger landslides on susceptible slopes.[20] Larger earthquakes may generate thousands of landslides within the area impacted by the earthquake.[21] Whether a particular earthquake produces a landslide depends on slope material strength and configuration, pore-water pressure, and the level of ground motion.[22] Given the Working Group on California Earthquake Probabilities (WGCEP) finding of a 100 percent chance that the San Francisco region will experience a Mw 5 or greater quake between 2014 and 2044, and a 72 percent chance of a Mw 6.7 or greater earthquake in the region during the same period,[23] San Francisco is extremely likely to experience one or more earthquake-induced landslides from a major earthquake event.

Non-earthquake induced landslides are most likely to occur during winter storm events that produce heavy or prolonged rainfall. Based on past occurrences of El Niño-enhanced periods of precipitation, San Francisco can expect to experience rain-induced landslide every eight to 10 years.[24] These are periods, typically during winters, when a

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[18] David K. Keefer, "Earthquake-Induced Landslides and Their Effects on Alluvial Fans," *Journal of Sedimentary Research*, Section A: Sedimentary Petrology and Processes 69(1) (1999), 84.

[19] Carl M. Wentworth, et al., Summary Distribution of Slides and Earth Flows in San Francisco County, California, USGS Open File 97-745 C, Sheet 6 of 11 (1997), accessed May 25, 2018, https://pubs.usgs.gov/of/1997/of97-745/sfdl.html.

[20] Keefer, "Landslides Caused by Earthquakes," 409; USGS, "Landslides 101, What is a landslide?" Accessed May 24, 2018, https://landslides.usgs.gov/learn/ ls101.php.

[21] Keefer, "Landslides Synopsis," C1.

[22] Keefer, "Landslides Caused by Earthquakes," 406.

[23] Edward H. Field and 2014 Working Group on California Earthquake Probabilities (WGCEP), *UCERF3: A New Earthquake Forecast for California's Complex Fault System,* Fact Sheet 2015–3009 (2015), 4, accessed May 18, 2018, https://dx.doi.org/10.3133/fs20153009.

[24] Christopher C. Burt, "California: Waiting for El Nino," Weather Underground WunderBlog Archive, December 9, 2015, accessed May 25, 2018, https://www.wunderground.com/blog/weatherhistorian/california-waiting-for-el-nino.html.

strong El Niño increases the frequency and intensity of Pacific storms. In addition, areas burned because of wildfires are particularly susceptible to landslides depending on slope conditions and soil characteristics. Additionally, record drought periods and associated diseases from invasive insects can lead to a deterioration of San Francisco's urban canopy and this can also contribute to increased landslide risk.

The Intergovernmental Panel on Climate Change (IPCC) has indicated with high confidence that urban climate change-related risks, including extreme precipitation, fires, and landslides, are increasingly affecting urban areas, resulting in widespread negative impacts on people and on local and national economies and ecosystems.[25] As both heavy rainfall and wildland-urban interface fires are anticipated to become more frequent with climate change, San Francisco may experience an increase in the frequency of landslides in the future.

[25] Aromar Revi, et al., "Urban Areas," Chapter 8 in *Climate Change 2014: Impacts, Adaptation, and Vulnerability*, Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the
Intergovernmental Panel on Climate Change, C.B. Field, et al. (eds.) (New York, NY, Cambridge University Press, 2014), 565, accessed May 25, 2018, https://www.ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-Chap8_FINAL.pdf.

Dam or Reservoir Failure Profile

4.4 Dam or Reservoir Failure

Impact Statement

Dam or reservoir failure may impact the Sunset, Midtown Terrace, Twin Peaks, Clarendon Heights, and University Mound areas of San Francisco, where state-regulated reservoirs are located. Factors that increase the risk of dam or reservoir failure include the age of the structures and the likelihood of an earthquake. Climate change impacts, including changing precipitation patterns, may also increase the risk of dam or reservoir failure in and outside of the County.

Nature

A dam or reservoir failure is an unplanned release of water resulting from the structural compromise or collapse of a dam or other structural element, such as the wall of a tank. The Federal Emergency Management Agency (FEMA) classifies the causes of dam failures into five general categories:[1]

- Hydrologic: Dam failures caused by extreme rainfall or snowmelt events that can lead to natural floods. The main causes of hydrologic dam failure include overtopping, structural overstressing, and surface erosion due to high velocity flow and wave action. Overtopping due to inadequate spillway design, debris blockage of spillways, or settlement of the dam crest accounts for about 34 percent of all dam failures in the United States.
- Geologic: Includes failures due to piping and internal erosion, slope instability and hydraulic fracturing, long-term seepage of water in earthen dams, inadequate geotechnical design of the embankment and foundation, inadequate seepage controls, or increased load situations.
- Structural: Involves failure of a critical dam component. Structural failures may stem from inadequate initial design, poor construction, poor construction materials, inadequate maintenance and repair, or gradual degradation and

[1] Federal Emergency Management Agency (FEMA), *Federal Guidelines for Inundation Mapping of Flood Risks Associated with Dam Incidents and Failures*, FEMA P-946 (Washington, DC, 2013), 4-4–4-8, accessed June 5, 2018, https://www.fema.gov/media-library-data/96171edb98e3f51ff9684a8d1f034d97/Dam_Guidance_508.pdf; FEMA, *Living with Dams: Know Your Risks*, FEMA P-956 (Washington, DC, 2013) 9, 10, accessed June 4, 2018, https://www.fema.gov/media-library-data/20130726-1845-25045-7939/fema_p_956_living_with_dams.pdf.

weakening over time. Structural failures have caused about 30 percent of all dam failures in the United States.

- Seismic: In earthquake zones, seismic failures typically are related to ground movement or liquefaction. Liquefaction can cause immediate dam failure or can result in slumping that exposes the dam crest to overtopping and erosion. Seismic-induced piping can occur due to internal cracking caused by earthquake ground motion, which may cause a dam to shift, settle, or crack in a way that prevents the dam from performing as designed.

- Human-caused: Failures related to improper design, maintenance, or operation of a dam, or to terrorist acts.

The age of a dam or reservoir may make it more susceptible to failure. As dams get older, deterioration and repair costs increase. Common characteristics of older dams include:[2]

- Deteriorating metal pipes and structural components;
- Sediment-filled reservoirs; and
- Increased runoff from subdivisions and businesses built upstream.

The sudden release of water following a dam or reservoir failure has the potential to cause dangerous flooding, resulting in human casualties; economic loss, including property damage; and environmental damage.[3] In addition, dam or reservoir failure may result in lifeline disruption, including impacts on delivery of drinking water and electricity to areas served by the dam or reservoir.[4] Dam or reservoir failure can occur rapidly, providing little warning, thus leaving little time to evacuate people located downstream from or below the failing structure. Damage occurs because of the momentum of the sediment-laden water, flooding over channel banks, and the impact of the debris carried by the flow.

[2] FEMA, *Living with Dams*, iii.

[3] Association of Dam Safety Officials, "What are the Top Issues Facing the Dam Community?" accessed June 5, 2018, https://damsafety.org/top-issues-facing-dam-community; FEMA, *Living with Dams*, 2, 3.

[4] See FEMA, *Living with Dams*, 1–3.

History

To date, there is no history of a dam or reservoir failure occurring within San Francisco boundaries. Nor is there a history of failures for dams or reservoirs located outside San Francisco that are owned by the city or by the SFPUC. However, on March 22, 2018, seepage was detected on the downstream face of the SFPUC-owned 60-foot earthen Moccasin Dam in Tuolumne County after heavy rainfall sent a major surge of water and debris into the Moccasin Reservoir. The seepage triggered activation of the Moccasin Dam Emergency Action Plan, which included evacuations of a downstream campground and fish hatchery close to the dam and prompted the closure of two nearby highways. The SFPUC drained the Moccasin reservoir into the larger Don Pedro Reservoir located downstream and conducted extensive inspections of the dam and its spillways. Though the dam itself never overtopped or failed,[5] cleanup and repair efforts cost approximately $43 million.[6]

Location

There are 15 reservoirs located within San Francisco County limits. Six San Francisco reservoirs are considered dams regulated by the California Department of Water Resources, Division of Safety of Dams (DSOD). Under California law, state-regulated dams are artificial barriers that impound or divert water and are 25 feet or more in height, or that store 50 acre-feet or more of water.[7] The state also regulates artificial barriers that are more than six feet in height, regardless of storage capacity; or that hold more than 15 acre-feet of water, regardless of height.[8]

State-regulated dams within San Francisco County limits are listed in Table 4-6, below. Each of these reservoirs are owned by the City and County of San Francisco and are managed by the SFPUC. Table 4-6 includes the names of the reservoirs and dams, the year of construction, the type of construction of the main dam, the reservoir capacity in acre-feet, and the dam height and crest length in feet. It also includes the DSOD assessment of downstream hazard. DSOD's categories for downstream hazard

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[5] See San Francisco Public Utilities Commission (SFPUC), News Releases, "Moccasin Reservoir Stabilized Following Threat of Dam Failure," March 22, 2018, accessed June 4, 2018, http://sfwater.org/index.aspx?recordid= 450&page=17; "Update on Status of Moccasin Dam and Reservoir," March 23, 2018, accessed June 4, 2018, https://sfwater.org/Index.aspx?page=17&recordid=452.

[6] San Francisco Chronicle, "March Storm Caused $43M in Damage at Moccasin Dam, Per SFPUC," May 2, 2018, accessed June 4, 2018, https://www.sfgate.com/news/bayarea/article/March-Storm-Caused-43M-In-Damage-At-Moccasin-12883240.php.

[7] See California Water Code § 6002.

[8] See California Water Code § 6003.

assessment are based on federal recommendations of low-, significant-, and high-hazard potential classifications. However, DSOD has included a fourth category, "Extremely High," to (Sunset North and South), Midtown Terrace (Sutro), Twin Peaks, Clarendon Heights, and identify dams that may impact highly populated areas or critical infrastructure or that may have short evacuation warning times. The assessment is not related to the condition of the dam or its auxiliary structures, or an indication of probability of dam failure.[9] State-regulated reservoirs within San Francisco County are located in the Sunset District University Mound.

TABLE 4-6
STATE-REGULATED DAMS WITHIN SAN FRANCISCO COUNTY[10]

Reservoir Name	Dam Name	Year Built	Dam Type	Reservoir Capacity (ac-ft)	Dam Height/ Crest Length (ft)	Downstream Hazard
Sunset Reservoir	Sunset North Basin	1938	Earth	275	74/2,300	Extremely High
	Sunset South Basin	1960	Earth	268	34/ 980	Extremely High
Sutro Reservoir	Sutro Reservoir	1952	Earth	96	55/850	Extremely High
Twin Peaks Reservoir	Stanford Heights	1928	Earth	37	31/1,480	Extremely High
Summit Reservoir	Summit Reservoir	1954	Earthen Embankment	43	39/120	Extremely High

[9] California Department of Water Resources, Division of Safety of Dams (DSOD), *Dams Within Jurisdiction of State of California, Dams Listed Alphabetically by County* (Sacramento, CA, 2017), ii, accessed June 5, 2018, https://www.water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/All-Programs/Division-of-safety-of-dams/Files/Publications/Dams-Within-Jurisdiction-of-the-State-of-California-Alphabetically-by-County.pdf; see FEMA, *Federal Guidelines for Inundation Mapping of Flood Risks Associated with Dam Incidents and Failures,* FEMA P-946 (Washington, DC, 2013), 6-4, accessed June 5, 2018, https://www.fema.gov/media-library-data/96171edb98e3f51ff9684a8d1f034d97/Dam_Guidance_508.pdf.

[10] California Department of Water Resources, Division of Safety of Dams, 2017

Reservoir Name	Dam Name	Year Built	Dam Type	Reservoir Capacity (ac-ft)	Dam Height/ Crest Length (ft)	Downstream Hazard
University Mound	University Mound North	1885	Earth	182	17/2,422	Extremely High
	University Mound South	1937	Earth	250	61/1,150	Extremely High

In addition, San Francisco is home to several smaller reservoirs that are not regulated by the state. Together with the state-regulated reservoirs shown in Table 4-6, these reservoirs are part of the SFPUC's San Francisco Retail Water System. This system includes 10 reservoirs and eight water tanks located within the city, which store water delivered by the Hetch Hetchy Regional Water System and the local Bay Area water system. The Hetch Hetchy Regional Water System provides most of San Francisco's drinking water.[11]

The City and County of San Francisco and the SFPUC also own several state-regulated dams located outside county boundaries. These dams and reservoirs are part of the Hetch Hetchy Regional Water System, which provides drinking water to other cities in the San Francisco Bay Area Region in addition to San Francisco. Dams and reservoirs in this system are in Alameda, San Mateo, and Tuolumne Counties. Table 4-7, below, contains a list of these dams and reservoirs. For a map of the Hetch Hetchy Regional Water System see Appendix B.

[11] SFPUC, "San Francisco Groundwater Supply Project," accessed June 5, 2018, https://sfwater.org/index.aspx? page=1136.

TABLE 4-7
CITY AND SFPUC-OWNED, STATE-REGULATED DAMS OUTSIDE SAN FRANCISCO COUNTY[12]

Dam Name	County	Year Built	Dam Type	Reservoir Capacity (ac-ft)	Dam Height/ Crest Length (ft)	Downstream Hazard
New Calaveras	Alameda	2018	Earth	96,850	210/1,210	Extremely High
James H. Turner	Alameda	1964	Earthen	50,500	193/2,160	Extremely High
Lower Crystal Springs	San Mateo	1888	Gravity	57,910	149/600	Extremely High
Pilarcitos	San Mateo	1866	Earth	3,100	103/520	Extremely High
San Andreas	San Mateo	1870	Earth	19,027	107/727	Extremely High
Cherry Valley	Tuolumne	1956	Earth and Rock	273,500	315/2,630	High
Early Intake	Tuolumne	1925	Constant Radius Arch	115	56/262	Low
Lake Eleanor	Tuolumne	1918	Multiple Arch	28,600	61/1,260	High
Moccasin Lower	Tuolumne	1930	Earth and Rock	554	60/720	High
O'Shaughnessy	Tuolumne	1923	Gravity	360,000	312/900	Extremely High
Priest	Tuolumne	1923	Hydraulic Fill	2,067	168/1,000	High

[12] California Department of Water Resources, Division of Safety of Dams, 2017

Extent and Probability of Future Events

In general, dam or reservoir failure is a low probability, high consequence event. Most of the dams and reservoirs making up the Hetch Hetchy Regional Water System are more than 85 years old. Damage to these structures could be caused by a major earthquake, by a severe storm with attendant runoff, by a slope failure, through terrorism, or by other means.

There is a 72 percent chance of magnitude 6.7 or greater earthquake occurring in the San Francisco Bay Area between 2014 and 2044.[13] In this regard, it is important to note that the SFPUC has performed, and continues to perform, extensive seismic work on its dams and reservoirs, including retrofits to the Sunset and University Mound reservoirs, upgrades to the water tanks within the city that make up the Emergency Firefighting Water System,[14] and the completed Calaveras dam replacement project.[15] San Francisco has only experienced one dam failure event within the broader system of dams the city manages and that occurred with the partial failure of the Old Calaveras Dam in 1918. Given this failure, the annualized frequency of occurrence during the 107-year period from 1918-2025 is 0.93% percent chance of occurring any given year.

As required by California law,[16] the SFPUC has prepared inundation maps showing areas of potential flooding in the event of sudden or total failure of state-regulated dams or reservoirs located in and outside San Francisco. SFPUC has submitted the maps to the California Governor's Office of Emergency Services and to DSOD for approval. State-approved maps are available on the DSOD web site.[17] Figure 4-11, below, shows potential inundation areas for reservoirs within San Francisco. With a changing climate that includes an expectation of increased extreme weather events in California, including prolonged periods of drought and intense wet periods with less snowpack, dam operation becomes more difficult and the risk of dam failure from overtopping may

[13] Edward H. Field and 2014 Working Group on California Earthquake Probabilities (WGCEP), *UCERF3: A New Earthquake Forecast for California's Complex Fault System,* Fact Sheet 2015–3009 (2015), 4, accessed May 18, 2018, https://dx.doi.org/10.3133/fs20153009.

[14] SFPUC, *Earthquake Safety and Emergency Response Bond Program 2010 & 2014 Quarterly Status Report* (March 2016) 2, 28, accessed June 5, 2018, http://www.sfearthquakesafety.org/uploads/1/9/4/3/19432507/ quarterly_status_report_jan_-_march_2016.pdf.

[15] SFPUC, "Calaveras Dam Replacement Project," accessed June 5, 2018, https://sfwater.org/index.aspx?page=979.

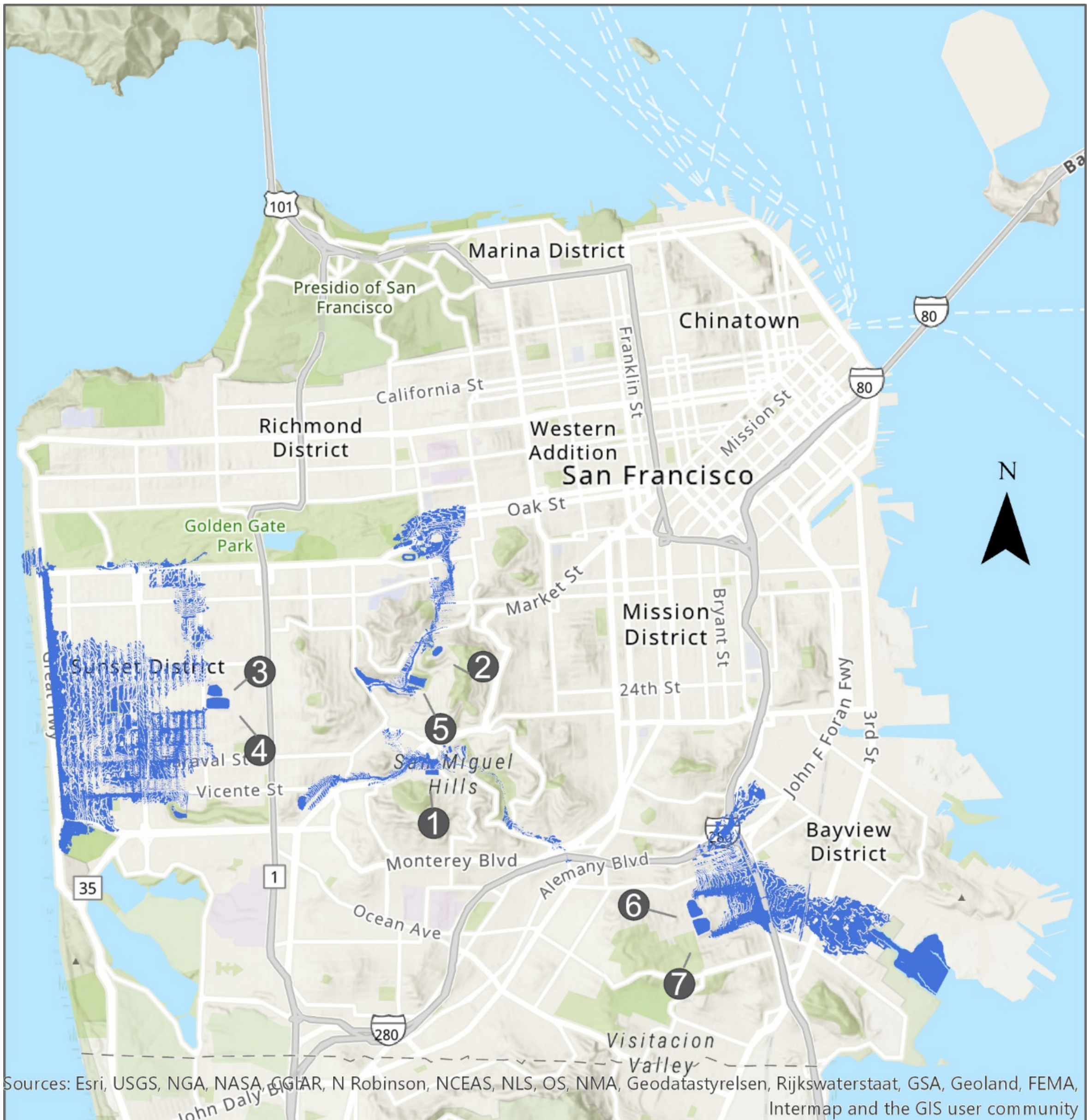
[16] See Cal. Water Code §§ 6160 et seq.; Cal. Govt. Code § 8589.5.

[17] See DSOD, Inundation Maps," accessed June 5, 2018, https://www.water.ca.gov/Programs/All-Programs/Division-of-Safety-of-Dams/Inundation-Maps.

increase.[18] According to the exposure analysis carried out in the development of the vulnerability and consequence assessment, 58,900 residents (Roughly 7%) and 19,000 households (Roughly 5%) could be exposed from reservoir or dam failure events.

[18] State of California, 2018. "2018 State of California Multi-Hazard Mitigation Plan.

FIGURE 4-11
RESERVOIR INUNDATION HAZARD AREA



Reservoir Inundation Hazard Area

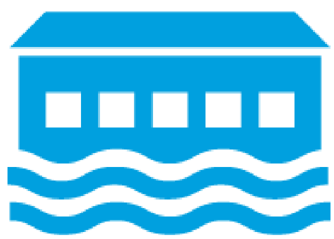
Reservoir Inundation Hazard Area

0 0.5 1 2
Miles

Data Source: SFDEM Data Library 2018; SFPUC 2018

Reservoir Key
1. Stanford Heights - Agua Way and Teresita Blvd.
2. Summit - La Avanzada St. and Palo Alto Ave.
3. Sunset North - 28th Ave and Ortega
4. Sunset South - 28th Ave and Quintara
5. Sutro - Clarendon Ave. and Olympia Way
6. University Mound North - University St. and Bacon St.
7. University Mound South - University St. and Bacon St.

Flooding Hazard Profile



4.5 Flooding

Flooding is the accumulation of water where such accumulations do not normally occur, or the overflow of excess water from a stream, river, lake, reservoir, or coastal body of water onto adjacent floodplains. Floodplains are lowlands adjacent to water bodies that are subject to recurring floods. In most cases, floods are naturally occurring events that are only considered hazards when people and property are affected. This hazard profile focuses on the flood hazards that have the potential to occur within San Francisco county limits (coastal and stormwater) and a brief description of a flood hazard that may affect publicly-owned assets located outside county limits (riverine).

- Coastal flooding in San Francisco is generally caused by high tides, storm surge, and wave action associated with Pacific Ocean storms. These low-pressure storms typically occur from November through February and affect low-lying areas adjacent to the open Pacific Ocean coast and the San Francisco Bay shoreline. As sea level rises, temporary coastal flooding associated with low pressure storms will be more frequent, extensive, and longer lasting.[1] In addition, low-lying areas near the shoreline that are not currently exposed to tidal inundation could experience inundation during high tides if no adaptation strategies are implemented.[2] This hazard is described in greater detail below.

- Stormwater flooding occurs in San Francisco during some high precipitation storm events as rainfall runoff collects in areas that at one time were naturally-formed waterways but are now contained within the City's combined sewer and stormwater collection system. As a result, streets aligned with historic waterways and some low-lying areas are prone to collect stormwater. The stormwater accumulating on the surface and backups from the combined sewer-stormwater system may enter nearby structures, resulting in property damage. The risk of stormwater flooding may increase in the future due to more intense precipitation events and sea level rise. This hazard is described in greater detail below.

- Riverine flooding occurs when runoff from rainfall and snowmelt exceeds the carrying capacity of streams and rivers. San Francisco does not have significant riverine flood sources within the county limits, because few natural watercourses

[1] City and County of San Francisco, 2016. "Sea Level Rise Action Plan."
[2] Ibid

remain. However, some publicly-owned assets outside county limits are located in areas that are subject to riverine flooding. This hazard is not described in greater detail below given the focus of this report on assets within the County jurisdiction and SFO.

Physical damage from floods includes the following:

- Inundation of facilities, causing water damage to structures and contents.
- Impact damage to buildings, roads, bridges, culverts, and other facilities from high-velocity flow and waves, and from debris carried by floodwaters. Debris may also accumulate on bridge piers and in culverts, increasing loads on these features or causing overtopping or backwater effects.
- Erosion of stream banks and shorelines, undermining or damaging nearby facilities.
- Release of sewage and hazardous or toxic materials as wastewater treatment plants and other facilities are inundated, storage tanks are damaged, and pipelines back up or are severed.

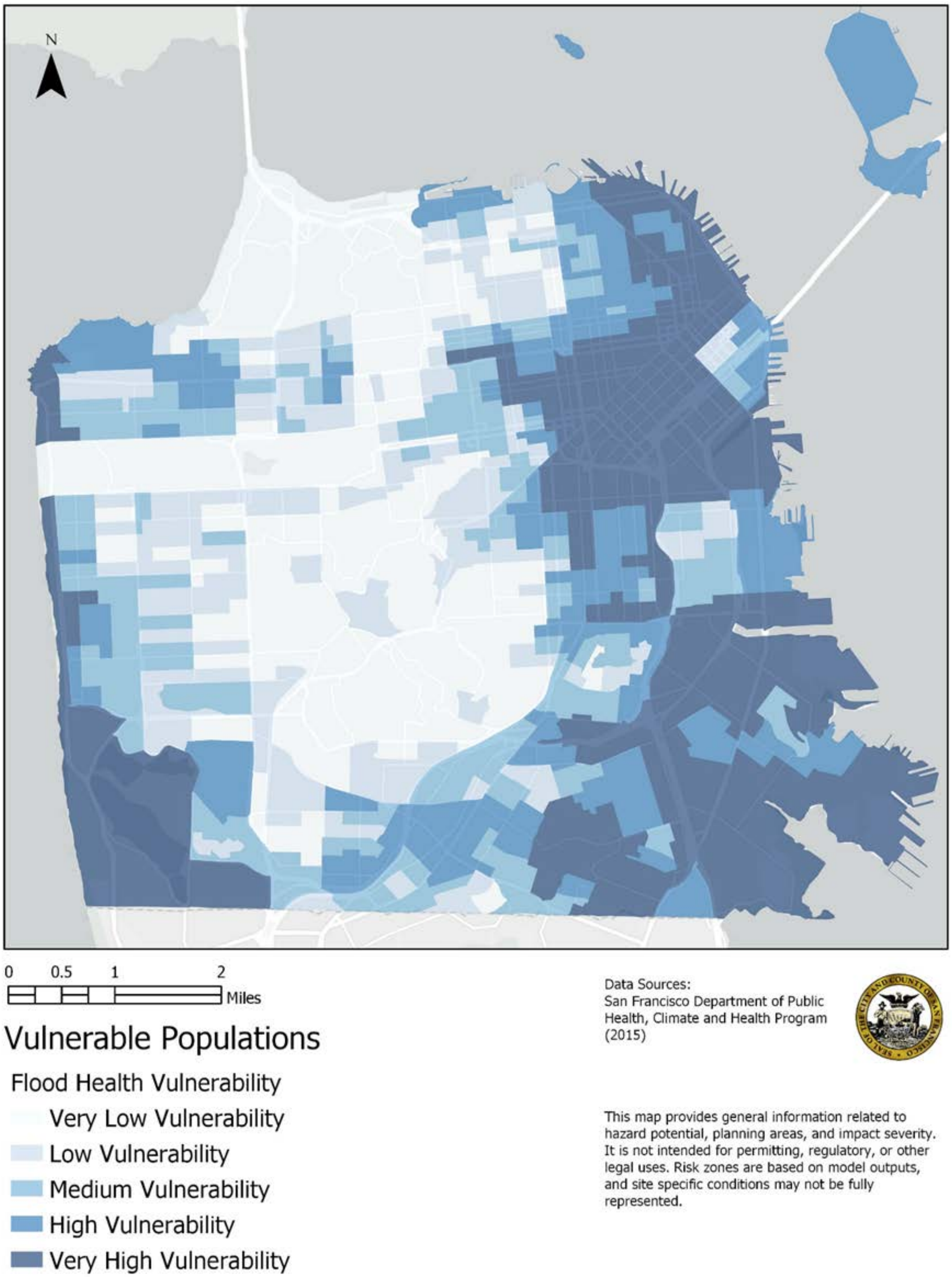
Flooding is often associated with low pressure storms that bring high winds and power outages (more information in the Wind Hazard section). Floods pose threats to life and public safety; disrupt the normal function of a community; force people to leave their residences, sometimes permanently; cause economic losses through the closure of businesses and government facilities; damage and disrupt transportation and transit systems; and damage and disrupt communications and utilities. Floods may also result in health impacts such as respiratory illnesses, vector-borne diseases, water-borne diseases, physical injuries, and medical device interruptions. In addition, floods may result in significant expenditures for emergency response.

Flooding, Extreme Storms, and Health Impacts

Coastal inundation and stormwater flooding can have profound impacts on the health of communities across San Francisco, particularly where vulnerable populations are geographically concentrated (see Vulnerable Populations Profile in Appendix A). To understand this risk, the San Francisco Department of Public Health created a flood vulnerability index in 2015 to determine which specific neighborhoods would likely see the largest impacts from current and future flooding. Indicators for this analysis included geographic location, living conditions, health conditions, and social vulnerability. The resulting map, seen in Figure 4-12 below, identified the following neighborhoods as particularly vulnerable to flooding events: The Pacific Coastline, the Southeastern quadrant of San Francisco, the Mission, and high-density areas such as South of Market, Chinatown, and the Tenderloin Neighborhoods.[3]

[3] San Francisco Department of Public Health. (2015). "San Francisco Flood Vulnerability: A Health Focused Assessment". Retrieved from: https://sfgov.maps.arcgis.com/apps/MapJournal/index.html?appid=69004eefbb3f4a27aa8b6c6566f8dc0b#

FIGURE 4-12
FLOOD VULNERABILITY INDEX



Coastal Flooding

Impact Statement

Currently, the shoreline of San Francisco Bay and the open Pacific Coast include areas that experience temporary flooding during extreme high tides and coastal storm events. As sea level rises, temporary coastal flooding will be more frequent and will inundate larger areas at greater depths and for longer durations. Areas that are particularly susceptible to increasing risk of coastal flooding due to sea level rise include Mission Bay, Islais Creek, Hunters Point, Candlestick Point, the Financial District, the Marina District, Treasure Island, and SFO. Coastal flooding can pose threats to life and public safety, cause physical damage to buildings and infrastructure, disrupt economic activity, and impair public health.

Nature

Coastal flooding in San Francisco is generally caused by the following phenomenon:

Annual high tide inundation (King Tides): King Tides are abnormally high but predictable astronomical tides that occur approximately twice per year. King Tides are the highest tides that occur each year when the gravitational influence of the moon and the sun on the tides are aligned, rather than opposed, and when the earth is at a point in its rotation which is particularly close to either the moon or sun. When King Tides occur during winter storms, the effects are particularly pronounced and make these events more dramatic. King Tides result in temporary flooding, often involving low- lying roads, boardwalks, and waterfront promenades. The Embarcadero waterfront (Pier 14) and the Marina area in San Francisco experience flooding under current King Tide conditions

Storm Surge: When Pacific Ocean storms coincide with high tides, storm surge due to meteorological effects can elevate Pacific Ocean and San Francisco Bay water levels, resulting in temporary flooding. Such storm surge events occurred on January 27, 1983, December 3, 1983, February 6, 1998, January 8, 2005, December 31, 2006, and December 24, 2012. Extreme high tides can cause severe flooding of low-lying roads, boardwalks, promenades, and neighborhoods; exacerbate coastal and riverine flooding and cause upstream flooding; and interfere with stormwater outfalls. The Ocean Beach area is prone to inundation and erosion associated with extreme high tides and storm surge.

El Niño winter storms: During the El Niño–Southern Oscillation (ENSO),[4] atmospheric and oceanographic conditions in the Pacific Ocean bring warm, higher waters to the Bay Area and may produce severe winter conditions that bring intense rainfall and storm conditions to the Bay Area. Tides are often elevated 0.5 to 3.0 feet above normal along the coast for months at a time, and additional storm surge and wave setup during storm events can elevate water levels even further. El Niño conditions prevailed in 1977- 1978, 1982-1983, 1997-1998, 2009-2010 and 2023. The 2015-16 El Niño produced wave energy conditions that were 50% larger than typically seen in the San Francisco Bay Area, with a variety of consequences. El Niño conditions in 2023 have contributed to ocean temperatures that are up to 11°F degrees above average and may contribute to this being the hottest year recorded on earth so far. Typical impacts include severe flooding of low-lying roads, boardwalks and waterfront promenades; storm drain backup; wave damage to coastal structures and erosion of natural shorelines (see Ocean Beach sidebar which highlights the power of coastal erosion).

Pacific Decadal Oscillation: Similar to the ENSO, this event references cyclical oceanic heating and cooling trends but on a longer time horizon than changes in the ENSO. These shifts occur over a 20 to 30-year period and, while typically less pronounced than the ENSO, persists for significantly longer.[5]

Ocean swell and wind-wave events (storm waves): Low pressure Pacific Ocean storms and strong thermal gradients can produce high winds that blow across the ocean and the Bay. When the wind blows over long reaches of open water, large waves are generated that impact the shoreline and cause damage. Typical impacts include wave damage along the shoreline, particularly to coastal structures such as levees, docks and piers, wharves, and revetments; backshore inundation due to wave overtopping of structures; and erosion of natural shorelines.

Physical damage from floods could include the following:

- Inundation of facilities, causing operational closures at critical transportation facilities such as SFO, the Port, BART, and various facilities operated by MTA.

[4] El Niño–Southern Oscillation (ENSO) is a natural oceanic-atmospheric cycle. El Niño conditions are defined by prolonged warming in the Pacific Ocean sea surface temperatures. Typically, this happens at irregular intervals of
two to seven years, and can last anywhere from nine months to two years
[5] AECOM, 2016. "Extreme Storms in San Francisco Bay – Past to Present". Retrieved from: http://www.r9map.org/Documents/Extreme_Storms_SF_Bay_Past_to_Present_FINAL.pdf

- Inundation and damage to various infrastructure including buildings, roads, bridges, culverts, pump stations, support structures, parks, and open space.
- Overland flooding may block access to underground utilities, may damage electrical boxes and substations causing prolonged power outages, and may damage pump stations and other electrical equipment resulting in equipment failure.
- Release of sewage and hazardous or toxic material when wastewater treatment plants, storage tanks and other facilities are inundated and compromised.
- Erosion of natural shorelines and stream banks, disruption of wetlands and natural habitats, and undermining of the support foundations and structures of important facilities

As sea level rises, temporary coastal flooding will be more frequent, extensive, and longer lasting. [6] In addition, low-lying areas that are not currently exposed to tides will experience inundation during high tides in the long-term if no adaptation strategies are implemented. [7]

History

Several areas along the shoreline are already experiencing periodic flooding and erosion, including: Ocean Beach on the Pacific Coast, which is subjected to significant coastal storms and waves; the Embarcadero, which is overtopped in several areas during the annual highest high tides, or King Tides; and San Francisco International Airport (SFO), which experiences wave overtopping of flood protection structures and inundation of low-lying areas.

Location

San Francisco is susceptible to coastal flooding along three sides of the city, with the open Pacific Ocean to the west and San Francisco Bay to the north and east.

[6] City and County of San Francisco, 2016. “Sea Level Rise Action Plan.”
[7] Ibid

<u>Flood Hazard Mapping Within the City and County of San Francisco</u>

San Francisco participates in the National Flood Insurance Program (NFIP). The City Administrator is the local responsible designee to address commitments and requirements of the NFIP. Under the NFIP, which is administered by the Federal Emergency Management Agency (FEMA), the federal government makes affordable flood insurance available in communities that participate in the program. In exchange, participating communities agree to adopt and enforce floodplain management requirements meeting the minimum NFIP criteria. San Francisco has participated in the NFIP since 2010 when it adopted a Floodplain Management Ordinance meeting NFIP minimum floodplain management requirements.

In support of the NFIP, FEMA publishes Flood Insurance Rate Maps (FIRMs) for participating communities. The FIRMs show areas that are subject to inundation during a flood having a 1% chance of occurrence in any given year (also referred to as the base flood or 100-year flood). In 2015, FEMA provided San Francisco with a "preliminary" or draft FIRM that were based on the following studies:

- Bay Area Coastal Study: This study includes analyses of coastal storm surge and wave hazards for the San Francisco Bay shoreline. FEMA used the analyses to develop flood hazard mapping for San Francisco's waterfront east of the Golden Gate Bridge, for Treasure Island, and for SFO.

- Open Pacific Coast Study: This study includes analyses of coastal storm surge and wave hazards for the open Pacific Ocean and the coastline. FEMA used the analyses to develop flood hazard mapping for the Pacific coastline of San Francisco west of the Golden Gate Bridge.

There are no natural riverine flood sources remaining within the county limits; therefore, FEMA did not complete an assessment if riverine flood hazards. Additionally, FEMA does not assess stormwater flooding, as this source of flooding is most directly related to the conveyance capacity of the City's sewer system and not a natural water body. The preliminary FIRM does not show flood hazard data for inland areas within the county limits; the FIRM only shows coastal flood hazard data for the Bay and Pacific coast shorelines.

FEMA completed final adjustments and provided a new FIRM map, effective as of March 23rd 2021, which has been formally adopted by the City. More information can be found on the SF GOV floodplain management requirements webpage. This website includes a copy of the floodplain ordinance as well as SFDBI's Information Sheet G-28 which stipulates construction requirements in the floodplain.

As described above, San Francisco adopted a Floodplain Management Ordinance in 2010, and uses that ordinance to regulate new construction and substantial improvement of buildings located in areas prone to flooding. This ordinance was amended in 2020 to reflect the findings from the final map. The final FIRM designates coastal flood hazard zones for portions of the waterfront piers, Mission Bay, Islais Creek, Bayview Hunters Point, Hunters Point Shipyard, Candlestick Point, Treasure Island, San Francisco International Airport, and Ocean Beach, which may have implications for development plans and insurance requirements in those areas.

FIRMs are organized on a countywide-basis and may include the following information:

- Special Flood Hazard Area (SFHA): A SFHA is an area that is subject to flooding during the one-percent-annual-chance flood. The SFHA is the basis for the insurance and floodplain management requirements of the NFIP. A SFHA may be associated with a stream, river, lake, or other flooding source; or with a coastal flooding source, such as San Francisco Bay.
- Base Flood Elevation (BFE): The BFE is the estimated flood elevation for the one-percent-annual-chance flood. The BFE is used for insurance ratings and for floodplain management.
- SFHA zone designations: An SFHA is defined using a zone designation that is based on the level of analysis used to establish the SFHA and the physical characteristics of the SFHA. "Zone AE" and "Zone VE" are used to represent flood hazards that were analyzed using detailed methods; whereas "Zone A" and Zone V" where determined by approximate methods. The zone designation also describes the type of risk associated with the flood hazard; it is used for insurance rating purposes and to determine the appropriate floodplain management requirements for structures located in that zone. "Zone AE" is used for inland flooding sources and for coastal flooding sources where waves are less than three feet in height. SFHAs in coastal areas where waves are three feet or greater in height are identified as "Zone VE" on the FIRM. The elevation of the flood hazard is generally reported after the zone designation (e.g., Zone AE 12

represents an area with a flood hazard, with waves less than 3 feet, with a water surface elevation of 12 feet NAVD88).

- Other flood hazard data: The FIRM may also show other flood hazard data, such as "Shaded Zone X" floodplains associated with a flood having a 0.2 percent chance of occurrence in a given year (the 500-year flood) or other hazards.

FIGURE 4-13
COASTAL FLOODPLAIN HAZARD AREA

0 0.5 1 2
Miles

FEMA FIRM Coastal Floodplain Hazard Map

Data Sources:
FEMA 2021

Areas Subject to Inundation During 1% Annual Chance Flood

Sea Level Rise Vulnerability Zone

For long-range planning, Capital Planning Committee (CPC) Guidance defines a Sea Level Rise (SLR) Vulnerability Zone based on the 2012 National Research Council's (NRC) upper range (unlikely, but possible), end-of-century SLR estimate.[8] The Zone (see Figure 4-14) therefore includes shoreline areas that could be exposed to 66 inches of permanent SLR inundation combined with temporary flooding from a 100-year (1% annual chance) extreme tide if no adaptation measures or actions are taken.

Groundwater Rise Vulnerability

Groundwater Rise (GWR) is a process influenced by SLR and other factors that may lead to emergent flooding in low-lying coastal communities prior to traditional flooding concerns around overtopping at the shoreline.[9] Areas of emergent groundwater are essentially wetlands or areas where the groundwater table is at or above the ground surface. As SLR occurs, saline groundwater intrusion can cause existing areas for freshwater groundwater to rise or spread in extant with significant implications for the emergence or occurrence of flooding in areas that previously would not be subject to flooding year-round.

[8] National Research Council, 2012. Sea-Level Rise for the Coasts of California, Oregon, and Washington. Past, Present, and Future.
[9] May CL, Mohan A, Plane E, Ramirez-Lopez D, Mak M, Luchinsky L, Hale T, Hill K. 2022. Shallow Groundwater Response to Sea-Level Rise: Alameda, Marin, San Francisco, and San Mateo Counties. Prepared by Pathways Climate Institute and San Francisco Estuary Institute. doi.org/10.13140/RG.2.2.16973.72164

FIGURE 4-14
SAN FRANCISCO SEA LEVEL RISE VULNERABILITY ZONE

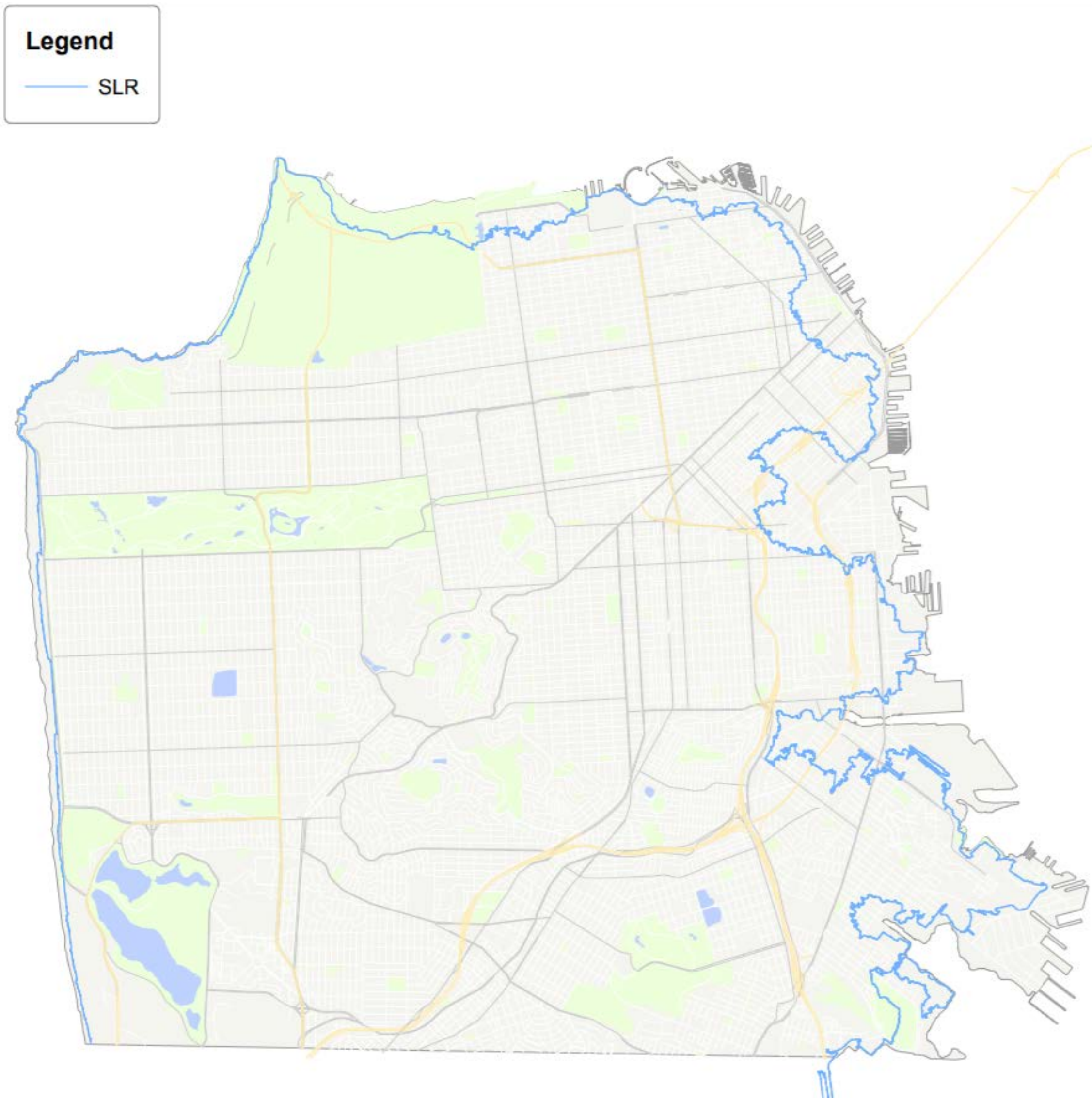


FIGURE 4-15
GROUNDWATER RISE 24" SLR FLOOD HAZARD MAP

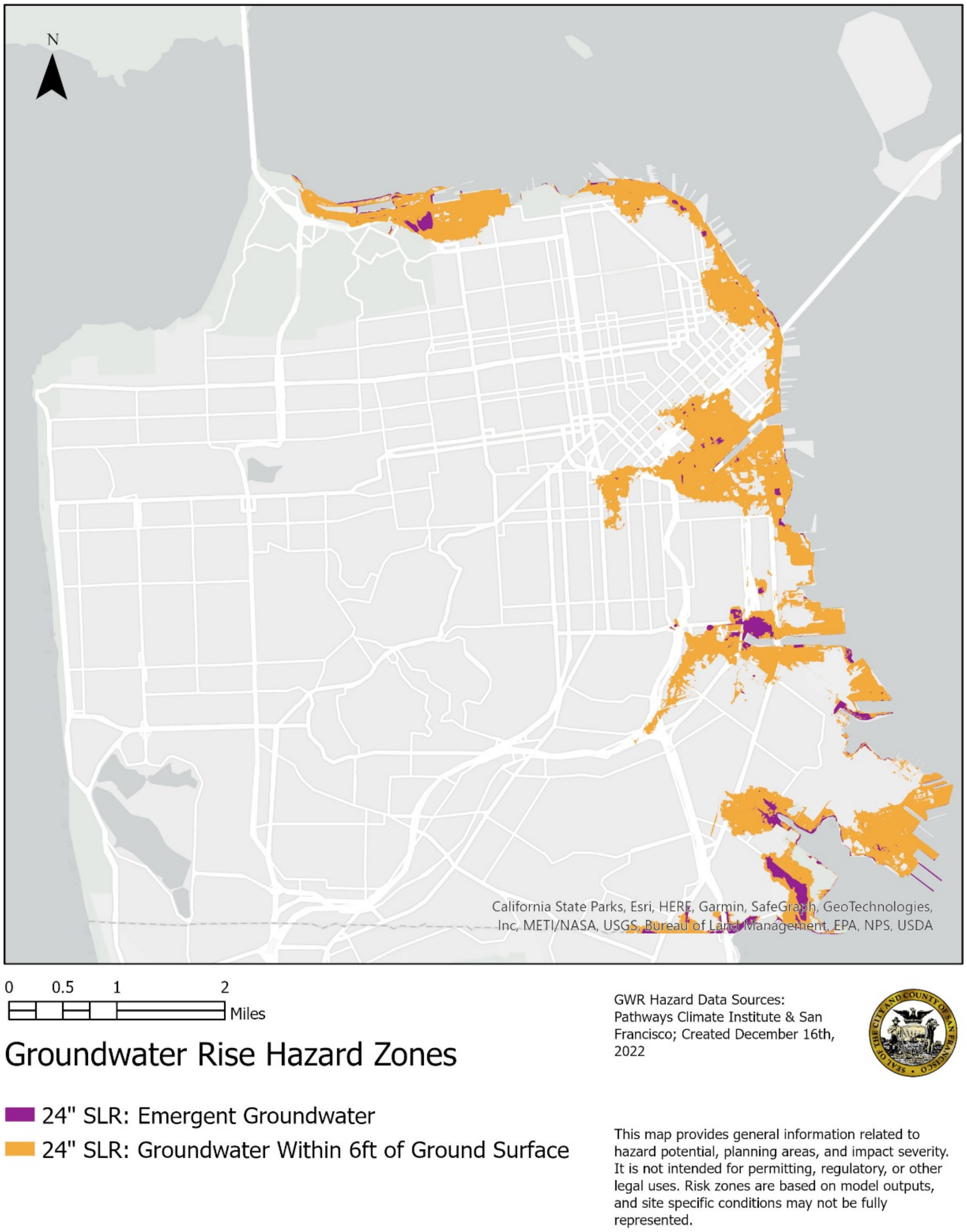
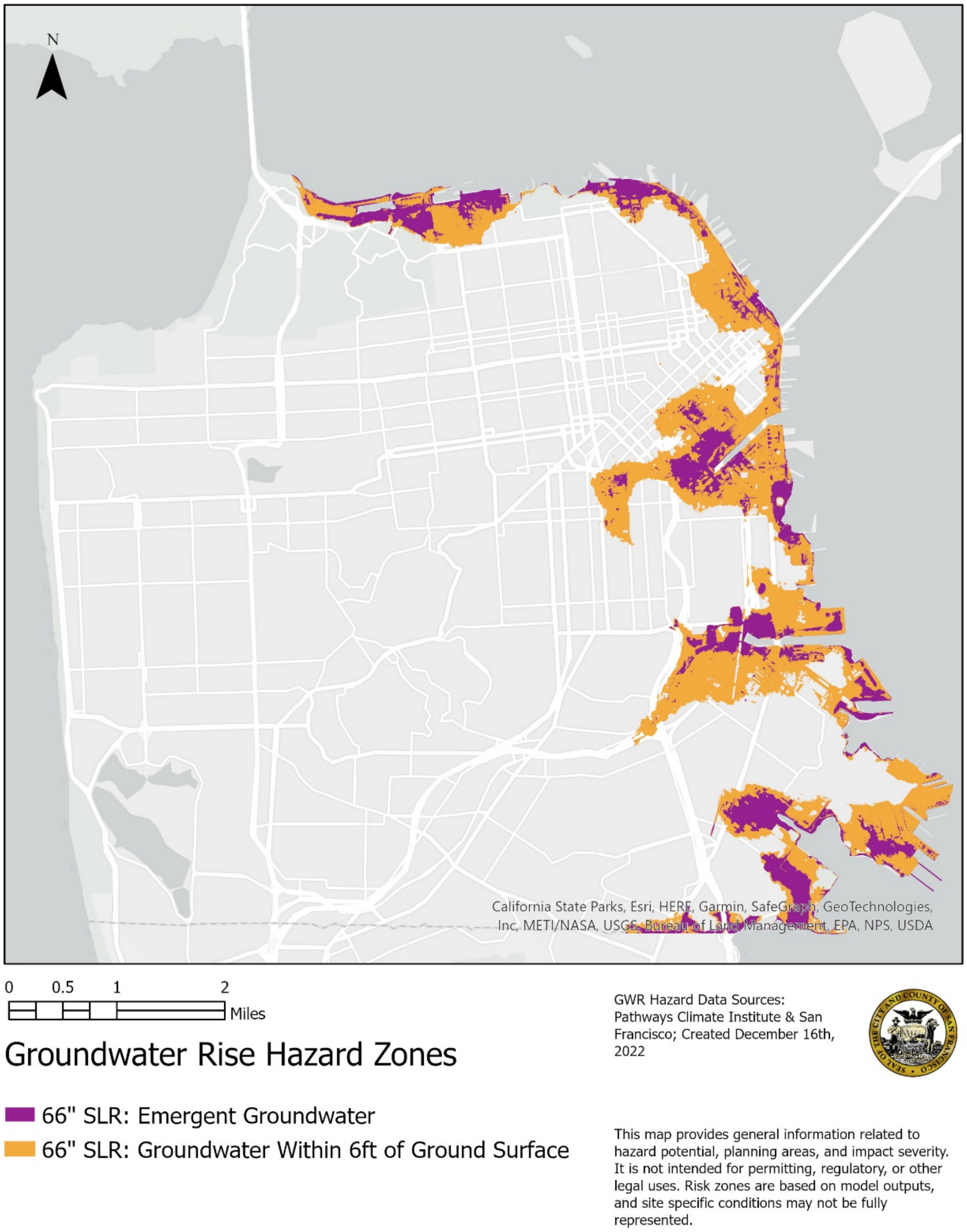


FIGURE 4-16
GROUNDWATER RISE 66" SLR FLOOD HAZARD MAP



Severity and Probability of Future Events

Floods are described in terms of their extent, including the horizontal area affected and the vertical depth of floodwaters, and the related probability of occurrence. Flood studies often use historical records, such as stream-flow and tide gages, to determine the probability of occurrence of floods of different magnitudes. The probability of occurrence is expressed as a percentage of the chance of a flood of a specific extent occurring in a given year. The magnitude of flood used as the standard for floodplain management in the United States is a flood having a probability of occurrence of one percent in any given year. This is known as the 100-year flood or base flood.

The most readily available source of information regarding the current one-percent-annual-chance flood hazard is the system of FIRMs prepared by FEMA (described above). FEMA has also created Increased Flooding Scenario Maps for the interior shoreline for all nine Bay Area counties, which are non-regulatory products that complement the FIRMs. These maps utilize the most up-to-date coastal floodplain mapping data based on FEMA's San Francisco Bay Area Coastal Study and provide additional information on how the 1-percent-annual-chance (i.e. 100-year) coastal floodplain may change with a 1-foot, 2-foot, and 3-foot increase in Bay water levels.

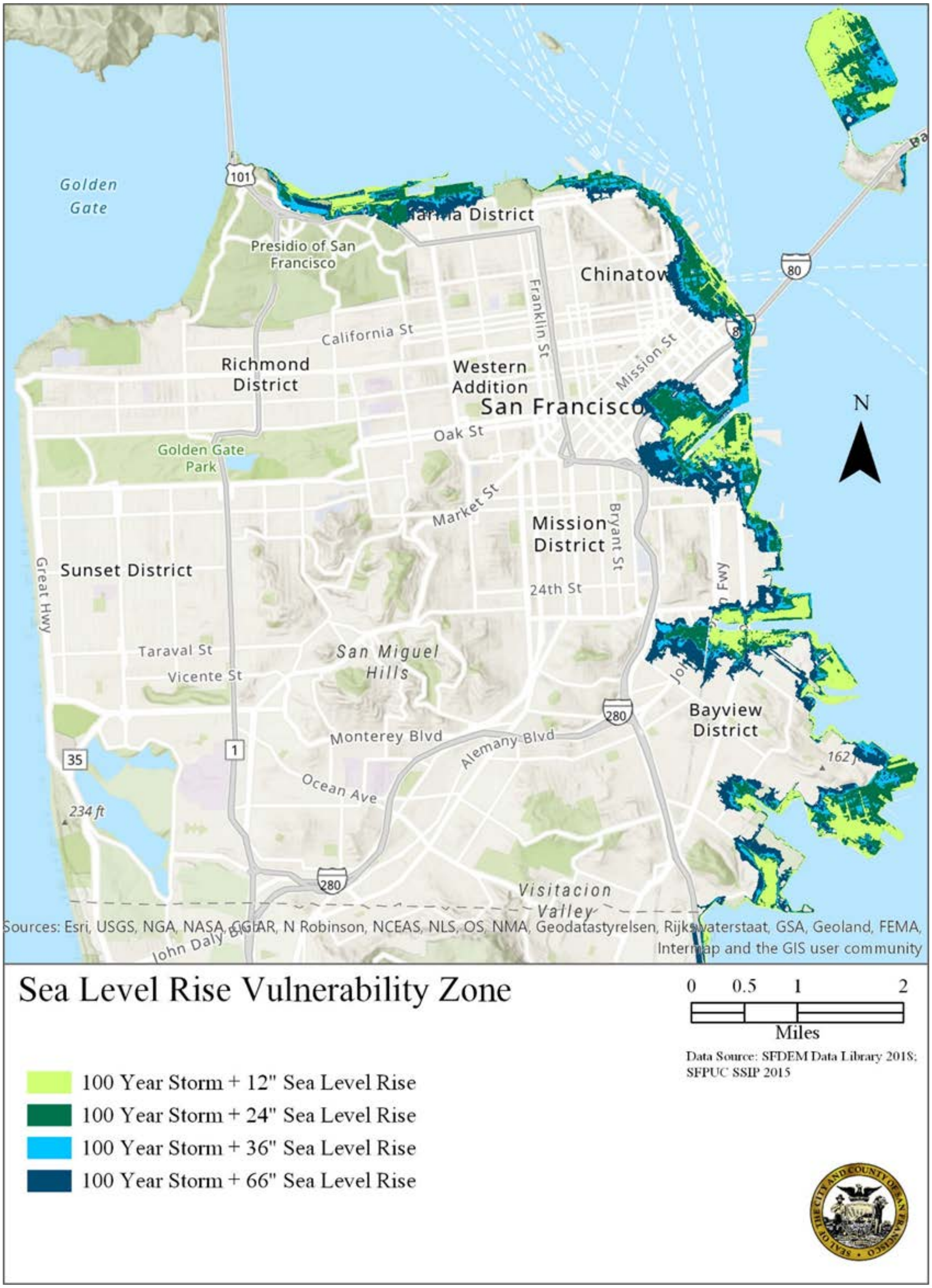
Projected sea level rise will worsen existing coastal flood hazards by increasing the elevation and frequency of flooding, extending the coastal flood hazard zone further inland, and accelerating shoreline erosion. Without action, a variety of coastal flood hazards will increase as seas rise, including:

- Temporary coastal flooding from extreme tides, storm surge, and large waves may increase in frequency and extent. Figure 4-17, seen below, shows the areas potentially exposed to temporary flooding during a 100-year storm with 12 to 66 inches of sea level rise.

- Permanent inundation of areas currently not exposed to regular tides: Sea level rise can cause areas that are not currently exposed to regular high tide inundation to be inundated regularly, resulting in the need to either protect or move people and infrastructure, and the loss of trails, beaches, vistas, and other shoreline recreation areas. 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, including portions of Mission Bay, Central SOMA, and Hunters Point, and areas adjacent to Islais Creek. Parts of the San Francisco International Airport could also be exposed to permanent inundation without action.

- 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.
- Elevated groundwater and increased salinity intrusion: As sea levels rise, groundwater and salinity levels are also predicted to rise. This will cause damage to below grade residential and commercial spaces and infrastructure.

FIGURE 4-17
TEMPORARY COASTAL FLOODING IN SEA LEVEL RISE VULNERABILITY ZONE



Stormwater Flooding

Impact Statement

Stormwater flooding occurs during storm events as rainfall runoff collects in areas that at one time were naturally-formed waterways but are now contained within the City's combined sewer and stormwater collection system. The Islais Creek area (Cayuga/Alemany), South of Market, Inner Mission, and Civic/Center Western Addition include significant areas that are at risk of stormwater flooding during a 100-year storm, as well as during rainfall events that occur more frequently. Smaller areas across the city also experience temporary flooding during precipitation events.[10] As precipitation events may become more intense and sea level rises due to climate change, the frequency and extent of stormwater flooding will increase. Stormwater flooding can cause physical damage to buildings and infrastructure, disrupt economic activity, and impair public health.

Nature

As San Francisco has developed over time, its hilly topography has been largely paved over. During storms, runoff flows along streets aligned with historic waterways and in areas that are built on landfill. The stormwater accumulating on the surface and backups from the combined sewer-stormwater system may enter nearby structures, resulting in property damage, forcing people to leave their homes, and causing disruptions to businesses. Additionally, fast-moving water on the surface is a threat to public safety, even at shallow depths. San Francisco's stormwater infrastructure is sized for the current 5-year storm, so heavier precipitation events can lead to localized flooding.

Stormwater flooding can also be exacerbated by high tides. As the sewage and stormwater system reaches maximum capacity during heavy precipitation events, the effluent may be discharged directly into the bay. High water levels in the bay can slow these discharges, causing backups in the sewage and stormwater system. These backups can increase the extent and duration of stormwater flooding. This phenomenon will be exacerbated as sea level rises. Discharges to the bay can create a

[10] San Francisco Public Utilities Commission. "Flood Maps." http://sfwater.org/index.aspx?page=1229

pollution problem when the effluent carries untreated sewage and debris, chemicals, trash, and other pollutants that have collected on streets.

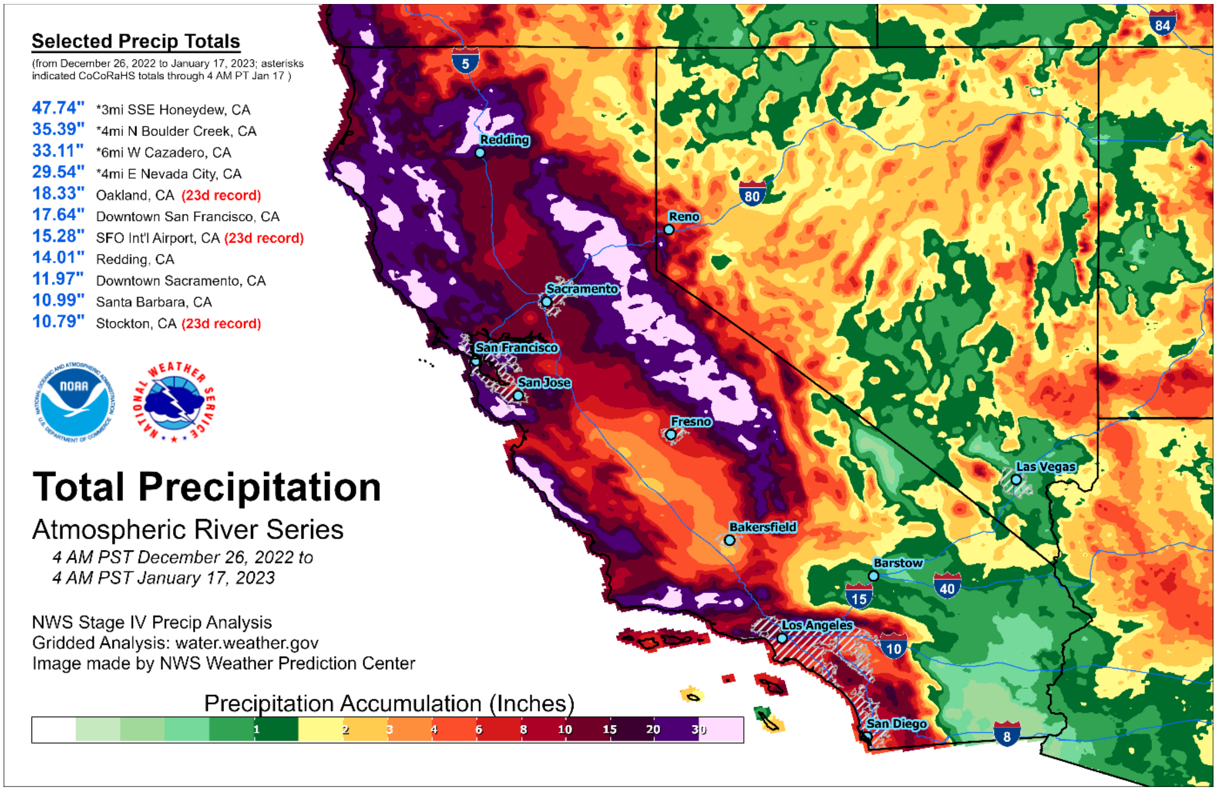
History

A query of the National Oceanic and Atmospheric Administration's Storm Events Database, indicates that San Francisco has 23 flood events from 1998 to 2018, primarily resulting in flooded roadways.[11] However, this same database indicated that there have been 34 flood events between 2018 and 2023, demonstrating the rise in these events as predicted with the climate changing. Several large storms in recent years have caused significant flooding in certain neighborhoods of San Francisco. For example, two very large storms in December 2014 caused property damage, loss of business revenue, and other significant impacts in some low-lying areas. Many of these areas also flooded in an extreme storm in February 2004.[12] From October 24th to 25th, 2021 a moderate to high strength atmospheric river event formed, originating from the Pacific Northwest, and impacted the Bay Area. During this event, record breaking rainfall led to the issuance of flood warnings with downed trees from wind gusts and numerous flooded roadways.[13] These impacts were seen across all most of the Bay Area.

More recently, from December 26th, 2022 to January 17th, 2023 much of California, with a particular focus on the northern part of the state, the Bay Area, and the Central Coast, experienced an extended series of atmospheric rivers which coincided with Extra Tropical Cyclone (ETC) events to create a string of storms that had wide ranging impacts. Six discreet storm systems were formed over this period, with over nine discreet atmospheric rivers contributing to large, damaging surf conditions, damaging wind gusts, and widespread flooding across the state. Downtown San Francisco recorded 17.64" inches of rain during this period and SFO Airport set a 23-day record with 15.28" Inches of rain.[14]

[11] National Oceanic and Atmospheric Administration. https://www.ncdc.noaa.gov/stormevents/
[12] San Francisco Public Utilities Commission, 2016. "Flood Resilience Report. Executive Summary." http://sfwater.org/Modules/ShowDocument.aspx?documentid=9127
[13] Atmospheric River Brings Historic Rainfall to the Bay Area (NWS): https://www.weather.gov/mtr/AtmosphericRiver_10_24-25_2021
[14] https://www.weather.gov/mtr/AtmosphericRivers_12_2022-01_2023

FIGURE 4-18
TOTAL PRECIPITATION: ATMOSPHERIC RIVER SERIES[15]



Location

The SFPUC has developed a 100-Year Storm Flood Risk Map that shows areas of San Francisco where significant flooding from storm runoff is highly likely to occur during a 100-year storm. A “100-year storm” means a storm with a 1% chance of occurring in a given year. The SFPUC used computer modeling that simulates the Citywide operation of the stormwater system during a 100-year storm to identify areas subject to flooding.

The map shows parcels that are highly likely to experience “deep and contiguous” flooding during a 100-year storm. “Deep and contiguous flooding” means flooding that is at least 6-inches deep spanning an area at least the size of half an average City block. This map shows flood risk from storm runoff only. It does not consider flood risk in San Francisco from other causes such as inundation from the San Francisco Bay or Pacific Ocean. Areas with stormwater flooding risks include the Islais Creek area (Cayuga/Alemany), South of Market, Inner Mission, and Civic/Center Western Addition.

[15] https://www.weather.gov/mtr/AtmosphericRivers_12_2022-01_2023

FIGURE 4-19
100-YEAR STORM FLOOD RISK HAZARD MAP

Severity and Probability of Future Events

As sea level rises and precipitation events become more intense, stormwater flooding may increase in frequency and severity. More intense precipitation may lead to localized flooding because stormwater infrastructure is sized for the current 5-year storm, and does not fully account for future conditions with a changing climate. For more detailed information see “Changing Precipitation Patterns” section of this chapter. However, this prospect represents an unprecedented challenge for existing stormwater management infrastructure with significant implications for the frequency and intensity of stormwater flooding. This effect will be exacerbated as sea levels rise because higher Bay waters will further slow stormwater discharge. This effect will be particularly severe in low-lying coastal areas, but slow discharge rates could affect system-wide drainage rates and cause upstream flooding.

High Wind Profile

4.6 High Wind

Impact Statement

Although San Francisco experiences winds throughout summer, especially in the afternoon and early evening, the most disruptive “high winds” occur either with strong storms in the winter or spring, or in late fall as part of the warm “Diablo winds”. Storm-related wind can down trees or power lines and contribute to electrical outages. When these storm-related winds hit 100mph along the coast or at higher elevations, they may become hazardous, especially for big rig trucks on bridges. The “Diablo winds” can stoke fires in nearby counties and transport smoke to San Francisco. Winds year-round can transport pollens and contribute to allergies.

Nature

Winds are horizontal flows of air that blow from areas of high pressure to areas of low pressure. Wind strength depends on the difference in pressure between the high- and low-pressure systems and the distance between them. A steep pressure gradient results from a large pressure difference or short distance between these systems, causing high winds.

The National Weather Service (NWS) defines “high winds” as sustained wind speeds of 40 miles per hour (mph) or greater lasting for one hour or longer, or winds of 58 mph or greater for any duration. The NWS issues a wind advisory when there are sustained winds of 25 to 39 mph, or gusts to 57 mph. A wind storm is an incident exceeding those values as measured by weather observation equipment, or as indicated by damage consistent with such wind speeds. NOAA currently operates a station in the north of the city that measures and categorizes windspeed. High winds are measured on a scale, known as the Beaufort Wind Scale, which extends from one to twelve. This scale corresponds to a wind speed in knots and an accompanying description of the impacts on land and sea, as seen in Table 4-8.

TABLE 4-8
BEAUFORT WIND SCALE[1]

Force	Wind Speed (knots)	WMO Classification
0	Less than 1	Calm
1	1-3	Light Air
2	4-6	Light Breeze
3	7-10	Gentle Breeze
4	11-16	Moderate Breeze
5	17-21	Fresh Breeze
6	22-27	Strong Breeze
7	28-33	Near Gale
8	34-40	Gale
9	41-47	Strong Gale
10	48-55	Storm
11	56-63	Violent Storm
12	64+	Hurricane

[1] NOAA. “Beaufort Wind Scale”. Retrieved from: https://www.spc.noaa.gov/faq/tornado/beaufort.html

In Winter, atmospheric river events occurring in concert with extra tropical bomb cyclones can lead to particularly strong wind events that are increasingly becoming more powerful with climate change. This can lead to damaging and powerful high wind events that disrupt transportation and other critical systems. During the summer months in San Francisco, temperature and pressure differences between the Pacific Ocean and the interior valleys of California create strong afternoon and evening sea breezes. These westerly winds flow across the Golden Gate and through breaks in the high terrain of the Coast Range, often reaching afternoon speeds of between 20 and 30 mph. Normally, San Francisco's hilly terrain breaks up strong winds, but occasionally strong storms with significant wind gusts halt normal activity in the city, and cause widespread power line damage and electrical outages due to toppled trees and broken limbs.

In addition, the typical summer weather pattern of cooler, more humid air flowing in an easterly direction from the ocean to inland areas reverses. These hot, dry offshore winds from the northeast, which typically occur in the Bay Area during the spring and fall, are known as "Diablo winds." Diablo winds can be quite strong, with gusts up to 40 mph. Diablo winds are most common in the fall when the jet stream dips farther south, and alternating areas of high and low pressure affect California. Fall is also the time of year when wildlands and the urban-wildland interface are particularly dry. Dry land cover, when combined with hot dry Diablo winds, may result in high fire danger. This was the meteorological scenario leading to the Oakland Hills firestorm in October 1991 and the North Bay fires in 2017.

History

In San Francisco, high winds associated with cyclonic systems and their cold fronts occur in the winter, generally between the months of November through March (refer to Table 4-9). On average, there have been 1.2 wind storm events per year. Data from the Golden Gate Weather Service on some of the larger, more recent, high wind storm events in San Francisco is presented in Table 4-10 below. NOAA's National Climatic Data Center has recorded 83 significant wind storm incidents in the San Francisco region from 1948 through 2023 as measured by wind gusts above 58 mph.[2]

2 These events were observed at NOAA's San Francisco International Airport Station. Wind data from San Francisco proper was not available.

On March 21, 2023, following multiple atmospheric rivers, San Francisco experienced a severe windstorm that resulted in two fatalities, uprooted over 700 trees, and caused widespread property damage across the city.[3] This wind event disrupted many aspects of the city functioning, and particularly impacted transportation in the city. Impacts included parts of the inbound bay bridge being blocked due to a flipped semi-truck, cancellations of ferry service due to high wind, as well as the 3rd street bridge closing due to damage from multiple barges becoming unmoored and ramming into the bridge structure.[4] Additionally, damage was incurred to the Trucadero Clubhouse in Stern Grove during the high wind events of 2023 when a large eucalyptus tree was downed onto the building's roof.[5] This event was also responsible for numerous glass failures at high rise buildings around the city.[6]

TABLE 4-9
HIGH WIND EVENTS BY MONTH, 1948-2023[7]

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Count of Events	18	14	7	7	3	4	0	0	0	5	8	20
Pct. of Events	20%	16%	8%	8%	3%	4%	0%	0%	0%	6%	9%	23%

3 SF Standard (2023). "5 Dead After Storm Rips Through San Francisco Bay Area". Retrieved from: https://sfstandard.com/2023/03/22/5-dead-after-storms-rip-through-san-francisco-bay-area/

4 CBS Bay Area (2023). "Update: Storm system slams into Bay Area unleashing deadly wind gusts". Retrieved from: https://www.cbsnews.com/sanfrancisco/news/stormfront-pinwheels-damaging-winds-into-san-francisco-bay-area/

5 ABC7 News(2023). "SF historic landmark Trocadero Clubhouse takes a big hit from 85-foot eucalyptus tree due to storm". Retrieved from: https://abc7news.com/trocadero-clubhouse-stern-grove-tree-fall-damage/12943863/

6 ABC7 News(2023). "SF supervisor calls for all downtown buildings to be inspected after windows shatter at 5 high-rises" Retrieved from: https://abc7news.com/windows-downtown-san-francisco-storm-glass-failure-sf-millennium-tower/12991572/

7 Based on observations from San Francisco International Airport Station

Source: National Centers for Environmental Information, NOAA. 2023. Accessed June 14, 2023

TABLE 4-10
SELECT HIGH-WIND EVENTS[8]

	Dec. 22, 1955	Oct. 12, 1962	Mar. 31, 1982	Dec. 22, 1982	Dec. 12, 1995	Dec. 16, 2002	Jan. 4, 2008	Oct. 13, 2009	Jan. 8, 2017	Jan. 4, 2023
San Francisco 24-Hour Rain Total	2.57"	3.11"	2.57"	2.00"	3.27"	2.07"	2.01"	2.48"	1.62”	1.06”
SFO Maximum Sustained Wind	42 mph	43 mph	47 mph	47 mph	54 mph	43 mph	53 mph	41 mph	44 mph	38 mph
Peak Bay Area Wind	90 mph	86 mph	81 mph	100 mph	103 mph	91 mph	87 mph	77 mph	77 mph	101 mph

Location

San Francisco as a whole is subject to strong southeasterly winds associated with powerful winter cold fronts. However, strong sea winds from the Pacific Ocean generally have a greater impact on the west side of San Francisco. Each year, at least one winter storm typically results in closure of the Great Highway, when wind gusts deposit large amounts of sand on the roadway. The Great Highway runs along the Pacific Ocean on the western boundary of San Francisco through the Outer Sunset and Outer Richmond Districts. Additionally, wind events can lead to impacts throughout the city, particularly around other transit corridors or concentrations of high-rise buildings.

Severity and Probability of Future Events

Given the information in Table 4-9, San Francisco has experienced at least 86 notable high wind event occurrences over the 75-year period from 1948-2023. This yields an annualized frequency of 1.14, meaning there is a high likelihood that the city will experience at least one high wind event every year. Storms combining strong winds with heavy rain have the largest impact on San Francisco during the winter months. Wind gusts of 40 mph have the potential to bring down trees and branches and to trigger

8 Golden Gate Weather Services, Bay Area Storm Index [http://ggweather.com/basi_archive.htm]

power outages leaving thousands of people without electricity. Windows in high rises may also experience damage and breakage from events as well. Based on previous wind events, San Francisco can continue to expect to experience at least one winter wind storm annually. As we saw from the beginning of 2023, there is also the possibility of San Francisco experiencing a series of storms.

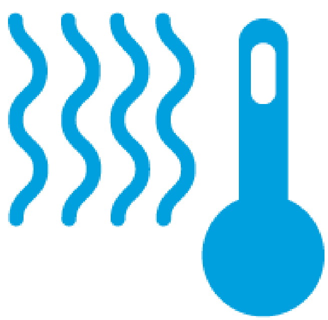
Sustained winds of more than 50 mph have been recorded in San Francisco during various Pacific Storms. During isolated storm incidents, gusts may peak at more than 100 mph along the coast and at higher elevations. In such conditions, Bay Area bridges become hazardous, especially for big rig trucks that may overturn on bridges during high wind events.

Climate change is expected to modify San Francisco's wind, the extreme storms that generate the most severe winds, and the impact of wind on San Francisco. While climate scientists project climate change to generally reduce wind in the United States, the pineapple-express extreme storms that generate the most severe wind in the San Francisco Bay Area are expected to increase in both frequency and severity.[9] Similarly, there is some evidence that climate change will lengthen the "Diablo winds" fire season.[10] Additionally, record drought periods and associated diseases from invasive insects can lead to a deterioration of San Francisco's urban canopy and this can also contribute to increased risk of trees falling in high wind events.

9 Kristopher Karnauskas, Julie Lundquist, and Lei Zhang (2018) Southward shift of the global wind energy resource under high carbon dioxide emissions. Nature Geoscience, 11, 38-43.

10 Henry Fountain, "California winds are fueling fires, It may be getting worse", New York Times, accessed October 11, 2017, https://www.nytimes.com/2017/10/11/climate/caifornia-fires-wind.html.

Extreme Heat Profile



4.7 Extreme Heat

Impact Statement

Historically, San Francisco has experienced extreme heat events six to seven days per year, generally between May and October. Though an excessive heat event in San Francisco impact all areas of the city, it does not affect all inhabitants equally. The elderly, the very young, and those with chronic health problems are most at risk when extreme heat occurs. Neighborhoods with the greatest risk, based on sociodemographic characteristics, include Chinatown, SOMA, Tenderloin Center, Bayview/ Hunters Point, and the Mission District. Climate change is expected to increase the frequency and severity of extreme heat events.

Nature

Located at the north end of a peninsula and surrounded on three sides by San Francisco Bay and the Pacific Ocean, San Francisco is almost perfectly positioned for moderate temperatures year-round. Cool marine air and coastal fog keep the average summertime temperatures between 60- and 70-degrees Fahrenheit. The warmest time of year is typically the late summer and early fall when the fog is less pronounced. However, occasional heat events (defined below) do occur for San Francisco. Given that San Francisco has such a relatively mild climate, a sudden spike in temperatures has a much greater impact on residents compared with noncoastal communities. Though air conditioning is the leading protective factor against heat-related illness and death, most residential units in San Francisco lack air conditioning.

According to the National Weather Service, extreme heat occurs when the temperature reaches extremely high levels or when the combination of heat and humidity causes the air to become oppressive and stifling. In San Francisco, heat or extreme heat is generated when a massive high-pressure ridge inhibits the normal onshore breezes, resulting in temperatures in the high 80s, 90s, and possibly the 100s. Generally, extreme heat is 10 degrees above the normal temperature over an extended period of time. In San Francisco, extreme heat events have been specified as occurring when daytime temperatures are at or above 85 degrees.[1] However, extreme heat can manifest itself in several other ways, including:

- A spell of sweltering humidity, which reaches levels commonly associated with moist tropical regions. Stress on the body can be exacerbated when atmospheric conditions cause pollutants to be trapped near the ground.
- An excessively dry condition, in which strong winds and blowing dust can worsen the situation.
- A rise in the heat index, the body's perception of the "apparent" temperature based on both the air's real temperature and the amount of moisture present in the air. Humidity and mugginess make the temperature seem higher than it is. In high humidity, an 85-degree day may be perceived as 95 degrees.

During heat or extreme heat events, local National Weather Service offices may issue heat-related messages as conditions warrant. Such messages include:

- Excessive Heat Outlook: Issued when the potential exists for an excessive heat event in the next three to seven days. An outlook carries a minimum 30 percent confidence level that the event will occur.
- Excessive Heat Watch: Issued when conditions are favorable for an excessive heat event in the next 12 to 48 hours. A watch is given when the level of confidence that the event will occur reaches 50 percent or greater.
- Excessive Heat Advisory: Issued when an excessive heat event is expected in the next 36 hours. An advisory is used for a less severe event that is not assumed to be life-threatening, when caution is advised to mitigate the event's impact.
- Excessive Heat Warning: The most serious alert, issued when an excessive heat event is expected in the next 36 hours, or such an event is occurring, is imminent, or has a very high probability of occurring. A warning assumes the potential for health consequences due to extreme heat.

[1] According to Cal-Adapt, an Extreme Heat day is defined as a day in April through October when the Maximum Temperature exceeds the location's Extreme Heat Threshold, which is calculated as the 98th percentile of historical maximum temperatures between April 1 and October 31 based on observed daily temperature data from 1961–1990.

While extreme heat events are less dramatic than something, they are potentially deadlier. A California Energy Commission study indicates that over the past 15 years, heat waves have claimed more lives in California than all other declared disaster events combined.[2]

History

Using data from the National Weather Service (NWS), San Francisco's daily temperature has exceeded 100 degrees only 11 times between 1921 and 2017, for a recurrence interval of approximately once every 9 years. Between 1921 and 2017, the NWS observation site in downtown San Francisco has averaged 6.6 days per year with high temperatures at or above 85 degrees. However, 1984, 1995, and 1996 were an exception to this average: There were 17, 18, and 18 days, respectively, during those years when temperatures were at or above 85 degrees.

On the rare days when the temperature reaches 100 degrees, the health impact is extreme. On June 14, 2000, San Francisco experienced a 103-degree heat wave, the highest temperature ever recorded for San Francisco at the time. This heat event resulted in reports of 102 heat-related illnesses and nine deaths in San Francisco. During the 2017 Labor Day weekend, San Francisco experienced the highest temperature ever recorded, with temperatures of 106 degrees observed. It is estimated that during this event, at least three people died, and 50 people were hospitalized due to heat-related illness in the city. The number of 911 calls overwhelmed ambulances and forced San Francisco to request mutual aid from neighboring counties.[3] These numbers likely underestimate the event's health impacts, as exposure to extreme heat can exacerbate underlying health conditions, leading to hospitalization and even premature death.

On September 6th 2020, over 10 Bay Area cities set new records for extreme heat with San Francisco experiencing 100° temperatures for the first time since 2017.[4] In San Francisco, the max temperature downtown was logged at 93 degrees during the month of October in 2020[5] The full extent of public health impacts attributed to heat during

[2] Heat waves are three sequential extreme heat days and are also expected to increase.
[3] There were 1,342 emergency calls on Friday, September 1, and 1,413 emergency calls on Saturday, September 2, the most since New Year's Eve 2012.
[4] https://abc7news.com/san-francisco-heat-wave-california-sf-fran-weather/6412112/
[5] National Weather Service. "Monthly Highest Max Temperature for SAN FRANCISCO DOWNTOWN, CA". Retrieved from: https://www.weather.gov/wrh/climate?wfo=mtr

this period is difficult to ascertain due to the simultaneous impacts of COVID-19 on the health care system.

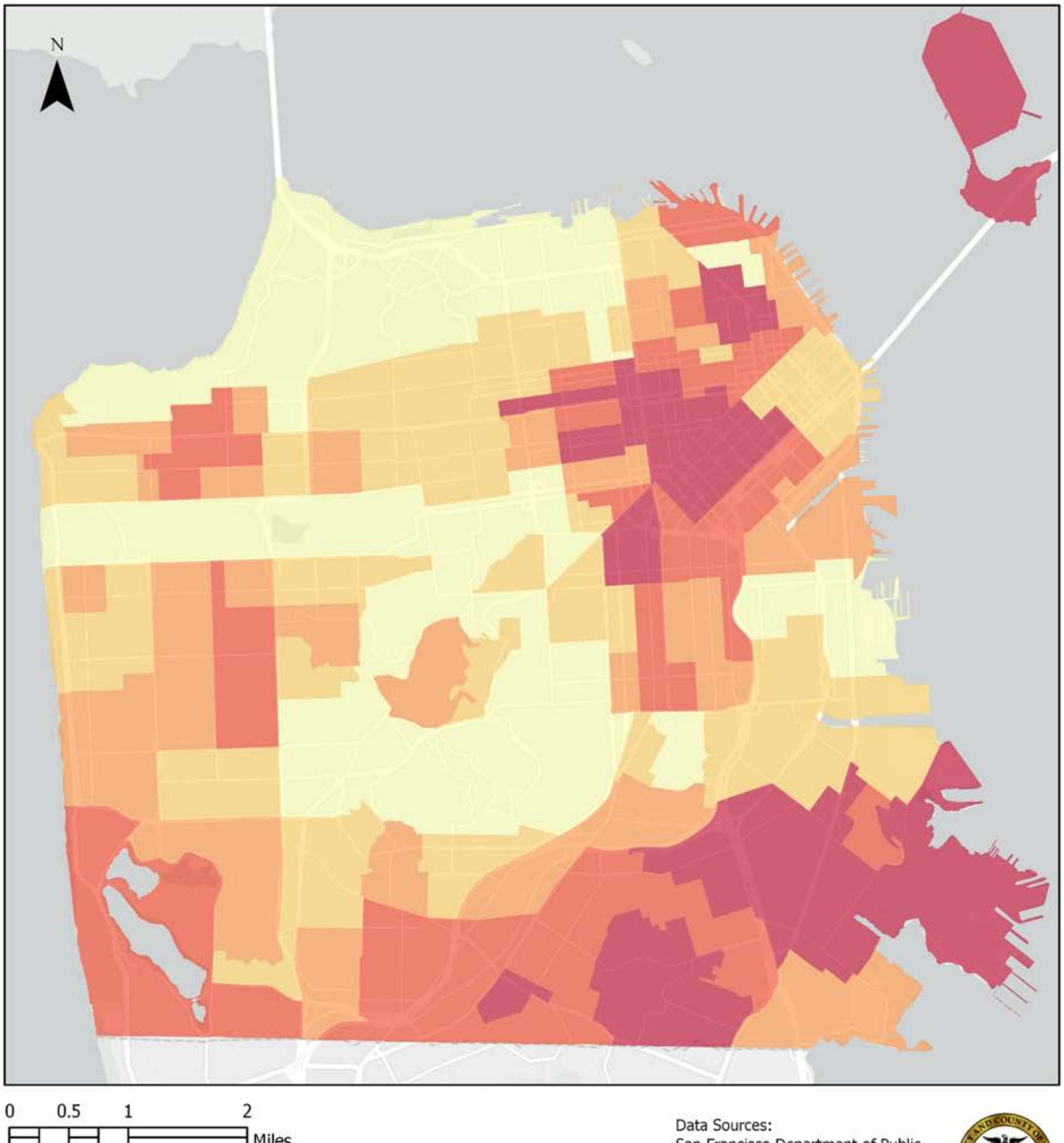
Location

As previously noted, though an excessive heat event in San Francisco impacts all areas of the city, it does not affect all inhabitants equally. The elderly, the very young, and those with chronic health problems are most at risk when extreme heat occurs. In addition, environmental exposure factors affect vulnerability to extreme heat. These factors include air quality, tree density, and proximity to parks/green space. Housing can also modify the relationship between temperature and heat-related illnesses. This is often called the Urban Heat Island (UHI) effect, which describes the temperature difference between dense urban areas and their more forested outer limits, where more intense urbanization contributes to increased relative temperatures. Due to the unique pattern of urbanization in the San Francisco bay area, temperatures can vary significantly over even small geographic scales. For example, the localized UHI in Downtown San Francisco contributes to a 1° C temperature increase relative to North Beach or Russian Hill, areas less than 1 km away[6]. This effect exacerbates extreme heat hazards by contributing to the duration and severity of individual extreme heat events in different parts of the City, posing significant health risks to the residents of various neighborhoods. For more information on the health impacts of extreme heat, visit the San Francisco Department of Public Health's Climate and Health Program webpage.

Using socioeconomic and census tract data for the entire city, the San Francisco Department of Public Health has developed a Heat Vulnerability Index to determine which neighborhoods have the highest concentration of residents at risk in excessive heat events. This index considers the following indicators: exposure to extreme heat, population sensitivity, and adaptive capacity. A map showing areas of vulnerability is shown in Figure 4-20). Neighborhoods with the greatest risk include Chinatown, SOMA, Tenderloin, Bayview/Hunters Point, and the Mission District. However, health impacts may extend to all neighborhoods in the city.

[6] CalEPA, Creating and Mapping an Urban Heat Island Index for California, accessed September 21, 2018, https://calepa.ca.gov/wp-content/uploads/sites/6/2016/10/UrbanHeat-Report-Report.pdf

FIGURE 4-20
HEAT VULNERABILITY INDEX



Vulnerable Populations

Extreme Heat Health Vulnerability

Some Health Impacts

Most Health Impacts

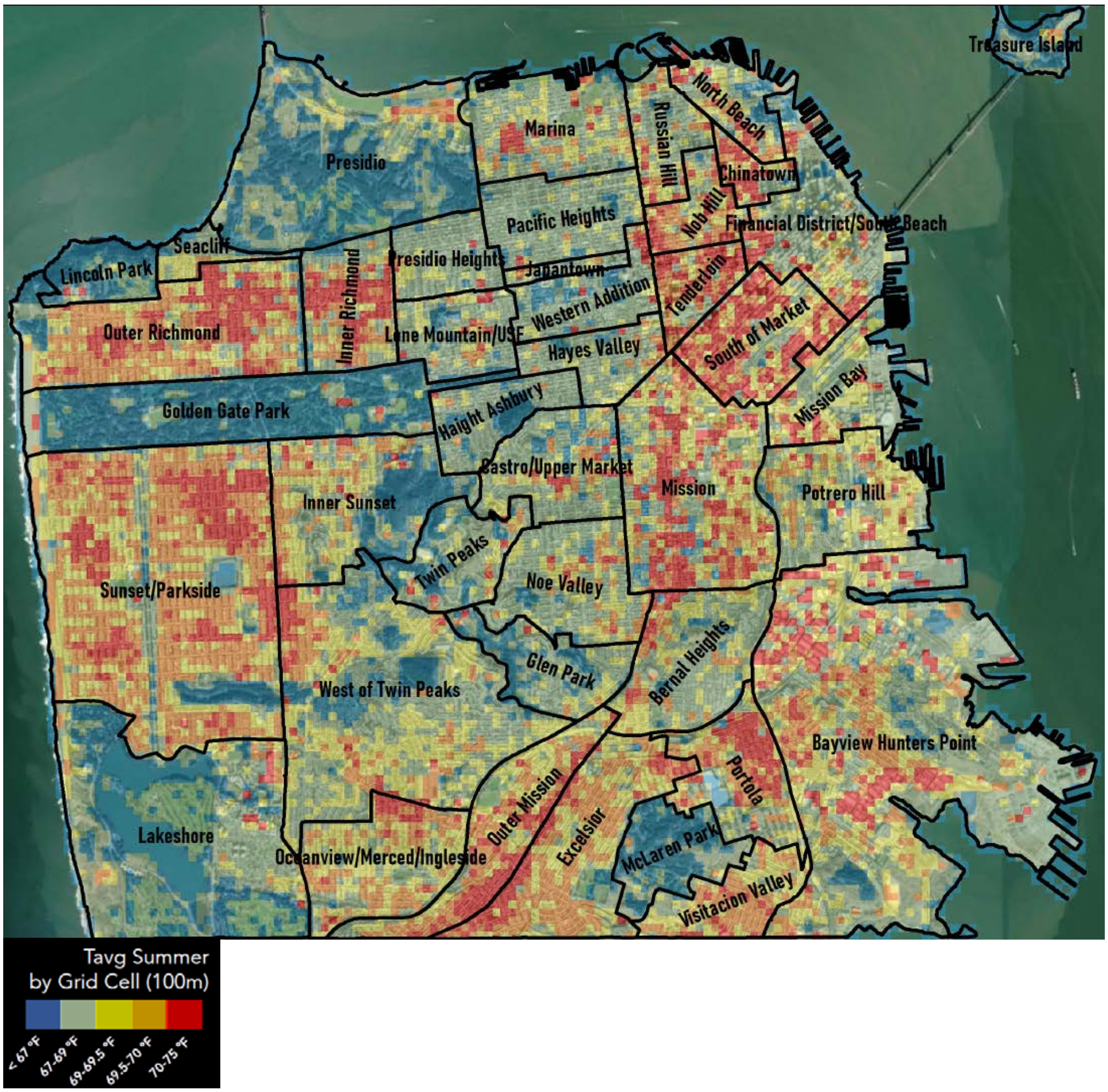
Data Sources:
San Francisco Department of Public Health, Climate and Health Program (2019)

This map incorporates exposure, sensitivity, and adaptive capacity indicators to create a Heat Health Vulnerability Index. The index assesses which neighborhoods are most vulnerable to the health impacts of extreme heat

The purpose of the Index is to predict the distribution of health impacts in San Francisco. While this Index predicts certain neighborhoods to have a greater concentration of extreme heat health impacts, we anticipate health impacts in every neighborhood and all neighborhoods must prepare their vulnerable residents for these health impacts.

The Urban Climate Lab Heat risk assessment simulated recent heat wave conditions at a high spatial resolution which, in combination with detailed land-use data, was used to estimate heat related mortality at the neighborhood level. This base case scenario was then used to test the projected effects of a variety of policy scenarios (steady tree loss, increased prevalence of high albedo building materials, increased urban greening, etc.). This will be used to inform different potential policy changes and communicate their effect on public health to key decision makers.

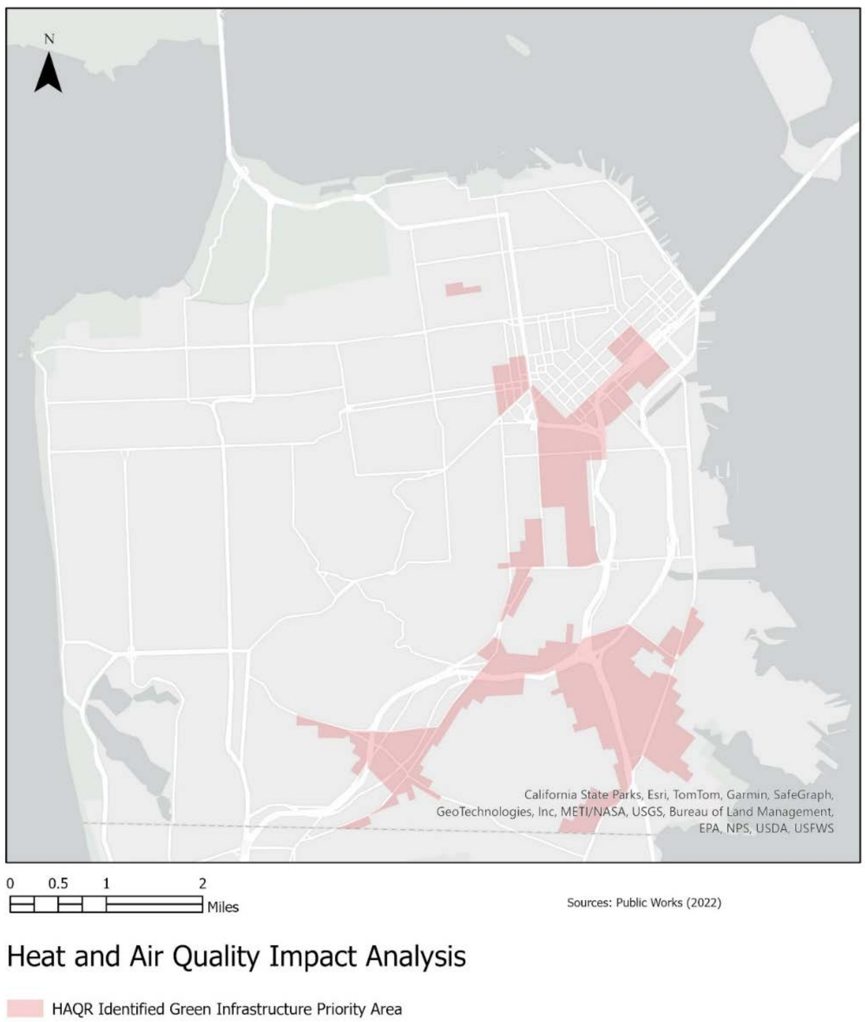
FIGURE 4-21
URBAN HEAT ISLAND ANALYSIS[7]



[7] Tavg Summer" is the average temperature over 3 summer months

This map was developed in partnership with Public Works. High exposure is determined for extreme heat and PM2.5 as a measure of exposure. This is then compared to areas of low tree canopy coverage and high poverty as a measure of adaptive capacity. Health data is integrated using instances of diabetes and asthma hospitalizations to identify where tree plantings can be prioritized to have the greatest impact on the health of San Francisco residents.

FIGURE 4-22
HAQR GREEN INFRASTRUCTURE PRIORITY ZONES[8]



Severity and Probability of Future Events

Historically, San Francisco has experienced temperatures in excess of 85 degrees six to seven days per year, generally between May and October. Climate change is expected to increase the frequency and severity of extreme heat events. Since 1920, average annual temperatures have been increasing across California, including the San Francisco Bay Area.

TABLE 4-11
30-YEAR AVERAGE TERMPERATURE PROJECTIONS

Emissions Scenario	Time Period	30-Year Average Temperature
Historical	Baseline (1961-1990)	64.1°F Degrees
Medium Emissions (RCP 4.5)	Mid-Century (2035-2064)	67.0° Degrees
	End-Century (2070-2099)	68.2° Degrees
High Emissions (RCP 8.5)	Mid-Century (2035-2064)	67.9° Degrees
	End-Century (2070-2099)	71.0° Degrees

Additionally, the frequency of extreme heat days is also projected to increase in frequency and intensity:

- Projections (85°F Degrees):

  Mid-Century (2035-2064): San Francisco can expect to have an average of 7 extreme heat days with particularly hot years having a maximum of 24 extreme heat events[9]

  Late-Century (2070-2099): San Francisco can expect an average of 15 extreme heat events[10] with particularly hot years having a maximum of 51 heat events.

- Projections (95°F Degrees):

[9] Cal-Adapt. (2018). [Number of Extreme Heat Days for San Francisco County, RCP 8.5, Global Climate Models HadGEM2-ES, CNRM-CM5, CanESM2, MIROC5].

[10] Ibid.

Mid-Century (2035-2064): San Francisco can expect an average of 1 day over 95°F per year with particularly hot years having a maximum of 7 days over 95°F.

Late-Century (2070-2099): San Francisco can expect an average of 2 days over 95°F per year with particularly hot years having a maximum of 10 days over 95°F.

Drought Hazard Profile

4.8 Drought

Impact Statement

California's Mediterranean climate is typified by dry summers followed by long, wet winters, thus making the state particularly susceptible to drought and flooding. The majority of San Francisco's water is brought to the city from the Hetch Hetchy watershed located in the Sierra Nevada Mountains through a complex series of reservoirs, tunnels, pipelines, and treatment systems.[1] As a result, changes in precipitation in the Sierra Nevada impacts the water supply in the Bay Area. Climate models project that a warming planet will lead to changes in precipitation distribution, including a reduced Sierra snowpack and earlier melting of the snowpack.[2]

Nature

The broad definition of drought is insufficient water over a prolonged time period. Drought condition indices typically consider the following factors: hydrological, meteorological, soil moisture, and applicable snowpack levels.[3] A drought occurs when there is a prolonged period of dryness in which precipitation is less than expected or needed in a given geographic location or climate over an extended period of time. In California, droughts typically occur in the winter, because winter is California's primary precipitation or wet season. During drought winters, the high-pressure belt that sits off the west coast of North America, and typically shifts southward during the season, remains stationary. As a result, Pacific storms that would normally approach the northern California coast are diverted elsewhere, depriving the Sierra Nevada mountain range of its normal winter storm activity and precipitation.

The San Francisco Bay Area and much of the state depend on spring runoff from the Sierra Nevada snowpack to replenish the water supply. Dry winters mean reduced snowpack. When dry winters occur over consecutive years, or when water demand increases beyond supply, drought is the result. Drought is a gradual phenomenon that may span multiple seasons and years.

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[1] San Francisco Public Utilities Commission, "About Us: Overview", accessed September 28, 2018, https://sfwater.org/index.aspx?page=355
[2] Reich, KD, N Berg, DB Walton, M Schwartz, F Sun, X Huang, and A Hall, 2018: "Climate Change in the Sierra Nevada: California's Water Future." UCLA Center for Climate Science.
[3] California National Resources Agency. California's Fourth Climate Change Assessment: San Francisco Bay Area Region Report. Retrieved from: http://www.climateassessment.ca.gov/regions/docs/20180827-SanFranciscoBayArea.pdf (Accessed: 9/10/2018)

Drought is often measured in terms of its effect on crops, or in terms of its environmental impact, such as livestock deaths, wildfire, impaired productivity of forest land, damage to fish habitat, loss of wetlands, and air quality effects. Drought may also be measured by its social effects, including economic and physical hardship and increased stress on residents of a drought-stricken area. In San Francisco, the primary impact of drought is reduced availability of water for residential and commercial use.

Drought severity is measured by the drought scale developed the U.S Drought Monitor. This scale, known as the "D-Scale", is a measure of how unusual a drought period is. The scale has the following categories, as seen in Table 4-12.

TABLE 4-12[4]
DROUGHT CLASSIFICATION

Category	Description	Values for Standard Precipitation Index and Standardized Precipitation Evapotranspiration Index
None	Normal or wet conditions	-0.49 or above
D0	Abnormally Dry	-0.5 to -0.79
D1	Moderate Drought	-0.8 to -1.29
D2	Severe Drought	-1.3 to -1.59
D3	Extreme Drought	-1.6 to -1.99
D4	Exceptional Drought	-2.0 or less

History

California's Mediterranean climate is typified by dry summers followed by long, wet winters, thus making the state particularly susceptible to drought and flooding.

[4] U.S Drought Monitor."Drought Classification". Retrieved from: https://droughtmonitor.unl.edu/About/AbouttheData/DroughtClassification.aspx

According to the Climate Readiness Institute at UC Berkeley, 10-year droughts occurred across the west in previous millennia.[5] In modern history, droughts exceeding three years are relatively rare in northern California.[6] To date, San Francisco County has not been declared a Presidential disaster area as a result of drought. However, statewide droughts have been declared in 1976-1977, 1987-1992, 2008, 2013-2016, and 2021-2023.[7]In 2013, the United States Department of Agriculture declared the state a drought disaster area to provide relief for farmers and for the agriculture industry and similarly extended this relief in 2021.[8]

In the winter of 2013, California experienced record warmth and dryness with some locations in northern California experiencing 50 consecutive days with no measurable precipitation. Governor Jerry Brown issued a proclamation of emergency in January 2014 that ordered state agencies to take specific actions and called on Californians to voluntarily reduce their water usage by 20 percent.[9] Although the severely dry conditions that afflicted much of the state ended, damage from the drought lingered for years in many areas. The drought reduced farm production in some regions, killed an estimated 100 million trees, harmed wildlife and disrupted drinking water supplies for many rural communities.

In January 2014, the SFPUC called on its retail customers to reduce water use by at least 10 percent. In February 2014, Mayor Edwin M. Lee issued an executive directive requiring all City departments to develop individual water conservation plans and take immediate steps to achieve a mandatory 10 percent reduction in their water consumption. In August 2014, the SFPUC imposed a mandatory reduction of 10% on outdoor irrigation of ornamental landscapes or turf with potable water by retail customers. Starting in July 1, 2015 the reduction was increased from 10% to 25%.[10] In

[5] Climate Readiness Institute, *Bay Area Water Future* by William D. Collins, accessed 10 June 2015 http://climatereadinessinstitute.org/wp-content/uploads/2015/06/Collins-CRI-Water-Future.compressed.pdf
[6] California Governor's Office of Emergency Services, *2018 California State Hazard Mitigation Plan*, accessed http://www.caloes.ca.gov/for-individuals-families/hazard-mitigation-planning/state-hazard-mitigation-plan
[7] Executive Department State of California. "Proclamation of a State of Emergency" Retrieved from: https://www.gov.ca.gov/wp-content/uploads/2021/10/10.19.21-Drought-SOE-1.pdf
[8] United States Department of Agriculture. "USDA Designates 50 Californai Counties as Primary Natural Disaster Areas" Retrieved from: https://www.fsa.usda.gov/news-room/emergency-designations/2021/ed_2021_0510_rel_0032
[9] ibid
[10] San Francisco Public Utilities Commission, Water *Resources Division Annual Report Fiscal Year 2014-15*, accessed https://sfwater.org/modules/showdocument.aspx?documentid=8207

response to these measures, single-family households reduced their water use by 16 percent compared to 2013.[11]

Early seasonal rain in the winter of 2014 helped alleviate some of the drought conditions, however, January 2015 was considered the driest January since meteorological records have been kept. Governor Brown signed emergency legislation to fast track more than $1 billion in funding for drought relief and critical water infrastructure projects. Despite record breaking summer heat, Californians continued to meet and surpass the Governor's 25 percent water conservation mandate, with a 31.3 percent reduction in July.[12]

Rain and snow levels in 2016 improved, but not enough to draw the state out of the drought. Moisture deficits across the state following the 2012-2016 drought had not been seen in the last 1,200 years and precipitated a 1 in 500 year low in the Sierra snowpack.[13] Fortunately, 2017 brought significant precipitation and the Governor ended the drought state of emergency on April 7, 2017 for all counties except Fresno, Kings, Tulare, and Tuolumne.

Additionally, the state entered immediately into another cycle of drought that in many ways was the most severe period ever recorded, and certainly the worst drought in the last 20 years. The 2-year period from 2019-2021 was one of driest two-year periods ever recorded, and often was just as dry and hot as the worst periods of the 2012-2017 drought period of recent memory. According to the U.S. Drought monitor, as of March 17th 2020, 27.8% of the state was experiencing DO (abnormally dry conditions) with 46.3% of the state experiencing D1 (moderate drought conditions).[14] The overall outlook was "Drought development likely" in the short term for the San Francisco area and much of northern/central California, as forecasted precipitation did not make up for

San Francisco Public Utilities Commission, Water *Resources Division Annual Report Fiscal Year 2015-16,* accessed https://sfwater.org/Modules/ShowDocument.aspx?documentid=9999

[12] California Governor's Office of Emergency Services, *2018 California State Hazard Mitigation Plan*, accessed http://www.caloes.ca.gov/for-individuals-families/hazard-mitigation-planning/state-hazard-mitigation-plan

[13] California National Resources Agency. California's Fourth Climate Change Assessment: San Francisco Bay Area Region Report. Retrieved from: http://www.climateassessment.ca.gov/regions/docs/20180827-SanFranciscoBayArea.pdf (Accessed: 9/10/2018)

[14] United States Drought Monitor. Accessed: 3/23/2020, retrieved from: https://www.drought.gov/drought/states/california

deficits at that time, with part of the San Francisco Bay Area and Sierra Nevada in "Drought persists" condition.[15]

By 2021, the state recorded the driest June ever seen in the 186 years of recordkeeping with many months being among the top five in terms of a lack of precipitation.[16] As opposed to previous cycles of drought, what little precipitation there was occurred predominantly in Southern California, leaving Northern California (and the areas in/around the San Francisco Bay Area) particularly dry and susceptible to drought impacts. This included impacts for many rivers and streams in the North California range and contributed to historically stressful conditions for many ecosystems. This was most dramatically demonstrated in the summer of 2021 when an estimated 31 million eggs for the winter-run Chinook Salmon died due to elevated water temperatures caused by drought conditions and low reservoir levels.[17]

However, drought conditions across the state were largely broken due to an unprecedented string of atmospheric rivers in Early 2023. These storms dropped a significant amount of precipitation which directly contributed to re-filling reservoirs, producing a record-breaking snow pack that nourished rivers and this broke drought conditions across much of the state. This is also in line with expected impacts from climate change, with whiplash periods between extreme drought and bursts of atmospheric river events.

As of July 25th 2023, drought conditions are largely abated for much of the state with the exception of abnormally dry conditions in parts of Northern California and moderate drought conditions in parts of Southern California.

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[15] National Weather Service: Climate Prediction Center. U.S. Monthly Drought Outlook: Valid for March 2020. Accessed: 3/23/2020. Retrieved from: https://www.cpc.ncep.noaa.gov/products/expert_assessment/mdo_summary.php

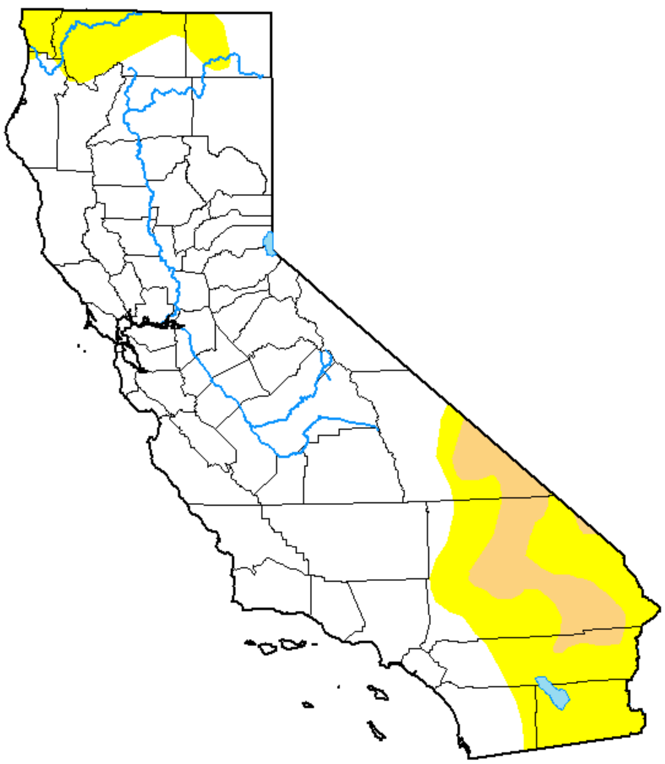
[16] CNN. "*The drought in California this summer was the worst on record*". Accessed August 1st, 2023. Retrieved from: https://www.cnn.com/2021/10/14/us/california-summer-drought-worst-on-record/index.html

[17] NOAA. "River Temperatures and Survival of Endangered California Winter-Run Chinook Salmon in the 2021 Drought". Accessed: August 1st, 2023. Retrieved from: https://www.fisheries.noaa.gov/west-coast/climate/river-temperatures-and-survival-endangered-california-winter-run-chinook-salmon#:~:text=Close%20to%2010%2C000%20adult%20salmon,that%20shrank%20reservoirs%20across%20California.

FIGURE 4-23
JULY 25RD DROUGHT CONDITIONS

U.S. Drought Monitor

USDA California Climate Hub



July 25, 2023

(Released Thursday, Jul. 27, 2023)

Valid 8 a.m. EDT

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	74.43	25.57	6.29	0.00	0.00	0.00
Last Week *07-18-2023*	74.45	25.55	6.29	0.00	0.00	0.00
3 Months Ago *04-25-2023*	68.04	31.96	7.98	0.00	0.00	0.00
Start of Calendar Year *01-03-2023*	0.00	100.00	97.93	71.14	27.10	0.00
Start of Water Year *09-27-2022*	0.00	100.00	99.76	94.01	40.91	16.57
One Year Ago *07-26-2022*	0.00	100.00	99.78	97.47	59.81	12.74

Intensity:

- None
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. For more information on the Drought Monitor, go to https://droughtmonitor.unl.edu/About.aspx

Author:
Brian Fuchs
National Drought Mitigation Center

droughtmonitor.unl.edu

Location

Drought is not localized to San Francisco, but occurs simultaneously across the region, and may extend statewide or across a larger expanse of western states.[18] The majority of San Francisco's water is brought to the city from the Hetch Hetchy watershed located in the Sierra Nevada Mountains through a complex series of reservoirs, tunnels, pipelines, and treatment systems.[19] As a result, shortages in precipitation in the Sierra Nevada impacts the water supply in the Bay Area. Because so much of the city's water is generated from outside of the City, drought must be considered a regional hazard that is not confined to a single geographic area.

Severity and Probability of Future Events

Drought is difficult to measure due to its diverse geographical and temporal nature and its operation on many scales. Despite that difficulty, various indices for measuring and characterizing drought can be useful. The most commonly used are the Palmer Drought Indices (Palmer Z Index, Palmer Drought Severity Index, and Palmer Hydrological Drought Index) and the Standardized Precipitation Index. For example, the Palmer Index shows that San Francisco's climate division, the central coastal zone that extends south to San Luis Obispo, experienced severe drought conditions in April 2013 and had improved to near normal by April 2018 following two years of healthy precipitation. Despite the improved precipitation conditions in 2017 and 2018, those conditions were short-lived with another cycle of drought starting shortly after. However, as seen above, this cycle was cut short by unprecedented precipitation.

A significant body of climate research indicates that extended periods of drought followed by increased precipitation are more likely to occur in the future. A recent UCLA study indicates that such dry-to-wet precipitation events are projected to increase over the next century.[20] Long-term climate forecast models suggest that a warming planet will lead to changes in precipitation distribution, including a reduced Sierra snowpack and earlier melting of the snowpack.[21] With projected drier conditions and increasing

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[18] Association of Bay Area Governments, *San Francisco Bay Area Risk Profile 2017*, accessed http://resilience.abag.ca.gov/wpcontent/documents/mitigation_adaptation/RiskProfile_4_26_2017_optimized.pdf

[19] San Francisco Public Utilities Commission, "About Us: Overview", accessed September 28, 2018, https://sfwater.org/index.aspx?page=355

[20] Daniel Swain et.al, "Increasing Precipitation Volatility in Twenty-First-Century California", *Nature Climate Change* accessed September 28, 2018, https://www.nature.com/articles/s41558-018-0140-y

[21] Reich, KD, N Berg, DB Walton, M Schwartz, F Sun, X Huang, and A Hall, 2018: "Climate Change in the Sierra Nevada: California's Water Future." UCLA Center for Climate Science.

population, managing drought and water supplies in California may become more challenging.

It can be difficult to determine exact probabilities of future droughts due to their nature, but studies have shown, while natural variability in precipitation is the primary driver for droughts, anthropogenic warming (as detailed in the extreme heat hazard section) is likely to increase the likelihood of extreme droughts in California. [22] It has also been found that when precipitation deficits occur at the same time as warm conditions, as is increasingly likely, drought occurrence is twice as likely.[23]

According to the FEMA National Risk Index, over the 22-year period from 2000, the city experienced 994 drought events. Therefore, the annualized frequency is around 7.6 events per year. [24]

[22] Williams AP, Seager R, Abatzoglou JT, Vook BI, Smerdon JE, Cook ER. (2015). *Contribution of Anthropogenic Warming to California Drought During 2012-2014*. Retrieved from: https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2015GL064924

[23] Diffenbaugh NS, Swain DL, and Touma D. (2015) *Anthropogenic warming has increased drought risk in California*. Retrieved from: https://www.pnas.org/content/112/13/3931

[24] FEMA (2025). "National Risk Index: San Francisco, California". Retrieved from: https://hazards.fema.gov/nri/report/viewer?dataLOD=Counties&dataIDs=C06075

Large Urban Fire Profile

4.9 Large Urban Fire

Impact Statement

Most of San Francisco is believed to have a moderate risk of large urban fires, but areas believed to be at greatest risk include the North Waterfront, South Beach, Mission District, Potrero Hill, Hunters Point, Civic Center, Downtown, Tenderloin, and Hayes Valley neighborhoods. The most likely cause of large urban fire in San Francisco is a severe earthquake (fire following earthquake), which has the potential to cause severe damage to buildings and infrastructure. When making decisions about capital projects, maintenance, operations, and investments in the City's fire fighting systems, the San Francisco Fire Department (SFFD), San Francisco Public Utilities Commission (SFPUC), and San Francisco Public Works (SFPW) utilize a model that reflects the fires that could arise after a 7.8 earthquake on the San Andres fault.

Nature

A Large Urban Fire is a large destructive fire that spreads across one or more city streets.[1] If not contained, a Large Urban Fire may expand uncontrollably beyond its original source location to engulf adjoining areas. Conflagrations can have many causes, including:[2]

- As secondary events to disasters such as earthquake (fires following earthquake), tsunami, flooding, and lightning strikes.
- Criminal acts, such as arson or acts of terrorism
- Civil unrest
- Residential accidents, including improper use of electrical and heating appliances, improper storage or handling of flammables, faulty connections, grease fires, misuse of matches and lighters, or improper disposal of charcoal and wood ashes;

[1] Introduction to *Fire Following Earthquake*, ed. Charles Scawthorn, John M. Eidinger, Anshel Schiff (Reston, VA: American Society of Civil Engineers, 2005), 1.

[2] William M. Kramer, *Disaster Planning and Control* (Tulsa: PennWell Fire Engineering Books, 2009), 138–140.

- Industrial accidents, such as hazardous material incidents, explosions, and transportation accidents.

Fire following earthquake: The process by which an earthquake triggers fires and a community suppresses those fires consists of the following interrelated events[3]:

- Occurrence of the earthquake: earthquake shaking causes damage to buildings and contents, including knocking things over (such as candle or lamps.)
- Ignition: Ignition sources include overturned heat sources, gas-related sources, abrades and shorted electrical wiring, spilled chemicals, and friction of things rubbing together.
- Discovery: In the confusion following an earthquake, discovery may take longer than it would otherwise.
- Report: Communications system dysfunction may delay reports to the Fire Department.
- Response: In the aftermath of a damaging earthquake, the response of the Fire Department may be impeded by other emergencies the firefighters must respond to, such as building collapse.
- Suppression: Numerous factors, including water supply functionality, building construction type, building density, wind and humidity conditions, manpower and equipment deployed affect success of suppression.

History

San Francisco was devastated by six major fires during the California Gold Rush era, from 1849 to 1855.[4] These fires destroyed significant portions of the city, and thus are considered "great fires." The largest fire to affect San Francisco to date occurred as a result of the Great San Francisco Earthquake of 1906. On the morning of April 18, 1906, a Mw 7.8 earthquake shook the San Francisco Bay region. Within two hours of the quake, 52 fires had ignited within San Francisco. The fires quickly spread throughout the northeastern portion of the city, burning an area covering approximately 4.7 square

[3] Applied Technology Council, 2017. "Study of Options to Reduce Post-Earthquake Fires in San Francisco."
[4] Virtual Museum of the City of San Francisco, "Early History of the San Francisco Fire Department," accessed May 29, http://guardiansofthecity.org/sffd/history/volunteer_department.html.

miles, and destroying 80 percent of the 28,000 buildings lost due to the quake. The 1906 earthquake severely damaged the city's water system, limiting firefighters' ability to suppress the fires.[5]

Construction of San Francisco's Auxiliary Water Supply System (AWSS), now referred to as the Emergency Firefighting Water System (EFWS), was completed in 1913 with the goal of avoiding such devastation in the aftermath of another earthquake. The system consists of a resilient 135-mile pipeline network, a high elevation reservoir, two large capacity tanks, two seawater pumping stations, and bay water intakes (suction connections). The system has unique capabilities, including the ability to deliver water at the high pressures needed by the SF Fire Department to fight large fires. Additionally, it has the ability to use water from the bay as an unlimited source for firefighting.

The SFPUC and our City partners are working on the planning, design, and construction of a new Potable Emergency Firefighting Water System (PEFWS) on the west side of the City. This seismically resilient system will serve drinking water during normal operations but can switch to delivering water at high pressure from our drinking water system or from Lake Merced during emergencies. When making capital project, maintenance, and operational decisions, the SFFD, SFPUC, and SFPW utilize a model that reflects the large urban fire that could arise after a 7.9 earthquake on the San Andres fault. Over the past decade, the city has undertaken a major effort to upgrade the Emergency Firefighting Water System.[6]

Working together, the SFPUC, and SFPW have completed the following in the past 5 years:

- Completed conceptual engineering report for first two PEFWS pipeline contracts.
- About 0.7 miles of PEFWS pipeline constructed along 19th Ave between Sloat Blvd and Vicente St. , along Vicente St. from 19th to 23rd Ave.
- Five miles of PEFWS pipeline in design for the western side of the city.

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[5] Charles Scawthorn, Thomas D. O'Rourke, and Frank T. Blackburn, "The 1906 San Francisco Earthquake and Fire—Enduring Lessons for Fire Protection and Water Supply," *Earthquake Spectra* 22, no. S2 (2006), S135–S139.

[6] San Francisco Public Utilities Commission, "Emergency Firefighting Water System," accessed May 29, 2018, https://sfwater.org/index.aspx?page=467.

- Planning in progress for relocation and replacement of fireboat manifolds
- Completed construction of new EFWS water supply and pipeline near the crest of Clarendon Ave and Dellbrook Ave
- Completed construction of AWSS Pumping Station No.2 seismic retrofit
- Construction of a new earthquake resistant ductile iron pipe along Marin St is in progress

San Francisco's most recent large urban fire incident occurred because of the Loma Prieta earthquake on October 17, 1989. A total of 41 fires were reported in San Francisco following the Loma Prieta earthquake; 27 of the 41 fires occurred within seven hours of the quake.[7] Of the 41 fires, 14 were due to electric wiring and equipment, 11 resulted from gas or electric stoves, and four were caused by water heaters or other gas appliances.[8] The largest fires occurred in the Marina District, resulting in the destruction of four buildings. The Fire Department utilized the fire boat Phoenix and the PWSS to prevent the Marina fire from becoming a conflagration. The Fire Department also relied on the AWSS to fight the Marina District fires, but water main breaks in the system several miles from the fires impaired its functionality.[9] The Fire Department reported fire losses due to the earthquake of over $10 million,[10] or $19.1 million in 2018 dollars.

Table 4-13 below shows the number of actual working fires and greater alarms that the San Francisco Fire Department has responded from 2018 through 2023, where the primary concern was a building fire. During this 6-year period, there were 35 5-alarm fires that occurred. This corresponds to an annualized frequency of 5.8 events. However, all 35 of those fires occurred during 2020, during a global pandemic when historically high numbers of residents were sheltering at home and this may have contributed to higher rates of large building fires (among other factors). The two years before and the three years after saw no reported 5-alarm fires.

[7] Jamshid Mohammed, Sam Alyasin, D. N. Bak, *Investigation of Cause and Effects of Fires Following the Loma Prieta Earthquake*, National Science Foundation Report IIT-CE-92-01 (1992), 4, 19, accessed May 29, 2018, https://nehrpsearch.nist.gov/static/files/NSF/PB93120046.pdf

[8] Ibid.

[9] Scawthorn, Eidinger, and Schiff, eds., *Fire Following Earthquake*, 29–31.

[10] Virtual Museum of the City of San Francisco, "Report on the Operations of the San Francisco Fire Department Following the Earthquake and Fire of October 17, 1989," Introduction, accessed May 29, 2018, http://www.sfmuseum.net/quake/report.html.

TABLE 4-13:
SAN FRANCISCO FIRE INCIDENTS, 2018-2023[11]

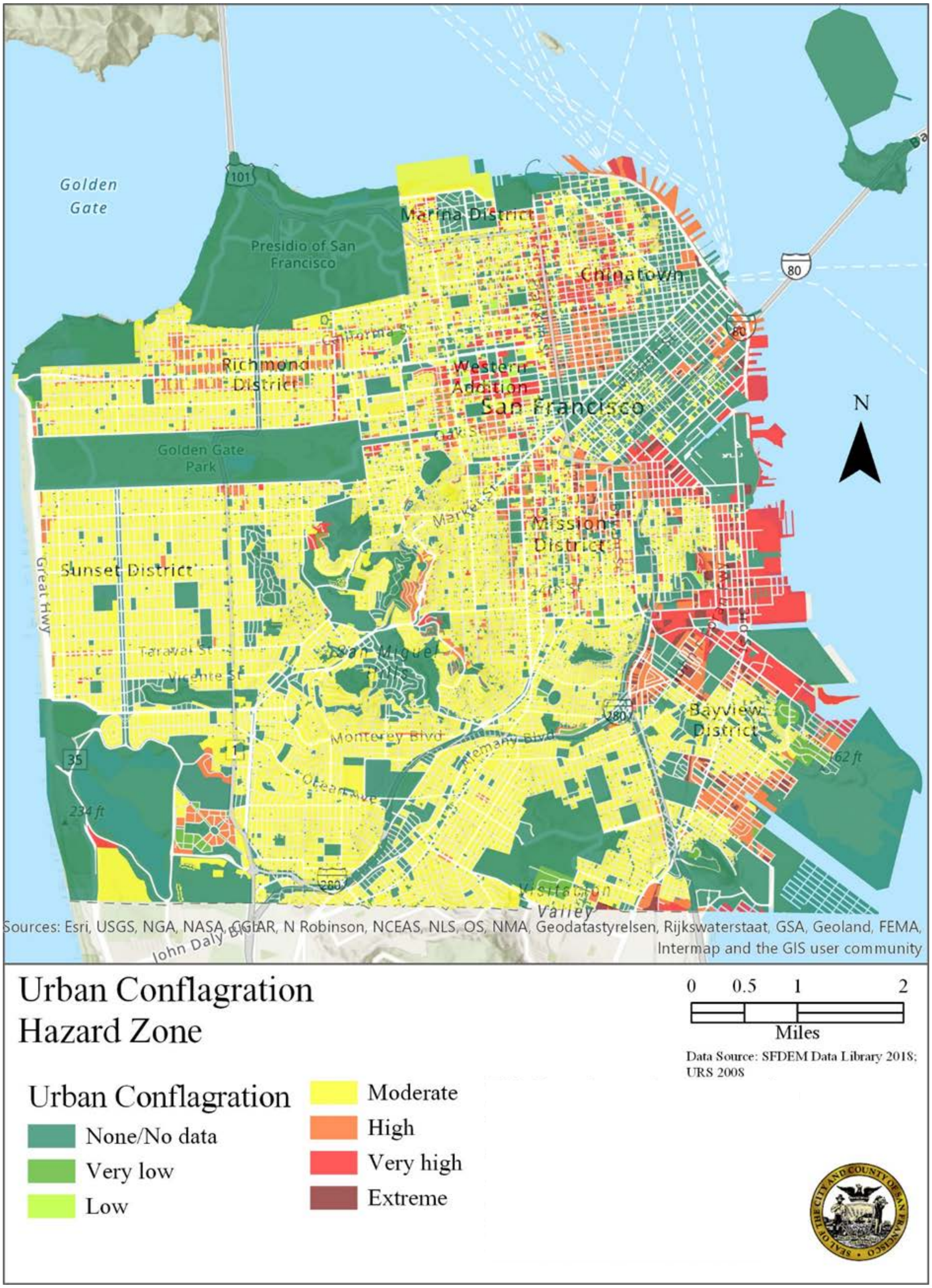
YEAR	Alarm Level 1	Alarm Level 2	Alarm Level 3	Alarm Level 4	Alarm Level 5	TOTAL
2018	294	16	9	4	0	323
2019	228	26	0	4	0	258
2020*	218	14	12	8	35	287
2021	233	16	3	0	0	252
2022	305	46	27	0	0	378
2023	220	26	24	0	0	270

Location

Figure 4-24, seen below, shows large urban fire hazard areas for all parts of the city for which Assessor parcel data is available. This model considers building construction material, land use, and structural age. For construction material, wood frame structures were assumed to be more vulnerable to conflagration than other structure types. Similarly, commercial and industrial land uses were calculated as a higher risk of large urban fires. Finally, older structures were assumed to have a high conflagration risk, as they pre-date modern fire codes. Areas within San Francisco believed to be at greatest risk for large urban fire include the North Waterfront, South Beach, Mission District, Potrero Hill, Hunters Point, Civic Center, Downtown, Tenderloin, and Hayes Valley neighborhoods.

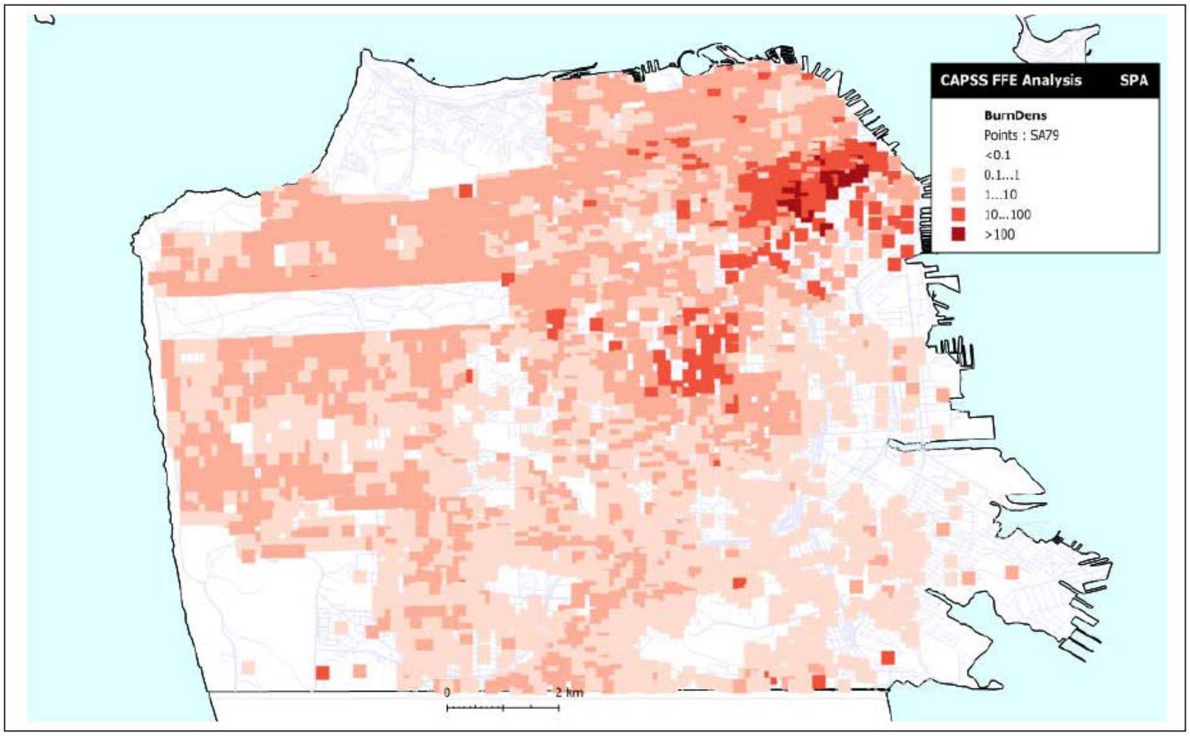
[11] SF OpenData Portal (2024). “Fire Incidents”. Retrieved from: https://data.sfgov.org/Public-Safety/Fire-Incidents/wr8u-xric/about_data

FIGURE 4-24
LARGE URBAN FIRE HAZARD ZONES



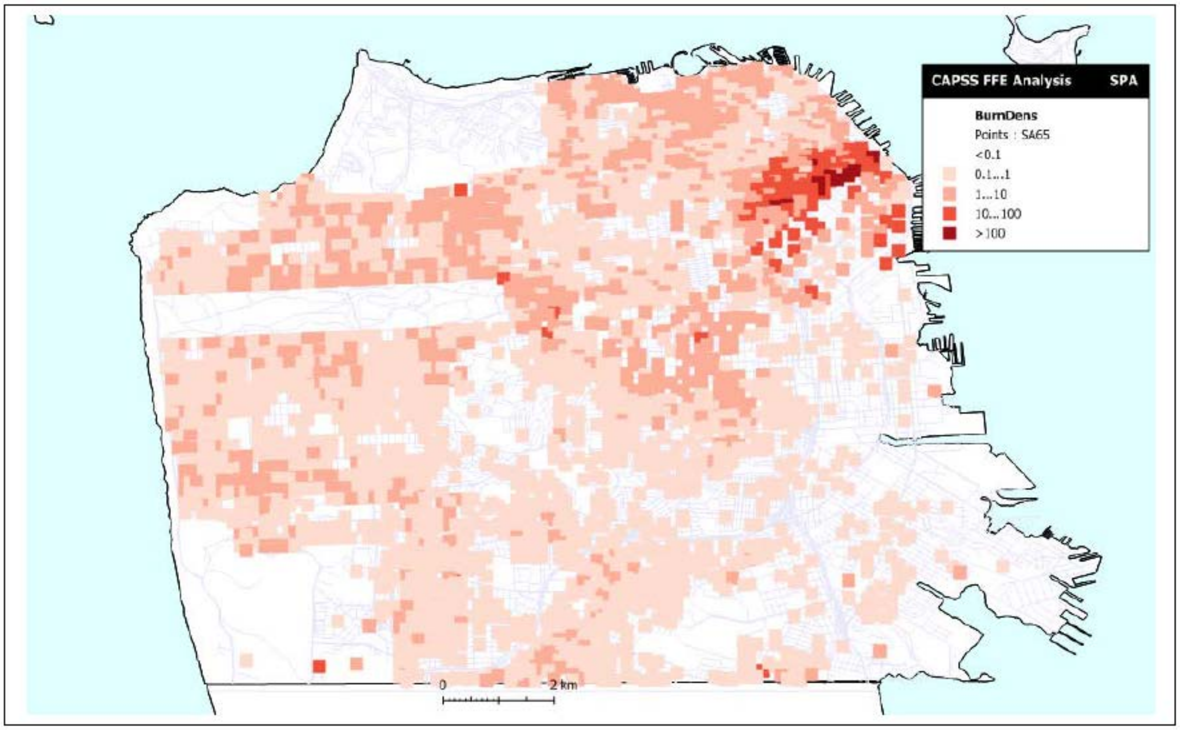
Fire following earthquake: In 2010, the Community Action Plan for Seismic Safety (CAPSS) Program produced a detailed study of the scope of the city's fire following earthquake hazard and risk. Figures 4-25 and 4-26 illustrate the geographic distribution of potential building losses (in 2010 dollars) due to fire following earthquake.

FIGURE 4-25: DISTRIBUTION OF BURN DENSITY PER BLOCK (MILLIONS $) IN 7.9 SAN ANDREAS SCENARIO[12]



[12] Scawthorn, 2010. "Analysis of Fire Following Earthquake Potential for San Francisco, California."

FIGURE 4-26: DISTRIBUTION OF BURN DENSITY PER BLOCK (MILLIONS $) IN 6.9 HAYWARD FAULT SCENARIO[13]



Severity and Probability of Future Events

Given the 72 percent chance of a magnitude 6.7 or greater earthquake in the San Francisco Bay Area between 2014 and 2044,[14] the most likely scenario leading to large urban fire in San Francisco is a severe earthquake in the Bay Area, particularly on the North San Andreas Fault zone. Because San Francisco's building stock is composed predominantly of wood, the fires resulting from such earthquakes may cause far more damage. Based on a detailed study of the scope of the city's fire following earthquake risk, an estimated 68-120 ignitions may occur in a 7.9 earthquake on the San Andreas fault resulting in an estimated \$4.1 - \$10.3 billion in losses. An estimated 27-68 ignitions may occur due to a 6.9 earthquake on the Hayward fault, resulting in an estimated \$1.3 - \$4.0 billion in damages.[15]

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[13] Ibid

[14] Edward H. Field and 2014 Working Group on California Earthquake Probabilities (WGCEP), *UCERF3: A New Earthquake Forecast for California's Complex Fault System,* Fact Sheet 2015–3009 (2015), 4, accessed May 18, 2018, https://dx.doi.org/10.3133/fs20153009.

[15] Applied Technology Council, 2017. "Study of Options to Reduce Post-Earthquake Fires in San Francisco."

During the 24-year period, from 2000-2024, there were 50 5-alarm fires that occurred. This corresponds to an annualized frequency of 2.08 events per year.

For discussion of wildfire and wildland-urban interface fires, see the Wildfire Hazard Profile.

Wildfire Hazard Profile

4.10Wildfire

Impact Statement

Within San Francisco, a small portion of the Crocker Amazon neighborhood has been designated as a high fire hazard area. Moderate fire hazard areas in the city designated by the state include wooded areas such as Mounts Sutro and Davidson, as well as Yerba Buena Island, significant portions of the Hetch Hetchy Regional Water System in San Mateo, Santa Clara, and Tuolumne Counties are also located in state-designated very high fire hazard areas. Though the expected severity of wildfires or wildland-urban interface fires within San Francisco is low to moderate, it remains high for areas outside the county where City-owned infrastructure is located, especially the Hetch Hetchy Water and Power Systems. Global warming and lower precipitation rates due to climate change are expected to increase the risk of damaging fires in Northern California.

Nature

A wildfire is an unplanned, uncontrolled fire in an area of combustive vegetation or fuel.[1] Wildfires typically occur in forests or other areas with ample vegetation. Relatedly, Wildland-urban interface (WUI) fires are wildfires that spread into communities.[2] The WUI is an area where houses meet or are interspersed with undeveloped wildland vegetation.[3] In these areas, wildfires can cause significant property damage and may present an extreme threat to public health and safety.[4] Both wildfires and WUI fires can be caused by human activities, such as arson, campfires, or trees being blown into power lines, and by natural events such as lightning strikes.[5]

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[1] Judith R. Phillips, "Natural Disasters: On Wildfires and Long-Term Recovery of Community-Residing Adults," in *Traumatic Stress and Long-Term Recovery: Coping with Disasters and Other Negative Life Events*, Katie E. Cherry ed. (Switzerland: Springer International Publishing, 2015), 25.

[2] Samuel L. Manzello and Stephen L. Quarles, *Summary of Workshop on Structure Ignition in Wildland-Urban Interface (WUI) Fires*, National Institute of Standards and Technology (NIST) Special Publication 1198 (2015), 1, accessed May 30, 2018, https://nvlpubs.nist.gov/ nistpubs/SpecialPublications/NIST.SP.1198.pdf.

[3] V. C. Radeloff, et al., "The Wildland-Urban Interface in the United States," *Ecological Applications* 15, no. 3 (2005), 799, accessed May 30, 2018, https://www.nrs.fs.fed.us/pubs/jrnl/2005/nc_2005_radeloff_001.pdf.

[4] U.S. Department of Agriculture (USDA), *The 2010 Wildland-Urban Interface of the Conterminous United States*, Abstract, accessed May 31, 2018, https://www.fs.fed.us/nrs/pubs/rmap/rmap_nrs8.pdf.

[5] William M. Kramer, *Disaster Planning and Control* (Tulsa: PennWell Fire Engineering Books, 2009), 142.

The following three factors contribute significantly to wildfire behavior and can be used to identify wildfire or WUI fire hazard areas:[6]

- Topography: Topography is the shape of land, including its elevation or height above sea level; slope, or the steepness of the area; aspect, the direction a slope faces; and features such as canyons, valleys, and rivers. Topographical features can help or hinder the spread of fire. For example, the steeper a slope, the faster fire will travel up the slope. South-facing slopes are also subject to more solar radiation, making them drier and thus intensify wildfire behavior.
- Fuel: Fuels are combustible materials. The composition of vegetation or other fuel in the area, including moisture level, chemical makeup, and density, determines its degree of flammability. Dense or overgrown vegetation increases the amount of fuel for the fire. The ratio of living to dead plant matter is also important. Accelerated plant growth during rainy winter seasons can become particularly dried out during summer dry months contributing to fire risks as autumn winds fan small spot fires into potentially large firestorms[7]. The risk of fire increases significantly during periods of prolonged drought, as the moisture content of both living and dead plant matter decreases, where a disease or infestation has caused widespread damage, or where anthropogenic forest management practices have allowed fuel to build up.
- Weather: Weather Characteristics such as temperature, humidity, wind, and lightning impact the probability of ignition and spread of fire. Extreme weather, such as high temperatures and low humidity, can lead to extreme wildfire activity. In contrast, cooling and higher humidity often mean reduced wildfire occurrence and easier containment.

[6] California Department of Forestry and Fire Protection (CAL FIRE) et al., *Living with Wildfire in Northwestern California*, 2nd ed. (2017), 13, accessed May 21, 2018, http://www.fire.ca.gov/HUU/downloads/Living_w-Wildfire_NW_CAL_April2017.pdf; National Park Service, "Wildland Fire - Learning In Depth: Wildland Fire Behavior," accessed May 31, 2018, https://www.nps.gov/articles/wildland-fire-behavior.htm.

[7] California National Resources Agency. California's Fourth Climate Change Assessment: San Francisco Bay Area Region Report. Retrieved from: http://www.climateassessment.ca.gov/regions/docs/20180827-SanFranciscoBayArea.pdf (Accessed: 9/10/2018)

Given that San Francisco is a highly-urbanized area, CAL FIRE has also characterized the city as a low vegetative fuels hazard area.[8] However, even small fires can cause significant property damage and casualties. This is especially true in WUI areas where structures and other human development abut or intermingle with wildland vegetation and may also become fuel.

The indirect effects of wildfires can also be disastrous. Besides stripping the land of vegetation and destroying forest resources, large, intense fires can harm the soil, waterways, and the land itself. Soil exposed to intense heat may lose its ability to absorb moisture and support life. Exposed soils erode quickly and enhance siltation of rivers and streams, which in turn enhances flood potential, harms aquatic life, and degrades water quality. In addition, because fires strip property of vegetation and root systems that normally retain soil, they increase a community's susceptibility to landslides and debris flows.[9]

CalFire's wildfire severity zone maps designates wildland zones with a hazard score based on two factors: flame length expected under worst case conditions and burn probability. This score is then divided into a scale, composed of three classes: Moderate, High, and Very High[10]. Additionally, another method to characterize the extent of potential wildfire hazard is through the fire size class scale. This scale is used in wildland contexts and can be seen described in Table 4-14.

[8] Cal FIRE Fire and Resource Assessment Program, "Characterizing the Fire Threat to Wildland-Urban Interface Areas in California," 4, accessed May 30, 2018, https://frap.fire.ca.gov/projects/wui/525_CA_wui_analysis.pdf.

[9] Daniel G. Neary, Kevin C. Ryan, Leonard F. DeBano, eds., *Wildland Fire in Ecosystems: Effects of Fire on Soil and Water*, General Technical Report RMRS-GTR-42, vol. 4 (Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, 2008) 51, 105, accessed May 31, 2018, https://www.fs.fed.us/rm/pubs/ rmrs_gtr042_4.pdf.

[10] CalFire. "Fire Hazard Severity Zones". Retrieved from: https://34c031f8-c9fd-4018-8c5a-4159cdff6b0d-cdn-endpoint.azureedge.net/-/media/osfm-website/what-we-do/community-wildfire-preparedness-and-mitigation/fire-hazard-severity-zones/fire-hazard-severity-zonesmap/short_fhsz_methods_042324.pdf?rev=8fc7f1245bbb4bab9e3afe42c25673a8&hash=6E5E3014AE4428F60FDB72CA86E0ABAB

TABLE 4-14
NWCG INCIDENT RESPONSE FIRE CLASS SIZES

Class	Fire Size
A	0 – ¼ acre
B	¼ – 10 acres
C	10 – 99 acres
D	100 – 299 acres
E	300 – 999 acres
F	1,000 – 4,999 acres
G	5,000+ acres

History

The California Department of Forestry and Fire Protection (CAL FIRE) has no record of any wildfires or WUI fires occurring within San Francisco from 1943 through 2016, the period during which the agency has maintained statistics.[11] However, there is a history of wildfire and WUI fire events that have threatened City-owned assets outside San Francisco's limits.

The Rim Fire, which began on August 17, 2013, in Tuolumne County, burned over 257,000 acres and threatened the Hetch Hetchy Regional Water System, which provides approximately 85 percent of San Francisco's total water needs. Though the Rim Fire reached the edges of the Hetch Hetchy Reservoir watershed, it did not impact water quality or water delivery operations. However, as of June 2017, the San Francisco Public Utilities Commission reported cumulative total expenses of approximately $23.8

[11] See Cal FIRE, "Past Wildfire Activity Statistics (Redbooks)," accessed June 21, 2024, https://www.fire.ca.gov/our-impact/statistics .

million for facilities and infrastructure damage and costs related to emergency response due to Rim Fire damage.[12]

The City and County of San Francisco declared a local emergency due to the Rim Fire on August 22, 2013. The Governor of California issued a state emergency proclamation for the fire on the same day, and on August 23, 2013, submitted a request for a federal fire management assistance declaration. A Fire Management Assistance declaration, FEMA-5049-FM, was issued on the same day, making FEMA funding available to reimburse up to 75 percent of the eligible firefighting costs for managing, mitigating, and controlling the fire. On December 13, 2013, the President of the United States issued Major Disaster Declaration DR-4158 for the Rim Fire, making it possible to obtain federal Public Assistance for repairs or replacement of damaged public facilities, and to undertake hazard mitigation projects to reduce the long-term risk to life and property from future fires.[13] To date, approximately $23 million in Public Assistance grants have been made available to the state for the Rim Fire. Almost $18 million has been made available for emergency work; $3.6 million has been made available for permanent work.[14]

Wildfires and WUI fires need not occur within San Francisco to impact our jurisdiction. In early October 2017, smoke from wildfires and WUI fires in Napa, Sonoma, and Solano Counties in Northern California converged over San Francisco and other Bay Area counties. These fires introduced levels of particulate matter pollution that the Bay Area Air Quality Management District (BAAQMD) indicated were unprecedented for the Bay Area.[15] As a result, from October 9th through 18th, the BAAQMD issued a number of health advisories and "Spare the Air Alerts" urging residents and visitors to limit outdoor activities and reduce exposure to smoke by remaining inside with windows closed.[16] The

[12] KPMG, "San Francisco Water Enterprise and Hetch Hetchy Water and Power: Statement of Changes in the Balancing Account, June 30, 2017," 18, accessed May 31, 2018, https://sfwater.org/modules/showdocument.aspx? documentid=12148.

[13] FEMA, Federal Aid Programs for the State of California, HQ-13-127 Factsheet (2013), accessed May 31, 2018, https://www.fema.gov/news-release/2013/12/13/federal-aid-programs-state-california-declaration.

[14] FEMA, California Rim Fire (DR-4158), accessed May 31, 2018, https://www.fema.gov/disaster/4158.

[15] Bay Area Air Quality Management District (BAAQMD), "Health Advisory, Spare the Air Alert," October 10, 2017, accessed June 4, 2018, http://www.baaqmd.gov/~/media/files/communications-and-outreach/publications/news-releases/2017/2017_092_staalert_healthadvisory_101017-pdf.pdf?la=en.

[16] See, e.g., BAAQMD, "Smoke Advisory," October 9, 2017, accessed June 4, 2018, http://www.baaqmd.gov/~/ media/files/communications-and-outreach/publications/news-releases/2017/smoke_171009-pdf.pdf?la=en; "Health Advisory, Spare the Air Alert," October 10, 2017, accessed June 4, 2018, http://www.baaqmd.gov/~/ media/files/communications-and-outreach/publications/news-releases/2017/2017_092_staalert_healthadvisory_ 101017-pdf.pdf?la=en.

poor air quality, coupled with high temperatures in the city, prompted San Francisco's officials to make a number of public libraries available as filtered-air sites for residents and visitors,[17] and to activate the city's Emergency Operations Center from October 9 to 14, 2017.[18] A 2018 survey of local air quality managers identified wildfires as the number one environmental event impacting air quality of districts' across the state[19]

Additionally, while voluntary, the regional mutual aid policy that the City has with surrounding counties means that even fires occurring outside of San Francisco proper has implications for our department's resource utilization. Mutual aid is intended to ensure that adequate resources, facilities, and other emergency support are provided to jurisdictions whenever their own resources prove to be inadequate to cope with a given situation at no charge to the receiving jurisdiction[20]. On July 23rd, 2018 the Carr Fire began in Shasta and Trinity County. Before being contained on August 30th it burned over 229,651 acres of wildland, caused the evacuation of 38,000 people, and required support from nearly every bay area county (including San Francisco) in the form of equipment and personal.[21]

Location

In 2007, pursuant to state law, CAL FIRE adopted Fire Hazard Severity Zone FHSZ maps for State Responsibility Areas (SRAs), the areas in California where the state is financially responsible for the prevention and suppression of wildfires. The maps use a fuel ranking assessment methodology that assigns a rank—moderate, high, or very high—based on expected fire behavior for unique combinations of topography and vegetative fuels under a given severe weather condition, including wind speed, humidity, and temperature.[22] CAL FIRE also has developed FHSZ maps for Local Responsibility

[17] See San Francisco Department of Public Health, "Public Health Advisory," October 9, 2017, accessed June 4, 2018, https://sfdem.org/article/public-health-advisory.

[18] San Francisco Department of Emergency Management, *City and County of San Francisco Department of Emergency Management 2017 Annual Report*, 11, accessed June 4, 2018, https://sfdem.org/sites/default/files/ DEM_2017_Annual_Report.pdf.

[19] Julia A. Ekstrom & Louise Bedsworth (2018) Adapting air quality management for a changing climate: Survey of local districts in California, Journal of the Air & Waste Management Association, 68:9, 931-944, DOI: 10.1080/10962247.2018.1459325

[20] City and County of San Francisco Emergency Response Plan. ESF#4: Firefighting Annex. Retrieved from: https://sfdem.org/sites/default/files/FileCenter/Documents/25-ESF%204%20-%20Firefighting%20Annex.pdf

[21] San Francisco Examiner: Bay City News. "Bay Area fire departments help battle raging Carr Fire". Retrieved from: http://www.sfexaminer.com/bay-area-fire-departments-help-battle-raging-carr-fire/

[22] CAL FIRE, "Wildland Hazard and Building Codes, Fire Hazard Severity Zone Development," accessed May 31, 2018, http://www.fire.ca.gov/fire_prevention/fire_prevention_wildland_zones_development.

Areas (LRAs) within California. LRAs include incorporated cities such as San Francisco, where fire protection is typically provided by a city fire department. The LRA fire hazard zone maps developed by CAL FIRE use an extension of the SRA FHSZ model, which reflects flame and ember intrusion from adjacent wildlands and from flammable vegetation in urban areas.[23]

The current CAL FIRE hazard map indicates that San Francisco has no Very High Fire Hazard Severity Zones in its LRA. However, as shown in Figure 4-27, CAL FIRE has designated a small portion of the Crocker Amazon neighborhood as a high fire hazard area. Moderate fire hazard areas include wooded areas near Fort Funston and Lake Merced in the Stonestown District; Stern Grove in the Central Sunset District; Mount Davidson and Glen Canyon Park in the Miraloma and Diamond Heights neighborhoods; the Forrest Knolls and Midtown Terrace neighborhoods; wooded areas of Sutro Heights, Lincoln Park, the Presidio, and Fort Mason; and Bayview Park and Candlestick Point Recreation Area in the Bayview-Hunters Point Districts of San Francisco. Yerba Buena Island has also been designated by CAL FIRE as a moderate fire hazard area.[24]

City-owned infrastructure located outside San Francisco County are also located in areas that are susceptible to wildfire or to WUI fire. Among these facilities are significant portions of the Hetch Hetchy Regional Water System, including the Crystal Springs Reservoir and Watershed in San Mateo County, parts of which are located in or near a very high fire severity zone (VHFSZ); the Moccasin Powerhouse and Reservoir, Priest Reservoir, Kirkwood Powerhouse, Holm Powerhouse, and O'Shaughnessy Dam, in Tuolumne County, all of which are located in a VHFSZ; and the Calaveras Dam located in Alameda County, which is located in a high fire severity zone. For a map showing the Hetch Hetchy Regional Water System and fire severity zones, see Appendix B.

[23] CAL FIRE, "Wildland Hazard and Building Codes, Fire Hazard Severity Zone Maps," accessed May 31, 2018, http://www.fire.ca.gov/fire_prevention/fire_prevention_wildland_zones.

[24] CAL FIRE, "Wildland Hazard and Building Codes, San Francisco County FHSZ Map," http://www.fire.ca.gov/fire_prevention/fhsz_maps_sanfrancisco.

Extent and Probability of Future Events

In general, the susceptibility for wildfires dramatically increases in the late summer and early autumn as vegetation dries out, decreasing plant moisture content and increasing the ratio of dead fuel to living fuel. Common causes of wildfires include arson and negligence. Though there is no historical record of a wildfire occurring in San Francisco, the impacts of climate change, including the increase in extreme heat days in the future, means that the probability of a future wildfire or WUI event within San Francisco is not easily quantified. The probability of a future wildfire or WUI fire in out-of-county areas where city-owned assets are located is high. The consequences of either type of event could be extremely damaging to buildings, infrastructure and potentially life threatening.

While it is difficult to attribute an individual fire event to climate change, the risk of wildfires is increasing due to climate change because of higher temperatures increasing the length of the fire seasons, creating drier fuels, and decreasing forest health.[25] At the local scale, urbanization has a demonstrated influence on WUI fire hazards. As development is sited in previously uninhabited wildlands, more ignition events can be expected to occur. Conversely, as semi-dense areas increase density these areas can actually expect a reduction in the number of fire events. This implies that land use considerations are essential for the city and region as they consider wildland/WUI fire hazards.[26] Figure 4-27, seen below, displays the extent of wildfire hazards in San Francisco.

Wildfire activity in California has increased over the past 10 years. This increase has been particularly severe in forested areas of the Sierra Nevada and Coast Ranges of Northern California. Researchers have attributed this increase to warmer spring and summer temperatures; lower precipitation rates; reduced snowpack and earlier snow melts; and longer, drier summer fire seasons in some middle and upper elevation forests. These trends are expected to continue under accepted climate change scenarios, leading to further increases in the risk of large, damaging wildfires in areas where city-owned infrastructure is located.[27]

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[25] California Natural Resources Agency & California Emergency Management Agency. California Adaptation Planning Guide. 2012. Sacramento.

[26] California National Resources Agency. California's Fourth Climate Change Assessment: San Francisco Bay Area Region Report. Retrieved from: http://www.climateassessment.ca.gov/regions/docs/20180827-SanFranciscoBayArea.pdf (Accessed: 9/10/2018)

[27] Anthony Westering and Benjamin Bryant, "Climate Change and Wildfire in California," *Climatic Change* 87 (2008), S231-232, accessed June 4, 2018,

Figure 4-27 details the wildfire hazard zones in San Francisco. Wildfire severity refers to the likelihood that a given area will burn over a 30 to 50-year period, considering the amount of vegetation, the topography and weather (temperature, humidity, and wind). [28] The hazard severity does not consider modifications to the area, such as fuel reduction.

Another measure of probability that is useful in this context comes from the FEMA National Risk Index. According to this measure, there is a 0.001% chance per year of a wildfire event occurring in San Francisco, based on the dataset in 2021.[29]

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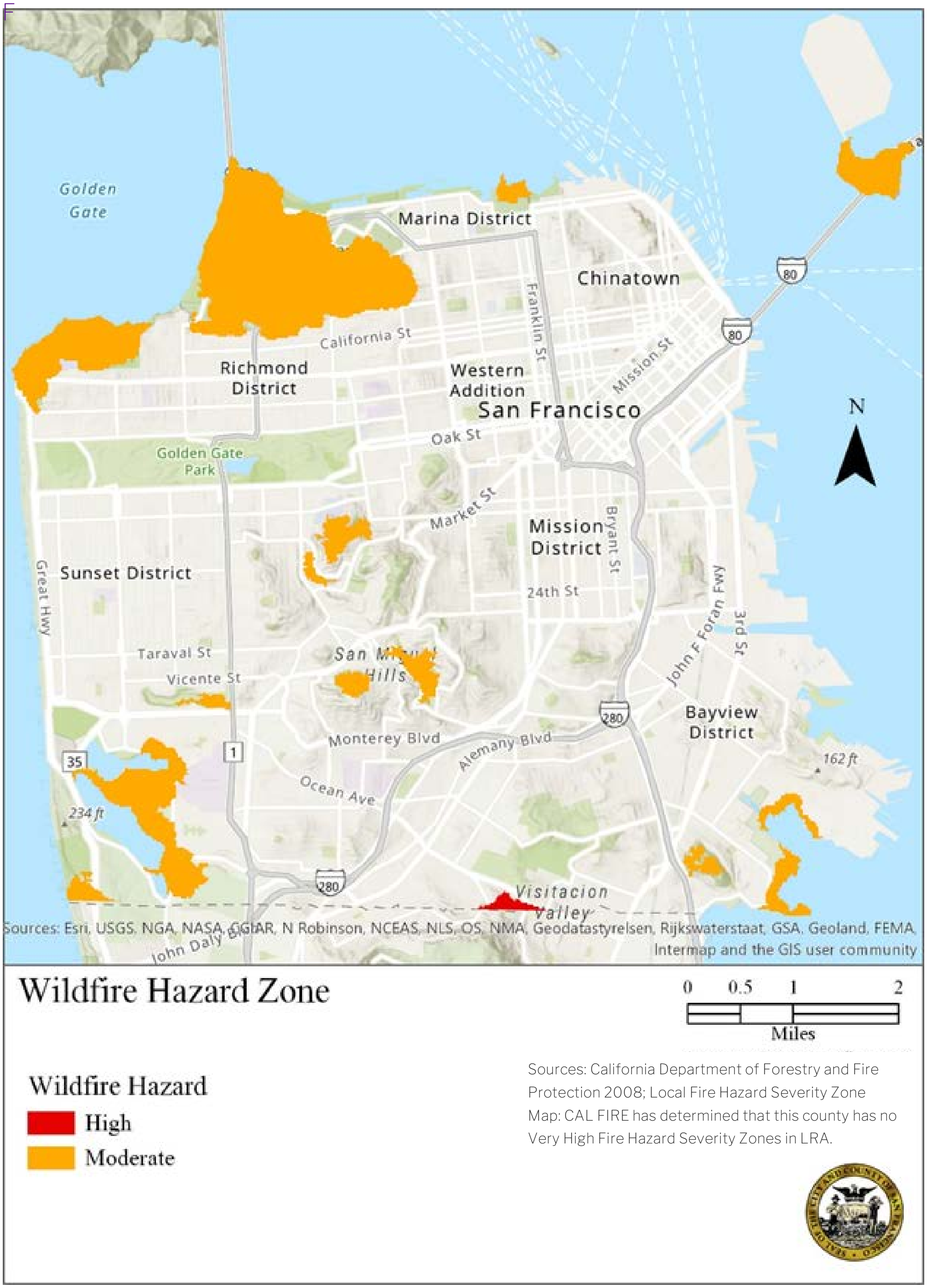
http://tenaya.ucsd.edu/~westerli/pdffiles/08CC_WesterlingBryant.pdf; see John T. Abatzogloua and A. Park Williams, “Impact of Anthropogenic Climate Change on Wildfire Across Western US Forests,” *Proceedings of the National Academy of Sciences* 113, no. 42 (2016), 11770,11775, accessed June 4, 2018, http://www.pnas.org/content/pnas/113/42/.11770.full.pdf.

[28] Cal FIRE, “Fire Hazard Severity Zones Maps,” https://osfm.fire.ca.gov/divisions/wildfire-planning-engineering/wildland-hazards-building-codes/fire-hazard-severity-zones-maps/.

[29] FEMA National Risk Index (2025). “San Francisco County, California”. Retrieved from: https://hazards.fema.gov/nri/report/viewer?dataLOD=Counties&dataIDs=C06075

FIGURE 4-27
CITY AND COUNTY OF SAN FRANCISCO FIRE HAZARD SEVERITY ZONES



Sources: California Department of Forestry and Fire Protection 2008; Local Fire Hazard Severity Zone Map: CAL FIRE has determined that this county has no Very High Fire Hazard Severity Zones in LRA.

Poor Air Quality Profile

4.11 Poor Air Quality

Impact Statement

Air quality is closely associated with public health. Exposure to pollutants increases rates of allergies, bronchitis, asthma attacks and other respiratory illnesses, heart disease and other cardiovascular illnesses, and is an environmental risk factor connected to premature birth and low birth weight, mental health conditions, and many cancers. Although all together San Francisco enjoys clean air relative to other urban areas in the country, current air pollution is not evenly distributed. In San Francisco, air pollution is influenced by proximity to freeways and other high-density arterials, industrial activity, and maritime activity. San Francisco is also vulnerable to air quality impacts of wildfires. Although it is unlikely a large wildfire occurs within San Francisco's city limits, smoke from wildfires elsewhere may be transported into the City and significantly impact San Francisco's air quality.

Nature

The Air Quality Index (AQI) measures air quality for the five pollutants regulated by the Clean Air Act: ground-level ozone, particulate matter, carbon monoxide, sulfur dioxide, and nitrogen dioxide[1].

- Ground-level ozone is created through a chemical reaction between sunlight, nitrogen oxide, and volatile organic compounds (VOCs), which are chemicals emitted from cleaning supplies, glues, paints, pesticides, and other household materials. Ground-level ozone is the main ingredient of smog.
- Particulate matter (PM) includes vehicle emissions and other fuel combustion, smoke from fireplaces or wildfires, dust, molds, and pollens. Particulate matter is organized by size, as emissions tend to be fine PM (<2.5 micrometers in diameter), while dusts, molds, and pollens tend to be coarse (<10 micrometers in diameter).
- Carbon monoxide is an odorless gas byproduct of combustion and is released by the burning of gasoline, kerosene, oil, propane, coal, and wood.

[1] https://airnow.gov/index.cfm?action=aqibasics.aqi

- Sulfur dioxide is a gas byproduct of industrial activities that involve the burning of materials that contain sulfur such as coal, oil, and gas. Sources of sulfur dioxide include power plants and other industrial activities.
- Nitrogen dioxide is another byproduct of the burning of fossil fuels and is largely emitted from cars, trucks, and power plants.

The AQI provides each pollutant a score 0 – 500. A score of 100 approximates the federally set EPA National Ambient Air Quality Standards (NAAQS). The AQI is presented as the highest score of the 5 pollutants. San Francisco generally enjoys good air quality as a dependable ocean breeze regularly dissipates pollution. However, when coastal high-pressure systems or inversion layers trap pollutants, San Francisco can experience short-term spikes in AQI.

History

According to data supplied by the Bay Area Air Quality Management District (BAAQMD), San Francisco enjoys good air quality most of the year, with AQI rarely above national standards. This data can be found in Table 4-37 below. Because there is only one air quality station in San Francisco, AQI measurements do not consider AQI variation throughout the City, and homes adjacent to high-density arterials, industrial uses, or maritime uses may have AQIs significantly higher than those reported below.

In 2018, a wildfire in Butte County coincided with the westward "Diablo Winds" and funneled wildfire smoke south and west through the delta into the San Francisco Bay. A high-pressure system off the coast blocked San Francisco's normal ocean breezes and trapped the wildfire smoke in the Bay Area. San Francisco's AQI was over 150 for 12 straight days, peaking at 228. This wildfire smoke emergency caused significant disruption as schools were canceled. It is likely that the wildfire smoke emergency impacts were not evenly distributed as residents with access to air filtration were less exposed to wildfire smoke.

The 2020 wildfire season was not only one of the worst in modern history for California, but its impacts were spread across much of the western region, with record breaking fires across much of the western United States of America. This contributed to 22 of the 30 poorest air quality days in the Bay Area occurring in the last 5 years[2]. This wildfire

[2] https://www.sfchronicle.com/california-wildfires/article/Not-just-California-Colorado-and-other-Western-15667992.php

season in particular led to historic poor air quality across the state, with the Bay Area experiencing 12 days of the worst air quality since tracking started in 1999. There were over 30 consecutive spare the air days declared by BAAQMD, and a Stanford study estimated that there were between 1,200 and 3,000 premature deaths in California attributable to the air quality experienced between August 1st, 2020 and September 10th, 2020. On September 9th many bay area residents woke to an orange hazy sky due to the dynamics between layers of smoke at different altitudes contributed by multiple sources across the Pacific Northwest and Northern California. While the air quality was not particularly poor in San Francisco that day, the collective psychological impact of that experience was pronounced.

FIGURE 4-28
ORANGE SKIES ON SEP 9, 2020 DUE TO WILDFIRES SMOKE

Credit: Christopher Michel

TABLE 4-15
SAN FRANCISCO AIR QUALITY INDEX (AQI)[3]

San Francisco	Total Days	Good	Moderate	Unhealthy for Certain Groups	Unhealthy	Very Unhealthy
Year		0 - 50	51 - 100	101 - 150	151 - 200	200 - 300
2023	335	314	20	1	0	0
2022	364	313	51	0	0	0
2021	365	312	53	0	0	0
2020	365	278	79	3	5	0
2019	365	315	49	1	0	0
2018	360	272	74	2	11	1
2017	365	276	82	7	0	0
2016	365	310	55	0	0	0
2015	365	300	65	0	0	0
2014	365	309	56	0	0	0
2013	364	254	109	2	0	0
2012	361	291	68	2	0	0
2011	365	252	111	2	0	0
2010	365	249	113	3	0	0
2009	365	196	164	5	0	0
2008	366	223	140	3	0	0
2007	365	281	79	5	0	0
2006	363	264	95	4	0	0
2005	365	288	70	7	0	0
2004	366	243	116	7	0	0
2003	365	294	66	5	0	0

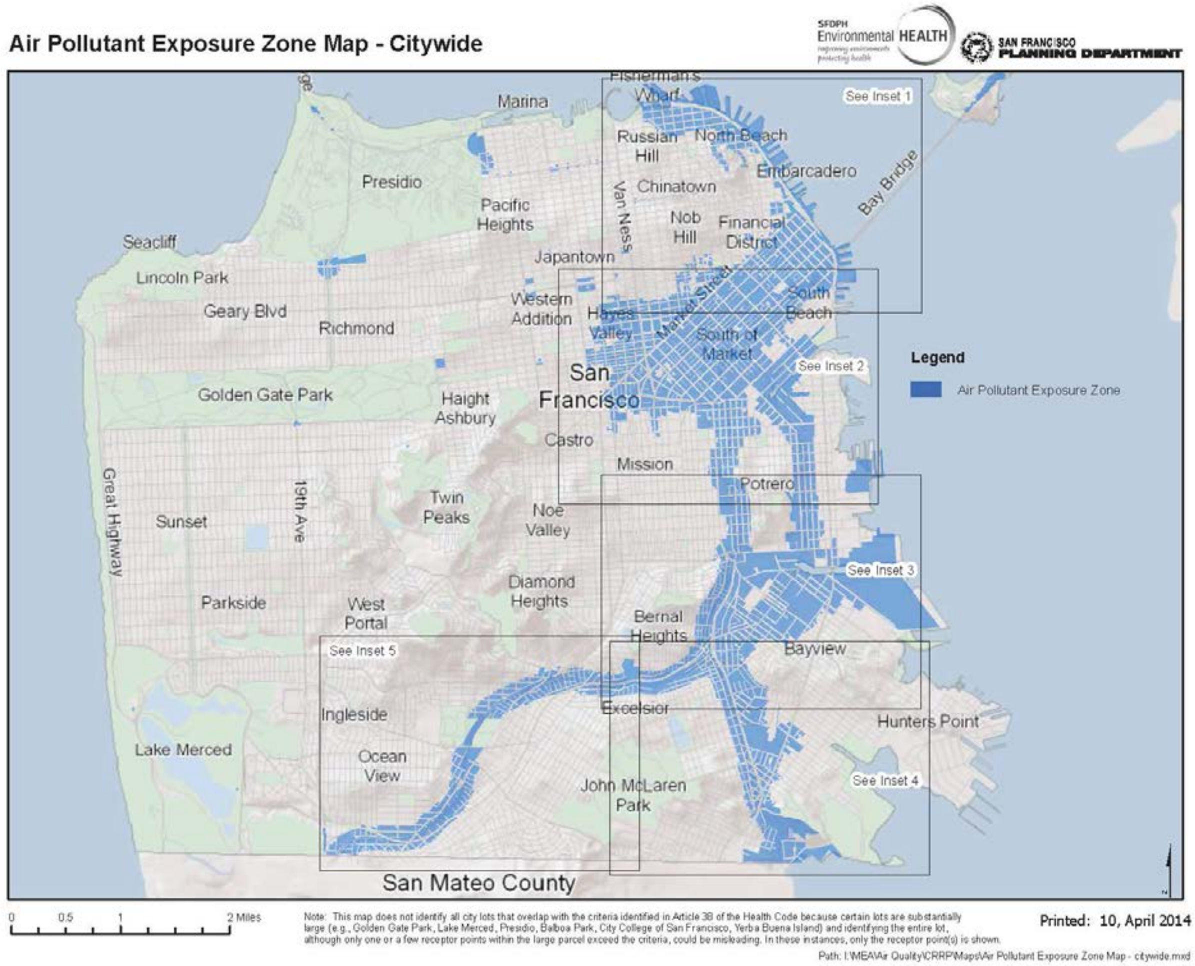
[3] BAAQMD. August 8th, 2023. *"Air Quality Index Data"*. Retrieved from: https://www.baaqmd.gov/about-air-quality/current-air-quality/air-monitoring-data/#/aqi-highs?date=2023-01-01&view=daily

San Francisco	Total Days	Good	Moderate	Unhealthy for Certain Groups	Unhealthy	Very Unhealthy
Year		0 - 50	51 - 100	101 - 150	151 - 200	200 - 300
2002	365	273	71	14	7	0
2001	365	291	61	10	3	0
2000	366	277	83	6	0	0

Location

In 2014, BAAQMD, the San Francisco Planning Department, and the San Francisco Department of Public Health identified neighborhoods most exposed to air pollution. The Air Pollution Exposure Zone (Figure 4-29) identifies air pollution exposure based on cancer risk, PM2.5 concentration and proximity to freeways and other high-density arterials. New construction in the air pollution exposure zone is regulated under Article 38 and is required to have adaptive infrastructure and safe construction practices to protect against the health impacts of air pollution. According to the air pollution exposure zone map, neighborhoods particularly impacted by air pollution include Bayview/Hunters Point, SOMA, Central Market/Tenderloin, and the Financial District.

FIGURE 4-29
ARTICLE 38 CITYWIDE MAP



Severity and Probability of Future Events

While San Francisco's air quality will remain above current EPA standards, climate change is likely to increase concentrations of both ground-level ozone and $PM_{2.5}$ which will increase morbidity and mortality in San Francisco.

- Climate change is expected to exacerbate yearly fluctuations in precipitation. During especially dry years, drought can impact air quality. The 2011-2016 drought contributed to the deaths of an estimated 66 million trees in the Sierra

Nevada forests. Future droughts will have similar impacts and create conditions for more frequent and intense wildfires[4].

- PM is likely to be impacted by climate change. PM levels are strongly affected by local weather patterns such as precipitation, wind speed, and vertical mixing. Increased mixing height, or the height of the air layer closest to the ground, and wind speeds have been shown to significantly reduce PM concentrations. However, atmospheric stagnation, characterized by low wind speeds and little vertical mixing, has been shown to be correlated with increased PM levels in Canadian cities[5], and is predicted to increase regionally as a result of modern climate change.
- Temperature increases are also expected to alter the growing season for allergen-producing plants.
- As climate change increases temperatures, hot and dry temperatures will accelerate the creation of ground-level ozone.

Additionally, the largest increases in ozone levels from climate change will also occur in areas where ozone is already high, meaning that those same communities that are affected most by current pollution will also suffer the worst of the changes. So, while the research suggests that average increases in ozone and PM levels will be relatively small, it is also clear that the impact of those increases will not be evenly distributed and can have significant effects on vulnerable populations.

Recent studies have shown that progress on improving air quality over the last 20 years has been virtually negated due to the increased frequency and intensity of wildfires, with impacts being particularly pronounced in the west. There are strong indications that this trend will continue in this direction in future decades as well. [6]

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[4] USDA Office of Communications *Forest Service Survey Finds Record 66 Million Dead Trees in Southern Sierra Nevada.* U.S. Forest Service. https://www.fs.fed.us/news/releases/forest-service-survey-finds-record-66-million-dead-trees-southern-sierra-nevada

[5] Cheng, C. S. (2005). *Differential and combined impacts of winter and summer weather and air pollution due to global warming on human mortality in south-central canada.* (No. 6795-15-2001/4400011). Toronto, CAN: Toronto Public Health.

[6] San Francisco Chronicle (2024). “California is ‘ground zero’ for poor air quality. Map shows how it could get worse. Retrieved from: https://www.sfchronicle.com/california/article/air-quality-smoke-ozone-18645106.php

For further discussion of poor air quality and mitigation planning, visit the San Francisco Heat and Air Quality Resilience Project website.

Pandemic Hazard Profile

4.12 Pandemic

Impact Statement

The COVID-19 pandemic lasted for over three years. The likelihood of future pandemics of this intensity is currently unknown, however the probability for a naturally occurring moderate outbreak of pandemic influenza is considered high. Throughout the last century, there have been five other influenza pandemics of varying severity, and a future pandemic is a near certainty. Daily impacts of moderate to severe flu will primarily impact human health, health services, and public health systems. It must be noted that the cumulative impact will likely be much more significant, as pandemics can last for months to years, with infections scattered across waves of infections and severity of these waves differing across communities due to systemic disparities and structural inequality. Many of the factors that are causing and exacerbating climate change can also increase the likelihood of pandemics becoming more frequent.

Pandemics severely strain the healthcare system by causing prolonged patient surge. Because of their frequency, duration, and scale, pandemics are one of the greater public health threats to the City and County of San Francisco; this threat has only increased with the rise in population density and international travel.

Additionally, our most recent experiences with COVID-19 demonstrated how disruptive these events can be to the economy and the impact that can have on the city's residents.

Nature

A pandemic is an epidemic of an infectious disease occurring worldwide, or over a very wide area, which crosses international boundaries and affects a large number of people. Pandemic influenza is one of the most pressing public health planning needs today. Even with a "moderate" pandemic, the cumulative effect on health and health care would be dire. For example, the 1918 "Spanish Flu," which had a 30 percent attack rate and a 2 percent case fatality rate, was defined by the Center for Disease Control (CDC) as a moderate event. Preliminary meta-analysis of COVID-19 from a study in 2021 established that the case fatality rate was incredibly variable. It demonstrated a wide range based on which population was being assessed and this can be seen in the table below:

TABLE 4-16
PRELIMINARY COVID CASE FATALITY RATE BY GROUPS[1]

Preliminary COVID-19 Case Fatality Rate by Group	
Population	Estimated Case Fatality Rate (CFR)
Overall Pooled	~10.0%
Pooled in General Population	~1.0%
Hospitalized Patients	~13.0%
Admitted Intensive Care	~37.0%
Patients Older than 50 Years Old	~19.0%

Pandemics are hazards that have a long duration. Though daily impacts may be low, cumulative impacts are likely to be overwhelming for both the health system and the community. During a moderate pandemic, San Francisco could see a sustained increase in intensive care unit admissions, in emergency department (ED) admissions, in patients needing to be placed in respiratory isolation, and in deaths. Capacity to provide medical care, including basic emergency medical system (EMS), hospital ED services, and isolation rooms, will be reduced. At the same time, a higher than usual absenteeism rate for all employees is expected. In an Influenza pandemic, It is estimated that there would

[1] Alimohamadi Y, Tola HH, Abbasi-Ghahramanloo A, Janani M, Sepandi M. Case fatality rate of COVID-19: a systematic review and meta-analysis. J Prev Med Hyg. 2021 Jul 30;62(2): E311-E320. doi: 10.15167/2421-4248/jpmh2021.62.2.1627. PMID: 34604571; PMCID: PMC8451339.

be an 18 percent decrease in workers secondary to being ill with the flu, with effects compounded over time. This was borne out in the city's experiences with COVID-19 over the last three years. This would have dramatic consequences both for the health care system and for the community in general.[2]

Compared to the 1918 pandemic event, an influenza pandemic today could have far-reaching, negative consequences for the health and well-being of San Francisco's residents and for the economic and social stability of the Bay Area. Our population includes more elderly than it did in the past. Our ability to respond effectively to a pandemic is also limited. Our health care system today has little surge capacity. "Just-in-time" ordering of needed supplies has replaced the warehousing of critical items onsite for most businesses and governmental organizations. In addition, unlike citizens in 1918, we are not accustomed to following government restrictions such as the rationing of goods and services.

History

The COVID-19 pandemic started in Wuhan China in late December of 2019 and following that spread to nearly every country in the world. San Francisco was one of the first cities to respond to the global COVID-19 pandemic with Mayor London Breed enacting an emergency declaration on February 25th 2020. The declaration was approved by the Board of Supervisors on March 3rd. On March 16, 2020, Mayor Breed, along with 5 other Bay Area counties, issued shelter in place orders for all residents for three weeks. This local shelter in place order was then extended to May 3rd, before moving to a phased process of re-opening with coordination from the state. [3] On March 19, 2020 Governor Newsom issued shelter in place orders for the whole state with no determined end date. More than a dozen states followed suit. The state then introduced a phased system of reopening county by county based on a tiered system that considered a variety of metrics of viral spread. The state didn't fully re-open until June 15th 2021.[4]

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[2] San Francisco Department of Public Health, Public Health and Medical Hazard Risk Assessment (2013), Internal Document., Public Health and Medical Hazard Risk Assessment (2013), *Internal Document*.
[3] The Mercury News (March 31st, 2020). *"Coronavirus: Bay Area shelter-in-place extended through May 3 with new restrictions.* Retrieved from: www.mercurynews.com/2020/03/31/coronavirus-bay-area-shelter-in-place-extended-through-may-3-with-new-restrictions/
[4] Office of Governor Gavin Newsom. (June 11th, 2023). *"As California Fully Reopens, Governor Newsom Announces Plans to Lift Pandemic Executive Orders"*. Retrieved from: www.gov.ca.gov/2021/06/11/as-california-fully-reopens-governor-newsom-announces-plans-to-lift-pandemic-executive-orders/

As of, June 14th 2023, there has been about 767, 984, 989 confirmed cases globally with as many as 6,943,390 deaths, with this likely being an under count of the global impact over the last three years. According to global statistics, the United States bore the brunt of this death toll with 103,436,829 cases of infection with 1,127,152 lives lost.[5] As of June 15, 2023, California experienced 102,197 deaths.[6] As of June 10th 2023, San Francisco has experienced 199,955 known cases with 1,216 deaths.[7] At the start of the COVID-19 pandemic, it was predicted that as many as 200,000 to 1.7 million people could die. These numbers were also borne out in the latest figures at the relative end of the global emergency.

The UN World Health Organization (WHO) declared the COVID-19 pandemic officially been over on May 5th, 2023.[8] While that marks the end of the COVID-19 virus as a global health emergency, it does not mean that the danger from this virus has ended as it will continue to change, mutate, and infect people today.

In addition to COVID-19, there have been five other pandemics since 1900. From April 12, 2009 to April 10, 2010, CDC estimated that between 151,700 and 575,400 people worldwide died from 2009 H1N1 virus infection during the first year the virus circulated. Additionally, CDC estimated that 80 percent of (H1N1)pdm09 virus-associated global deaths were in people younger than 65 years of age, which differs from typical seasonal influenza epidemics during which about 70 percent to 90 percent of deaths are estimated to occur in people 65 years of age and older. In the United States estimates included 60.8 million cases, 274,304 hospitalizations, and 12,469 deaths due to the (H1N1)pdm09 virus. In San Francisco, 208 hospitalizations and 60 intensive care unit (ICU) or fatal cases were reported during the 2009 H1N1 Pandemic. See introduction section for updated number on COVID-19 local and global impacts.

Because pandemics are recurring events, it is not a question of whether there will be another pandemic; the question is when the next pandemic will occur and how severe it

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[5] World Health Organization (June 14th, 2023). "*WHO Coronavirus (COVID-19) Dashboard"* Retrieved from: covid19.who.int/

[6] California All. (June 15th, 2023). *"Tracking COVID-19 in California"*. Retrieved from: covid19.ca.gov/state-dashboard/#county-statewide

[7] SF Gov. (June 10th, 2023). "*COVID-19 Cases and Deaths: COVID-19 cases and deaths in San Francisco, including new cases and cumulative totals."* Retrieved from https://sf.gov/data/covid-19-cases-and-deaths Accessed June 10th, 2023.

[8] United Nations: UN News (May 5th, 2023). *"WHO chief declares end to COVID-19 as a global health emergency"*. Retrieved from: news.un.org/en/story/2023/05/1136367#:~:text=WHO%20chief%20declares%20end%20to%20COVID%2D19%20as%20a%20global%20health%20emergency,-5%20May%202023&text=The%20head%20of%20the%20UN,no%20longer%20a%20global%20threat.

will be. Additionally, there is strong evidence that many of the factors that cause or exacerbate climate change can also contribute to higher rates of cross-species viral transmission, known as spillover events, which is a key contributor in producing potential pandemic viruses.[9] Previous pandemics occurred in 1918-1920, 1957-1958, 1968-1969, 1977-1978, and 2009-2010. The 1918-1920 Pandemic, often referred to as the Spanish Flu, was unusually severe and had a high mortality rate. It is estimated that the 1918 Pandemic killed up to one percent of the world's population, or 40,000,000 people worldwide, including more than 500,000 in the United States.

Location

By definition, a pandemic is a global event; San Francisco as a major center for domestic and international tourism and business would expect to be significantly affected by a pandemic flu. The World Health Organization (WHO) classifies pandemics according to phases. Phase 1 starts with the virus circulation among domesticated or wild animals prior to human infection. Additional phases coincide with community level outbreaks in multiple countries in multiple WHO regions, culminating with Phase 6. A Phase 6 Pandemic involves a virus that is widespread, with human-to-human transmissibility.

Since travelers and residents are free to travel throughout the city, it is anticipated that from a hazard mitigation perspective, San Francisco will be uniformly affected geographically. However, based on the actual pandemic virus, certain populations within San Francisco may have different morbidity and mortality than the general population. In general, the following groups tend to be at higher risk for seasonal influenza complications: individuals with specific chronic medical conditions; children younger than five years old, with children younger than two at special risk; adults 65 years of age and older; pregnant women; American Indians; and Alaskan Natives.

During the Covid-19 pandemic, legacies of structural oppression contributed significantly to disparities in impacts to different populations. Social vulnerability was tied largely to socio-economic factors and exacerbated by the economic effects that occurring in concert with the spread of the virus, with a particular focus on particular economic sectors and pronounced impacts on low-income communities and communities of color. Reports from April 2020 showed the loss of as many as 175,000

[9] Carlson, C.J., Albery, G.F., Merow, C. et al. Climate change increases cross-species viral transmission risk. Nature 607, 555–562 (2022). https://doi.org/10.1038/s41586-022-04788-w

jobs in the SF Metropolitan Area, with much of these losses concentrated in the food service and hospitality sectors.

Severity and Probability of Future Events

As mentioned above, the COVID-19 pandemic has been the defining health issue of the world for multiple years. The fact that we have experienced a pandemic this year does not decrease the likelihood of experiencing another pandemic (with a different strain) next year.[10] Based on the Bay Area Regional Risk Assessment conducted in 2013, the probability of a naturally occurring, mild to moderate pandemic affecting San Francisco is considered high. In many respects, the City and County of San Francisco is more vulnerable to a pandemic today than it was in 1918. Population density in the city is higher than in 1918, and people in the Bay Area travel more internationally and come into contact with far more people on a daily basis than did people in 1918.

The extent of a pandemic depends on the actual virus involved. The 2009 H1N1 Pandemic was generally considered mild, with a very low case fatality rate; it is estimated that 0.001 percent to 0.007 percent of the world's population died of respiratory complications associated with the (H1N1) pdm09 virus infection during the first 12 months the virus circulated. In contrast, the 1918 Pandemic had a higher case fatality rate, with a reported 1-3% mortality rate worldwide. As stated earlier, based on the CDC's scale, the 1918 Pandemic is considered a moderate pandemic influenza.

The speed of onset of a Pandemic also varies depending on the particular influenza virus, how rapidly it spreads, the availability of vaccines and antivirals, and the effectiveness of medical and non-medical containment measures. Some influenza strains remain at early phases, with no human-to-human transmission for many years, while others move through the stages to become a pandemic relatively quickly. Global travel and movement of populations speeds up the spread of disease.

Pandemics can last years. Pandemics also present as discrete waves over an extended period of months. The subsequent waves may occur several months after the initial

[10] Sandman, P. (February 27, 2007) "A severe pandemic is not overdue - it's not when but if" Center for Infectious Disease Research and Policy: Weekly Briefing. Accessed March 24, 2020. Retrieved from http://www.cidrap.umn.edu/news-perspective/2007/02/severe-pandemic-not-overdue-its-not-when-if

wave. The level of illness during the subsequent waves are often more severe than that in the first wave, with waves reducing in severity over time as more people build immunity.

Hazardous Materials Release Profile

4.13 Hazardous Materials Release

Impact Statement

According to state & local databases there are approximately 2,700[1] Hazardous Materials facilities throughout San Francisco. Accidental hazardous materials releases can occur wherever hazardous materials are manufactured, stored, transported, or used. Most of these facilities are located along the east/southeast portion of the city; therefore, the risk is greatest in that part of the city.

Nature

Hazardous materials have properties that make them potentially dangerous and harmful both to human health and to the environment. Accidental hazardous material release can occur wherever hazardous materials are manufactured, stored, transported, or used. Depending on the substance involved, the release may affect nearby populations and may contaminate critical or sensitive environmental areas. The universe of hazardous materials is large and diverse. Hazardous substances can be in liquid, solid, or gas form, and can include toxic chemicals, radioactive materials, infectious substances, and wastes.

Over the past 25 years there has been heightened awareness and attention paid to the health hazards posed by toxic materials. During this period, many federal, state, and local regulations governing hazardous materials have been put into place. These regulations are continually updated and augmented. The Hazardous Materials and Waste Program at the San Francisco Department of Public Health (DPH) implements six state environmental mandates and two local mandates regulating hazardous materials activities. DPH environmental health staff inspect regulated businesses at least once every three years.

A release of hazardous materials can occur from any of the following:

- Fixed facilities such as refineries, storage facilities, manufacturing facilities, warehouses, wastewater treatment plants, swimming pools, dry cleaners, automotive sales and repair, and gas stations.

[1] Josuwa Bernardo (SFDPH), *SF Hazardous Materials Sites*, 2018, Distributed by California State Water Resource Board (SWRCB). Email Correspondence regarding compiled data.

- Highway and rail transportation, such as tanker trucks and railcars transporting hazardous materials.
- Commercial maritime transportation, including transportation of petroleum products by barges and ocean-going tankers and spills associated with petroleum terminals.
- Air transportation involving cargo packages.
- Pipeline transportation of substances such as petroleum products, natural gas, and other chemicals.
- Contaminated sites or contaminated lands, which could occur through groundwater migration, surface water flow, soil exposure, and release to the air[2].

Though large petroleum storage or manufacturing facilities are typically located outside of residential areas, pipelines are ubiquitous in our communities. Virtually all liquid gas, which accounts for about 28 percent of energy consumed annually in the United States, is transported by transmission pipelines.

Related to hazardous materials releases, contaminated lands also represent a hazard. Contaminated lands are sites with similar substances or materials that pose a health hazard to people or the environment. These sites can be vulnerable to sea level rise and storm events that may cause flooding or groundwater intrusion, which risks disturbing contaminated soil with consequences to public health, the environment, and the economy. Many sites are remediated in place due to the complexity and risks of removal and disposal of contaminated materials.

Currently, efforts are being made to understand any potential emerging issue that may come from sea level rise in relation to hazardous materials found in contaminated sites thought to be capped and sufficiently remediated. Many of the city's coastal areas feature legacy contaminated sites from historic industrial, commercial, or military uses and sea level rise threatens to alter and mobilize pollutants thought to be sufficiently abated by site-scale remediation efforts.

[2] SF Planning (2020). "Sea Level Rise Vulnerability and Consequences Assessment". Retrieved from: https://sfplanning.s3.amazonaws.com/default/files/plans-and-programs/planning-for-the-city/sea-level-rise/SLRVCA_Report_09.pdf

History

Hazardous materials incidents impacting the San Francisco Bay Area have occurred because of spills from commercial and recreational vessels in the San Francisco Bay; from transportation accidents that resulted in petroleum spills; from sewer breaks and overflows; and from various accidents or incidents related to the manufacture, use, and storage of hazardous materials by industrial and commercial facilities. One of the most publicized incidents occurred on November 7, 2007, when the container ship Cosco Busan struck the Delta Tower of the San Francisco - Oakland Bay Bridge during a thick fog. Over 53,569 gallons of heavy fuel oil, often referred to as "bunker fuel," spilled into San Francisco Bay, soiling San Francisco's western, northern, and northeastern coastline, as well as other shorelines throughout the Bay Area. The spill impacted birds, marine mammals, fish, and humans, and required clean-up and response efforts from local, state, and federal authorities.

More recently, October 30, 2009, another tanker vessel, the Dubai Star, spilled over 400 gallons of intermediate fuel oil during a refueling incident just south of the Bay Bridge. The spill affected more than 10 miles of shoreline, from just north of the east approach to the Bay Bridge to San Leandro Bay along the Alameda County coastline. The impact included bird mortalities, as well as beach and fisheries closures.

The National Response Center (NRC), which serves as the sole national point of contact for reporting all oil, chemical, radiological, biological, and etiological discharges into the environment in the United States, shows that from 2002 through 2012, a total of 806 hazardous material incidents were reported in the study area. Of this number, 586 were water-related incidents including bilge oil, gasoline, hydraulic oil, jet fuel, and diesel oil spills. Common causes of these incidents included operator error and equipment failure. During this same 10-year period, NRC data also indicates that there were 45 rail-related incidents, and 49 land-based, non-rail spill incidents. According to NRC, for the year 2017, there were at least 30 reported material incidents in San Francisco that received federal notice.[3] From 2018 Through 2022 there were at least 262 incidents reported.[4]

[3] United States Coast Guard, "2017 Report" accessed September 25, 2018. (*National Response Center*, http://www.nrc.uscg.mil/)
[4] United States Coast Guard, "2018 through 2023 Reports" accessed August 7, 2023. (*National Response Center*, http://www.nrc.uscg.mil/)

Location

Accidental hazardous material release can occur wherever hazardous materials are manufactured, stored, transported, or used. In San Francisco, a hazardous material event is most likely to occur within the City's industrial area, which is concentrated in the southeast part of the city. The primary PG&E gas transmission pipeline also runs through the southeast part of the city.

In addition, a variety of transportation corridors traverse the city. Though federal regulations impose restrictions on the use of certain routes to transport hazardous materials within the city, vehicles using San Francisco's transportation corridors commonly carry a variety of hazardous and highly flammable materials, such as gasoline, petroleum products, and other chemicals known to cause human health problems. Similarly, container ships, car carriers, tankers, and other types of vessels constantly move through the shipping channels of San Francisco Bay, presenting a risk to the local marine environment in the event of a spill. Hazardous materials also are transported to and from, are used, and are stored at the San Francisco International Airport (SFO) and at adjacent airport facilities just south of San Francisco.

An analysis performed for the Port's Waterfront Resilience Program catalogued several specific sites in the Mission Creek/Mission Bay and Islais Creek/Bayview that are enrolled in regulatory cleanup programs and exposed to emergent groundwater from sea level rise.[5] The number of sites and their attendant regulatory programs are seen below:

<u>Department of Toxic Substances Control (DTSC) Sites</u>

- Seventeen DTSC Sites were identified in the Mission Creek/Mission Bay geography and eleven sites were identified in the Islais Creek/Bayview geography.
- With 84-inches sea level rise (an upper-end estimate of sea level rise that could occur by 2100), seven sites could be exposed to coastal flooding from direct overtopping of the shoreline by coastal floodwaters, ten could experience emergent groundwater, and eighteen could have shallow groundwater table within 6 feet of the ground surface.

[5] CH2m/Arcadis. Pathways Climate Institute. (January, 2023). "Contaminated Lands: Mission Creek/Mission Bay and Islais Creek/Bayview: Sites under the regulatory authority of the state of California"

Regional Water Quality Control Board (RWQCB) Sites

- Thirty-six Open Cleanup Program Sites were identified in the Mission Creek/Mission Bay geography and five were identified in the Islais Creek/Bayview geography.
- Three Closed Cleanup Program Sites were identified in the Mission Creek/Mission Bay geography, and three were identified in the Islais Creek/Bayview geography.
- Four Open Leaking Underground Storage Tank (LUST) sites were identified in the Mission Creek/Mission Bay geography, and three were identified in the Islais Creek/Bayview geography.
- Two-hundred and eighty-two Closed LUST Sites were identified in the Mission Creek/Mission Bay geography, and one-hundred and sixty-two sites were identified in the Islais Creek/Bayview geography.

Newly created datasets and research efforts like this have exposed gaps in our understanding of this new issue that will need to be filled to develop the most effective adaptation measures to understand and reduce any risks to communities near these sites.

Severity and Probability of Future Events

The geographic and economic characteristics of San Francisco make it likely that hazardous materials releases will continue to occur. Based on statistics maintained by DPH, from 2007 through 2017, there were 413 hazardous materials incidents requiring a response in San Francisco. According to CalOES, there were 412 hazardous materials spills during the period between 2017 and 2023.[6] San Francisco's commercial sector and transportation routes share space with several bodies of water, wetlands, environmentally sensitive areas, and a densely-populated urban environment, creating areas of great potential risk for a hazardous material release as well as increasing their potential for impacts. Moreover, SFO, a large international airport, is just a few miles from downtown San Francisco. Thus, the threat to San Francisco of a hazardous material incident impacting land, sea, or air remains high.

Hazardous material releases are notable among the hazard profiles this plan addresses because of the degree to which it can be expected to occur in combination with other

[6] https://www.caloes.ca.gov/office-of-the-director/operations/response-operations/fire-rescue/hazardous-materials/spill-release-reporting/

hazards. For example, as flooding increases in occurrence there will likely be an increased number of hazardous material incidents due to the compromise of coastal/floodplain storage infrastructure.

Chapter 05

Vulnerability and Consequence Assessment

Lottas Fountain, which served as a meeting point after the 1906 Great Earthquake

To develop the Vulnerability and Consequences Assessment, City staff relied on the risk assessment process developed by the Association of Bay Area Government's (ABAG) Resilience Program and Adapting to Rising Tides (ART), which closely follows FEMA's Local Mitigation Planning Handbook. The assessment described in this chapter describes the vulnerabilities of San Francisco's assets to the natural hazards identified in Chapter 04, as well as the broader consequences that can occur as a result. Understanding how hazards affect assets and identifying potential consequences is key to developing resilience actions. Much of the information presented in this chapter is summarized from the detailed assessment found in Appendix A.

5.1 Assessment Overview

The assessment process has four primary components: Multi-Hazard Exposure Assessment, FEMA National Risk Index, Vulnerability and Consequence Profiles, and Key Planning Issues.

Multi-Hazard Exposure Assessment

The Project Team conducted an exposure assessment for natural hazards that have spatial data available to better understand the geographic scope of hazards in San Francisco and the potential scale of impact. This assessment evaluated the exposure of assets across a broad range of sectors. The results of this assessment informed the subsequent components of the vulnerability and consequence assessment.

FEMA National Risk Index

The Project Team used this tool to compare the relative Expected Annual Losses (EAL) across different hazard types in San Francisco to better understand and communicate which hazards are the greatest drivers of risk.

Vulnerability & Consequence Profiles

The Project Team performed more in-depth risk assessment through the development of Vulnerability and Consequences Profiles for 29 asset classes across eight different sectors. The asset classes are described in Chapter 03 and the profiles can be found in Appendix A. To provide detailed risk assessment information on a large number of asset classes, the Vulnerability and Consequence profiles are focused on a limited set of hazards. The Project Team focused on ground shaking and liquefaction due to the high level of exposure across all assets and high level of risk (estimated $3.08 billion in 2018 dollars economic impact to General Fund facilities in San Francisco according to Hazus). The team also decided to focus on weather and fire-related hazards that are projected to become more severe due to climate change, namely flooding, extreme heat, and wildland-urban interface fire, and poor air quality.

The Vulnerability and Consequence Profiles include the results of an exposure analysis performed using Geographic Information System (GIS) and characterize vulnerability by identifying how an asset class will be affected by a hazard and the ability to adjust based on the following four categories:

- Physical: the conditions or design aspects that make assets particularly vulnerable
- Functional: the functions, roles, or relationships that make assets particularly sensitive or limit their ability to adjust to a hazard event
- Informational: challenges in obtaining the data and information necessary to sufficiently understand and/or manage vulnerabilities
- Governance: challenges with management, regulatory authority, or funding options.

The consequences assessment identifies broader impacts if an asset is damaged, or its function disrupted. Three categories of impacts have been identified:

- Society and Equity: impacts to health and safety, community networks, mobility, affordability, and workforce opportunities
- Economy: property and infrastructure damage, interruption of economic activity, and loss of revenue
- Environment: impacts to water, air, and/or soil, biodiversity, public access, ecosystem service benefits

Key Planning Issues

Key Planning Issues highlight the findings of the Vulnerability and Consequence Profiles, summarize the vulnerabilities found in the Multi-Hazard Exposure Assessment, and communicate issues that cut across multiple sectors, hazards, or geographies. The Key Planning Issues highlight significant and/or near-term vulnerabilities that require coordination between numerous asset managers, issues that may cluster in a particular geography, and vulnerabilities that require regulatory changes to solve. They are used to support the development of cross-cutting strategies and are described in section 5.3.

5.2 Multi-Hazard Exposure Assessment

In 2018 and 2019, the Project Team conducted an exposure assessment for any of the identified hazards that have a defined geographic spatial extent and high-quality spatial data available, often using publicly available data sources. In this context, exposure refers to the potential for an asset to experience a physical hazard, such as shaking from an earthquake or inundation from a coastal flood event. Exposure is estimated by analyzing the overlap between hazard areas and asset location. Table 5-1 describes the hazard scenarios and data sources used in the exposure assessment.

While the exposure analysis is from the previous update cycle, the city has conducted numerous assessments since then to deepen understanding of the hazards facing the community, these have been either more focused in geography or more specific in the assets assessed. The insights from these subsequent assessments, which often also included GIS analysis, were included in the updated key planning issues below which describe new identified vulnerabilities to assets. The assessment in 2018 and 2019 was comprehensive and assets have not shifted considerably over the 5-year update cycle. Most crucially, where new considerations have appeared, such as in the impacts of climate change on hazards, changes in population patterns, or changes in land-use and development, these have been updated throughout the plan where appropriate. These can be found particularly in Chapter 02, throughout this chapter, as well as Appendix A.

TABLE 5-1: HAZARDS AND SCENARIOS USED IN EXPOSURE ASSESSMENT

Hazard	Scenarios / Zones	Data Source
Groundshaking	San Andreas 7.8	USGS, ABAG (2018)
	Hayward 7.0	USGS, ABAG (2018)
Liquefaction	Liquefaction Zone	USGS (2018)
Landslide	Earthquake Induced Landslide Zone	USGS, California Department of Conservation (2018)
Tsunami	Inundation Zone	California Department of Conservation (2021)
Coastal Flooding	100-Year Coastal Flood Zone	FEMA National Flood Hazard Layer (2018)
	100-Year Storm + Mid-Century Sea Level Rise (~24 inches)	BCDC: ART Sea Level Rise Maps (2018)
	100-Year Storm + End-of-Century Sea Level Rise (~66 inches)	BCDC: ART Sea Level Rise Maps (2018)
Stormwater Flooding	100-Year Stormwater Flood	SFPUC 100-Year Storm Flood Risk Map (2021)
Reservoir Failure	Inundation Area	SFPUC (2018)
Wildfire	High	Cal Fire and Resource Assessment Program (2018)
	Moderate	Cal Fire and Resource Assessment Program (2018)

Exposure Summary

The Multi-Hazard Exposure Assessment includes exposure of overall population, households, critical response facilities, commercial parcels, and industrial parcels. This set of assets provides a high-level view of the potential impacts to the population and building stock, as of the last assessment at this scale in 2019. The findings have been integrated into the paragraph statements below, the vulnerability and consequence profiles in Appendix A, and the key planning issues in this chapter, where appropriate.

Limitations

Several hazards analyzed in Chapter 04 do not have spatial data available by which to analyze different levels of exposure, including extreme heat, poor air quality, and high wind. Furthermore, not all hazard exposure datasets account for the potential increase in risk due to climate change. As such, an exposure analysis is only one component of vulnerability and risk. To that end, the hazards analysis in Chapter 04 provides another qualitative lens and the Vulnerability and Consequences Assessment provided in Appendix A provides a second.

Seismic

Nearly every sector and asset in San Francisco would be exposed to violent or very strong ground shaking from a M7.8 earthquake on the San Andreas fault. In the event of a M7.0 earthquake on the Hayward fault, less of the population is exposed to very strong shaking but significant amounts of shaking are experienced by most of the city. A smaller subset of residents may also be exposed to liquefaction or landslide hazards. Over half of the City's industrial areas and almost a third of its commercial areas are located within liquefaction hazard zones. There are also a significant number of critical facilities located in liquefaction hazards zones.

Flooding

The SFPUC has developed a 100-Year Storm Flood Risk Map that shows areas of San Francisco where significant flooding from storm runoff is highly likely to occur during a 100-year storm. According to this mapping, thousands of residents could be exposed to stormwater flooding during a 100-year storm.

Projected sea level rise will worsen existing coastal flood hazards by increasing the elevation and frequency of flooding and extending the coastal flood hazard zone farther inland. Exposure to coastal flooding during a 100-year storm could increase by end-of-century due to sea level rise. Currently only a few critical facilities would be exposed to coastal flooding in a 100-year flood. However, this figure could increase by the end-of-century due to sea level rise. While exposure of commercial and industrial parcels to coastal flooding with mid-century sea level rise appears very limited, in raw numbers this represents hundreds of parcels that would be potentially inundated by mid-century.

National Flood Insurance Program (NFIP)-insured structures

San Francisco is a participant in the National Flood Insurance Program (NFIP), which is managed by FEMA and provides flood insurance for applicable properties based on a risk mapping process. The City has adopted a Floodplain Management Ordinance that is intended to reduce the risk of damage from flooding within the city and facilitate administration of this program at the local level. According to the National Flood Insurance Program Redacted Claims Dataset, San Francisco does not have any structures within the county that have been repetitively damaged.[1] However, there have been 15 claims in San Francisco through the NFIP program since records have been collected, none of which meeting the definition of repetitive damage properties.

Wildland-Urban Interface Fire

According to available CalFire mapping, a small percentage (approximately 1%) of San Francisco residents are exposed to moderate or high wildland-urban interface fire risk. For more information on where exposure occurs, please see Chapter 4.

[1] FIMA NFIP Redacted Claims Data Set: https://www.fema.gov/media-library/assets/documents/180374

5.3 FEMA National Risk Index

FEMA has produced a National Risk Index (NRI)[2] that can be used to identify communities that are most at risk to 18 natural hazards. The NRI is available at the county and census tract scales. This tool can help communicate comparative natural hazard risks, such as comparing the relative risk of hazards within a county, comparing census tract risks within a county, or comparing the county's risk to the rest of the nation.

The NRI includes expected annual loss (EAL), which estimates the average economic loss in dollars resulting from natural hazards each year.[3] The calculation considers exposure, annualized frequency of hazard events, and the historic loss ratio, representing the estimated percentage of an exposed building value, population, or agriculture value expected to be lost due to the natural hazard occurrence. In this way, the value captures both building/infrastructure economic loses, productivity losses to agriculture, as well as potential causalities. This is one measure that can help communities quantify the relative impact from different hazard events.

In San Francisco, the earthquake hazard is the highest driver of EAL by orders of magnitude greater than any other hazard (Table 5-2). Other hazards with relatively higher EAL include flooding, drought, and heatwaves. Wildfire, tsunami, and landslides represent the lowest three.

While this tool provides one snapshot of relative hazard impacts, there are important limitations to this dataset. The NRI uses historical data for hazard events, which may underrepresent future impacts due to climate change. For example, for the Flooding hazard, the NRI includes exposures from the Flood Insurance Rate Map (FIRM) and Special Flood Hazard Areas (SFHA) 1% annual chance and 0.2% annual chance flood areas. Flood risks in San Francisco are especially driven by sea level rise and this is not captured. For more information on climate-related hazards, readers should consult recent local risk assessments described in Chapter 2 or within the hazard profiles in Chapter 5.

[2] FEMA(2023). *National Risk Index: Technical Documentation.*
[3] FEMA (2024). *National Risk Index: Expected Annual Loss.* Retrieved from: https://hazards.fema.gov/nri/expected-annual-loss

Despite the limitations of this NRI, it provides one lens to consider relative risk in an environment where there are limited resources. Risk reduction benefit also plays a role in the prioritization of actions in Chapter 07.

TABLE 5-2:[4]
EXPECTED ANNUAL LOSS (EAL) BY HAZARD TYPE

Hazard Type	EAL Value
Earthquake	$300,947,723
Flooding*	$2,323,738
Drought	$2,081,313
Storm-related*	$646,291
Heat Wave	$482,150
Landslide	$164,743
Tsunami	$60,582
Wildfire	$10,746

Source: FEMA National Risk Index

5.4 Key Planning Issues

The Key Planning Issues highlight significant and/or near-term vulnerabilities that require coordination between numerous asset managers, issues that may cluster in a particular geography, and vulnerabilities that require regulatory changes to solve. The vulnerability statements were used to support the development of the Strategy Chapter (07). The Key Planning Issues are:

1. Existing Buildings
2. New Housing and Development
3. Communities at Increased Risk
4. Engagement and Capacity Building
5. Business and Workforce
6. Transportation
7. Water and Wastewater
8. Open Space and Biodiversity

[4] Asterisks represent hazard values that have been combined. Flooding includes Coastal Flooding and Riverine Flooding. Storm-Related combines Hail, Lightning, Strong Wind and Tornado values.

9. Communications and Power
10. Waterfront

The table below, Table 5-2, shows the legend for the hazard icons shown in each Key Planning Issue. The thirteen hazards addressed by the HCR Plan are displayed in a light gray tone in each Key Planning Issue. The icons displayed in a solid color indicate the hazard(s) that are applicable to a particular issue. The colors are associated with the primary hazard groups. The "All Hazards" group is indicated by displaying solid icons for all thirteen hazards.

TABLE 5-3: HAZARD ICON LEGEND

Earthquake	Tsunami	Landslide	Dam or Reservoir Failuure	Flooding	High Wind	Extreme Heat	Drought	Large Urban Fire	Wildfire	Poor Air Quality	Pandemic	Hazardous Materials
Geological				Weather-related				Combustion-related			Biological / Toxic	

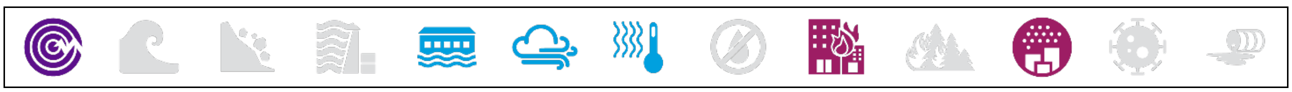
Existing Buildings

San Francisco has a relatively older building stock, with nearly half of housing units constructed before 1940, and numerous barriers exist to improving their resilience. Many older buildings were designed before engineers understood certain types of seismic vulnerabilities and are not designed to be resilient to increasing climate hazards, such as extreme heat, poor air quality, and flooding. These hazards will put additional stress on San Franciscans that are already under pressure from the housing crisis (affordability, crowding, displacement) and the overall high cost of living.

<u>Geographies</u>

- Citywide

<u>Hazards</u>



<u>Sectors</u>

Sector	Asset Class
Housing	Single-Family, Multi-Family, Subsidized Affordable
Business & Industry	Commercial, Industrial, Maritime
Public & Community Services	Municipal Buildings, Educational Facilities, Community Health Facilities
Emergency Response	Critical Response Facilities, Other Emergency Sites

<u>Vulnerabilities</u>

- Seismic building codes are designed for life safety rather than recovery, so repairs and re-occupation following an earthquake may take an extended period of time.
- Older soft-story, non-ductile concrete, tilt-up, and steel buildings that have not been retrofitted may be vulnerable to damage or collapse in an earthquake.
- The City lacks comprehensive data on the seismic vulnerability of privately-owned buildings, including those that have performed seismic retrofits.
- Private schools are not required to be upgraded to the same earthquake standard as public schools.

- Evaluations of municipal buildings have found many to be Seismic Hazard Rating (SHR) 4. Sixteen buildings are rated SHR4, including three shelters.
- Models predict that in a magnitude 7.8 San Andreas earthquake, 18,300 residential buildings could be damaged in San Francisco, temporarily or permanently displacing 20% of all households.
- Nearly 12,000 multi-family units are exposed in both the 100-year stormwater flood zone and coastal flood zone with 24” of sea level rise.
- Most buildings are not built to withstand any amount of flooding.
- Historic buildings/districts often have preservation-related design restrictions, so changes to improve resilience may be limited or most costly. Damage could lead to permanent loss of unique historic resources and impact tourism.
- Older, un-weatherized buildings (typically also without air conditioning) can lead to unhealthy conditions for occupants during extreme heat events.
- There is no comprehensive resilience design code, especially for climate hazards, and the associated costs/benefits.
- Large urban fires following earthquakes are a concern for existing buildings due to damage to natural gas infrastructure and other potential ignition sources.
- Currently, the majority of low-income renters and homeowners (< 80% adjusted median income (AMI) are housing cost burdened (> 30% of income spent on housing).
- The share of subsidized affordable housing exposed to flooding hazards is higher than market rate housing. The SLR vulnerability zone (66 inches) contains over 4,000 subsidized affordable units. The loss of affordable housing can also lead to the loss of services located in housing, such as residential care facilities for the elderly and childcare.
- Renters cannot easily make improvements to their units that would make them more resilient to hazards.
- The Port has several piers with under-pier utilities that are at risk from storm events and sea level rise. As water levels rise, the window for maintenance and replacement work decreases, while damage to and disruption of the utilities increases.

New Housing and Development

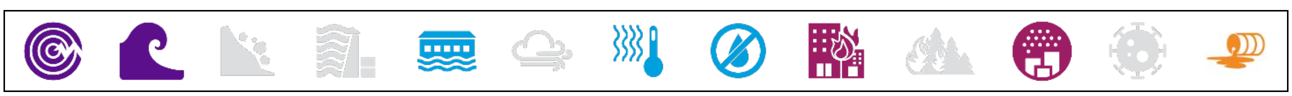
To accommodate a growing population, major development projects are planned or underway in areas that may be exposed to hazards, including coastal flooding and liquefaction. See section 3.2 for a summary of new development and related mitigation actions. New construction is built to modern building code standards and development projects can finance resilient infrastructure improvements such as elevated shorelines. Therefore, new development in San Francisco is often more resilient than older buildings and neighborhoods. However, building codes do not always consider future climate hazards and are designed for life safety rather than rapid recovery in an earthquake. In addition, surrounding infrastructure such as transportation and utilities may remain vulnerable, potentially impacting current and future residents and businesses.

Due to changes in state laws, there has been a recent emphasis on increasing housing development in "high opportunity" neighborhoods on the west side of the city, which also happen to be less vulnerable to some hazards. Where and how to develop new housing remains a pressing issue and is likely to be the guiding force for development in the foreseeable future.

Geographies

- Citywide
- Particularly: Mission Bay/SOMA (Downtown), Bayview Hunter's Point (Southeast), Waterfront, Treasure Island

Hazards



Sectors

Sector	Asset Class
Public and Community Services	Housing
Population	Communities at Increased Risk
Business and Industry	Industrial, Commercial

Vulnerabilities

- The seismic building code focuses on life safety rather than recovery. As a result, even new buildings may be damaged in a major earthquake and may not be occupiable while repairs are made.
- Without adaptation, shoreline development could be exposed to flooding due to sea level rise. Potential impacts include temporary damage to buildings and infrastructure during storms or permanent inundation. However, new shoreline development projects include resilience strategies, including elevating the shoreline and development areas to protect to at least 2050 projected sea level rise (SLR) and adaptive management strategies to further protect communities to 2100 and beyond, pending monitoring and new science.
- New developments along the Bay shoreline may be designed to accommodate flooding due to SLR through elevation/construction methods, but the existing transportation and utility systems that service them may not be resilient in their current condition resulting in potential loss of infrastructure service.

Some development sites with legacy contamination due to military and/or industrial uses will need to undergo analysis, including vulnerability to sea-level rise and groundwater rise, and remediation prior to development to avoid potential exposure.

- New development may increase demand for water supplies. To mitigate this potential impact, new development is constructed with high efficiency water fixtures, native and drought tolerant landscaping, and recycled water systems.
- New development may increase the demand for post-earthquake firefighting water supplies. The Emergency Firefighting Water System 2050 Planning Study recommended increasing conveyance capacity and geographic coverage of the EFWS based on 2050 population estimates. New developments requiring

infrastructure upgrades are also required to expand or upgrade the EFWS pipe network. This has occurred in Mission Bay, Pier 70, and other locations.

- New development is built to modern building code standards and feature tighter building envelopes and other features that would represent increased resilience to poor air quality.
- Construction costs are extremely high in San Francisco, which impacts the affordability of housing. Any new code requirement for resilience needs to consider the societal costs and benefits.
- Sixty percent of subsidized affordable housing units are located in 5 neighborhoods: Bayview Hunter's Point, Mission, South of Market, Tenderloin, and Western Addition. However, the recently updated housing element and associated proposed re-zoning would allow for more development to occur in less hazard prone neighborhoods with greater adaptive capacity.

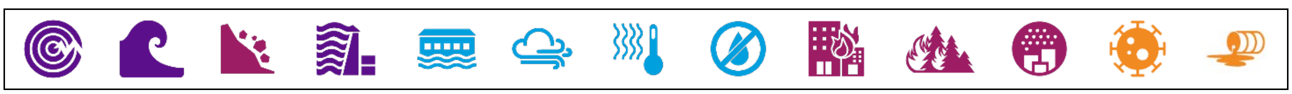
Communities at Increased Risk

Numerous factors contribute to communities being at increased risk including socioeconomic and demographic factors, housing quality and living conditions, community characteristics and social cohesion, and pre-existing health conditions. Appendix A includes a detailed breakdown of demographics by neighborhood and Section 3.3 includes a summary of changes in San Francisco's population patterns, including an increase in the number of people experiencing homelessness and an overall increase in the elderly population. Existing policies and programs often do not adequately consider these factors and their influence on climate resilience or hazard mitigation. This is particularly impactful for people who are unsheltered, in unstable housing situations, and renters.

Geographies

- Citywide
- Particularly: Bayview Hunters Point, Chinatown, Excelsior, Japantown, Mission, Ocean View-Merced Heights-Ingleside, Outer Mission, Potrero Hill, SOMA, Tenderloin, Treasure Island, Visitacion Valley, and Western Addition

Hazards



Sectors

Sector	Asset Class
Population	Communities at Increased Risk

Vulnerabilities and Potential Impacts

All Hazards

- Infants and children are particularly vulnerable to hazards due to physiology as well as reliance on caregivers. Neighborhoods with the highest proportion of children are Presidio, Sea Cliff, Bayview Hunters Point, Visitacion Valley, Portola, Glen Park, Excelsior.

- Seniors and older adults are also at increased risk of morbidity and mortality from hazard events because they are more likely to have chronic health conditions, mobility constraints, and socially isolated. Neighborhoods with the highest counts of seniors include Sunset/Parkside, West of Twin Peaks, Outer Richmond, Excelsior and Mission.
- Due to historical and current oppression, numerous racial and ethnic groups are at increased risk to impacts from hazards and climate change. These groups are also concentrated in particular geographies within the city.
- Income and poverty impact the adaptive capacity of any given community, with communities in poverty having less resources to adapt to climate change impacts.
- San Francisco has a notably large unhoused population as a proportion of the total population. Unhoused folks are much more likely to have other conditions that reduce their adaptive capacity as well as having greater exposure to hazard events.
- Social isolation is an influential factor in predicting who will be most impacted by hazard events. A lack of robust social network, participation in group activities, or access to networks of support can significantly impact health and potential outcomes and this is particularly true for certain hazards like extreme heat.
- Communities with limited English proficiency can face barriers in accessing community based social services.
- Housing costs and rent burden can increase turnover from evictions and magnify issues of social isolation, leaving communities less able to cope when hazard events occur.
- Pre-existing health conditions can impact people's ability to access resources during a hazard event or lead to them having increased sensitivity when these events occur.
- The communities that are most sensitive to climate and hazard impacts are often those who face significant barriers to accessing emergency preparedness and response resources.

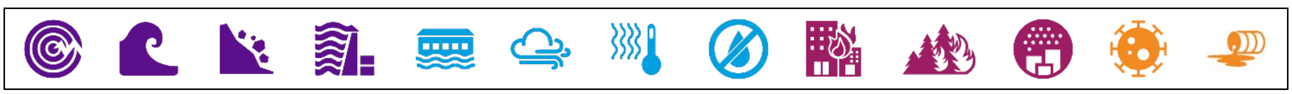
Engagement and Capacity Building

Residents, workers, and businesses may not have access to information about current and future hazards and climate change impacts, how the City is working to increase resilience, and how they can participate, prepare, and benefit. Strong relationships within neighborhoods, at the block level, and even within large multi-unit buildings can ensure that residents stay safe during and following a hazard event. However, the resources, connections, and skills of community-based organizations, local businesses, local and regional agencies needed to leverage this support can be difficult to develop.

<u>Geographies</u>

- Citywide

<u>Hazards</u>



<u>Sectors</u>

Sector	Asset Class
People	General Population, Communities at Increased Risk
Emergency Response	Critical Response Facilities, Other Emergency Sites

<u>Vulnerabilities</u>

- San Francisco has experienced an increase in extreme weather events, highlighting the importance of preparedness and public communications strategies.
- The lack of timely information may lead to avoidable health impacts.
- Emergency services may be strained if residents have not been empowered to help themselves during a hazard event.
- Avoiding conflicting messaging for different hazards that are likely to occur concurrently is a challenge.
- Residents receive information from a variety of sources, including TV, radio, print media, social media and word-of-mouth. Understanding these platforms and

networks, particularly culturally specific platforms, is essential to effectively communicate.

- There is also a nexus between populations that face greater vulnerabilities to hazards and climate change but are less likely to receive information about how to respond during hazard events.
- Specific populations require tailored communication strategies in order to be effective. This is in tension with available resources for communication and engagement work.
- Community-based organizations provide critical services and often directly interface with residents as a trusted point-of-contact, but often lack resources to invest in hazard mitigation and emergency preparedness. This is particularly true for smaller organizations.
- Volunteer resident emergency response networks often provide one-time training. Developing more robust, on-going networks requires additional resources.
- The City's complex public decision-making processes can make it difficult and time-consuming for many people to participate in processes that stand to directly impact them. Even when people can participate, there is often deep-seated skepticism about whether their feedback will be incorporated.

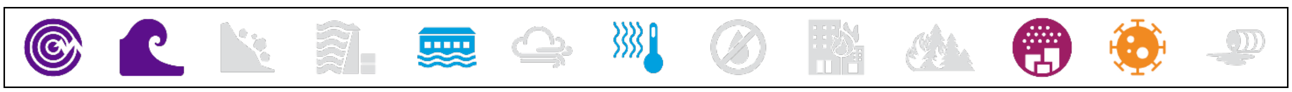
Business and Workforce

Many businesses don't have the resources to invest in hazard mitigation actions and are dependent upon building owners to invest in mitigation. Many businesses, especially smaller ones, can't withstand disruption from a hazard without support. In addition, a missed paycheck for a lower-income worker puts severe strain on ability to pay for housing and other essential needs. This can have a cascading effect in the event of a hazard with implications for the long-term recovery and vulnerability of the broader community.

Geographies

- Citywide
- Particularly: Downtown, SOMA, Financial District, Bayview, Waterfront

Hazards



Sectors

Sector	Asset Class
Business and Industry	Commercial Buildings, Industrial Buildings, Maritime

Vulnerabilities

- Downtown is vulnerable to long-term disruption due to damage to tall buildings from a large seismic event. This disruption could extend not just to the businesses housed in these buildings but also to nearby neighborhoods, including associated housing, employment, and economic opportunity.
- The Downtown economy was significantly impacted by COVID-19 stay-at-home orders and subsequent remote work policies, with high commercial vacancy rates and loss of small businesses that serve office workers.
- As experienced with COVID-19, a pandemic can have profound disruptions for businesses and workers, with many requiring public assistance.
- It is unknown how many businesses have performed advance planning to ensure continuity of operations if a hazard event occurs.

- By late-century, at least 1,000 commercial and industrial parcels could be inundated due to sea level rise.
- San Francisco's industrial buildings are concentrated in areas built on bay fill, which are susceptible to flooding and liquefaction in an earthquake.
- San Francisco has an estimated 650 older tilt-up buildings, which are vulnerable to damage in large earthquakes. These buildings provide important neighborhood services and are worksites for thousands of employees.
- San Francisco has an estimated 2,600 non-ductile concrete buildings, which are vulnerable to damage in large earthquakes. Damage to even one tall concrete building could cause rippling disruption to the neighborhood and adjacent infrastructure.
- People who work outside are particularly vulnerable to health impacts from extreme heat due to high exposure.

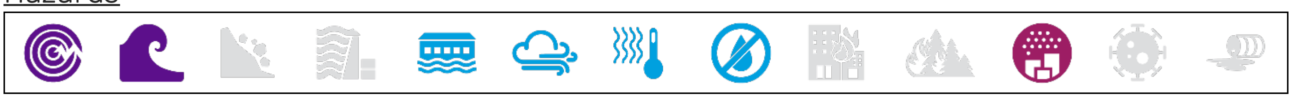
Transportation

On a daily basis, and in response to and recovery from a hazard event, San Franciscans depend on reliable, affordable, and accessible transportation. In addition, the functionality of many City and community assets depends on transportation access. Critical transportation assets are vulnerable to current and future hazards and impairment could have citywide or regional consequences. These considerations relate to the city's climate goals of achieving 80% sustainable trips (walking, biking, public transit) in a world with more frequent and disruptive climate hazard events.

Geographies

- Citywide

Hazards



Sectors

Sector	Asset Class
Transportation	Roadways, Public Transit, SFO, Water-Based Transportation

Vulnerabilities

- Residents depend on public transit for access to critical facilities during and after a hazard event.
- Current roadway flooding impacts safety and access for bicyclists, pedestrians, and motorists. This issue may become more severe in the future with SLR and intense precipitation events.
- The transportation network faces exposure to flooding near creeks, including Mission Creek and Islais Creek.
- Embarcadero Station and parts of Muni T-Third and Caltrain may be exposed to future flooding due to SLR. MUNI Metro East light rail and Ocean Blvd see current impacts from King Tides and winter storm flooding.

- Embarcadero roadway is currently subject to flooding during King Tides and flooding will become more frequent and severe due to future SLR.
- Embarcadero roadway is also subject to significant seismic risk. A Loma Prieta scale earthquake would lead to loss of roadway transportation use for up to a year.
- Air quality and extreme heat events impact biking, walking, and transit use due to health concerns.
- Roadways and transit equipment/facilities are vulnerable to damage from liquefaction, especially if underground utilities and fuel tanks are damaged; damage to SFMTA maintenance facilities can also impact transit operations.
- Debris and interruptions of overhead wires and power sub-stations from earthquakes and high winds may impact roadway accessibility and transit function.
- BART access to SFO may see disruption in a strong shaking event and some SFO terminals may be vulnerable to damage if they have not been recently seismically retrofitted. Runways may be vulnerable to liquefaction and strong shaking damage as well.
- Bridges have limited redundancy. Third Street, with two bascule bridges that may be exposed to future flooding due to SLR, is one of the primary north-south corridors in the southeast.
- Even if bridges are seismically retrofitted, their approaches may be damaged in a major earthquake.
- Access to ferries may be impacted by liquefaction damage in an earthquake. This may affect emergency response efforts. Electrification of the transportation sector may create vulnerabilities in the case of a loss of power / blackout.
- SFO faces a threat from SLR to some of its facilities, including runways and buildings that house critical functions.
- Some MTA facilities are outdated for current needs and subject to impacts from multiple hazards. These include many centralized municipal maintenance yards that are outdated and face combined flood vulnerabilities.
- Electrification of the transportation sector may reduce vulnerabilities related to fossil fuel dependency. while also introducing new vulnerabilities related to the electric grid dependency.

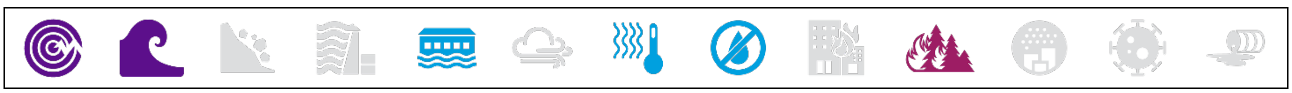
Water and Wastewater

Water and wastewater utilities are critical for the daily needs of households and businesses and protecting water quality. Disruption can have significant consequences for public health, ecosystem health, and the economy. The SFPUC has made significant improvements, and more are planned/underway through Sewer System Improvement Program (SSIP), Water System Improvement Program (WSIP), and the Emergency Firefighting Water System (EFWS). Even with major improvements, elements of these utility systems will remain vulnerable to hazards. For some systems, there are limited alternatives and redundancies so reducing damage and disruption is critical.

<u>Geographies</u>

- Citywide

<u>Hazards</u>



<u>Sectors</u>

Sector	Asset Class
Utilities and Infrastructure	Combined Sewer, Potable Water, Emergency Firefighting Water System (EFWS)

<u>Vulnerabilities</u>

- The combined sewer and potable water systems may be vulnerable to future coastal flooding due to sea level rise, particularly sensitive assets in low-lying areas.
- Stormwater/wastewater, potable water, EFWS and other utility systems (including reservoirs) may experience damage during a significant earthquake event.
- The regional potable water system is vulnerable to impacts from drought event primarily due to reduced reservoir levels.
- Wildfire is a threat to the regional potable water system, predominantly in the out-of-county assets managed by the SFPUC.

- Earthquakes and climate change-driven storms may present challenges for regional reservoir systems.
- Wastewater transport and storage boxes along Ocean Beach are vulnerable to impacts from coastal erosion and sea level rise.
- Impacts to underground utility infrastructure are expected to increase due to emergent groundwater rise.

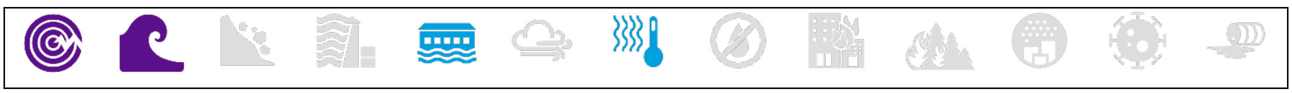
Open Space and Biodiversity

95% of San Francisco's land area has been developed and its remaining natural heritage is in a precarious state due to the ongoing challenges of invasive species, urban growth, pollutants, the effects of climate change, and other human impacts. Nature-based solutions weave natural features and processes into a community's landscape through planning, design, and engineering practices.[5] They can promote resilience and adaptation while being integrated into a community's built environment or its natural areas. While nature-based solutions have many hazard mitigation benefits, they can also help a community meet its climate, social, environmental, and economic goals.

Geographies

- Citywide

Hazards



Sectors

Sector	Asset Class
Open Space	Parks and Open Space

Vulnerabilities

- Without action, coastal flooding due to sea level rise could eventually drown shoreline habitats resulting in the loss of critical ecosystem services and biodiversity. Flooding can negatively impact planted areas and trees and saltwater flooding is especially damaging to planted areas.
- Recreation facilities need on-going management to ensure wildfire prevention in larger park areas.

[5] FEMA, 2021. "Building Community Resilience with Nature Based Solutions: A Guide for Local Communities." https://www.fema.gov/sites/default/files/documents/fema_riskmap-nature-based-solutions-guide_2021.pdf

- Approximately 95% of San Francisco has been modified due to urban expansion and its remaining natural heritage is in a vulnerable condition. The environmental integrity of these open spaces is under constant threat from invasive species, urban development, pollutants, climate change and other human impacts, making active management essential.
- Pressures from development (either through accidental damage to vegetation or land-use conversion) can contribute to a loss of tree canopy. This can subsequently reduce the biodiversity of these areas and the associated benefits they provide.
- Biodiversity provides vital ecosystem services that the City relies on for hazard mitigation and climate adaptation and is facing a global crisis.
- As storms have become more intense and carry more precipitation in recent years, the number of trees downed by wind has increased. This has implications for maintaining and increasing the City's urban tree canopy as an adaptation to increased extreme heat events.
- Climate models project changes in precipitation distribution, potentially impacting water supplies and ecosystems. This includes increased water quality issues from silt, sand, and pollution flowing in the bay.
- Racially motivated, historic disinvestment has led to communities of color having less access to green space and tree canopy coverage, which contributes to disproportionate climate and health impacts.

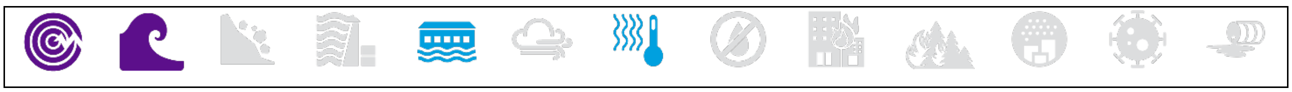
Communications and Power

Functioning power and communications systems are critical for response and recovery following a disaster. Additionally, many other systems are dependent upon power and communications. Hardening these systems is not only essential to reducing potential disruptions, but it can also be life or death for residents that rely on power for medical devices. In addition, as the buildings and transportation sectors transition away from fossil fuels and to electric power, new vulnerabilities may arise that need to be mitigated.

Geographies

- Citywide

Hazards



Sectors

Sector	Asset Class
Utilities and Infrastructure	Power, Natural Gas, Communications

Vulnerabilities

- Electrical substations are the weak link to the network as they can be impacted by a wide range of hazards. While data is currently limited, at least one substation is potentially exposed to coastal flooding by sixty-six inches of projected SLR.
- In the past, increased demand on power systems statewide due to heat events can lead to blackouts in parts of San Francisco.
- Some important facilities do not have adequate backup power sources to maintain operations during blackout conditions.

- Access to adequate supply of diesel fuel for backup power generation will be a challenge in the long-term following significant hazard events. Additionally, triaging the distribution of this limited fuel during an event will require thoughtful planning.
- Many systems are dependent upon communications, including internet.
- Damage to natural gas infrastructure can lead to an urban conflagration.
- Compared to other utilities, water and natural gas systems have relatively longer restoration timelines following an earthquake due to complex reconstruction needs.
- The electric power grid is currently strained during extreme heat events. These events are projected to increase in the future, potentially leading to brownouts or blackouts.
- Hydroelectric power is a key source for San Francisco and with increased and/or persistent drought, there could be impacts to efficiency of power generation.
- Public transit is highly dependent on electric power for its operation.
- As buildings and transportation sectors increasingly electrify to reduce dependence on fossil fuels, they may experience increased disruption during power outages.
- The Hetch Hetchy Power System is vulnerable to wildfires as it crosses through very high wildfire hazard areas in the Sierra Nevada mountains and foothills.

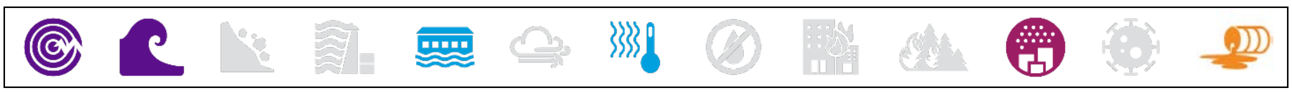
Waterfront

San Francisco's waterfront communities may be exposed to multiple hazards, including increasing flood risks due to sea level rise, liquefaction, and tsunami. The waterfront includes a mix of densely populated neighborhoods (existing and planned), vulnerable populations, and critical infrastructure, including transit, shoreline protection, and stormwater/wastewater. Damage or disruption to waterfront assets and communities could have citywide or regional consequences.

Geographies

- Particularly: Embarcadero/Financial District, Mission Bay, Islais Creek, Bayview, and Ocean Beach

Hazards



Sectors

Sector	Asset Class
Emergency Response	Other Emergency Facilities
Transportation	Public Transit, Roadways (including bridges), SFO, Water-Based Transportation
Utilities & Infrastructure	Stormwater/Wastewater, Shoreline Protection
Housing	Multi-family, Affordable
Business & Industry	Commercial, Industrial, Maritime

Vulnerabilities

- The legacy of building on bay fill makes some parts of the waterfront more susceptible to seismic and flooding hazards.
- Co-location of historic pile supported structures and weak soil behind and under the seawall poses significant seismic challenges. Until the Seawall Safety Program undertakes improvements, the seawall remains seismically vulnerable, which has implications for nearby utilities, transportation assets, and buildings.

- A daytime severe seismic event would put as many as 40,000 people at risk within Port property alone due to high occupancy uses combined with high collapse risk.
- Older, timber-pile-supported structures in Fisherman's Wharf are at high risk as well.
- Current and former industrial uses of waterfront areas can lead to issues around soil contamination and hazardous materials. Sea level rise may exacerbate these issues.
- Transportation and utilities especially face exposure to flooding near creeks, including Mission Creek and Islais Creek.
- The efficacy of several stormwater outfalls may be vulnerable to flooding due to SLR.
- Currently, approximately 1,400 people would be exposed to coastal flooding during a 100-year flood.
- Embarcadero Station, T-Third, and Caltrain may be vulnerable to future coastal flooding due to SLR.
- Embarcadero roadway is currently subject to flooding during King Tides and flooding will become more frequent and severe due to future SLR. It is also subject to significant seismic risk. A Loma Prieta-scale earthquake would lead to loss of roadway transportation use for up to a year.
- Waterfront segments between Pier 7 and Rincon Park currently fall below the 100-year flood protection standard.
- With 1 foot of sea-level rise the Embarcadero roadway and surrounding buildings near the foot of Market Street will be significantly inundated during a 100-year extreme tide.
- At just over 2 feet of sea-level rise with a 100-year flood, the Embarcadero roadway and promenade would experience widespread overtopping of the shoreline cutting off landside access to all Port facilities.
- Staging areas and transportation assets along the waterfront play a critical role in emergency response after a major hazard event.
- Emergency Firefighting Water System (EFWS) manifolds are vulnerable to SLR and critical for fire response in these neighborhoods.
- Wastewater infrastructure is vulnerable to erosion events at Ocean Beach.

Chapter 06

Capabilities Assessment

Southeast Community Center

This chapter describes San Francisco's existing authorities, policies, programs, and resources to advance resilience. It also provides an assessment of opportunities for expansion or improvement of those capabilities. Section 6.1 describes the City's roles in mitigation, activities underway, and future opportunities. Section 6.2 provides an update to the actions identified in the 2020 Hazards and Climate Resilience Plan. This chapter highlights capabilities and resources to mitigate hazards and set the stage for the actions detailed in Chapter 07.

Background

San Francisco has a long history of learning from natural disasters. As a result, the City has developed extensive codes, policies, programs, projects, and studies that are recognized around the globe. For example, the Emergency Firefighting Water System (EFWS) that was designed before, but constructed after, the Great Earthquake of 1906, when over 80 percent of San Francisco was destroyed. EFWS was used 83 years later when the fireboat and other aspects of the system were needed put out large fires resulting from collapsed soft-story buildings and broken gas mains from the Loma Prieta Earthquake. As a result of those collapsed buildings, San Francisco implemented a mandatory soft-story retrofit program that was completed in 2022. The program dramatically improved the safety of over 54,600 buildings, benefiting more than 111,000 residents.

Other programs put in place after the 1989 Loma Prieta Earthquake include over $20 billion in capital improvements, a completed Unreinforced Masonry Building retrofit ordinance, regularly updated building codes, performance-based design for tall buildings, and community-based resilience hubs that cover a large portion of the city. The work to prepare for the next big earthquake continues, such as addressing seismically vulnerable concrete buildings.

San Francisco has also been aggressive in its efforts to adapt to the impacts of climate change. These include capturing rainwater and reducing runoff, restoring natural areas, planting trees, preserving biodiversity and open space, developing resilience efforts for the entire waterfront, and creating an Environmental Justice Framework for the General Plan, ensuring policies address legacies of environmental racism. The city also recently completed a first-of-its-kind Heat and Air Quality Implementation Plan that seeks to identify and address the public health impacts of extreme heat and wildfire smoke in San Francisco. This plan provides a framework to address current local extreme heat and wildfire smoke events while preparing for future ones.

Further detail on these capabilities can be found in the following section.

6.1 SF Government Activities

The City and County of San Francisco plays a variety of roles with respect to how it develops and implements measures to increase resilience to hazards. These roles are categorized under five areas:

1. Funding and Finance
2. Public Asset Owner
3. Community Services Delivery
4. Research, Planning, and Guidance
5. Adoption and Enforcement of Regulations

The following describes the capabilities under each of these areas and includes examples. A comprehensive list of each capability is available in Appendix C.

Funding and Finance

Given that San Francisco is one of the most expensive places in the world to live and build, the ability to have strong funding and financial mechanisms is critical to San Francisco's mitigation efforts. The City's 10-Year Capital Plan and its 5-Year Financial Plan lay the foundation for hazard mitigation and climate adaptation funding. The Capital Plan establishes policies to fund large- and small-scale projects and incorporates life-safety, resilience, and sustainability in its core funding principles. The Financial Plan lays out policies to meet San Francisco's obligations and ensure sufficient rainy-day reserves and financing is available in the case of a large disaster or other emergency. These tools have helped San Francisco improve its infrastructure while maintaining the highest bond ratings possible.

The Office of Resilience and Capital Planning (ORCP) that is part of the City Administrator's Office oversees the 10-Year Capital Plan. ORCP updates the Capital Plan every odd numbered year. The FY 2024-2033 Capital Plan projects $41.4 billion in city investments . The 5-year Financial Plan is jointly developed by the Controller's Office, the Mayor's Budget Office, and the Board of Supervisor's Budget Analyst's Office. Like the Capital Plan, they update the Financial Plan every odd-numbered year.

Both the Capital Plan and the Financial Plan use a wide range of revenue sources for infrastructure and services. The most common sources are general fund revenue, general obligation bonds, certificates of participation, revenue bonds, general taxes, fees, and grants. Descriptions of these revenue sources can be found in Appendix C, Table C-1.

Opportunities for Expansion/Improvement

Despite a large economy, the City and County still has unfunded needs. For example, the Capital Plan defers $6.67 billion in identified needs from General Fund departments. In addition, the capital investment needs to achieve net-zero greenhouse gas emissions and adapt to climate impacts extend beyond the scale of existing local revenue sources. In an environment where needs exceed public funding capacity, developing innovative financing mechanisms is necessary.

The City can consider expanding financial incentives for private investment in mitigation actions. The City currently offers Property Assessed Clean Energy (PACE) financing for soft-story retrofits and will need to consider additional financial incentives and programs for future mitigation and retrofit efforts.

A current opportunity for expanding funding for climate resilience are competitive grant programs coming from the federal Infrastructure Investment and Jobs Act (IIFA) and Inflation Reduction Act (IRA). For example, the Mayor's Office of Housing and Community Development and Environment Department are considering how to leverage new financial products from the Inflation Reduction Act to rehabilitate affordable housing to be more sustainable and resilient. City departments and community stakeholders are working to position resilience the city's needs for these funding opportunities.

Public Asset Building and Maintenance

As an owner and builder of buildings and infrastructure, San Francisco has strong programs, mechanisms, and staff expertise to design, develop, construct, and maintain its assets. The buildings (vertical assets) range from public restrooms to complex hospitals and sewer treatment facilities. The infrastructure (horizontal assets) range from local streets to regional water delivery and transportation networks. Taking care of our capital infrastructure is an important part of building a resilient city. The City and County of San Francisco strives to maintain and improve existing assets and design new ones to withstand future hazards and serve the public's needs no matter what kinds of chronic stresses or acute shocks they face.

An example of San Francisco's mitigation capabilities for its buildings includes the Neighborhood Fire Stations Program, which addresses the most urgently needed repairs and retrofits to critical firefighting facilities and infrastructure. This program is funded by Earthquake Safety and Emergency Response (ESER) General Obligation Bonds that are placed on the ballet every six years or so.

An example of San Francisco's mitigation capabilities for its infrastructure is the Sewer Safety Improvement Program, a 20-year $7 billion citywide investment to upgrade San Francisco's aging sewer infrastructure to ensure a reliable, sustainable, and seismically-safe sewer system for generations to come. This program is funded with revenue bonds. Descriptions of these and other public asset maintenance and building programs can be found in Appendix C, Table C-2.

Opportunities for Expansion/Improvement

The City and County can continue to retrofit vulnerable assets, especially for impacts that are new or increasing, such as sea level rise, extreme heat, and poor air quality.

Secondly, climate adaptation projects involve multiple agencies and complex improvements that anticipate future changes to the environment. The City and County will increasingly need to coordinate complicated multi-agency adaptation projects, such as the Waterfront Resilience Program and Ocean Beach Climate Change Adaptation. The City can research and pilot innovative project delivery and governance systems such as a Joint Benefits Districts.

Community Services Delivery

The City and County of San Francisco offers many services to help residents reduce their vulnerability before and after a natural disaster. These services include increasing public awareness of hazards and empowering communities to care of and advocate for themselves.

The San Francisco Homeless Outreach Team is a collaboration between the Department of Homelessness and Supportive Housing and Department of Health Street Medicine Team. The program aims to engage and stabilize the most vulnerable and at-risk homeless individuals and to help prevent the harmful effects of homelessness. Through outreach, medical services, engagement, and advocacy, the program is dedicated to transitioning individuals into stable living and healthcare environments with access to services that promote greater health and housing retention, and reduce vulnerability and the need for emergency services.

The Department of Emergency Management launched the Extreme Weather Resilience Program in 2023. This program will establish a network of culturally competent community-based organizations and equip them to maintain services during extreme weather events such as heat waves or poor air quality events due to wildfire smoke. These groups will stay open during events and offer shelter to their constituents.

Descriptions of these and other community services can be found in Appendix C, Table C-3.

Opportunities for Expansion/Improvement

The City can continue to improve the resilience of the facilities that provide services to vulnerable populations, such as shelters, subsidized affordable housing, and clinics. City can also consider ways to increase the resilience of leased facilities, such as public health clinics. There are also new State and federal grant opportunities for community-based resilience hubs that could support the provision of community services before and during an emergency. The City can help build capacity or coordination among departments and community organizations to secure those resources. Furthermore, the City can also do additional planning for communities facing increased exposure or sensitivity to extreme weather events. Pairing this planning with increases in staffing capacity, such as Disaster Service Workers, will help accommodate the potential for more frequent and extended emergency activations due to extreme weather.

Research, Planning, and Guidance

The City and County of San Francisco invests in innovative hazards and climate change research that directly inform policies, programs, and services. The City consistently strives to better understand the local impacts of hazards and climate change, such as sea level rise and extreme heat, given San Francisco's unique local characteristics including a highly developed bay shoreline, dense urban form, and old and historic building stock.

The Department of Public Health developed the Climate Health Program to develop solutions to support healthy and climate-ready communities. The Program has produced vulnerability assessments on heat and flooding and developed education and outreach materials.

Starting in 2014, and updated in 2015, 2020, The City and County of San Francisco developed Guidance for Incorporating Sea Level Rise into Capital Planning in San Francisco to provide direction to all departments on how to incorporate sea level rise into new construction, capital improvement, and maintenance projects. The guidance includes steps for assessing and adapting projects to the impacts of sea level rise. It helps project managers and others doing construction in San Francisco to apply the latest sea level rise projections and guidance from the State to their projects.

Published in 2011, the Community Action Plan for Seismic Safety (CAPSS) created a 30-year plan to mitigate the risk San Francisco faces from earthquakes. CAPSS studied four probable earthquake scenarios and found that they could devastate the city's housing stock and have long-term implications on the City's affordability to middle- and low-income residents. Hundreds of people could be killed and thousands injured. The price tag of earthquake damage would be many billions of dollars. Taking action before an earthquake strikes is far less costly than repairing the damage, both in terms of dollars required and the social impacts. The CAPSS advisory committee, a diverse group of San Francisco residents, met over 30 times to develop recommendations. CAPSS continues to be the guiding document for San Francisco's on-going efforts and is implemented through the Earthquake Safety Implementation Program (ESIP). This has included the recent launce of the Concrete Building Safety Program (CBPS) which will focus on identifying and strengthening vulnerable concrete buildings in the City.

Ecosystem restoration of land and water and urban forestry and greening with local native plant species are key strategies for supporting both biodiversity and climate resilience. San Francisco's Biodiversity Guidelines translate various local policies, as well as State, National and international biodiversity plans and policies, into concrete actions that support the City's biodiversity goals and the conservation and restoration of San Francisco's natural heritage. The intent of these guidelines is to support project managers to bring biodiversity into the built environment.

Descriptions of these and other research, planning, and guidance documents can be found in Appendix C, Table C-4.

Opportunities for Expansion/Improvement

As climate change impacts increase, research will continue to be essential to ensure that the City can be proactive. A major area of planning has been and will continue to be sea level rise planning. Capital planning guidance can be updated to reflect new science from Ocean Protection Council as described in Chapter 03 and expanded for additional climate stressors beyond sea level rise. The City also has the opportunity to fill gaps in adaptation planning for parts of the shoreline that were not included in the Army Corps Flood Study, such as parts of the Southern and Northern Waterfront, which will also support developing a countywide shoreline resiliency plan, which is now required as part of Senate Bill (SB 272) 272. Continuing to better understand combined flooding impacts, including groundwater rise, by watershed is also a research need as will be critical to the Army Corps Flood Study and SB 272.

The HAQR Project has also identified a number of research opportunities to better understand heat and air quality as issues facing San Francisco. Monitoring and evaluation of public health and building weatherization programs to understand their impact and benefit is also an area for expansion.

The City can also continue to follow the CAPSS work plan, moving into more complex vulnerable building types, such as non-ductile concrete, tilt-ups, and steel moment frame buildings, that will have their own research needs to develop policies and programs.

Additionally, implementation of planned projects often requires federal grant resources that require local matching contributions. This will impact the funding of other projects and complicates the process of moving projects from planning to implementation.

Adopts and Enforces Regulations

San Francisco adopts regulations that govern the construction of buildings, the form of urban development, and natural resource protection, among others. Regulations are one of the primary mechanisms the City has for achieving mitigation and adaptation of privately owned buildings. For example, San Francisco passed a Soft Story Retrofit Ordinance in 2013 which mandates retrofits to wood-frame buildings of two or more stories with five or more residential dwelling units built before 1978 that are vulnerable to potential collapse in an earthquake. This program improves the safety of nearly 5,000 buildings and more than 111,000 residents.

In 2012, San Francisco adopted the Onsite Water Reuse for Commercial, multi-family, and Mixed-Use Development Ordinance, commonly known as the Non-Potable Ordinance. This amended the health code to allow for the collection, treatment, and use of alternate water sources, such as graywater, rainwater, and foundation drainage, for non-potable applications in individual buildings and at the district scale. This is a mandatory requirement for all new construction of 250,000 square feet or more.

San Francisco is a participant in the National Flood Insurance Program. An updated Floodplain Management Ordinance was passed in 2021 which adopted the finalized maps establishing Flood Insurance Rate Maps (FIRMs) for the City. FIRMs identify special hazard areas facing inundation from a 100-year flood event. This regulation is essential to protecting buildings by allow them to participate in the regulatory flood insurance process.

Descriptions of these and other regulatory efforts can be found in Appendix C, Table C-5.

Opportunities for Expansion/Improvement

Building and planning codes could be improved to better accommodate flooding, extreme heat, and poor air quality. Additional service level standards for utilities and building performance standards in light of expected earthquakes can also be further developed. In a City where the cost of construction is extremely high, any additional regulations need to be carefully studied to understand potential impacts to housing costs and impacts to low-income owners and renters.

6.2 Status of 2020 HCR Actions

In order to assess progress on local mitigation efforts, the 2025 HCR update involved collecting and reviewing information from across City departments on the implementation status of actions from the 2020 HCR. As mentioned in the 2020 Plan Maintenance Chapter (08), the implementation status has been tracked and published in Annual Progress Reports available on the Hazards and Climate Resilience Plan webpage. The 2023 Annual Progress Report found that over three-quarters of the HCR actions have made notable progress. Table 6-1 summarizes the status of these projects as of the late 2023 and more detail can be found in the 2023 Annual Progress Report.

TABLE 6-1:
STATUS OF ACTIONS FROM 2020 HCR

HCR Strategy Code	Strategy Name	Status	Corresponding 2025 Update Strategy (or rationale for removal)
B-1.01	Assess and seismically retrofit municipal buildings	Progressing	B-1.1
B-1.02	Develop an earthquake risk improvement program for non-structural components of municipal buildings	Not yet started	B-1.1
B-1.03	Develop a voluntary program for seismic retrofits of one- to four-unit wood frame soft-story buildings	Progressing	B-1.1
B-1.04	Implement the Tall Building Strategy to address the seismic vulnerability of buildings taller than 250 feet	Progressing	B-1.3
B-1.05	Extend and Improve the Building Occupancy Resumption program (BORP)	Not yet started	B-1.3
B-1.06	Complete the Mandatory Soft-Story Retrofit program (pre-1978	Completed	N/A

HCR Strategy Code	Strategy Name	Status	Corresponding 2025 Update Strategy (or rationale for removal)
	buildings with 5+ units and 2+ stories)		
B-1.07.01	Develop a program (standards and guidance) to screen, evaluate and retrofit older steel buildings	Not yet started	B-1.2
B-1.07.02	Develop a program to screen, evaluate, and retrofit non-ductile concrete buildings	Progressing	B-1.2
B-1.08	Implement the SFMTA Parking Garage Strategy	No longer needed	This action has been folded into other capital planning processes
B-2.01	Develop multi-hazard resilience design guidelines for municipal buildings	Delayed	B-3.2
B-2.02	Review the Guidance for incorporating sea level rise into capital planning	On-going	B-3.1
B-2.03	Develop a program to analyze, identify, and evaluate properties at risk of stormwater flooding	Completed	B-3.3
B-2.04	Implement floodproofing and elevation projects for properties at risk of stormwater flooding citywide	Progressing	B-3.3
B-3.01	Study emergency clean air and cooling capacity at key community facilities	Progressing	B-2.2
B-3.02	Increase privately-owned building weatherization rates	Progressing	B-2.5

HCR Strategy Code	Strategy Name	Status	Corresponding 2025 Update Strategy (or rationale for removal)
B-3.03	Support increased building electrification (fuel switching) and mechanical upgrade	Progressing	B-2.5
B-5.01	Amend the capital improvement program for transportation facilities to consider hazard mitigation opportunities	Progressing	IN-3.1
B-5.02	Install solar and storage systems at critical facilities	Progressing	IN-1.1
B-5.03	Secure a resilient public safety training facility for San Francisco Fire Department (SFFD)	Progressing	B-1.1
B-5.04	Increase resilience and operation efficiency of maintenance yards	Delayed	B-2.1
B-5.05	Explore options to use Recreation Centers as public respite facilities	Progressing	B-2.2
B-5.06	Develop comprehensive and coordinated code amendments for multi-hazard resilience of private development	Progressing	B-3.3
C-1.01	Address seismic retrofit needs within San Francisco's affordable housing stock	Progressing	B-1.4
C-1.02	Develop a downtown resilience strategy	Modified significantly	Focus has been on economic recovery
C-1.03	Improve San Francisco's Implementation of the State's Safety Assessment Program	Not yet started	B-1.2

HCR Strategy Code	Strategy Name	Status	Corresponding 2025 Update Strategy (or rationale for removal)
C-1.04	Develop a post hazard open for business campaign	Progressing	Moving forward through other planning mechanisms
C-1.05	Continue to meet housing production goals (10,000 units by 2020)	On-going	C-6.1
C-1.06	Develop a public outreach campaign and wayfinding plan for tsunami awareness and evacuation procedures	Not yet started	C-4.4
C-1.07	Assess vertical evacuation options in high-hazard areas and guidance for large-building refuges	Not yet started	C-4.1
C-2.01	Conduct studies to better understand how sea level rise may interact with contaminated lands and potential health risks	Progressing	C-1.5
C-4.01	Expand household hazardous waste collection efforts	Progressing	C-1.7
C-4.02	Replace mercury-containing lighting in preschools and daycare centers	No longer needed	Not a high priority
C-4.03	Explore toxins abatement workforce development programs	Delayed	Not enough state and federal support
C-4.04	Improve citywide resilience to pandemics and infectious diseases	Progressing	C-4.5

HCR Strategy Code	Strategy Name	Status	Corresponding 2025 Update Strategy (or rationale for removal)
C-5.01	Identify and create Clean Air/Cooling Hub (CACH) Public Respite Facilities	Progressing	B-2.2
C-5.02	Develop a Homelessness Disaster Response Plan	Not yet started	C-4.3
C-5.03	Support volunteer emergency preparedness, response, and recovery programs including the Neighborhood Emergency Response Team (NERT).	Progressing	C-2.2
C-5.04	Create a program to coordinate existing City programs providing in-home and resident-facing services related to hazard and climate mitigation	Progressing	B-2.5
C-5.05	Develop a Preparedness Equipment Purchase Program to direct and fund the purchase of climate preparedness equipment	Progressing	B-2.2
C-5.06	Expand the Neighborhood Empowerment Network (NEN) Empowered Communities Program (ECP) to additional neighborhoods	Progressing	B-2.2
C-5.07	Perform Gap analysis of vulnerable populations (ie. Access and Functional Needs) and available city services	Not yet started	C-4.2
C-5.08	Develop Community Based Capacity Building Initiative	Not yet started	C-2.1

HCR Strategy Code	Strategy Name	Status	Corresponding 2025 Update Strategy (or rationale for removal)
C-5.09	Establish Evacuation Strategy for People with Access and Functional Needs	Progressing	C-4.1
C-5.10	Continue Small Business COOP Assistance	Progressing	C-5.1
C-5.11	Support the Small Business Development Center	Progressing	C-5.2
C-5.12	Establish disaster relief funding and small business resilience fund	Progressing	C-5.1
C-5.13	Expand layoff outplacement services	Progressing	C-5.2
C-5.14	Expand Women's Entrepreneurship Fund	Progressing	C-5.1
C-5.15	Study the overlap between vulnerable populations and vulnerable buildings	Progressing	C-3.4; B-1.2, B-2.5
C-5.16	Develop and manage a system for hazard and climate resilience data	Progressing	C-3.3
C-5.17	Develop a communications strategy for citywide climate resilience efforts	Completed	C-3.1
C-5.18	Improve San Francisco's climate health research capacity	Progressing	C-3.4
C-5.19	Develop and Implement a Centralized Air Quality and Extreme Heat Preparedness Campaign	Progressing	Work is occurring through other planning mechanisms

HCR Strategy Code	Strategy Name	Status	Corresponding 2025 Update Strategy (or rationale for removal)
C-5.20	Implement SFMTA's Traffic Signals Strategy	On-going	This action has been folded into other capital planning processes
C-5.21	Improve and prepare behavioral health services for hazard events	On-going	C-3.4
IN-1.01	Southern Waterfront Seismic Study	Completed	IN-6.2
IN-1.02	Conduct a research project for earthquake mitigation of marine structure piles	No longer needed	This is being completed by a University
IN-1.03.01	Develop technologies, systems, and capacity to treat sanitary sewage at SFO	Completed	N/A
IN-1.03.02	Develop redundant and resilient electrical power capacity and distribution at SFO	Modified significantly	IN-1.3
IN-1.04	Conduct a Risk and Resilience Assessment and Emergency Response Plan for the City's water infrastructure system	Completed	IN-8.4
IN-1.05	Complete the Lifelines Restoration Performance Project and implement recommendations	Progressing	C-3.2
IN-1.06	Increase the Resilience of the Municipal Fiber Optic Network	Progressing	IN-2.1
IN-1.07	Increase the Resilience of the 911 Radio System	Progressing	IN-2.2

HCR Strategy Code	Strategy Name	Status	Corresponding 2025 Update Strategy (or rationale for removal)
IN-1.08	Implement multi-hazard mitigation improvements for harbor dock infrastructure	No longer needed	This work is being pursued through other planning mechanisms
IN-1.09	Develop a hazard mitigation and emergency response evacuation plan for SF Zoo	Completed	
IN-1.10	Implement the East Harbor Renovation Project	Progressing	IN-5.4
IN-2.01	Develop projects to address flooding around Islais Creek	Progressing	IN-5.3
IN-2.02	Develop a process to move utilities from under pier structures	Modified significantly	IN-5.2
IN-2.03	Continue to implement the Ocean Beach Master Plan	Progressing	IN-6.4
IN-2.04	Adapt shoreline parks to sea level rise and salt water intrusion, using marshes and plant diversity	Progressing	IN-4.5
IN-2.05	Assess the current stormwater catchment potential of open space managed by the Recreation and Parks Department	Progressing	IN-6.7; IN-7.6
IN-2.06	Expand the StreetTreeSF Climate Resilient Tree Planting Initiative	Progressing	C-1.1; C-1.2
IN-2.07	Complete the Extreme Precipitation Study	Completed	

HCR Strategy Code	Strategy Name	Status	Corresponding 2025 Update Strategy (or rationale for removal)
IN-2.08	Complete a comprehensive assessment of combined flood risks for San Francisco	Progressing	IN-6.7
IN-2.09	Participate in US Army Corps of Engineers (USACE)/Port Flood Study	Progressing	IN-6.2
IN-2.10	Explore increasing tree canopy and shade structures in parks	Progressing	C-1.1; C-1.3
IN-2.11	Assess current plant palettes and tree canopy needs to increase consideration of future climate conditions in the selection options	Not yet started	This work is being pursued through other planning mechanisms
IN-2.12	Diversify water supply options year-round by improving the use of new water sources and drought management	Progressing	IN-8.3
IN-2.13	Continue to conserve and monitor water use by capital projects	On-going	IN-7.6
IN-2.14	Develop a Long-term Vulnerability Assessment and Adaptation Plan for the Hetch Hetchy Regional Water System	Progressing	IN-8.4
IN-2.15	Implement a Coastal Mulitmodal Resilience Strategy	Progressing	IN-3.2
IN-2.16	Strengthen citywide efforts to conserve, restore, and steward biodiversity	Progressing	IN-4.4 IN-4.3
IN-3.01	Complete studies, analysis, and capital projects to improve and expand the Emergency	Progressing	IN-7.4

HCR Strategy Code	Strategy Name	Status	Corresponding 2025 Update Strategy (or rationale for removal)
	Firefighting Water System (EFWS)		
IN-3.02	Improve the capacity of the Portable Water Supply System to fight fires following earthquakes and other large urban fires	Progressing	IN-7.4
IN-3.03	Continue to mitigate wildfire hazards in SFPUC owned-watersheds to protect source water quality and minimize risk to SFPUC water and power infrastructure.	On-going	IN-8.2
IN-3.04	Improve Fire Prevention in Recreation Areas	On-going	IN-4.1
IN-5.01	Conduct a system wide multi hazard vulnerability and operational assessment for Muni	Progressing	IN-3.1 IN-3.2
IN-5.02	Reduce seismic and flood risk along three miles of the San Francisco Waterfront from Fisherman's Wharf to Mission Creek	Progressing	IN-5.1
IN-5.03	Continue to advance Sewer System Improvement Program (SSIP) projects to meet level of service objectives	Progressing	Moving forward in other capital planning mechanisms
IN-5.04	Implement the Pipe Replacement Prioritization Program	On-going	IN-7.1
IN-5.05	Continue to improve power distribution infrastructure to	Progressing	IN-1.2, IN-7.2

HCR Strategy Code	Strategy Name	Status	Corresponding 2025 Update Strategy (or rationale for removal)
	support new development and increase resiliency		
IN-5.06	Improve Resilience and Sustainability for regional dams and ancillary facilities from probably maximum flood (PMF) and maximum credit earthquake (MCE) events	Progressing	IN-8.1
IN-5.07	Develop a Citywide Climate Resilience Framework	Progressing	C-3.1
IN-5.09	Implement SFMTA Asset Management and State of Good Repair Strategy	On-going	Moving forward in other planning mechanisms
IN-5.10	Implement SFMTA Transit Fixed Guideway Strategy	On-going	Moving forward in other planning mechanisms

Chapter 07

Strategy

Green Stormwater Infrastructure on Page Street

This chapter represents San Francisco's strategy to reduce vulnerabilities identified in the Key Planning Issues (Chapter 05) and address priorities identified through stakeholder engagement (Chapter 02). The strategy consists of 3 pillars, 17 objectives, and 74 actions that update the 2020 HCR based on an evaluation of progress made and new priorities. The strategy balances being comprehensive of the range of hazards, risks, and priorities within the San Francisco community with a pragmatic lens of what will be feasible to implement by 2030 and will provide significant benefit, especially to those who are most adversely impacted by hazards. Actions suggested by stakeholders that may not be feasible to implement in the next five years, but should be explored further, are included in Table 7-9.

7.1 Hazards and Climate Resilience Goals

The 2025 goals build upon related citywide planning documents and remain unchanged from the 2020 Hazards and Climate Resilience Plan.

- Protect the public health, safety, quality of life, environment, and economic and social capital of San Francisco by reducing the risk of damage and disruption from hazards.
- Build and support the capacity of City government and the greater San Francisco community, to prevent, protect against, respond to, mitigate, and recover from hazards.
- Advance local, regional, State, federal, private, and community collaborations and partnerships to deliver actionable, effective, and innovative risk reduction solutions and data to support decisions.
- Proactively seek to address racial, health, and economic inequities of hazard impacts and advance equity through the just distribution of risk reduction and resilience benefits.
- Increase public awareness of hazards, risks, and City action to build resilience through education, empowerment, and engagement.

7.2 Developing the Strategy

Overview

The ORCP Project Team, in partnership with numerous departments, developed the HCR actions over the course of the plan update process (see Chapter 02: Planning Process). Starting with on-going or not yet completed actions from the 2020 HCR, the Project Team worked with Planning Team members to identify new priorities and emerging issues and formulate actions that would address identified vulnerabilities. The Project Team also drew from opportunities for expansion and improvement from the Capabilities Assessment (Chapter 06). Recommendations and insights from this stakeholder engagement process have been integrated into existing actions or added as new actions as described in Chapter 02). A prioritization process was applied to evaluate the feasibility and benefit of actions prior to inclusion in the Plan.

Prioritization Process

The Project Team compiled and drafted actions based on the process above and stated in Chapter 02, leading to the development of about 74 draft actions for further refinement and potential inclusion in the 2025 HCR. Due to the large number of actions, an important focus of the 2025 update was to determine which actions are highest priority for implementation based on feedback from subject matter experts and considering community feedback. Prioritization is also important for more effective public communications and plan maintenance.

The Project Team developed an Eisenhower matrix prioritization methodology that included the criteria of feasibility and benefits. In this exercise, costs are embedded as a consideration within feasibility but it is anticipated that as HCR actions become actual projects or policy proposals, more rigorous cost-benefit analysis may occur.

- Feasibility considers cost, available funding sources, legal authority, staff capacity, or political support to implement the action in the 2025-2030 timeframe.
- Benefits consider hazard risk reduction including avoided casualties and damages, and co-benefits including environmental, equity, and economic.

FIGURE 7-1: PRIORITIZATION MATRIX

	Feasibility High	**Feasibility Low**
Benefits High	**Higher priority**	**Medium priority**
Benefits Low	**Medium priority**	**Lower priority**

After establishing the criteria and matrix, ORCP developed a survey tool to gather the Planning Team's subject matter expertise and best professional judgement on the priority levels of the strategies. The following 5-point scale was provided in the survey.

TABLE 7-1: PRIORITIZATION SCALE

Priority Level	Score	Description
Higher	4-5	Higher feasibility and higher benefits.
Medium	3	Moderate or mixed feasibility and benefits.
Lower	1-2	Lower feasibility and lower benefits.

Based on the median score of survey responses for each action, 80 percent of the actions were designated higher priority, 20 percent as medium priority, and 0 percent designated as lower priority. Based on these results, the Planning Team estimates that the vast majority of the draft actions have a high level of feasibility and high benefits, and therefore warrant being high priority for the City to implement. These results help confirm a high level of support for the action among the Planning Team members.

While 74 actions is a significant reduction from the 95 actions from the 2020 HCR, the 2025 HCR still has a large number of actions. As a result, the Project Team developed 17 objectives to organize the actions and support communications. The Project Team continues to seek every opportunity to streamline the Plan to better reflect stakeholder priorities, high feasibility, and high community benefits.

7.3 Objectives and Actions

The 2025 HCR builds off previous plans and addresses a wide range of vulnerabilities. The hazard mitigation strategy is comprised of 74 actions organized into three pillars, with 17 associated objectives. The three pillars are:

(B) *Buildings*: San Francisco's buildings are constructed or retrofitted to withstand current and future hazards and support the health of their occupants and broader community

(C) *Communities*: San Francisco's communities have the resources to plan, prepare, and bounce back from current and future hazards.

(IN) *Infrastructure:* San Francisco's infrastructure is strong, adaptable, and sustainable to serve the community's needs on a daily basis and during and after a hazard.

TABLE 7.2: OBJECTIVES IN THE 2025 HCR

(B) BUILDINGS	
B-1	Increase the resilience of existing seismically vulnerable buildings.
B-2	Increase climate and multi-hazard resilience of existing buildings.
B-3	Design and construct new buildings for high resilience performance for current and future hazards.
(C) COMMUNITIES	
C-1	Limit exposure and protect public health against hazards related to environmental health.
C-2	Support the growth of community resilience networks to empower all people.
C-3	Increase the City's capacity to improve resilience through collaboration among peer agencies, the private sector, and community-based organizations
C-4	Support robust emergency response planning in partnership with communities most adversely impacted by hazards.
C-5	Prepare small businesses and workers to bounce back faster after a hazard.
C-6	Make housing more affordable to increase community adaptive capacity.
(IN) INFRASTRUCTURE	
IN-1	Increase the resilience of electric power systems and increase access to resilient backup power.
IN-2	Increase the resilience and redundancy of critical communications systems.
IN-3	Support sustainable and resilient multi-modal mobility.
IN-4	Promote, design, and use nature-based solutions to mitigate current and future hazards.
IN-5	Protect waterfront assets and communities from near-term flooding and seismic hazards.
IN-6	Adapt the City's bay and ocean shorelines to current and future climate flood hazards.
IN-7	Increase the resilience of local water and wastewater systems to natural hazards and climate change.

Tables 7-3 to 7-5 outline the 2025 HCR actions, including the action code, title, and lead department(s) and serves as a Table of Contents for the detailed tables to follow. Each action is assigned a code that identifies its pillar and objective.

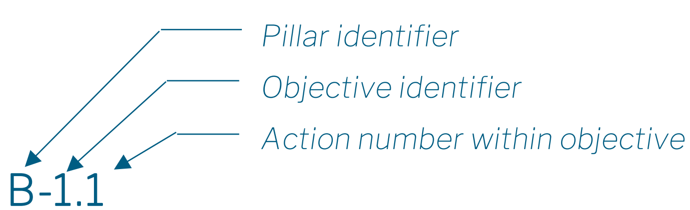


TABLE 7-3: BUILDINGS-RELATED OBJECTIVES AND ACTIONS

CODE	OBJECTIVE/ACTION TITLE	LEAD
B-1	Increase the resilience of existing seismically vulnerable buildings.	
B-1.1	Assess and seismically retrofit municipal buildings or secure new resilient facilities as needed.	ORCP
B-1.2	Implement priority tasks of the Earthquake Safety Implementation Program, such as addressing vulnerable concrete, steel, and soft-story buildings.	ORCP, DBI
B-1.3	Implement the recommendations of the Tall Building Safety Strategy.	ORCP, DBI
B-1.4	Address mandatory seismic retrofit needs within San Francisco's affordable housing stock.	MOHCD
B-2	Increase climate and multi-hazard resilience of existing buildings.	
B-2.1	Increase resilience and operation efficiency of municipal maintenance yards.	DPW
B-2.2	Determine the City and community facilities that will comprise a network of respite locations open to the public for a range of emergencies and the services, roles, and responsibilities necessary to facilitate their use.	DEM
B-2.3	Seek to add resilience scope to affordable housing rehabilitation funding opportunities with support from state/federal funds.	MOHCD
B-2.4	Continue to implement Floodwater Management Grant Program to assist residents with floodproofing.	SFPUC
B-2.5	Support increased building electrification (fuel switching), mechanical upgrade, and weatherization.	SFE, SFPUC
B-2.6	Document historic and cultural resources, particularly in the most hazardous areas.	Planning
B-3	Design and construct new buildings for high resilience performance for current and future hazards.	
B-3.1	Continue to implement the Sea Level Rise Capital Planning Guidance and update as new science is available.	ORCP
B-3.2	Develop multi-hazard resilience design guidelines for capital planning.	ORCP
B-3.3	Incorporate flood resilience into the San Francisco Building Code.	SFPUC

TABLE 7-4: COMMUNITIES-RELATED OBJECTIVES AND ACTIONS

COMMUNITIES		LEAD
C-1	Limit exposure and protect public health against hazards related to environmental health.	
C-1.1	Develop projects in green infrastructure priority zones.	ORCP
C-1.2	Develop public education initiatives to connect benefits of green infrastructure to public health.	DPW
C-1.3	Investigate and pilot strategies to cool impervious surfaces.	SFO, DPW
C-1.4	Enhance monitoring, measurement, and improvement of indoor air quality and temperatures.	SFO, DPH
C-1.5	Conduct studies to better understand how sea level rise may interact with contaminated lands and potential health risks.	DPH
C-1.6	Protect human health and the environment through close involvement in the framework of property controls and mitigations at the Hunters Point Shipyard	OCII
C-1.7	Expand household hazardous waste collection efforts.	SFE
C-2	Support the growth of community resilience networks to empower all people.	
C-2.1	Continue to support neighborhood level capacity building.	DEM, DPH, ORCP
C-2.2	Support volunteer emergency preparedness, response, and recovery programs including the Neighborhood Emergency Response Team (NERT).	SFFD
C-3	Increase the City's capacity to improve resilience through collaboration among peer agencies, the private sector, and community-based organizations.	
C-3.1	Coordinate resilience engagement across departments and projects through ClimateSF	ORCP
C-3.2	Track progress and update the Lifelines Restoration Performance Project recommendations	ORCP
C-3.3	Develop and improve systems for hazard and climate resilience data.	ORCP
C-3.4	Improve San Francisco's climate health research capacity.	DPH
C-3.5	Develop citywide policy and proposed governance structure for flood resilience.	SFPUC

C-4	Support robust emergency response planning in partnership with communities most adversely impacted by hazards.	
C-4.1	Establish an evacuation strategy for people with Access and Functional Needs, including vertical evacuation and large-building refuges.	DEM
C-4.2	Pilot a wellness check program for vulnerable populations including homebound seniors, and people with access and functional needs.	HSA
C-4.3	Develop a Homelessness Disaster Response Plan	HSH
C-4.4	Develop a public outreach campaign and wayfinding plan for tsunami awareness and evacuation procedures	DEM
C-4.5	Improve citywide resilience to pandemics and infectious diseases.	DPH
C-5	Prepare small businesses and workers to bounce back faster after a hazard.	
C-5.1	Establish disaster relief funding and small business resilience fund.	OEWD
C-5.2	Continue to scale and mobilize layoff outplacement services for post-disaster economic impacts.	OEWD
C-6	Make housing more affordable to increase community adaptive capacity.	
C-6.1	Continue to meet housing production goals.	MOHCD, OCII, TIDA

TABLE 7-5: INFRASTRUCTURE RELATED ACTIONS

INFRASTRUCTURE		LEAD
IN-1	Increase the resilience of electric power systems and increase access to resilient backup power.	
IN-1.1	Enhance energy resilience at critical facilities.	SFPUC, DPW
IN-1.2	Improve and expand power distribution infrastructure and advanced energy systems to support new development and increase resiliency.	SFPUC
IN-1.3	Complete the Electrical Capacity Upgrade Project to ensure redundant electrical power capacity and distribution across SFO	SFO
IN-1.4	Develop a roadmap for disaster resilient EV charging infrastructure	Fleet, ORCP
IN-2	Increase the resilience and redundancy of critical communications systems	
IN-2.1	Increase the Resilience of the Municipal Fiber Optic Network	DT
IN-2.2	Increase the Resilience of the 911 Radio System	DT
IN-3	Support sustainable and resilient multi-modal mobility	
IN-3.1	Incorporate opportunities for hazard mitigation into the planning and design of all SFMTA facility improvements and property re-development.	SFMTA
IN-3.2	Study, plan, design, and implement improvements to the multimodal transportation system that are vulnerable to coastal flooding.	SFMTA
IN-3.3	Improve the public right-of-way state-of-good-repair, including retrofitting bridges and other key structures.	ORCP, DPW
IN-3.4	Decrease the geographic vulnerability inherent to the island communities on Treasure Island and Yerba Buena Islands by increasing low-emission, connectivity to San Francisco.	TIMMA
IN-3.5	Implement the SFO Infrastructure Resilience Framework to improve resilience of critical facilities, assets, operations, and lifeline utility systems.	SFO

IN-4	Promote, design, and use nature-based solutions to mitigate current and future hazards.	
IN-4.1	Continue to improve wildfire prevention through vegetation management in Recreation Areas.	RPD
IN-4.2	Maximize drought tolerant, native species in plantings for parks and landscaping whenever feasible.	RPD, DPW
IN-4.3	Strengthen citywide efforts to conserve, restore, and steward biodiversity.	SFE
IN-4.4	Develop public private partnerships to conserve and steward biodiversity and habitat on Treasure Island and Yerba Buena Islands.	TIDA
IN-4.5	Adapt the shoreline to sea level rise and salt-water intrusion using nature-based solutions and maximizing native plan diversity, where feasible.	RPD, Port
IN-5	Protect waterfront assets and communities from near-term flooding and seismic hazards.	
IN-5.1	Implement Embarcadero Early Projects to address areas of highest earthquake and flood risk along the Embarcadero waterfront.	Port
IN-5.2	Make under deck pier structure utilities more resilient to flooding and seismic hazards.	Port
IN-5.3	Develop projects and seek funding to implement the Islais Creek Southeast Mobility Adaptation Strategy (ICSMAS).	Port, DPW, SFMTA
IN-5.4	Implement the Marina Improvement and Remediation Project	RPD
IN-5.5	Implement the Ocean Beach Climate Adaptation Project, which represents 2 of 6 key moves of the Ocean Beach Master Plan.	SFPUC
IN-5.6	Implement the San Francisco Airport Shoreline Protection Program.	SFO
IN-6	Adapt the City's bay and ocean shorelines to current and future climate flood hazards.	
IN-6.1	Develop subregional shoreline resiliency plan by 2034 per SB 272	Planning, ORCP
IN-6.2	Advance the Waterfront Resilience Program and San Francisco Waterfront Coastal Flood Study to reduce flooding and seismic risk along the 7.5 miles of Port jurisdiction.	Port
IN-6.3	Develop the Yosemite Slough Neighborhood Adaptation Plan	Planning
IN-6.4	Advance plans and projects for Ocean Beach and Great Highway North of Sloat Blvd.	RPD, GGNRA
IN-6.5	Advance the Adaptive Management Strategy from the Treasure Island Infrastructure Plan to ensure continual protection to changing conditions.	TIDA

IN-6.6	Develop and support major development projects and public/private partnerships that deliver resilient waterfront infrastructure.	Port, TIDA, OCII
IN-6.7	Develop comprehensive assessments of combined flood risks in each watershed.	SFPUC
IN-7	Increase the resilience of local water and wastewater systems to natural hazards and climate change.	
IN-7.1	Implement the Pipe Replacement Prioritization Program	SFPUC
IN-7.2	Support the completion and handover of new power, water, wastewater distribution infrastructure at Treasure Island and discontinue the use of the legacy navy systems.	TIDA, SFPUC
IN-7.3	Complete construction of the Treasure Island Water Resource Recovery Facility to improve water treatment, increase water security, and to connect recycled water to San Francisco's first neighborhood with a complete green infrastructure system.	SFPUC
IN-7.4	Complete studies and capital projects to improve and expand the Emergency Firefighting Water System (EFWS).	SFPUC
IN-7.5	Improve the capacity of the Portable Water Supply System to fight fires following earthquakes and other large urban fires.	SFFD
IN-7.6	Pursue data-driven implementation of Green (GI) Infrastructure projects to be able to manage 1 billion gallons of stormwater per year using GI by 2050.	SFPUC
IN-7.7	Complete construction of the Recycled Water Treatment Plant to ensure redundancy of water supply on SFO campus.	SFO
IN-8	Increase resilience of the regional water system to natural hazards and climate change.	
IN-8.1	Improve Resilience and Sustainability for regional dams and ancillary facilities from flood and earthquake events	SFPUC
IN-8.2	Mitigate wildfire hazards in SFPUC owned-watersheds to protect source water quality and minimize risk to SFPUC water and power infrastructure.	SFPUC
IN-8.3	Diversify water supply options year-round by improving the use of new water sources and drought management	SFPUC
IN-8.4	Continue climate adaptation planning for the Hetch Hetchy Regional Water System	SFPUC

Since the 2025 HCR organizes actions by objective rather than hazard, table 7-6 summarizes which actions relate to the 13 natural hazards for readers with an interest in a specific hazard.

TABLE 7-6: ACTIONS BY HAZARD

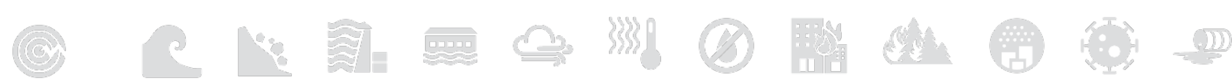
HAZARD	ACTION CODES
Earthquake	B-1.1, B-1.2, B-1.3, B-1.4, C-3.2, IN-5.1, IN-5.2, IN-6.2
Landslide	IN-3.3
Tsunami	C-4.4, IN-6.5
Flooding	B-2.4, B-3.1, C-1.5, C-1.6, C-3.5, IN-3.2, , IN-4.5, IN-5.1, IN-5.2, IN-5.3, IN-5.4, IN-5.5, IN-5.6, IN-6.1, IN-6.2, IN-6.3, IN-6.4, IN-6.5, IN-6.7, IN-7.6, IN-8.1
Dam or Reservoir Failure	IN-8.1
Extreme Heat	B-2.2, C-1.1, C-1.2, C-1.3, C-4.2
Drought	IN-4.2, IN-8.3
Wildfire	IN-4.1, IN-8.2
Large Urban Fire	B-1.2, B-1.3, IN-7.4, IN-7.5
High wind	IN-4., IN-6.4
Poor Air Quality	B-2.2, C-1.1, C-1.2, C-1.4, C-4.2,
Pandemic	C-4.5,
Hazardous Materials Release	C-1.5, C-1.6, C-1.7, IN-5.4
All-Hazard	B-2.1, B-2.3, B-3.2, B-2.6, B-3.3, C-2.1, C-2.2, C-3.1, C-3.3, C-3.4, C-4.1, C-4.3, C-5.1, C-5.2, C-6.1, IN-1.1, IN-1.2, IN-1.3, IN-1.4, IN-2.1, IN-2.2, IN-3.1, IN-3.3, IN-3.4, IN-3.5, IN-4.3, IN-4.4, IN-7.1, IN-7.2, IN-7.3, IN-7.7, IN-8.4

7.4 Action Details

The action tables in the following section provide relevant details to implementation.

Action Key

The example table describes the different components that can be found in each action.

<table>
<tr><th>CODE #</th><th colspan="3">Action Name</th></tr>
<tr><td colspan="2">KEY PLANNING ISSUES:
Explain key planning issue</td><td colspan="2">VULNERABILITY ADDRESSED:
Describes the issue from the vulnerability and consequences assessment that the action seeks to address</td></tr>
<tr><td>LEAD:
Agency in charge of implementing
PARTNERS:
Agencies or other groups as potential partners</td><td colspan="3">ACTION SUMMARY:
Short description of the action</td></tr>
<tr><td colspan="2">COST:
Low / Med / High (described below)</td><td>SF GOVERNMENT ACTIVITY:
Public Assets Owner (described below)</td><td>STATUS:
New / Scaling / Sustaining (described below)</td></tr>
<tr><td colspan="2">POTENTIAL FUNDING SOURCES:
General Funds, Special funds, Grants, Etc.</td><td>PRIORITY LEVEL</td><td>TIMELINE:
Estimated date of completion</td></tr>
<tr><td colspan="4">Applicable hazards:
</td></tr>
</table>

Cost

The costs represent the rough order-of-magnitude resources that may be required to implement the action. For ongoing actions, the cost may be fully or partially funded. For new or proposed actions, funds may not be committed and are subject to approval through the City's budgeting process. Action costs are indicated at one of the following three levels:

- Low: $0–$500K
- Medium: $500K to $5M
- High: $5M and above

Potential Funding Sources

The following definitions explain some of the general funding source categories that may be available to fund actions in the chapter. For more detailed description of funding sources, see Capabilities chapter and appendix.

- General Fund: composed of various taxes collected by the city, which include property, sales, business, and hotel taxes. This can include funds from set-asides.
- Special Funds: Funds raised from specific revenue sources that are legally restricted to expenditures for a specific purpose.
- Debt: Bonds, Certificates of Participation, and other forms of financing used to pay for projects.
- Privately Funded: Sources provided by private entities, often due to regulations or mandatory policies.
- Grants: Grants provided through state or federal funding programs, usually on a competitive basis. There are several applicable grants that can be leveraged to fund the mitigation strategy. Table 7-7 highlights a non-exhaustive list of potential grant sources.

TABLE 7-7: FUNDING SOURCES

ISSUING ENTITY	GRANT PROGRAM
U.S Federal Emergency Management Agency	Building Resilient Infrastructure and Communities
U.S Federal Emergency Management Agency	Hazard Mitigation Grant Program
U.S Federal Emergency Management Agency	Flood Mitigation Assistance
U.S Environmental Protection Agency	Thriving Communities Grant Program
U.S Environmental Protection Agency	Community Change Grant
U.S Department of Transportation	Promoting Resilience Operations for Transformative, Efficient, and Cost-Saving Transportation (PROTECT) Program
California Integrated Climate Adaptation and Resilience Program	Adaptation Planning Grant Program
California Integrated Climate Adaptation and Resilience Program	Regional Resilience Planning and Implementation Grant Program
California Integrated Climate Adaptation and Resilience Program	Extreme Heat and Community Resilience Grant Program

California Department of Transportation	Sustainable Transportation Planning Grants
Ocean Protection Council	Senate Bill (SB 1) Grant Program
Ocean Protection Council	Proposition 68 Grant Program
Ocean Protection Council	California State General Fund

SF Government Activity

Each action is associated with a type of government activity that refers to how it is put into action in relation to San Francisco's capabilities to influence resilience as described in Chapter 06. The activities included the following:

- Funding and Financing
- Public Assets Ownership
- Community Services Delivery
- Research, Planning & Guidance
- Adoption & Enforcement of Regulations

Actions that encompass more than one government activity are assigned to the activity that most directly engages or impacts stakeholders. For example, a new regulation that might require research before implementation, is assigned to "Adopt & Enforce Regulations" because of the impact that a regulation has on the applicable population.

Actions that involve the planning, design, construction, and/or operation of public facilities are assigned to the "Public Assets Owner" activity, even though, to a great extent, the ownership of a facility could be considered a subset of the activity "Community Services Delivery".

Status

This section of the action description indicates whether the action is a completely new initiative or an activity that is already existing and being carried forward.

Timeline

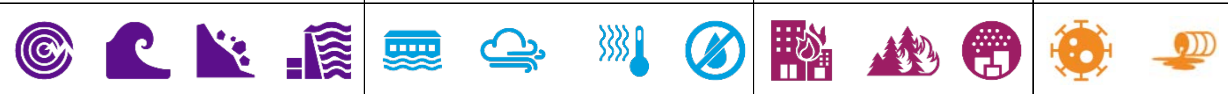
Describes the expected date by when the action will be completed. Often this will be over the course of the plan implementation period (~5 years). Actions can also be implemented over a longer time period, particularly those that are on-going or have very long implementation paths.

Applicable Hazards (Icons)

Table 7-5 shows the legend for the 13 hazard icons shown at the bottom of each action. Hazards that are applicable to the specific action are shown in color whereas non-applicable hazards are faded out. The color coding matches the primary hazard groups. The "All Hazards" group is indicated by displaying icons in color for all thirteen hazards and by the green color bar around the action code.

TABLE 7-8: HAZARD ICON LEGEND

Earthquake	Tsunami	Landslide	Dam or Reservoir Failuure	Flooding	High Wind	Extreme Heat	Drought	Large Urban Fire	Wildfire	Poor Air Quality	Pandemic	Hazardous Materials
Geological				Weather-Related				Fire-Related			Biological & Toxic	



PILLAR: BUILDINGS (B)

B-1.1	Assess and seismically retrofit municipal building or secure new resilient facilities as needed.	
KEY PLANNING ISSUES: Existing Buildings	VULNERABILITY ADDRESSED: Some municipal buildings are Seismic Hazard Rating (SHR) 4, including three homeless shelters.	
LEAD: ORCP PARTNERS: DPW, SFFD, SFPD, RED, DPH, HSH, Port, SFMTA, others	ACTION SUMMARY: ORCP uses seismic hazard ratings (SHR), HAZUS, and other tools to assess risk and prioritize seismic-strengthening projects within the public facilities portfolio. Effective prioritization ensures retrofits first work to reduce life safety risk and then to minimize potential interruptions to essential services for San Francisco's most vulnerable populations. Known priority buildings at the time of writing include 170 Otis, Kezar Pavilion, the Hall of Justice, the City's homeless shelters, Chinatown Health Center, Pier 1, as well as some fire and police stations.	
COST: High	SF GOVERNMENT ACTIVITY: Public Assets Owner	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: General Fund, Debt, Grants	PRIORITY LEVEL: High	TIMELINE: On-going

B-1.2	Implement priority tasks of the Earthquake Safety Implementation Program, such as addressing vulnerable concrete, and steel, and soft-story buildings.	
KEY PLANNING ISSUES: Existing Buildings	VULNERABILITY ADDRESSED: Some older, un-retrofitted buildings are vulnerable to damage in an earthquake.	
LEAD: ORCP, DBI PARTNERS: DPW, MOHCD, OEWD, DEM	ACTION SUMMARY: The Earthquake Safety Implementation Program is a 30-year set of tasks for improving the seismic safety of privately-owned buildings. Upcoming priority tasks include addressing vulnerable concrete buildings, tilt-up buildings, pre-Northridge steel-moment frame buildings, and soft-story buildings with fewer than 5 units. Other tasks include developing post-earthquake repair and retrofit guidance for steel and concrete buildings, developing performance standards for building uses important to post-disaster recovery, and reducing the risk of fire-following earthquake.	
COST: Medium to develop program, High to implement	SF GOVERNMENT ACTIVITY: Adopt & Enforce Regulations	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: Special Funds, Privately Funded, Grants	PRIORITY LEVEL: High	TIMELINE: Concrete screening by 2028 Steel inventory by 2027

B-1.3	Implement the recommendations of the Tall Building Safety Strategy.	
KEY PLANNING ISSUES: Existing Buildings New Housing and Development	VULNERABILITY ADDRESSED: Seismic codes are designed for life safety rather than recovery, so post-earthquake repair may take an extended period of time in complex tall buildings, potentially impacting recovery.	
LEAD: ORCP, DBI PARTNERS: DEM	ACTION SUMMARY: This action involves the updating of existing policies and development of new policies addressing post-earthquake building safety inspection, requirements for repair and retrofit, and establishing cordons around buildings. It also involves expanding the database of tall buildings to better understand risk, establishing performance-based seismic design standards, and making amendments to the San Francisco Existing Building code to better address seismic resilience goals.	
COST: Medium	SF GOVERNMENT ACTIVITY: Research, Planning & Guidance	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: General Funds, Special funds, Debt, Privately Funded	PRIORITY LEVEL: High	TIMELINE: By 2029

B-1.4	Address mandatory seismic retrofit needs within San Francisco's affordable housing stock.	
KEY PLANNING ISSUES: Existing Buildings	VULNERABILITY ADDRESSED: In a major earthquake, thousands of residential buildings could be damaged, leading to temporary or permanent displacement.	
LEAD: MOHCD PARTNERS: ORCP	ACTION SUMMARY: The San Francisco Mayor's Office of Housing and Community Development (MOHCD) manages acquisition and rehabilitation programs that provide funding to non-profit organizations to acquire older, rent-controlled properties, rehabilitate them, and preserve them as permanent affordable housing. This action will task MOHCD with applying for state and federal grants to fund mandatory seismic retrofits, such as FEMA hazard mitigation funding, to subsidize owners to perform necessary retrofits or sell their properties, thereby reducing potential displacement of renters of damaged housing following earthquake events and reducing the necessity of landlords raising rents for building improvements.	
COST: High	SF GOVERNMENT ACTIVITY: Public Assets Owner	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: General Funds, Grants	PRIORITY LEVEL: High	TIMELINE: By 2034

B-2.1	Increase the resilience and operation efficiency of municipal maintenance yards.	
KEY PLANNING ISSUES: Existing Buildings	VULNERABILITY ADDRESSED: Many municipal maintenance yards are outdated, centralized, and vulnerable to multiple hazards.	
LEAD: DPW PARTNERS: SFPUC, SFMTA	ACTION SUMMARY: Replacement of older yards with new facilities equipped for climate and seismic resilience will modernize maintenance yards for the challenges of the 21st century. These improvements include design specifications for on-site solar and battery systems, onsite water recycling/storage, high-performance building systems allowing operations in line with net-zero carbon commitments, as well as resilient landscaping for stormwater management. Decentralizing yards to smaller satellites across the City also increases staff and fleet fuel efficiencies. This action also provides safer and healthier workplaces for essential City workers.	
COST: High	SF GOVERNMENT ACTIVITY: Public Assets Owner	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: General Funds, Debt, Grants	PRIORITY LEVEL: Medium	TIMELINE: By 2029

B-2.2	Determine the City and community facilities that will comprise a network of respite locations open to the public for a range of emergencies and the services necessary to facilitate their use.	
KEY PLANNING ISSUES: Existing Buildings Communities at Increased Risk	VULNERABILITY ADDRESSED: The communities that are most sensitive to climate and hazard impacts are often those who face significant barriers to accessing emergency preparedness and response resources.	
LEAD: DEM PARTNERS: DPH, HSA, HSH, ORCP, MOH, DPW	ACTION SUMMARY: While there are a few buildings that can open as public respite facilities, there isn't a comprehensive strategy. A comprehensive approach would require identifying ideal locations, necessary building improvements, staffing policies, associated funding, and other details required to systematically maintain a network of these facilities in the case of a significant heat event. Assessing these considerations and developing solutions requires a dedicated focus with staffing and funding for implementation. This action will focus on addressing those barriers to establish a comprehensive approach.	
COST: Medium	SF GOVERNMENT ACTIVITY: Public Assets Owner	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: General Funds, Debt	PRIORITY LEVEL: High	TIMELINE: By 2029

B-2.3	Seek to add resilience scope to affordable housing rehabilitation funding opportunities with support from state/federal funds.	
KEY PLANNING ISSUES: Existing Buildings Communities at Increased Risk	VULNERABILITY ADDRESSED: San Francisco's building stock is largely un-adapted to extreme heat and wildfire smoke and residents of affordable and supportive housing are more likely to be sensitive to the impacts of climate change due to pre-existing health conditions and other factors.	
LEAD: MOHCD PARTNERS: ORCP, SFE	ACTION SUMMARY: This action seeks to identify or create new sources of funding that are tailored towards these projects and can specifically be used to ensure that voluntary heat and air quality measures can be integrated into both city and non-profit projects.	
COST: High	SF GOVERNMENT ACTIVITY: Community Services Delivery	STATUS: New
POTENTIAL FUNDING SOURCES: General Funds, Grants	PRIORITY LEVEL: High	TIMELINE: By 2029

B-2.4	Continue to implement Floodwater Management Grant Program to assist residents with floodproofing.	
KEY PLANNING ISSUES: Existing Buildings	VULNERABILITY ADDRESSED: Nearly 12,000 multi-family units are exposed in both the 100-year stormwater flood zone and coastal flood zone with 24" SLR.	
LEAD: SFPUC PARTNERS:	ACTION SUMMARY: SFPUC has developed a program through which property owners affected by stormwater management can receive grants to reduce the risk of flood damage. This action supports the implementation of floodproofing, elevation, and acquisition projects based on interest from property owners. The City will work with interested property owners to assess eligibility for the program; evaluate options; develop the scope and cost; and, if federal funding is being contemplated, perform the required cost-benefit analysis and environmental impact analysis reviews.	
COST: High	SF GOVERNMENT ACTIVITY: Adopt & Enforce Regulations	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: Debt, Privately Funded, Grants	PRIORITY LEVEL: High	TIMELINE: By 2029

B-2.5	Support increased building electrification (fuel switching), mechanical upgrade, and weatherization.

KEY PLANNING ISSUES: Existing Buildings

VULNERABILITY ADDRESSED: Un-weatherized buildings with natural gas equipment are more susceptible to hazards including fire following earthquake, extreme heat, and wildfire smoke.

LEAD: SFE, SFPUC

PARTNERS: DPW, SFO, OEWD, DBI, DPH, SFPUC, BayREN, PG&E

STRATEGY SUMMARY: Building electrification supports resilience in multiple ways. Following catastrophic events, high performance all-electric buildings will come back online quicker than mixed fuel buildings. All-electric critical facilities, will be better able to take advantage of on-site solar energy stored in batteries. As older buildings in San Francisco generally don't have mechanical cooling systems, the addition of electric heat pumps will help occupants to stay comfortable during more frequent extreme heat days in the future. Providing financial assistance for these efforts is essential to accelerating building resiliency.

COST:	SF GOVERNMENT ACTIVITY:	STATUS:
High	Adopt & Enforce Regulations	Sustaining
POTENTIAL FUNDING SOURCES:	**PRIORITY LEVEL:**	**TIMELINE:**
Special Funds, Debt, Privately	Medium	On-going

B-2.6	Document historic and cultural resources, particularly in the most hazardous areas.

KEY PLANNING ISSUES: Existing Buildings

VULNERABILITY ADDRESSED: Document historic and cultural resources, particularly in the most hazardous areas.

LEAD: Planning

PARTNERS: Port, ORCP, MOHCD

ACTION SUMMARY: The San Francisco Citywide Cultural Resources Survey is an effort to identify and document places and resources of cultural, historical, and architectural importance to San Francisco's diverse communities. This strategy will result in a comprehensive survey of all properties in San Francisco to augment housing and building stock data with information on architectural and cultural significance, building materials, age, and more. This strategy will be integrated into broader resiliency planning efforts to inform where new development should and should not be prioritized based on factors such as hazard vulnerability and historic resource status. In case a disaster does occur, this strategy will memorialize what resources have been damaged or destroyed, and guide rehabilitation efforts.

COST:	SF GOVERNMENT ACTIVITY:	STATUS:
Low	Research, Planning & Guidance	New
POTENTIAL FUNDING SOURCES:	**PRIORITY LEVEL:**	**TIMELINE:**
General Funds, Grants	Medium	By 2029

B-3.1	Continue to implement the Sea Level Rise Capital Planning Guidance and update as new science is available.	
KEY PLANNING ISSUES: New Housing and Development	VULNERABILITY ADDRESSED: The sea level rise vulnerability zone is home to vital facilities and infrastructure, including roadways, utilities, transit, parks, and Port facilities.	
LEAD: ORCP PARTNERS: DPW, Planning, SFPUC, SFMTA, MOHCD, others	ACTION SUMMARY: The Sea Level Rise (SLR) Capital Planning Guidance was adopted in 2014 and updated in 2015 and 2020. The guidance will be updated in 2025 to incorporate updated projections and guidance from the State and consider other advancements in local sea level rise planning. Project managers for projects over $5 million will continue to use the Guidance, ensuring that SLR projections are incorporated into asset design and adaptation actions taken into consideration. ORCP will continue to improve implementation of the guidance, provide training for project managers, and analyze data from the effort.	
COST: Low	SF GOVERNMENT ACTIVITY: Public Assets Owner	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: General Funds	PRIORITY LEVEL: High	TIMELINE: On-going

B-3.2	Develop multi-hazard resilience design guidelines for capital planning.	
KEY PLANNING ISSUES: New Housing and Development	VULNERABILITY ADDRESSED: There is no comprehensive resilience design code, which outlines what municipal and private buildings need to do, and the associated costs/benefits.	
LEAD: ORCP PARTNERS: Planning, DPW, MOHCD	ACTION SUMMARY: Developing multi-hazard capital planning guidelines, rooted in the current and future needs of a climate resilient city, is essential to meet the sustainability and climate action goals of the city. This action includes performance guidelines for climate and seismic hazards, including flooding, extreme heat, and drought. The action might also include risk analysis and adaptation, architectural/engineering standards (building electrification systems, solar and energy storage, heating, venting, and air conditioning system coordination across units in large buildings, etc.), and inform capital priorities for adaptation. The guidelines should offer a cost-benefit analysis process to help project managers decide what resilience strategies to pursue.	
COST: Low	SF GOVERNMENT ACTIVITY: Public Assets Owner	STATUS: Scaling
POTENTIAL FUNDING SOURCES: General Funds	PRIORITY LEVEL: High	TIMELINE: By 2029

B-3.3	Incorporate flood resilience into the San Francisco Building Code
KEY PLANNING ISSUES: New Housing and Development	VULNERABILITY ADDRESSED: During extreme storms, storm runoff flows still follow the naturally-formed historical waterways. When this occurs, we can experience flooding that sometimes results in property damage.
LEAD: SFPUC PARTNERS: DBI, ADM, Planning, MOHCD	ACTION SUMMARY: Complementary to the SFPUC's Floodwater Grant Program, the SFPUC is working with partners to develop flood resilient building code modifications that would apply to the 100-year stormwater flood risk area. The requirements would align with existing the Flood Management Ordinance tied to the FEMA 100-Year Floodplain and including establishing a design flood elevation (DFE) with freeboard, wet floodproofing of the lowest floor, and barring residential uses below the DFE. The benefit-cost ratio for these code requirements for new construction is 10:1. The near-term step is seeking public feedback about different options and then going through the legislative process to enact the building code changes.

COST:	SF GOVERNMENT ACTIVITY:	STATUS:
High	Adopt & Enforce Regulations	New
POTENTIAL FUNDING SOURCES:	PRIORITY LEVEL:	TIMELINE:
Privately-funded, grants	Medium	By 2027

PILLAR: COMMUNITIES (C)

C-1.1	Develop projects in green infrastructure priority zones.	
KEY PLANNING ISSUES: Communities at Increased Risk Open Space and Diversity	VULNERABILITY ADDRESSED: Racially motivated, historic disinvestment has led to communities of color having less access to green space and tree canopy coverage, which contributes to disproportionate climate and health impacts.	
LEAD: ORCP PARTNERS: DPW, DPH, RPD Planning	ACTION SUMMARY: This action will utilize assessments that combine environmental, socio-economic, and health metrics to develop priority capital projects and other strategic investments and partnerships to develop and implement green infrastructure projects in these areas. This includes the HAQR Green Infrastructure Priority Zone assessment and the Planning department's Environmental Justice Communities. Projects will also integrate considerations of San Francisco Updated Street Tree list and Biodiversity Guidelines.	
COST: Low	SF GOVERNMENT ACTIVITY: Public Assets Owner	STATUS: New
POTENTIAL FUNDING SOURCES: General Funds, Grants	PRIORITY LEVEL: High	TIMELINE: By 2027

C-1.2	Develop public education initiatives to connect benefits of green infrastructure to public health	
KEY PLANNING ISSUES: Communities at Increased Risk Engagement and Capacity Building	VULNERABILITY ADDRESSED: Historic disinvestment has led to communities of color having less access to green space and tree canopy coverage, which contributes to disproportionate climate and health impacts.	
LEAD: DPW PARTNERS: DPH, ORCP	ACTION SUMMARY: This action involves developing and carrying out a public awareness campaign to educate residents on the numerous benefits of green infrastructure to encourage increased stewardship and buy-in for tree plantings initiatives. Green infrastructure provides significant benefits to San Francisco's residents, including health benefits from mitigating climate hazards in addition to the mental benefits of interacting with green spaces. This supports the City's goals on adaptation and specifically supports environmental justice and resilience to heat and poor air quality.	
COST: Low	SF GOVERNMENT ACTIVITY: Community Services Delivery	STATUS: New
POTENTIAL FUNDING SOURCES: General Funds, Grants	PRIORITY LEVEL: Medium	TIMELINE: By 2029

C-1.3	Investigate and pilot actions to cool impervious surfaces.		
KEY PLANNING ISSUES: Communities at Increased Risk Transportation	VULNERABILITY ADDRESSED: People who work outside are particularly vulnerable to health impacts from extreme heat due to high exposure.		
LEAD: SFO, DPW PARTNERS: DPH, SFE, SFUSD, SFPUC	ACTION SUMMARY: In the near-term, this action focuses on the completion and implementation of the Smart Surfaces Study for SFO Airport. This study assesses the impacts of extreme heat on the airport workforce. The findings will be assessed, and measures implemented to protect airport workers from the increasing impact of extreme heat on the campus. This will provide numerous benefits to public health and the efficiency of building operations. Lessons will be shared with other City agencies that manage large amounts of impervious surfaces to inform future pilot projects.		
COST: Low	SF GOVERNMENT ACTIVITY: Public Assets Owner	STATUS: New	
POTENTIAL FUNDING SOURCES: Special Funds	PRIORITY LEVEL: High	TIMELINE: By 2027	

C-1.4	Enhance monitoring, measurement, and improvement of indoor air quality and temperatures.		
KEY PLANNING ISSUES: Communities at Increased Risk Existing Buildings	VULNERABILITY ADDRESSED: San Francisco is vulnerable to poor air quality from wildfires. Air pollution is also influenced by proximity to freeways and other high-traffic arterials, industrial, and maritime activity. Exposure to pollutants increases rates respiratory and cardiovascular illnesses.		
LEAD: SFO, DPH PARTNERS: ORCP	ACTION SUMMARY: This action focuses on implementing Phase II of the SFO air quality framework, which seeks to improve the air quality on the airport campus through a combination of outdoor air quality controls, electrification of fossil fuel infrastructure, aircraft measures, reducing heat islands, and installation of measure that trap particulates. Phase II focuses on developing the business case and will culminate in pilot projects in the Phase III. In addition, the action involves developing a network of indoor and outdoor heat and air quality monitors to inform and evaluate heat and air quality improvement projects.		
COST: Low	SF GOVERNMENT ACTIVITY: Public Assets Owner	STATUS: New	
POTENTIAL FUNDING SOURCES: Grants	PRIORITY LEVEL: High	TIMELINE: By 2027	

C-1.5	Conduct studies to better understand how sea level rise may interact with contaminated lands and potential health risks	
KEY PLANNING ISSUES: Communities at Increased Risk Waterfront	VULNERABILITY ADDRESSED: The impacts of sea level and groundwater rise on contaminated sites and remediation techniques is an emerging issue requiring research and planning.	
LEAD: DPH PARTNERS: Port, OCII, ORCP, DTSC, SWRCB, CBOs, SFPUC	ACTION SUMMARY: This action involves seeking funding to conduct modeling, using the best available science, of the impacts of sea level and groundwater rise on areas with known contamination, including the mobilization of pollutants. Such studies should be designed to (1) improve understanding and communications of potential risks to human health and the environment, (2) establish a decision-making framework for implementing mitigation measures, (3) and inform waterfront adaptation planning.	
COST: Medium	SF GOVERNMENT ACTIVITY: Research, Planning, & Guidance	STATUS: Scaling
POTENTIAL FUNDING SOURCES: General Funds	PRIORITY LEVEL: High	TIMELINE: By 2030

C-1.6	Protect human health and the environment through close involvement in the framework of property controls and mitigations at the Hunters Point Shipyard.	
KEY PLANNING ISSUES: Waterfront New Housing and Development	VULNERABILITY ADDRESSED: The former military base includes contaminated sites and could be exposed to future flooding due to sea level and groundwater rise.	
LEAD: OCII PARTNERS: DPH, Navy, EPA, DTSC, City Attorney's Office, Shipyard Hunters Point CAC	ACTION SUMMARY: The Navy is the lead agency responsible for investigating and cleaning up contaminated sites at the Hunters Point Shipyard, Regulatory Agencies provide oversight, while DPH and OCII are closely involved and review and comment. The Navy is obligated to examine its proposed and prior cleanup activities every five years to ensure the remedies are still protective of human health and the environment in light of new science or emerging risks, and community input is solicited as part of the process. This Five-Year Review requirement remains in place following the transfer of Shipyard to OCII. The 2024 Five-Year Review included a Climate Resilience Assessment that identified potential vulnerabilities due to sea and groundwater level rise. The Navy will complete additional studies based on the findings from the 2024 Five-Year Review.	
COST: High	SF GOVERNMENT ACTIVITY: Public Assets Owner	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: Special Funds	PRIORITY LEVEL: High	TIMELINE: On-going

C-1.7	Expand household hazardous waste collection efforts.	
KEY PLANNING ISSUES: Communities at Increased Risk	VULNERABILITY ADDRESSED: Improper management of household hazardous waste increases the risk of human exposure to hazardous materials and potential contamination of soil and groundwater.	
LEAD: SFE PARTNERS: Recology San Francisco and DPH	ACTION SUMMARY: This action expands education to San Francisco residents and businesses about the importance of safely disposing of hazardous waste and promoting San Francisco's established programs for proper management of these items. Emphasis will be placed on the collection and recycling of lithium batteries as they are more prone to catching fire if they are damaged or disposed of incorrectly.	
COST: Low	SF GOVERNMENT ACTIVITY: Community Services Delivery	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: Special Funds, Grants	PRIORITY LEVEL: Medium	TIMELINE: On-going

C-2.1	Support neighborhood level capacity building.	
KEY PLANNING ISSUES: Engagement and Capacity Building Communities at Increased Risk	VULNERABILITY ADDRESSED: Community-based organizations provide critical services and act as a first point of contact but often lack the resources to preemptively invest in hazard mitigation and emergency preparedness.	
LEAD: DEM, DPH, ORCP PARTNERS: SFE, Planning, Port	ACTION SUMMARY: This action involves supporting community-based partners to enhance their capacity to serve their constituents and neighborhoods with needed services on a regular basis and continue to serve and/or modify their services during emergencies. This action includes programs like the DEM Extreme Weather Resilience Program, the Heat and Air Quality Resilience Program. It also includes connecting and supporting community partners to access state and federal resources to create community-serving resilience hubs, involving building retrofits and community services.	
COST: Medium	SF GOVERNMENT ACTIVITY: Community Services Delivery	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: General Funds, Grants	PRIORITY LEVEL: High	TIMELINE: On-going

C-2.2	Support volunteer emergency preparedness, response, and recovery programs including the Neighborhood Emergency Response Team (NERT).	
KEY PLANNING ISSUES: Engagement and Capacity Building	VULNERABILITY ADDRESSED: After a major event, emergency responders may need to prioritize their actions. Residents and community groups with the appropriate skills could help their neighbors until responders are available.	
LEAD: SFFD PARTNERS:	ACTION SUMMARY: SFFD routinely conducts Neighborhood Emergency Response Team (NERT) training. This training educates people about disaster preparedness for hazards that might impact their area and trains them in basic disaster response skills, such as fire safety, light search and rescue, team organization, and disaster medical operations. This action supports the NERT program, its growth in participation and retention. This will include increasing funding and staffing support the work of daily operations, community engagement, and training. This effort aims to increase the program from less than 1 percent of residents trained to 5 percent of residents within 3 years and to further support these residents.	
COST: Medium	SF GOVERNMENT ACTIVITY: Community Services Delivery	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: General Funds, Grants	PRIORITY LEVEL: High	TIMELINE: On-going

C-3.1	Coordinate resilience engagement across departments and projects through ClimateSF.	
KEY PLANNING ISSUES: Engagement and Capacity Building	VULNERABILITY ADDRESSED: The City's complex public decision-making processes can make it difficult and time-consuming for many people to participate in processes that stand to directly impact them.	
LEAD: ORCP PARTNERS: Planning, Port, SFPUC, DPH, SFE	ACTION SUMMARY: Community engagement is an integral part of climate resilience planning. Agencies currently rely on project-based engagement, which can often lead to engagement fatigue in EJ Communities and departments may not always have dedicated resources for engagement. This action will support engagement at a city-wide level through increased coordination between existing climate resilience engagement points. This will allow for more robust, ongoing connections with community partners to support all climate resilience work.	
COST: Low	SF GOVERNMENT ACTIVITY: Research, Planning & Guidance	STATUS: New
POTENTIAL FUNDING SOURCES: General Funds	PRIORITY LEVEL: High	TIMELINE: On-going

C-3.2	Track progress and update the Lifelines Restoration Performance Project recommendations	
KEY PLANNING ISSUES: Engagement and Capacity Building	VULNERABILITY ADDRESSED: Following a disaster, recovery will depend on the timely restoration of lifeline systems such as transportation, communication, water, and wastewater, electricity, natural gas, and fuel, which have complex interdependencies.	
LEAD: ORCP PARTNERS: California Resiliency Alliance	ACTION SUMMARY: The Lifelines Restoration Performance Project developed a simple infrastructure resilience assessment framework with performance goals—that is, desired targets for system recovery timelines following a scenario earthquake event, evaluate the current state of performance for specific systems in that earthquake, and recommended actions to achieve desired restoration times. The Lifelines Council is currently focused on monitoring and implementing these recommendations. An update of the report is planned for 2025.	
COST: Low	SF GOVERNMENT ACTIVITY: Research, Planning & Guidance	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: General Funds	PRIORITY LEVEL: High	TIMELINE: On-going

C-3.3	Develop and improve systems for hazard and climate resilience data	
KEY PLANNING ISSUES: Engagement and Capacity Building	VULNERABILITY ADDRESSED: Quickly accessing hazard and asset GIS data is a challenge for many departments. Members of the public have also expressed interest in more accessible local hazard and climate data.	
LEAD: ORCP PARTNERS: DT	ACTION SUMMARY: ORCP, Planning, and DEM have collected robust GIS data relating to hazards (seismic, SLR, etc.) and relevant assets. To benefit future projects and implementation of the HCR, a system needs to be established to organize, maintain, and make this data accessible to other departments. This benefits future projects involving neighborhood level hazard or asset specific vulnerability assessments. Publishing non-sensitive data through a public data/mapping sharing platform will be pursued to improve accessibility for community-based organizations the public.	
COST: Low	SF GOVERNMENT ACTIVITY: Research, Planning & Guidance	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: General Funds	PRIORITY LEVEL: High	TIMELINE: By 2027

C-3.4	Improve San Francisco's climate health research capacity.	
KEY PLANNING ISSUES: Engagement and Capacity Building Communities at Increased Risk	VULNERABILITY ADDRESSED: Pre-existing health conditions can impact people's ability to access resources during a hazard event or lead to them having increased sensitivity when these events occur.	
LEAD: DPH PARTNERS:	ACTION SUMMARY: Interventions to protect the public from the health impacts of climate change-related hazard events will be most successful if based on data-informed research and best practices. The SF Climate and Health Program has developed a range of resources. As the health impacts of climate change become more significant, it is important that San Francisco's climate health research capacity scales appropriately. As climate change advances, research is an essential pursuit to ensure that the City can be proactive in protecting residents from its impacts.	
COST: Low	SF GOVERNMENT ACTIVITY: Research, Planning & Guidance	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: General Funds, Grants	PRIORITY LEVEL: High	TIMELINE: On-going

C-3.5	Develop citywide policy and proposed governance structure for flood resilience.	
KEY PLANNING ISSUES: Engagement and Capacity Building Water and Wastewater	VULNERABILITY ADDRESSED: Multiple agencies have jurisdiction relating to management of current and future flood hazards, leading to challenges for planning, policy, and implementation.	
LEAD: SFPUC PARTNERS: Port, Planning, ORCP, DPW	ACTION SUMMARY: Recent studies have increased knowledge on projected impacts from changing precipitation patterns from storm systems as well as novel flood risks such as emergent groundwater flooding. As sea level rise further compounds these flood risks, the City will explore new approaches to managing flood risk and the policies and governance frameworks necessary to managing increasing risks in a cost-effective way.	
COST: Medium	SF GOVERNMENT ACTIVITY: Adoption & Enforcement of Regulations	STATUS: New
POTENTIAL FUNDING SOURCES: General Funds, Grants	PRIORITY LEVEL: High	TIMELINE: By 2029

C-4.1	Establish an evacuation strategy for people with Access and Functional Needs, including vertical evacuation and large-building refuges.	
KEY PLANNING ISSUES: Communities at Increased Risk	VULNERABILITY ADDRESSED: People with access and functional needs are acutely impacted by disasters and often face unique challenges.	
LEAD: DEM PARTNERS: MOD, SFFD	ACTION SUMMARY: By developing a coordinated evacuation strategy, with consideration for the needs of populations with access and functional needs, support for this population can be effectively communicated to the public in case evacuation procedures need to be pursued. Low-lying areas are particularly at risk from flooding and tsunami. In areas where high ground is not immediately available, vertically evacuating and seeking refuge in tall buildings might be the best option for life safety, especially for people with disabilities or access and functional needs.	
COST: Medium	SF GOVERNMENT ACTIVITY: Research, Planning & Guidance	STATUS: New
POTENTIAL FUNDING SOURCES: General Funds, Grants	PRIORITY LEVEL: High	TIMELINE: By 2027

C-4.2	Pilot a wellness check program for vulnerable populations including homebound seniors, and people with access and functional needs.	
KEY PLANNING ISSUES: Communities at Increased Risk	VULNERABILITY ADDRESSED: Social isolation is a significant factor in illness and death from extreme heat, particularly in communities that already face increased health risks.	
LEAD: HSA PARTNERS: DEM, DPH, MOD, HSH	ACTION SUMMARY: This action would increase coordination between existing wellness check programs to increase regional collaboration opportunities, reduce redundancies, and standardize culturally competent messaging practices.	
COST: Low	SF GOVERNMENT ACTIVITY: Community Services Delivery	STATUS: New
POTENTIAL FUNDING SOURCES: General Funds, Grants	PRIORITY LEVEL: High	TIMELINE: By 2029

C-4.3	Develop a Homelessness Disaster Response Plan	
KEY PLANNING ISSUES: Communities at Increased Risk Research and Planning	VULNERABILITY ADDRESSED: San Francisco has a large unhoused population as a proportion of the total population. Unhoused people have more exposure to hazard events and are much likely to have other conditions that reduce their adaptive capacity.	
LEAD: HSH PARTNERS: DPH, DEM	ACTION SUMMARY: In the event of a disaster, homeless people are among the most vulnerable populations to experience impacts. To address this, HSH is working with consultants from the Technical Assistance Collaborative (TAC) to develop a Homelessness Disaster Response Plan. The plan will identify key recommendations and next steps for HSH and partners to plan for, mitigate, and respond to the unique needs of this population during a large-scale disaster.	
COST: Low	SF GOVERNMENT ACTIVITY: Community Services Delivery	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: General Funds, Grants	PRIORITY LEVEL: High	TIMELINE: By 2029

C-4.4	Develop a public outreach campaign and wayfinding plan for tsunami awareness and evacuation procedures	
KEY PLANNING ISSUES: Communities at Increased Risk	VULNERABILITY ADDRESSED: The areas at greatest risks for tsunami include low-lying, waterfront areas with a relatively high vulnerability.	
LEAD: DEM PARTNERS:	ACTION SUMMARY: New scientific information and maps showing increased coastal flood potential from separate and combined factors, including sea level rise, King tides, and tsunamis. Public awareness is key to saving lives during extreme events. Visible signage on kiosks, sidewalks, and streets will help direct egress and save lives during these events. Specific populations require tailored communication strategies to be effective.	
COST: Low	SF GOVERNMENT ACTIVITY: Research, Planning & Guidance	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: General Funds, Grants	PRIORITY LEVEL: Medium	TIMELINE: By 2029

C-4.5	Improve citywide resilience to pandemics and infectious diseases.	
KEY PLANNING ISSUES: Communities at Increased Risk	VULNERABILITY ADDRESSED: Pandemics can have severe adverse impacts to human health, the health care sector, and economic activity.	
LEAD: DPH PARTNERS: OEWD, DEM	ACTION SUMMARY: Developing strategies to lessen the impacts of future diseases will improve San Francisco's ability to protect the health and social well-being of San Francisco's residents, workers, visitors, and the economy.	
COST: TBD	SF GOVERNMENT ACTIVITY: Community Services Delivery	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: General Funds, Privately	PRIORITY LEVEL: Medium	TIMELINE: By 2029

C-5.1	Establish disaster relief funding and small business resilience fund.	
KEY PLANNING ISSUES: Business and Workforce	VULNERABILITY ADDRESSED: Small businesses often have fewer cash reserves to withstand temporary closures or reduced demand due to hazards, but are important sources of employment, goods, and services.	
LEAD: OEWD PARTNERS:	ACTION SUMMARY: Explore the ability to offer grants, low-interest loans, and other technical assistance related to preventing closure of businesses impacted by natural disasters or fire. Grants could cover eligible, unmet rehabilitation repair, replacement, and mitigation needs or projects that will increase sales, increase foot traffic, and retain and create jobs.	
COST: Subject to grant funding	SF GOVERNMENT ACTIVITY: Community Services Delivery	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: General Funds, Special funds, Grants	PRIORITY LEVEL: Medium	TIMELINE: By 2029

C-5.2	**Scale and mobilize layoff outplacement services for post-disaster economic impacts.**	
KEY PLANNING ISSUES: Business and Workforce	VULNERABILITY ADDRESSED: Workers are vulnerable to job losses after a disaster event, which can cause economic and social impacts to ripple through communities, especially lower-income communities.	
LEAD: OEWD PARTNERS:	ACTION SUMMARY: This action would aim to preemptively support those workers facing layoffs following a disaster event, to reduce the potential economic disruption that could ripple through communities following these events. A primary focus would be to enable affected workers to return to work as quickly as possible organize with partners to provide services to businesses and affected employees to ensure a transition that is as seamless as possible.	
COST: Medium	SF GOVERNMENT ACTIVITY: Community Services Delivery	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: General Funds, Grants	PRIORITY LEVEL: High	TIMELINE: By 2029

C-6.1	**Continue to meet housing production goals.**	
KEY PLANNING ISSUES: New Housing and Development	VULNERABILITY ADDRESSED: The majority of low-income residents are housing cost-burdened. Sixty percent of subsidized affordable housing units are concentrated in 5 neighborhoods.	
LEAD: MOHCD, OCII, TIDA, OEWD Joint Development PARTNERS: Planning, DBI	ACTION SUMMARY: The City has a goal to create 82,000 housing units, 32,881 of which being very-low or low-income units, by 2030. These homes serve families, seniors, essential workers, and people formerly experiencing homelessness. Living in an affordable home increases one's ability to cope with impacts of a hazard event. The recently updated Housing Element, implementation of approved development agreements, and re-zoning will allow for more housing development to occur in neighborhoods with less hazard exposure and greater adaptive capacity. Stakeholders engaged stressed the importance of building housing that meets the needs of San Francisco's vulnerable populations.	
COST: High	SF GOVERNMENT ACTIVITY: Funding and Financing	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: General Funds, Special Funds, Debt, Privately Funded, Grants	PRIORITY LEVEL: High	TIMELINE: By 2029

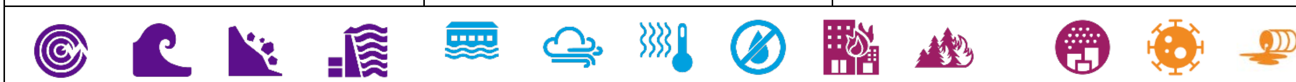
PILLAR: INFRASTRUCTURE (IN)

IN-1.1	Enhance energy resilience at critical facilities.	
KEY PLANNING ISSUES: Communications and Power Existing Buildings	VULNERABILITY ADDRESSED: Some important facilities do not have adequate backup power to maintain operations during a power outage. Following a hazard event, fuel supplies for back-up generators may be highly constrained.	
LEAD: SFPUC, DPW PARTNERS: SFE, ORCP, SFO, others	ACTION SUMMARY: Chapter 7 of the Environment Code requires installing solar PV and battery storage at Critical Community Institutions that are undergoing major renovation, HVAC replacement, electrical upgrade or new construction. Chapter 7 offers other methods to achieve energy resilience for other municipal facilities that are not Critical Community Institutions. This action also involves exploring other technologies, such as SFO piloting bi-directional charging with their bus fleet to provide power to their critical facilities in the event of a power outage. Some community-based organizations are also pursuing energy resilience projects through state and federal grant sources.	
COST: High	SF GOVERNMENT ACTIVITY: Public Assets Owner	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: Special Funds, Debt, General Funds, Grants	PRIORITY LEVEL: High	TIMELINE: On-going

IN-1.2	Improve and expand power distribution infrastructure and advanced energy systems to support new development and increase resiliency.	
KEY PLANNING ISSUES: Communications and Power New Housing and Development	VULNERABILITY ADDRESSED: Electrical distribution infrastructure can be impacted by a wide range of hazards and is critical to achieving housing and climate goals. Electric power is a critical lifeline.	
LEAD: SFPUC PARTNERS:	ACTION SUMMARY: By building new electric distribution infrastructure, the City can provide reliable power to new developments along the central and southeast waterfront. These investments will include advanced energy systems that constitute the best available technologies for meeting energy needs, including energy efficiency, demand response, smart grid components, and on-site distributed resources such as solar with batteries. This action provides SFPUC with the ability to implement various City objectives independent of PG&E, including advancing building and transportation decarbonization objectives featured in the City's Climate Action Plan. Stakeholders emphasized the importance of addressing power demands, brownouts, and outages.	
COST: High	SF GOVERNMENT ACTIVITY: Public Assets Owner	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: Special Funds, Debt, Privately Funded	PRIORITY LEVEL: High	TIMELINE: By 2034

IN-1.3	Complete the Electrical Capacity Upgrade Project to ensure redundant electrical power capacity and distribution across SFO	
KEY PLANNING ISSUES: Communications and Power Transportation	VULNERABILITY ADDRESSED: Distribution infrastructure can be impacted by a wide range of hazards and electric power is a critical lifeline.	
LEAD: SFO PARTNERS:	ACTION SUMMARY: The long-term plan for SFO is to have fully redundant 12 kilovolt electrical power feeds from two separate sources with the capacity to provide power to SFO through 2040. The two substations feeding SFO will have redundant transformer capacity and cabling into SFO. Planning will occur in 2019–2020 and design/construction in phases from 2021–2025. This action is part of the SFO's FY19/20 Infrastructure Capital Improvement Program.	
COST: High	SF GOVERNMENT ACTIVITY: Public Assets Owner	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: Special Funds, Debt, Grants	PRIORITY LEVEL: Medium	TIMELINE: By 2027

IN-1.4	Develop a roadmap for disaster resilient fleets and EV charging infrastructure		
NEEDS KEY PLANNING ISSUES: Communications and Power Transportation	VULNERABILITY ADDRESSED: The transition to zero emission vehicle (ZEV) fleets relies on power sources that are unreliable or not yet available. This could cause significant challenges for utilizing City vehicles during emergency operations, and more detailed planning is needed.		
LEAD: Fleet, ORCP PARTNERS: SFPUC,SFE, MTA, SFFD	ACTION SUMMARY: Create a roadmap for resilient ZEV power infrastructure that prioritizes life safety and disaster-response operations, acknowledges the need for redundancy, and identifies potential solutions for electric and hydrogen power needs. Wherever resources allow, invest in contracts, infrastructure, and equipment that will help the City meet its expected fuel and power needs.		
COST: Medium	SF GOVERNMENT ACTIVITY: Research, Planning, and Guidance	STATUS: New	
POTENTIAL FUNDING SOURCES: General Fund, Special Funds	PRIORITY LEVEL: Medium	TIMELINE: By 2029	



IN-2.1	Increase the Resilience of the Municipal Fiber Optic Network	
KEY PLANNING ISSUES: Communications and Power	VULNERABILITY ADDRESSED: Disruption to the City's fiber network due to a hazard event could result in a breakdown of communication between City departments, buildings, and the public for several days; severely affecting disaster response.	
LEAD: DT PARTNERS:	ACTION SUMMARY: Presently, there are no staff authorized to maintain or repair the fiber network. Authorizing two fiber crews consisting of ten employees to install redundant fiber paths and a well-designed backup microwave link will ensure enhanced reliability and resilience for fiber infrastructure in case of a major disaster.	
COST: High	SF GOVERNMENT ACTIVITY: Public Assets Owner	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: General Funds, Debt, Grants	PRIORITY LEVEL: High	TIMELINE: On-going

IN-2.2	Increase the Resilience of the 911 Radio System	
KEY PLANNING ISSUES: Communications and Power	VULNERABILITY ADDRESSED: Many systems are dependent upon communications, including internet.	
LEAD: DT PARTNERS:	ACTION SUMMARY: The 911 Radio System consists of ten widely distributed, interconnected, fixed radio sites that are vulnerable to hazards. A power failure will shut the system down if the emergency generators are not promptly refueled. Acquiring additional fuel trucks will increase the fuel capacity of the system. Adding fixed and mobile radio sites will also ensure enhanced reliability and resiliency of the system in case of disaster.	
COST: High	SF GOVERNMENT ACTIVITY: Public Assets Owner	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: General Funds, Debt, Grants	PRIORITY LEVEL: High	TIMELINE: By 2029

IN-3.1	Incorporate opportunities for hazard mitigation into the planning and design of all SFMTA facility improvements and property re-development.	
KEY PLANNING ISSUES: Transportation Existing Buildings	VULNERABILITY ADDRESSED: Some SFMTA facilities are aging, and yards are particularly outdated for current needs and vulnerable to multiple hazards.	
LEAD: SFMTA PARTNERS: DPW	ACTION SUMMARY: The Building Progress Program is a $2.3 billion multi-year effort to repair, renovate, and modernize the SFMTA's aging facilities to keep the City moving and transition to a zero-emission bus fleet. Current major efforts include Potrero Yard and Presidio Yard Modernization Projects, and Kirkland Yard Electrification Project. Additionally, flood adaptation is occurring at MUNI Metro East Maintenance Facility through the Port's Waterfront Resilience Program. Efforts will also include acting on the recently created gas equipment inventory to support future electrification efforts.	
COST: High	SF GOVERNMENT ACTIVITY: Public Assets Owner	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: General Fund, Debt, Grants, Special Funds	PRIORITY LEVEL: High	TIMELINE: On-going

IN-3.2	Continue to study, plan, design, and implement improvements to the multimodal transportation system that are vulnerable to coastal flooding.	
KEY PLANNING ISSUES: Transportation Waterfront	VULNERABILITY ADDRESSED: Current king tide flooding impacts safety and mobility. Flood risk will become more severe in the future with SLR and intense precipitation events. The transportation network is particularly vulnerable to flooding near creeks and the Embarcadero.	
LEAD: SFMTA PARTNERS: Port, Planning, DPW, SFPUC, SFCTA	ACTION SUMMARY: This action involves studies, plans, and implementing improvements to the multimodal transportation system that are vulnerable to flooding. This action includes technical studies and vulnerability and risks assessments. Examples of this work include implementing the Ocean Beach Master Plan, San Francisco Waterfront Coastal Flood Study, Islais Creek Mobility Adaptation Strategy, and coastal planning efforts such as the Embarcadero Connectivity Plan.	
COST: Medium	SF GOVERNMENT ACTIVITY: Public Assets Owner	STATUS: Existing
POTENTIAL FUNDING SOURCES: General Funds, Debt, Grants	PRIORITY LEVEL: High	TIMELINE: By 2029

IN-3.3	Improve the public right-of-way state-of-good-repair, including retrofitting bridges and other key structures.	
KEY PLANNING ISSUES: Transportation	VULNERABILITY ADDRESSED: Older infrastructure may not be built to modern standards, may experience material degradation over time, or not be designed for climate change, resulting in poorer performance in during a hazard.	
LEAD: ORCP, DPW PARTNERS: Mayor's Office, SFMTA, SFCTA, Caltrans	ACTION SUMMARY: Maintaining the right-of-way, which includes roads, transit, sidewalks, bridges, and other structures, in a state-of-good-repair is critical to achieving safety and desired performance before, during, and after a hazard event. The City's 10-Year Capital Plan lays out renewal programs, enhancement projects, and emerging needs to give as full a picture of San Francisco's capital needs as possible. The "Infrastructure and Streets" and "Transportation" chapters capture the capital needs related to the City's Better Streets Plan, Vision Zero policy. and other efforts related to the right-of-way.	
COST: High	SF GOVERNMENT ACTIVITY: Public Assets Owner	STATUS: Scaling
POTENTIAL FUNDING SOURCES: General Funds, Debt, Grants	PRIORITY LEVEL: High	TIMELINE: On-going

IN-3.4	Decrease the geographic vulnerability inherent to the island communities on Treasure Island and Yerba Buena Islands by increasing low-emission, connectivity to San Francisco.	
KEY PLANNING ISSUES: Transportation Communities at Increased Risk	VULNERABILITY ADDRESSED: Communities that are physically isolated may experience more significant consequences if transportation assets are impacted by a hazard.	
LEAD: TIMMA PARTNERS: SFCTA, SFMTA, TIDA, WETA	ACTION SUMMARY: This strategy includes expansion of transit and active transportation options to and around the islands as alternatives to driving; provision of service with zero-emission vehicles and vessels; and implementation of active travel demand management measures to shift travel to sustainable modes.	
COST: High	SF GOVERNMENT ACTIVITY: Public Assets Owner; Funding and Finance	STATUS: New
POTENTIAL FUNDING SOURCES: General Funds, Special funds, Grants	PRIORITY LEVEL: Medium	TIMELINE: By 2030

IN-3.5	Implement the SFO Infrastructure Resilience Framework to improve resilience of critical facilities, assets, operations, and lifeline utility systems.	
KEY PLANNING ISSUES: Transportation Communications and Power	VULNERABILITY ADDRESSED: BART access to SFO may see disruption in a strong shaking event and some SFO terminals may be vulnerable to damage if they have not been recently seismically retrofitted. Runways may be vulnerable to liquefaction and strong shaking damage as well.	
LEAD: SFO PARTNERS:	ACTION SUMMARY: The San Francisco International Airport Infrastructure Resilience Framework developed a high-level guide for improving the critical facilities and lifeline utility systems at the SFO campus. This action focuses on taking that guide and operationalizing it into specific projects that can ensure that the airport is in the best position to endure hazard events and provide support during the recovery of any significant Bay Area event. This action supports the implementation of associated programs at the airport such as the Airport Emergency Plan, the updated Business Continuity Plan, and the Infrastructure Modernization Program.	
COST: High	SF GOVERNMENT ACTIVITY: Public Assets Owner	STATUS: New
POTENTIAL FUNDING SOURCES: Debt	PRIORITY LEVEL: High	TIMELINE: By 2034

IN-4.1	Continue to improve wildfire prevention through vegetation management in Recreation Areas.	
KEY PLANNING ISSUES: Open Space and Biodiversity	VULNERABILITY ADDRESSED: Recreations areas need on-going management in order to ensure wildfire prevention in larger park areas.	
LEAD: RPD PARTNERS:	ACTION SUMMARY: Each year, RPD conducts fire abatement in coordination with the San Francisco Fire Department. Fire abatement is the process of reducing the volume of flammable vegetation (a.k.a. "fuel") in areas susceptible to wildfire risk. This work includes cutting dry grass, removing downed limbs, and pruning flammable (i.e., typically dead and dry) vegetation. This does not include removing green vegetation, live plants and trees, and low-fuel material. Areas where fire abatement has been conducted around buildings is referred to as "defensible space." RPD performs its abatement procedure by clearing flammable vegetation that is on our property within a 30' feet buffer zone adjacent to habitable structures. We generally complete our abatement by May 31st each year.	
COST: Medium	SF GOVERNMENT ACTIVITY: Public Assets Owner	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: General Funds, Special funds	PRIORITY LEVEL: High	TIMELINE: On-going

IN-4.2	Maximize drought tolerant, native species in plantings for parks and landscaping whenever feasible.	
KEY PLANNING ISSUES: Open Space and Biodiversity, Water Conservation	VULNERABILITY ADDRESSED: Native plants provide foundational ecosystem functions and planting natives promotes native biodiversity. Changes in precipitation distribution will potentially impact water supplies and ecosystems.	
LEAD: RPD, DPW PARTNERS: SFE	ACTION SUMMARY: San Francisco is a global biodiversity hotspot, containing dozens of natural ecological communities, a wide array of wildlife, and over 500 local native plants. However, San Francisco is also 95% developed, and biodiversity in the city is under serious threat. RPD and DPW recognize the need to protect remnant native landscapes in San Francisco and plant native plants. RPD and DPW also recognize the need to conserve water whenever possible. The agencies commit to maximize native and drought tolerant plants whenever feasible to address these related goals and integrate considerations into the City's Updated Street Tree List and Biodiversity Guidelines.	
COST: High	SF GOVERNMENT ACTIVITY: Public Assets Owner	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: General Funds, Special Funds, Grants	PRIORITY LEVEL: High	TIMELINE: On-going

IN-4.3	Strengthen citywide efforts to conserve, restore, and steward biodiversity.	
KEY PLANNING ISSUES: Open Space and Biodiversity	VULNERABILITY ADDRESSED: Biodiversity provides ecosystem services that the City relies for hazard mitigation and climate adaptation and faces a global crisis.	
LEAD: SFE PARTNERS: Various public and private agencies	ACTION SUMMARY: The Biodiversity Inter-Agency Working Group (BiodIWG) will continue to implement the San Francisco Biodiversity Policy. One of the goals is Resilience in a Living City which involves, leveraging natural ecosystems to conserve water, prevent flooding, manage pests and improve air quality. The BiodIWG has identified potential new initiatives (including ReimaginingSF) that will promote local ecosystem restoration, and biodiverse greening while also advancing climate resilience. These key opportunity efforts will be further refined and prioritized for incorporation into department work plans.	
COST: Medium	SF GOVERNMENT ACTIVITY: Public Assets Owner	STATUS: Existing
POTENTIAL FUNDING SOURCES: General Funds, Privately Funded, Grants	PRIORITY LEVEL: High	TIMELINE: On-going

IN-4.4	Develop public private partnerships to conserve and steward biodiversity and habitat on Treasure Island and Yerba Buena Islands.	
KEY PLANNING ISSUES: Open Space and Biodiversity Communities at Increased Risk	VULNERABILITY ADDRESSED: Biodiversity provides the City with essential ecosystem services such as hazard mitigation and climate adaptation but is facing a global crisis.	
LEAD: TIDA PARTNERS: SFE, RPD	ACTION SUMMARY: TIDA has a long-term framework for restoration, enhancement and protection of Yerba Buena Island's 37 acres of natural areas. Stewardship of vital YBI natural areas will be critical. Over the course of the development of Treasure Island, another 103 acres of restored habitat with an ecological focus will be created. To date, TIDA has partnered with SFE and nonprofits on stewardship. By 2028, TIDA seeks to establish partnerships with RPD and local nonprofits to support care and community stewardship for these lands beyond what is possible by City staff. including community volunteer opportunities, community science events, shoreline clean-ups, workforce training and work entry programs.	
COST: Low	SF GOVERNMENT ACTIVITY: Public Assets Owner	STATUS: New
POTENTIAL FUNDING SOURCES: General Funds, Special Funds, TI CFD, Privately Funded, Grants	PRIORITY LEVEL: Med	TIMELINE: By 2029

IN-4.5	Adapt shoreline parks to sea level rise and salt-water intrusion using nature-based solutions and maximizing native plan diversity, where feasible.	
KEY PLANNING ISSUES: Waterfront Open Space and Biodiversity	VULNERABILITY ADDRESSED: Without action, coastal flooding due to sea level rise could eventually drown shoreline habitats resulting in the loss of critical ecosystem services, biodiversity, and open space.	
LEAD: RPD, Port PARTNERS: TIDA, OCII, GGNRA, and State Parks	ACTION SUMMARY: Shoreline parks are vulnerable to sea level rise. Without adequate planning and design these parks could become inundated leading to the loss of critical open space, waterfront access, habitat, and biodiversity. Where feasible, shoreline park adaptation planning should incorporate nature-based solutions to promote the adaptation and resilience of these spaces in response to rising sea levels.	
COST: TBD	SF GOVERNMENT ACTIVITY: Public Assets Owner	STATUS: New
POTENTIAL FUNDING SOURCES: General Funds, Debt, Grants	PRIORITY LEVEL: High	TIMELINE: On-going

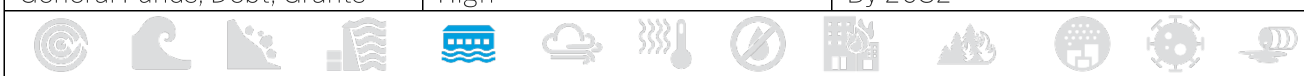
IN-5.1	Implement Embarcadero Early Projects to address areas of highest earthquake and flood risk along the Embarcadero waterfront.	
KEY PLANNING ISSUES: Waterfront	VULNERABILITY ADDRESSED: The Embarcadero Seawall is over 100 years old and is at significant risk from a seismic event and future flooding.	
LEAD: Port PARTNERS: Planning, SFMTA, SFPUC, BART	ACTION SUMMARY: This action is focused on implementing early projects in the Embarcadero area to lower earthquake and flood risk. Building on extensive risk assessment work over the last few years, these projects will provide a range of benefits from life safety improvements to improved ecological opportunities while improving the resilience of the embarcadero area and the seawall to impacts from a large seismic event and near-term flooding. This includes improvements to numerous bulkhead and wharf structures to withstand expected seismic events and will tie into larger efforts to safeguard the entire waterfront as a part of the Waterfront Resilience Program.	
COST: High	SF GOVERNMENT ACTIVITY: Public Assets Owner	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: City GO Bond, General Funds, Grants	PRIORITY LEVEL: High	TIMELINE: By 2034

IN-5.2	Make under deck pier structure utilities more resilient to flooding and seismic hazards.	
KEY PLANNING ISSUES: Waterfront	VULNERABILITY ADDRESSED: The Port has many piers with under-pier utilities that are at risk from storm events, sea level rise, and earthquakes. As water levels rise, the potential for damage to and disruption of the utilities increases.	
LEAD: Port PARTNERS: SFPUC	ACTION SUMMARY: Typical utility infrastructure serving piers includes critical life safety services such as fire water service piping, sanitary sewer piping, and electrical power service lines. These utilities typically pass through the seawall and run under the pier deck. Earthquakes risk damaging utilities as they pass through the seawall onto the pier. Sea level rise will increase exposure of underdeck utilities to splash, waves, and floating debris, causing increased corrosion and risk of damage. This action will strengthen or relocate under deck utilities as part of large tenant improvement projects, pier development projects, and seawall strengthening & replacement projects.	
COST: TBD	SF GOVERNMENT ACTIVITY: Public Assets Owner	STATUS: New
POTENTIAL FUNDING SOURCES: TBD	PRIORITY LEVEL: Medium	TIMELINE: By 2034

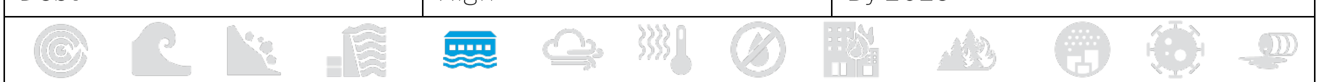
<table>
<tr><th>IN-5.3</th><th colspan="3">Develop projects and seek funding to implement the Islais Creek Southeast Mobility Adaptation Strategy (ICSMAS).</th></tr>
<tr><td colspan="2">KEY PLANNING ISSUES:
Waterfront
Transportation</td><td colspan="2">VULNERABILITY ADDRESSED:
The legacy of building on bay fill makes the waterfront more susceptible to seismic and flooding hazards.</td></tr>
<tr><td>LEAD:
Port, DPW, SFMTA
PARTNERS:
Planning, ORCP, SFPUC</td><td colspan="3">ACTION SUMMARY:
This action involves tracking how the key asset strategies and adaptation pathways from the 2021 Islais Creek Southeast Mobility Adaptation Strategy are being integrated or refined in the Port's Waterfront Resilience Program, San Francisco Waterfront Coastal Flood Study, and agency capital plans. The PUC's future work on stormwater modeling and citywide flood resilience policy will help inform agency decision-making on project scopes, timelines, or operational changes to manage near-term flood risks that may not be addressed by a federally funded Army Corps project(s).</td></tr>
<tr><td colspan="2">COST:
Low to track, high to implement potential projects</td><td>SF GOVERNMENT ACTIVITY:
Public Assets Owner</td><td>STATUS:
Sustaining</td></tr>
<tr><td colspan="2">POTENTIAL FUNDING SOURCES:
General Funds, Grants</td><td>PRIORITY LEVEL:
Medium</td><td>TIMELINE:
Begin tracking by 2025</td></tr>
</table>

<table>
<tr><th>IN-5.4</th><th colspan="3">Implement the Marina Improvement and Remediation Project</th></tr>
<tr><td colspan="2">KEY PLANNING ISSUES:
Waterfront
Open Space and Biodiversity</td><td colspan="2">VULNERABILITY ADDRESSED:
San Francisco's waterfront is vulnerable to coastal flooding due to sea level rise and seismic risks.</td></tr>
<tr><td>LEAD:
RPD
PARTNERS:
PG&E</td><td colspan="3">ACTION SUMMARY:
The Project will implement environmental remediation, improve the marina infrastructure and amenities, increase public access and recreational amenities in the Marina and parkland, and improve the Marina Bay Trail. This project is a joint effort by RPD and Pacific Gas and Electric Company (PG&E) to ensure an environmentally and fiscally sustainable marina as defined in a 2021 Final Settlement Agreement (FSA), and to clean up contamination in the East Harbor from manufactured gas plants in the area over 100 years ago.</td></tr>
<tr><td colspan="2">COST:
High</td><td>SF GOVERNMENT ACTIVITY:
Public Assets Owner</td><td>STATUS:
Sustaining</td></tr>
<tr><td colspan="2">POTENTIAL FUNDING SOURCES:
General Funds, Debt, Grants</td><td>PRIORITY LEVEL:
Medium</td><td>TIMELINE:
Construction to begin in 2026</td></tr>
</table>

IN-5.5	Implement the Ocean Beach Climate Adaptation Project, which represents 2 of 6 key moves of the Ocean Beach Master Plan.	
KEY PLANNING ISSUES: Waterfront Open Space and Biodiversity Water and Wastewater	VULNERABILITY ADDRESSED: Climate-induced sea level rise and severe erosion are threatening the southern portion of Ocean Beach, with implications for recreation amenities and major wastewater infrastructure.	
LEAD: SFPUC PARTNERS: SFMTA, RPD, ORCP	ACTION SUMMARY: The Ocean Beach Climate Change Adaptation Project addresses sea level rise, erosion, and shoreline protection at the southern end of Ocean Beach. The main strategies include managed retreat, asset protection through grey infrastructure, and natural adaptation measures that improve public access and habitat quality. The project is divided into short-and long-term improvements. The short-term improvements are meant to improve interim conditions while the long-term project is under development.	
COST: High	SF GOVERNMENT ACTIVITY: Public Assets Owner	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: General Funds, Debt, Grants	PRIORITY LEVEL: High	TIMELINE: By 2032



IN-5.6	Implement the San Francisco Airport Shoreline Protection Program	
KEY PLANNING ISSUES: Transportation Waterfront	VULNERABILITY ADDRESSED: SFO faces threat from SLR to some of its facilities, including runways and buildings that house critical functions.	
LEAD: SFO PARTNERS:	ACTION SUMMARY: This action would support the airport's ongoing work to install contiguous concrete sheet pile walls and steel king pile walls along the entire 8-mile shoreline for the campus. Design criteria will carefully balance the need for protection with the need to ensure safe and efficient operation of aviation activities. The system incorporates 42 inches of future sea level rise in addition to the existing FEMA requirements for 100-year flood event protection.	
COST: High	SF GOVERNMENT ACTIVITY: Public Assets Owner	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: Debt	PRIORITY LEVEL: High	TIMELINE: By 2029



IN-6.1	Develop subregional shoreline resiliency plan per SB 272	
KEY PLANNING ISSUES: Waterfront	VULNERABILITY ADDRESSED: San Francisco's waterfront is vulnerable to coastal flooding due to sea level rise and seismic risks.	
LEAD: Planning, ORCP PARTNERS: Port, RPD, TIDA, OCII, GGNRA, others	ACTION SUMMARY: SB 272 mandates local jurisdictions to develop subregional (i.e. county-wide) resiliency plans and submit to Bay Conservation and Development Commission (BCDC) by 2034. The legislation prioritizes state funding to create these plans and prioritizes funding for projects in jurisdictions with approved plans. The action involves identifying gaps in San Francisco's existing/on-going shoreline adaptation plans in order to meet BCDC guidelines and developing partnerships, scopes of work, and funding applications to address those gaps. Key gaps include parts of the Northern and Southern Waterfronts.	
COST: Low	SF GOVERNMENT ACTIVITY: Research, Planning & Guidance	STATUS: New
POTENTIAL FUNDING SOURCES: General Funds, Grants	PRIORITY LEVEL: Medium	TIMELINE: By 2034

IN-6.2	Advance the Waterfront Resilience Program and San Francisco Waterfront Coastal Flood Study to reduce flooding and seismic risk along the 7.5 miles of Port jurisdiction.	
KEY PLANNING ISSUES: Waterfront Transportation Utility	VULNERABILITY ADDRESSED: By 2050, 100-500 structures and assets will be vulnerable to flooding. Up to 40,000 people could be at risk on Port property if an earthquake occurs during the day.	
LEAD: Port PARTNERS: Planning, SFMTA, SFPUC, DPW, ORCP, RPD, USACE, FEMA, Caltrans	ACTION SUMMARY: The US Army Corps of Engineers (USACE)/Port of San Francisco Flood Study analyses flood risks and the impacts of sea level rise to the San Francisco waterfront from Aquatic Park to Heron's Head Park and determines the federal economic interest at risk from flooding in the study area. The Draft Plan released in early 2024 will inform subsequent stages of funding and design in order to develop targeted construction projects. The proposed solutions are estimated to cost $13.5 B and if approved by congress, the Federal government would pay 65% of the cost. The strategy will include seeking funding to design and construct the Flood Study Recommended Plan.	
COST: High	SF GOVERNMENT ACTIVITY: Research, Planning & Guidance	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: General Funds, Grants, Bond, Port Revenue, State and Federal Sources, PPPs	PRIORITY LEVEL: High	TIMELINE: By 2029

IN-6.3 Develop the Yosemite Slough Neighborhood Adaptation Plan

KEY PLANNING ISSUES:	VULNERABILITY ADDRESSED:
Waterfront Communities at Increased Risk	San Francisco's waterfront is vulnerable to coastal flooding due to sea level rise and seismic risks. The Yosemite Slough neighborhood also faces environment justice burdens and racial inequities.

LEAD:	ACTION SUMMARY:
Planning PARTNERS: Port, PUC, ORCP, SFMTA, DPH, RPD, DPW, OCII	Focused on the Yosemite Slough wetland and surrounding neighborhood, the adaptation plan will develop strategies to protect the community from sea level rise through the end of the century. The project is designed to advance racial & social equity, cross-sector collaboration, and community capacity in planning for multiple climate risks. City staff are partnering with CBOs to deliver the project and will align adaptation strategies with existing sea level rise efforts elsewhere in the City. The City is continuing to pursue state and federal funding opportunities to bring necessary investments to Bayview Hunters Point and advance environmental justice, including opportunities with the U.S. Army Corps of Engineers.

COST:	SF GOVERNMENT ACTIVITY:	STATUS:
Medium	Research, Planning & Guidance	New
POTENTIAL FUNDING SOURCES:	**PRIORITY LEVEL:**	**TIMELINE:**
General Funds, Grants	High	By 2026

IN-6.4 Advance plans and projects for Ocean Beach and Great Highway North of Sloat Blvd.

KEY PLANNING ISSUES:	VULNERABILITY ADDRESSED:
Waterfront Transportation	Ocean Beach is vulnerable to coastal flooding and erosion-related impacts due to sea level rise, storms, and high-wind.

LEAD:	ACTION SUMMARY:
RPD, GGNRA PARTNERS: SFMTA, SFPUC, State and Federal Agencies	This action involves seeking funding, partnerships, and community stewardship to implement nature-based solutions to restore dunes and reduce erosion and sand blowing onto the Great Highway. The Great Highway Pilot Project will help determine how the Great Highway will be used in the future as a recreational space. The Ocean Beach Master Plan and San Francisco Estuary Institute (SFEI) Dune Study call for sand replenishment between Santiago St. and Sloat Blvd. to reduce coastal erosion. Lastly, the O'Shaughnessy Ocean Beach parking lot should be improved to be more resilient while maintaining access.

COST:	SF GOVERNMENT ACTIVITY:	STATUS:
High	Research, Planning & Guidance	Sustaining
POTENTIAL FUNDING SOURCES:	**PRIORITY LEVEL:**	**TIMELINE:**
General Funds, Grants	Medium	Dunes by 2029 Sand replenishment by 2027

IN-6.5	Advance the Adaptive Management Strategy from the Treasure Island Infrastructure Plan to ensure continual protection to changing conditions.	
KEY PLANNING ISSUES: Waterfront New Housing and Development	VULNERABILITY ADDRESSED: Given the low-lying geography and artificial construction, the Treasure Island Infrastructure Plan address vulnerabilities related to earthquake, tsunami, flooding, drought, and hazardous materials.	
LEAD: TIDA PARTNERS: Planning, SFPUC, SFMTA, MOHCD	ACTION SUMMARY: As Treasure Island continues to develop over the coming decade, resilience measures in the Treasure Island Infrastructure Plan and related development agreements will be critical to implement and require partnerships with private developers, public infrastructure owners, non-profits. Adaptive management strategies for SLR include elevating grades to 3 feet above the current 100-year flood elevation with the first floor of buildings 42 inches above that level; building shoreline protection and development setbacks that can accommodate future SLR adaptation; maximizing the use of green infrastructure, and resorting of 300 acres of open spaces with native species.	
COST: High	SF GOVERNMENT ACTIVITY: Public Assets Owner	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: CFD, Grants	PRIORITY LEVEL: High	TIMELINE: By 2044

IN-6.6	Develop and support major development projects and public/private partnerships that deliver resilient waterfront infrastructure.	
KEY PLANNING ISSUES: Waterfront New Housing and Development	VULNERABILITY ADDRESSED: San Francisco's waterfront is vulnerable to coastal flooding due to sea level rise and seismic risks.	
LEAD: Port, TIDA, OCII PARTNERS: Planning, OEWD	ACTION SUMMARY: Major development projects are an important component to a comprehensive shoreline resiliency strategy, and they provide an opportunity to secure private investment and use financing mechanisms such as Community Facilities Districts and Infrastructure Finance Districts to deliver resilient waterfront infrastructure, including shoreline protection, flood-resilient buildings, soil remediation and geotechnical stabilization, green infrastructure for stormwater management, and other measures. Multiple city agencies are involved in the planning, design, and review of major development projects' resilience strategies.	
COST: Medium	SF GOVERNMENT ACTIVITY: Funding and Financing	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: Privately Funded, Special Funds, IFD, CFD, Grants	PRIORITY LEVEL: High	TIMELINE: On-going

IN-6.7	Develop comprehensive assessments of combined flood risks in each watershed.	
KEY PLANNING ISSUES: Water and Wastewater	VULNERABILITY ADDRESSED: Flood risk in San Francisco takes several forms, including coastal flooding from extreme tides/storms and sea level rise, extreme precipitation, stormwater, and groundwater.	
LEAD: SFPUC PARTNERS: Port, Planning	ACTION SUMMARY: More research is needed to understand how multiple flooding sources influence each other and how best to plan for their coincidence. This is best achieved at the watershed scale where a combined flood risk analysis can result in a more comprehensive understanding of current and future flood risks and the best strategies to reduce risk. The model from Islais Creek is currently being used in Yosemite Slough. The Army Corps Flood Study area is another top priority for combined flood risk modeling. Stakeholders noted the importance of including groundwater in this analysis process.	
COST: Medium	SF GOVERNMENT ACTIVITY: Research, Planning & Guidance	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: General Funds, Grants	PRIORITY LEVEL: High	TIMELINE: By 2029

IN-7.1	Implement the Pipe Replacement Prioritization Program	
KEY PLANNING ISSUES: Water and Wastewater	VULNERABILITY ADDRESSED: Potable water, EFWS and other utility systems may experience damage during a significant earthquake event.	
LEAD: SFPUC PARTNERS: SFFD, DPW	ACTION SUMMARY: The SFPUC prioritizes water pipelines for replacement based on risk scores and condition assessments. San Francisco's distribution system pipes are categorized by risk and consequence of failure, and larger transmission mains are seismically hardened when replaced. San Francisco's Emergency Fire Water System (EFWS) is prioritized for expansion or replacement with seismically reliable pipelines based on post-seismic, fire-fighting demand analysis. Large regional transmission water mains undergo rigorous condition assessment to prioritize replacement; these pipes are seismically strengthened when replaced or upgraded.	
COST: High	SF GOVERNMENT ACTIVITY: Public Assets Owner	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: Debt, Grants	PRIORITY LEVEL: High	TIMELINE: On-going

IN-7.2 Support the completion and handover of new power, water, wastewater distribution infrastructure at Treasure Island and discontinue the use of the legacy navy systems.

KEY PLANNING ISSUES:	VULNERABILITY ADDRESSED:
Water and Wastewater Communications and Power	Treasure Island has legacy Navy infrastructure that is now significantly beyond its design life and is prone to disruptions from hazards

LEAD:	ACTION SUMMARY:
TIDA, SFPUC PARTNERS: DPW	Treasure Island and Yerba Buena Island are currently served by a multi-tiered utility infrastructure system. In areas served by the older (Navy) infrastructure, TIDA is responsible for implementing improvements to help reduce the frequency, duration, and impact of outages. As the principal private developer completes construction of new utility infrastructure, the City formally accepts it and delegates ownership to SFPUC. This process is anticipated to be completed in 2042.

COST:	SF GOVERNMENT ACTIVITY:	STATUS:
High	Public Assets Owner	New
POTENTIAL FUNDING SOURCES:	**PRIORITY LEVEL:**	**TIMELINE:**
General Funds, Special funds, Grants	Medium	By 2044

IN-7.3 Complete construction of the Treasure Island Water Resource Recovery Facility to improve water treatment, increase water security, and to connect recycled water to San Francisco's first neighborhood with a complete green infrastructure system.

KEY PLANNING ISSUES:	VULNERABILITY ADDRESSED:
Water and Wastewater Communities at Increased Risk	Reduced snowpack due to drought and warmer temperatures can impact regional water supplies. Treasure Island and Yerba Buena Islands are expected to gain 20,000 residents by 2040 and is currently served by a wastewater treatment plant that is well-past lifespan.

LEAD:	ACTION SUMMARY:
SFPUC PARTNERS: DPW, TIDA	The goal of the Treasure Island Water Resource Recovery Facility (TIWRRF) is to minimize treated effluent discharge while using the disinfected recycled water for landscaping, irrigation, plumbing and more. The new plant will have an annual average wastewater treatment capacity of 1.3 million gallons per day. It will also facilitate a nutrient-removal process to ensure discharged water does not contain materials that can contribute to algae growth in the Bay and the project will include wetlands habitat. The TIWRRF facility will be held to SFPUC's level of service goals of maximizing control of odors, minimize noise, and be an aesthetically pleasing facility.

COST:	SF GOVERNMENT ACTIVITY:	STATUS:
High	Public Assets Owner	New
POTENTIAL FUNDING SOURCES:	**PRIORITY LEVEL:**	**TIMELINE:**
General Funds, Debt, Grants	Medium	Completion to begin by 2026

IN-7.4	Complete studies and capital projects to improve and expand the Emergency Firefighting Water System (EFWS).	
KEY PLANNING ISSUES: Water and Wastewater	VULNERABILITY ADDRESSED: Fire following earthquake could cause severe damage to buildings and infrastructure.	
LEAD: SFPUC PARTNERS: SFFD, ORCP, DPW	ACTION SUMMARY: The San Francisco Public Utilities Commission (SFPUC), Fire Department (SFFD), and Public Works (DPW) are collaborating to complete studies, develop design, and implement capital projects, to improve and expand the EFWS. Capital investments prioritize areas where the existing EFWS is limited. For example, SFPUC is initiating planning and design to construct seismically resilient pipeline to convey water to several neighborhoods in the westside of San Francisco. Additional pipelines and pump stations are envisioned to continue expanding the system on the westside in the subsequent phases.	
COST: High	SF GOVERNMENT ACTIVITY: Public Assets Owner	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: General Funds, Debt	PRIORITY LEVEL: Medium	TIMELINE: On-going

IN-7.5	Improve the capacity of the Portable Water Supply System to fight fires following earthquakes and other large urban fires.	
KEY PLANNING ISSUES: Water and Wastewater	VULNERABILITY ADDRESSED: Fire following earthquake has the potential to cause severe damage to buildings and infrastructure.	
LEAD: SFFD PARTNERS:	ACTION SUMMARY: Portable Water Supply System (PWSS) hose tenders are key pieces of equipment that allow the Fire Department to provide high-pressure and high-volume water to fight large fires from any water source, even when the potable or auxiliary water pumps and pipes are damaged or not functioning due to loss of power. This is especially important for fighting fires following earthquakes and fires in tall buildings. PWSS is an important resource for areas that are not served by the Emergency Firefighting Water System (EFWS) or in areas where the EFWS might be damaged after an earthquake (e.g., liquefaction zones). A 2011 analysis recommended that the City have 20 hose tenders. Future studies may seek to quantify apparatus needs with regards to level of service and post-earthquake firefighting capabilities.	
COST: High	SF GOVERNMENT ACTIVITY: Community Services Delivery	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: General Funds, Grants	PRIORITY LEVEL: High	TIMELINE: By 2029

IN-7.6	Pursue data-driven implementation of Green (GI) Infrastructure projects to be able to manage 1 billion gallons of stormwater per year using GI by 2050.	
KEY PLANNING ISSUES: Water and Wastewater Open Space and Biodiversity	VULNERABILITY ADDRESSED: Stormwater flooding impacts safety, mobility, and may cause structure damage. The risk of stormwater flooding may increase in the future due to more intense precipitation events and sea level rise.	
LEAD: SFPUC PARTNERS:	ACTION SUMMARY: Through the Green Infrastructure Grant Program and implementation of the Stormwater Management Ordinance, the city is on track to meet the goal of capturing 1 billion gallons of stormwater per year using GI by 2050. The City is on track to meet this goal, but it will require continuing to develop and implement innovative green infrastructure interventions, whether through the green school yards program or in the public right of way.	
COST: Medium	SF GOVERNMENT ACTIVITY: Public Assets Owner	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: General Funds, Debt	PRIORITY LEVEL: High	TIMELINE: By 2050

IN-7.7	Complete construction of the Recycled Water Treatment Plant to ensure redundancy of water supply on SFO campus.	
KEY PLANNING ISSUES: Water and Wastewater Transportation	VULNERABILITY ADDRESSED: Reduced snowpack due to drought and warmer temperatures or a major earthquake can impact regional water supplies.	
LEAD: SFO PARTNERS:	ACTION SUMMARY: Airport will build and operate an advanced water treatment plant that will create up to 800k gallons per day of recycled water suitable for non-potable reuse. The project will include a pumping and distribution system to deliver non-potable water for use in toilets, landscaping, and industrial uses.	
COST: High	SF GOVERNMENT ACTIVITY: Public Assets Owner	STATUS: New
POTENTIAL FUNDING SOURCES: Capital Funds, Grants	PRIORITY LEVEL: High	TIMELINE: By 2027

IN-8.1	Improve resilience and sustainability for regional dams and ancillary facilities from flood and earthquake events.	
KEY PLANNING ISSUES: Water and Wastewater	VULNERABILITY ADDRESSED: The regional water system includes aging dams and reservoirs, which could be damaged by a major earthquake, severe storm, slope failure, or other means.	
LEAD: SFPUC PARTNERS: State Division of Safety of Dams (DSOD)	ACTION SUMMARY: The existing Capital Improvement Program (CIP) has identified priority rehabilitation projects for local dam structures, including seismic roof strengthening at Merced Manor and University Mound South Basin, floor and wall repairs at Summit Reservoir, and seismic and geotechnical embankment analyses at Sandford Heights Reservoir and Sunset South Basin. For dams classified as “High” and “Extremely High,” downstream hazard potential SFPUC will update seismic stability analysis against the maximum credible earthquake and evaluate the hydraulic adequacy against the probable maximum flood for embankment and spillway. The analysis will identify deficiencies to be addressed through future projects in the CIP.	
COST: High	SF GOVERNMENT ACTIVITY: Public Assets Owner	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: Debt, Grants	PRIORITY LEVEL: High	TIMELINE: By 2034

IN-8.2	Mitigate wildfire hazards in SFPUC owned-watersheds to protect source water quality and minimize risk to SFPUC water and power infrastructure.	
KEY PLANNING ISSUES: Water and Wastewater Communications and Power	VULNERABILITY ADDRESSED: The Hetch Hetchy System is vulnerable to wildfires as it crosses through very high wildfire hazard areas in the Sierra Nevada mountains and foothills.	
LEAD: SFPUC PARTNERS:	ACTION SUMMARY: SFPUC staff and contractors regularly manage vegetation in SFPUC watershed and right of way (ROW) lands to mitigate fire hazards and protect water quality and power transmission. In addition to vegetation management to mitigate fire hazards, SFPUC has updates its Wildfire Mitigation Plan annually to describe efforts related to electrical infrastructure, to reflect new jurisdiction under the California Public Utilities Commission.	
COST: Medium	SF GOVERNMENT ACTIVITY: Public Assets Owner	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: General Funds, Special funds	PRIORITY LEVEL: High	TIMELINE: On-going

IN-8.3	Diversify water supply options year-round by improving the use of new water sources and drought management	
KEY PLANNING ISSUES: Water and Wastewater	VULNERABILITY ADDRESSED: Climate models project changes in precipitation distribution, including a reduced Sierra snowpack and earlier melting of the snowpack, potentially impacting water supply.	
LEAD: SFPUC PARTNERS:	ACTION SUMMARY: The SFPUC's Water Supply Improvement Program (WSIP) is a $4.8 billion, multi-year, capital program to upgrade the Regional Water System (RWS). The SFPUC undertook the WSIP to ensure the ability of the RWS to meet Level of Service (LOS) goals for water quality, seismic reliability, delivery reliability, and water supply. The Water Supply LOS goal stated in WSIP is to meet customer water needs in non-drought and drought periods.	
COST: High	SF GOVERNMENT ACTIVITY: Public Assets Owner	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: Debt, Grants	PRIORITY LEVEL: High	TIMELINE: By 2049

IN-8.4	Continue climate adaptation planning for the Hetch Hetchy Regional Water System	
KEY PLANNING ISSUES: Water and Wastewater	VULNERABILITY ADDRESSED: The Hetch Hetchy Regional Water System is vulnerable to multiple climate hazards, including wildfire, drought, and flooding at is traverses from the Sierra Nevada to the Bay Area.	
LEAD: SFPUC PARTNERS:	ACTION SUMMARY: The SFPUC Water Enterprise is conducting a long-term vulnerability assessment to its Levels of Service (LOS) for the Hetch Hetchy Regional Water System (RWS). To address the challenge of planning for uncertain factors and risks, a vulnerability-based planning approach will explore a range of future conditions to identify vulnerabilities, assess the risks associated with these vulnerabilities, and later develop an adaptation plan that is flexible and robust to a wide range of future outcomes. The plan will guide water supply decisions of the RWS over the next 50 years or longer.	
COST: High	SF GOVERNMENT ACTIVITY: Public Assets Owner	STATUS: Sustaining
POTENTIAL FUNDING SOURCES: General Funds, Debt	PRIORITY LEVEL: High	TIMELINE: By 2029

7.5 Additional Actions for Consideration

During the strategy development process, additional actions were suggested that the City will continue to consider for implementation in subsequent Plan updates. These may be longer-term actions or actions that do not yet have a clear implementation path for the next five years.

TABLE 7-9: ADDITIONAL ACTIONS

Potential Lead	Actions for Consideration
ADM/TTX	Explore strategies for increasing access to insurance to support financial resilience to hazards, especially for lower-income residents.
OEWD/DEM	Support small business Continuity of Operation Planning (COOP) planning.
OEWD	Explore workforce development programs for emerging climate and hazard mitigation related industries.
HSA	Address food insecurity especially as climate hazards may impact agriculture and supply chains.
Planning	Develop comprehensive and coordinated code amendments for multi-hazard resilience of private development.
SFE/RPD/ DPW	Explore growing food for communities in public open spaces

Table 7-10 highlights how numerous HCR actions align with strategies from San Francisco's Climate Action plan.

TABLE 7-10: 2025 HCR ACTION CROSSWALK TO THE CLIMATE ACTION PLAN

(B) BUILDINGS		CAP Strategies
B-1.1	Assess and seismically retrofit municipal buildings or secure new resilient facilities as needed.	BO.2
B-2.1	Increase resilience and operation efficiency of municipal maintenance yards.	BO.2, ES.2
B-2.3	Seek to add resilience scope to affordable housing rehabilitation funding opportunities with support from state/federal funds.	ES.1, ES.2, BO.2, H.2, H.4
B-2.5	Support increased building electrification (fuel switching), mechanical upgrade, and weatherization.	BO.1, BO.2
(C) COMMUNITIES		**CAP Strategies**
C-1.1	Develop projects in green infrastructure priority zones.	HE.1,HE.5, HE.6
C-1.2	Develop public education initiatives to connect benefits of green infrastructure to public health.	HE.2
C-3.1	Coordinate resilience engagement across departments and projects through ClimateSF	HE.1
C-6.1	Continue to meet housing production goals.	H.3, H.4
(IN) INFRASTRUCTURE		**CAP Strategies**
IN-1.1	Enhance energy resilience at Critical Community Institutions	ES.2,BO.2
IN-1.4	Develop and advance a roadmap for disaster resilient fleets and EV charging infrastructure	ES.2
IN-3.1	Continue to incorporate opportunities for hazard mitigation into the planning and design of all SFMTA facility improvements and property re-development.	TLU.1
IN-3.2	Continue to study, plan, design, and implement improvements to the multimodal transportation system that are vulnerable to coastal flooding.	TLU.1
IN-4.1	Continue to improve wildfire prevention through vegetation management in Recreation Areas.	HE.3
IN-4.2	Maximize drought tolerant, native species in plantings for parks and landscaping whenever feasible.	HE.6
IN-4.4	Continue to develop public private partnerships to conserve and steward biodiversity and habitat on Treasure Island and Yerba Buena Islands.	HE.6
IN-5.3	Develop projects and seek funding in coordination with other agencies to implement the Islais Creek Southeast Mobility Adaptation Strategy (ICSMAS).	TLU.1

IN-7.2	Support the completion and handover of new power, water, wastewater distribution infrastructure at Treasure Island and discontinue the use of the legacy navy systems.	ES.2
IN-8.2	Continue to mitigate wildfire hazards in SFPUC owned-watersheds to protect source water quality and minimize risk to SFPUC water and power infrastructure.	ES.1
IN-8.3	Diversify water supply options year-round by improving the use of new water sources and drought management	WS.3

Chapter 08

Plan Maintenance

Mountain Tunnel, Hetch Hetchy Water System

San Francisco is committed to maintaining the HCR so that it remains an active, viable document, and that the mitigation actions it sets forth are tracked, evaluated, and updated through implementation. The plan maintenance phase will be managed by the ORCP Project Team with support from the HCR Planning Team. These groups will also ensure that the 2025 HCR information is integrated into existing and future planning efforts over the 5-year implementation period. The following section describes the plan maintenance process in more detail.

8.1 Monitoring, Evaluation, and Updates

To build on previous hazard mitigation planning successes, the Office of Resilience and Capital Planning (ORCP) will continue to convene the Planning Team once per year as a primary method of monitoring, evaluating, and updating the HCR. This convening will include soliciting information on new hazard information, capabilities, new risk assessments, and significant changes to assets. These meetings will also seek to identify any emerging issues.

In addition to the annual Planning Team meeting, ORCP will produce a mid-cycle progress report in 2027. The progress/status of the mitigation actions (Chapter 7) will be gathered through staff-level informational interviews for each department. The informational interviews will include the following questions:

- What is the status of each action (i.e. completed, progressing, on-going, no longer needed, modified significantly, delayed, not yet started)?
- Has each action been integrated into your department's yearly budget or capital planning process?
- What was accomplished on actions? Please highlight specific successes.
- What obstacles, problems, or delays, if any, did the project encounter during this period?
- In what ways has equity been considered in the implementation of the actions?

Evaluation of Plan effectiveness will also occur through the progress report by collecting information through the interviews above on how the HCR Goals (Chapter 7) have been advanced. The following are examples of the types of measures that may be collected for each goal:

- Protect the public health, safety, quality of life, environment, and economic and social capital of San Francisco by reducing the risk of damage and disruption from hazards.
    - Number of municipal buildings seismically retrofitted
    - Number of privately owned buildings seismically retrofitted through voluntary or mandatory programs
    - Number of floodproofing grants distributed
    - % of bay shoreline with a sea level rise adaptation plan

- Build and support the capacity of City government and the greater San Francisco community, to prevent, protect against, respond to, mitigate, and recover from hazards.
    - Number and amount of grants received for mitigation programs
    - New local policies that support mitigation capabilities
- Advance local, regional, State, federal, private, and community collaborations and partnerships to deliver actionable, effective, and innovative risk reduction solutions and data to support decisions.
    - Amount of state or federal matching dollars received for mitigation
    - Number of new partnerships developed
    - Number of new hazard related datasets made publicly available
- Proactively seek to address racial, health, and economic inequities of hazard impacts and advance equity through the just distribution of risk reduction and resilience benefits.
    - Number of resilience plans or projects in EJ Communities
    - Number of community-based organizations involved in resilience plans and projects
- Increase public awareness of hazards, risks, and City action to build resilience through education, empowerment, and engagement.
    - Number of community engagement events relating to climate and hazard resilience

In preparation for the next five-year update of the HCR Plan (2030), the Planning Team shall commence the following activities in 2028.

1. Review insights from the mid-cycle progress report.
2. Thoroughly analyze and update the risk of natural hazards in the Planning Area.
3. Provide a detailed review and revision of existing mitigation actions.
4. Prepare new mitigation actions.
5. Prepare an updated draft plan and submit it to Cal OES and FEMA for preliminary review.
6. Submit the updated draft HCR Plan to the Board of Supervisors and Mayor for adoption.
7. Submit the updated HCR Plan to FEMA for final approval.

8.2 Integration into Other Planning Mechanisms

The Hazard and Climate Resilience Plan integrates with several City and County of San Francisco planning activities including those described below.

Climate Action Plan

The 2021 Climate Action Plan (CAP) provides a blueprint for achieving net zero carbon emissions by 2040. The climate mitigation strategies in the HCR are reflective of the priorities found in the CAP and that plan was developed with a focus on integrating opportunities for climate adaptation into the pursuit of emissions reduction goals. In Chapter 7: Table 7-10, notes strategies that have some overlap in scope with actions in the Climate Action Plan. The 2020 HCR priorities were integrated into the 2021 Climate Action Plan and the priorities from the current HCR update will be integrated in the upcoming 2025 CAP Update.

Safety and Resilience Element

The Safety and Resilience Element of the General Plan was updated to incorporate relevant objectives and policies from the 2020 HCR and this practice will continue as they follow their mandated update cycles in alignment with the 2025 HCR update and subsequent cycles.

Capital Planning

The 10-Year Capital Plan includes funding principles to make trade-offs between competing needs. “Protects Life Safety and Enhances Resilience” will continue to be Funding Principle #2 and the projects identified in the 2020 HCR were considered in the planning process including evaluating how current capital budget requests support climate resilience efforts. This practice will continue for the 2025 HCR update and subsequent cycles.

Emergency Management

Information from the HCR will be integrated into future updates of the City's emergency management planning documents. Within the next five years, the Department of Emergency Management, in partnership with other City departments and local, regional, state, and federal partners, will update or finalize the City's plans for earthquake response, mutual aid (Emergency Support Function 7), firefighting (Emergency Support Function 4), evacuation, and first responder and DSW return. San Francisco will also host several significant exercises to test these plans, including San Francisco Fleet Week communications exercises, a regional full-scale earthquake exercise, and build exercises on first responder and DSW return processes from the 2024 San Francisco Fleet Week exercise series. Information from the 2020 HCR will be used in the update process for these planning mechanisms and will also consider the 2025 HCR update upon completion.

Subregional Shoreline Resiliency Plan

Any local government within the Bay Conservation and Development Commission's (BCDC) jurisdiction is required to prepare a "shoreline resiliency plan" by 2034 per Senate Bill 272. It is strongly encouraged that plan submission occur before the legislative deadline and competitive funding is available to incentivize earlier planning and San Francisco is planning to start this planning effort as soon as feasible. This shoreline resiliency plan will provide additional community engagement opportunities and help ensure that all vulnerable segments of the shoreline are brought into one plan and adaptation strategies are aligned. The resulting plan will update past assessments with current science such as groundwater inundation risks and incorporate additional adaptation strategies tailored to local needs. Adaptation pathways, strategies, or projects developed through the shoreline resiliency plan will be integrated into the next available HCR update.

Local Coastal Program

In early 2024, the City and California Coastal Commission began a partnership to identify opportunities to update and align San Francisco's Local Coastal Program to better reflect the shared contemporary goals of our two agencies. The outcomes from that work will be integrated into the next available HCR update.

8.3 Continued Public Participation in Plan Maintenance

The HCR is meant to be a living document. To keep the public involved in the on-going plan maintenance process, the ORCP Project Team will:

- Integrate opportunities for HCR feedback into relevant resilience public engagement activities occurring across City departments. This coordination will happen through ClimateSF, a multi-agency program to coordinate and amplify climate work across the City, which is also reflected in the new action C-3.1 in Chapter 07.
- Support the Shoreline Resiliency Plan described above as a critical opportunity for public participation around planning for sea level rise. It is anticipated that community engagement will especially focus on Environmental Justice (EJ) communities that also face potential flood risk due to sea level rise, including: Treasure Island and Yerba Buena Island, North Beach, and Bayview Hunters Point.
- Publicize citywide opportunities for resilience feedback and engagement through ClimateSF, which includes a quarterly newsletter that members of the public can sign up for at this website: https://onesanfrancisco.org/climateSF
- Document new priorities identified through public participation and community engagement in the HCR Progress Report and make available online.
- Maintain a publicly accessible copy of the Plan available online and a printed copy in the Office of Resilience and Capital Planning in City Hall room 347. Post notice of any changes to the Plan on the website: https://onesanfrancisco.org/hazards-and-climate-resilience-plan

Appendix A

Vulnerability and Consequence Profiles

Appendix A contains the Vulnerability and Consequence Profiles, as described in Chapter 05. These profiles provide an exposure assessment of key asset classes in San Francisco and characterize their vulnerability to disruption by hazard events and the potential consequences from their disruption. Subject matter experts were consulted to ensure that the profiles reflect the best available information at the time of the analysis. These assets span both public and private ownership but share an essential characteristic, they are essential to ensuring the delivery of vital services to the general public. These assets are segmented into different sectors for communication to relevant stakeholders (public stakeholders, City staff and decision makers, etc.). These profiles can be used by decision makers, departmental staff, and the general public to obtain a more complete understanding of assets within the city, how they relate to each other, and how they may be impacted by hazards. The findings from the profiles informed the strategies found in Chapter 07.

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People Sector

Communities at Increased Risk

While all San Franciscans are vulnerable to the health impacts of hazard events, vulnerability is not evenly distributed. A person, household, or community's resilience depends on an array of interconnected and compounding physical, social, political, environmental, and economic disparities. As one of the goals of the Hazard and Climate Resilience Plan is to "address the inequitable impacts of current and future hazards and promote the just distribution of risk reduction and resilience benefits through implementing policies and programs that address existing racial, economic, and health disparities" , it is necessary to first identify the specific factors that contribute to vulnerability, assess how these factors contribute to a person, household, or community's vulnerability to hazard events, and locate the neighborhoods where these people, households, or communities are concentrated.

A nuanced analysis of the factors that contribute to vulnerability will allow the Hazard and Climate Resilience plan to develop more sophisticated programs and policies that proactively address the disproportionate impacts of hazard events and advance equity through the just distribution of risk reduction and resilience benefits.

This section will divide vulnerability factors into four separate categories that represent a pathway that connects a hazard to health impacts and either modifies the intensity of exposure to the hazard, increases a person's sensitivity to that exposure, or affects the capacity of that person or community to prepare for or respond to that exposure. These categories are:

- socioeconomic and demographic factors,
- housing quality and living conditions,
- community characteristics and social cohesion, and
- pre-existing health conditions.

This section will define each category, detail how some significant factors affects vulnerability, and identify the San Francisco neighborhoods where those vulnerable populations are concentrated. Significance was determined by the availability of research connecting the vulnerability factor to hazard-related health impacts and the availability of data on the local geographic distribution of that vulnerability factor.

TABLE A-1: FACTORS THAT INFLUENCE VULNERABILITY

Socioeconomic and Demographic Factors	Housing and Living Conditions	Community Characteristics and Social Cohesion	Pre-Existing Health Conditions
• Age: o Infants o Children* o Seniors* • Income and Poverty* • Race / Ethnicity* • Educational Attainment • Employment Status • Citizenship Status • Single Parent Families • Outdoor Workers	• Unhoused Populations* • Housing Quality* o Housing Health and Safety Violations o Air Conditioning Ownership o Soft Story buildings • Housing Affordability* o Rent Burden o Home Ownership	• Social Isolation* o Living Alone o Voting Rates o Linguistic Isolation* o Violent Crime o Displacement and No-Fault Evictions* • Community Characteristics o Access to Transportation o Access to Hospitals and Community Health Centers	• Disability and Functional Limitations* • Chronic Disease o Respiratory Illnesses o Cardiovascular Illnesses o Diabetes o Cancer • Behavioral and Mental Health • Preventable Hospitalizations
Significant Factor = *			

Socioeconomic and Demographic Factors

Socioeconomic and demographic factors represent a broad array of physical, economic, and cultural attributes that influence a person or community's sensitivity to a hazard, or ability to prepare for, respond to, or recover from hazard events.

Children

Children are particularly vulnerable to hazards because of both their physiology that impacts their sensitivity to certain hazards, and their adaptive capacity, as children are reliant on adults for emergency preparation and response activities. Children are vulnerable to environmental exposures like poor air quality. A child's respiratory rate can be two-to three times higher than an adult respiratory rate, so children experience the effects of poor air quality to a greater degree than an adult. Children are also vulnerable to extreme heat as children have a higher surface area to body mass ratio compared to adults while having reduced sweating capacity. Children have more sensitive immune systems and are more likely to have physical contact with contaminated water following a storm or flood. In addition, when certain stressors occur earlier in life, especially during critical development periods, they can cause more severe and long-lasting impacts.1 For example, stress associated with hazard events may have lasting impacts into adulthood.

Data available in 2024 is from American Community Survey (ACS) 2018-2022 estimates. There were an estimate 115,402 children (population under age 18) in San Francisco[2] Neighborhoods with the highest proportion of children are Presidio, Sea Cliff, Bayview Hunters Point, Visitacion Valley, Portola, Glen Park, Excelsior. Refer to Table A-2 for data tabulated by neighborhood.

TABLE A-2: POPULATION UNDER AGE 18 BY NEIGHBORHOOD, 2018-2022 [3]

Neighborhood	Percent of residents under Age 18	Count of residents under Age 18
Bayview Hunters Point	22.1%	8,955
Bernal Heights	18.6%	4,616
Castro/Upper Market	9.3%	2,097
Chinatown	9.9%	1,355
Excelsior	17.1%	6,645
Financial District/South Beach	5.5%	1,275
Glen Park	20.1%	1,757
Golden Gate Park	-	-
Haight Ashbury	12.2%	2,245

[1] Mishra, Gita D., Rachel Cooper, and Diana Kuh. "A Life Course Approach to Reproductive Health: Theory and Methods." *Maturitas* 65, no. 2 (February 2010): 92–97. https://doi.org/10.1016/j.maturitas.2009.12.009.
[2] ACS 2018-2022
[3] ACS 2012-16; *Indicates unstable data

Hayes Valley	8.1%	1,550
Inner Richmond	15.7%	3,303
Inner Sunset	13.1%	3,619
Japantown	2.8%	102
Lakeshore	8.7%	1,095
Lincoln Park	-	-
Lone Mountain/USF	10.0%	1,643
Marina	12.9%	3,078
McLaren Park	-	-
Mission	12.3%	6,887
Mission Bay	14.1%	2,272
Nob Hill	4.4%	1,095
Noe Valley	15.5%	3,573
North Beach	13.3%	1,558
Oceanview/Merced/Ingleside	14.9%	3,678
Outer Mission	16.3%	3,690
Outer Richmond	15.7%	6,999
Pacific Heights	10.3%	2,379
Portola	15.2%	2,392
Potrero Hill	13.2%	1,983
Presidio	25.6%	1,011
Presidio Heights	15.8%	1,658
Russian Hill	5.6%	963
Seacliff	22.8%	536
South of Market	8.7%	2,145
Sunset/Parkside	16.3%	12,849

Tenderloin	10.8%	3,462
Treasure Island	15.8%	496
Twin Peaks	9.1%	727
Visitacion Valley	18.2%	3,284
West of Twin Peaks	16.9%	6,343
Western Addition	9.4%	2,087
San Francisco	**13.6%**	**115,402**

Seniors

Older adults are at increased risk for morbidity and mortality during hazard events because they are more likely to have chronic health conditions, mobility constraints, are more likely to be socially isolated, public transportation dependent, and rely on city and federal resources. Seniors are particularly vulnerable to extreme heat events because they are more likely to have pre-existing cardiovascular, respiratory, and renal conditions. They are at a greater risk for dehydration because of their reduced sense of thirst and higher likelihood of taking medications, such as blood pressure medication, that may cause more frequent urination and perspiration. Older adults are more physically impaired by floodwaters covering walkways and more likely to contract an infection. Older adults are also vulnerable to the health impacts of power disruption associated with many hazard events because they are more likely to have mobility disabilities and be dependent on electronic medical devices. Older adults who live alone experience heightened vulnerability.

Data available in 2024 is from American Community Survey (ACS) 2018-2022 estimates. ACS 2018-2022 estimates 142,119 senior citizens (residents age 65-plus) in San Francisco. Neighborhoods with the highest proportion of seniors are Japantown, Chinatown, Seacliff, and Twin Peaks.[4] Refer to Table A-3 and Figure A-1 for more information.

TABLE A-3: POPULATION OVER AGE 65 BY NEIGHBORHOOD, 2012-2016[5]

Neighborhood	Percent of residents age 65+	Count of residents age 65+

[4] ACS 2018-22
[5] ACS 2018-22

Bayview Hunters Point	14.3%	5,795
Bernal Heights	13.3%	3,291
Castro/Upper Market	12.8%	2,897
Chinatown	30.4%	4,168
Excelsior	18.6%	7,214
Financial District/South Beach	12.9%	2,971
Glen Park	16.6%	1,448
Golden Gate Park	-	-
Haight Ashbury	9.9%	1,835
Hayes Valley	7.4%	1,408
Inner Richmond	17.3%	3,622
Inner Sunset	16.9%	4,680
Japantown	42.7%	1,582
Lakeshore	13.9%	1,736
Lincoln Park	79.6%	148
Lone Mountain/USF	12.0%	1,980
Marina	10.8%	2,574
McLaren Park	100.0%	129
Mission	12.4%	6,967
Mission Bay	7.8%	1,252
Nob Hill	16.5%	4,086
Noe Valley	13.9%	3,209
North Beach	17.2%	2,014
Oceanview/Merced/Ingleside	18.6%	4,581
Outer Mission	18.7%	4,231
Outer Richmond	20.1%	8,946

Pacific Heights	18.4%	4,240
Portola	19.1%	3,000
Potrero Hill	9.2%	1,386
Presidio	3.8%	149
Presidio Heights	16.1%	1,683
Russian Hill	18.6%	3,220
Seacliff	24.6%	578
South of Market	16.5%	4,054
Sunset/Parkside	21.0%	16,541
Tenderloin	16.7%	5,367
Treasure Island	1.7%	52
Twin Peaks	24.4%	1,940
Visitacion Valley	16.7%	3,007
West of Twin Peaks	24.2%	9,080
Western Addition	22.8%	5,058
San Francisco	16.7%	142,119

Income and Poverty

While San Francisco has a comparatively high median household income, this wealth is not evenly distributed. While median household income in San Francisco is $136,689, this number is stratified by race.[6] The median income for white households is over $172,722 a year, while the median income for Black/African American households is $50,144 a year.[6]

TABLE A-4: MEDIAN HOUSEHOLD INCOME BY RACE/ETHNICITY

Median Household Income by Race/Ethnicity	San Francisco
All Households	$136,689
White	$172,722
Black / African American	$50,144
American Indian / Alaskan Native	$55,617
Asian	$114,960
Native Hawaiian / Pacific Islander	$102,637
Some Other Race	$84,662
Two or More Races	$135,331
Hispanic / Latino (of any race)	$97,137
White alone, not Hispanic / Latino	$176,815

Poverty is correlated with numerous health outcomes including rates of infant mortality, heart disease, cancers, and mental health. During hazard events, income allows households to more quickly respond to stressors and absorb losses. Populations in poverty often experience societal marginalization and have been found less likely to evacuate during a disaster.[7]

6 ACS 2018-22
7 Fothergill, A., and L. A. Peek, 2004: Poverty and disasters in the United States: A review of recent sociological findings. Natural Hazards, 32, 89-110. doi:10.1023/B:NHAZ.0000026792.76181.d9

Neighborhoods with the lowest median income are McLaren Park, Chinatown, Tenderloin, Lakeshore and South of Market. Neighborhoods with the highest poverty rate include: Chinatown, Treasure Island, Tenderloin, Lakeshore, and Bayview Hunter's Point. Refer to Tables A-5 and A-6 for more information.

TABLE A-5: MEDIAN HOUSEHOLD INCOME BY NEIGHBORHOOD, 2018-2022[8]

Neighborhood	Median Income
Bayview Hunters Point	$99,262
Bernal Heights	$165,686
Castro/Upper Market	$172,151
Chinatown	$29,625
Excelsior	$110,581
Financial District/South Beach	$204,77
Glen Park	$186,875
Golden Gate Park	-
Haight Ashbury	$199,676
Hayes Valley	$181,425
Inner Richmond	$154,375
Inner Sunset	$166,260
Japantown	$92,829
Lakeshore	$66,291
Lincoln Park	-
Lone Mountain/USF	$162,851
Marina	$210,637
McLaren Park	$12,169
Mission	$144,048

[8] ACS 2018-22; *Indicates unstable data

Mission Bay	$222,692
Nob Hill	$92,000
Noe Valley	$209,146
North Beach	$128,783
Oceanview/Merced/Ingleside	$118,841
Outer Mission	$138,545
Outer Richmond	$125,682
Pacific Heights	$197,581
Portola	$104,978
Potrero Hill	$239,625
Presidio	$236,445
Presidio Heights	$173,851
Russian Hill	$148,597
Seacliff	$250,001
South of Market	$90,590
Sunset/Parkside	$145,525
Tenderloin	$34,241
Treasure Island	$96,000
Twin Peaks	$163,468
Visitacion Valley	$92,788
West of Twin Peaks	$188,591
Western Addition	$128,152
San Francisco	**$141,333**

TABLE A-6: PERCENT OF HOUSEHOLDS BELOW 200% OF FPL BY NEIGHBORHOOD, 2018-2022[9]

Neighborhood	Percent of residents below 200% FPL	Count of residents below 200% FPL
Bayview Hunters Point	36.5%	14,751
Bernal Heights	17.6%	4,331
Castro/Upper Market	11.7%	2,636
Chinatown	58.1%	7,936
Excelsior	21.5%	8,168
Financial District/South Beach	15.3%	3,507
Glen Park	15.0%	1,305
Golden Gate Park	-	-
Haight Ashbury	12.1%	2,204
Hayes Valley	15.9%	2,993
Inner Richmond	13.4%	2,786
Inner Sunset	13.3%	3,558
Japantown	35.0%	1,271
Lakeshore	37.1%	3,892
Lincoln Park	-	-
Lone Mountain/USF	20.3%	2,960
Marina	7.2%	1,725
McLaren Park	*	*
Mission	22.9%	12,721
Mission Bay	23.5%	3,639
Nob Hill	23.6%	5,663
Noe Valley	8.0%	1,849

[9] ACS 2018-22; *Indicates unstable data

North Beach	27.9%	3,272
Oceanview/Merced/Ingleside	20.6%	5,035
Outer Mission	19.7%	4,400
Outer Richmond	17.1%	7,624
Pacific Heights	9.9%	2,225
Portola	18.8%	2,950
Potrero Hill	12.8%	1,914
Presidio	10.9%	432
Presidio Heights	10.7%	1,114
Russian Hill	14.8%	2,555
Seacliff	6.3%	148
South of Market	34.3%	8,297
Sunset/Parkside	15.4%	12,078
Tenderloin	48.4%	15,253
Treasure Island	57.5%	1,744
Twin Peaks	11.8%	825
Visitacion Valley	31.5%	5,638
West of Twin Peaks	9.4%	3,522
Western Addition	30.4%	6,709
San Francisco	20.7%	173,759

Race

Race is a societally imposed identity that governs the distribution of risk and opportunities in our race-conscious society.[10] In San Francisco, like across the United States, significant racial inequities exist, such as the income disparities referenced in the previous section, higher instances of adverse health conditions, limited access to the

[10] Jones, Camara Phyllis. "Invited Commentary: 'Race,' Racism, and the Practice of Epidemiology." *American Journal of Epidemiology* 154, no. 4 (August 15, 2001): 299–304. https://doi.org/10.1093/aje/154.4.299.

decision-making process, tenuous relationships with first responders, and more. These inequities point to race as a major indicator of community vulnerability. Because of historic and current impacts of structural racism that have created imbalances in political, cultural, and economic power, many minority groups lack the political access and economic resources to recover from hazard events. Many of these same groups are often concentrated in at-risk neighborhoods of the city, live in vulnerable housing stock, and have greater rates of poverty. For example, rates of preventable hospitalizations among Black/African Americans was nearly four times that of Whites.[11]

While San Francisco is a racially diverse city, many its racial groups are segregated by neighborhood. Much of San Francisco's African American population is concentrated in the Bayview Hunters Point and Western Addition neighborhoods. Chinatown, Portola, Oceanview/Merced/Ingleside, Visitacion Valley, and Outer Mission are all majority Asian. The Latino population is concentrated in the Mission District, Excelsior, and Bernal Heights. The rest of the city is predominately white, with the highest concentrations in the Marina, Haight Ashbury, the Castro/Upper Market, Pacific Heights and Noe Valley. Refer to Table A-7 and Figure A-2 for more information.

TABLE A-7:
RACIAL COMPOSITION OF SAN FRANCISCO NEIGHBORHOODS, 2018-2022[12]

		Not Hispanic or Latina/o/x						
Neighborhood	Percent Hispanic or Latina/o/x	Percent White alone	Percent Black or African American alone	Percent American Indian and Alaska Native alone	Percent Asian alone	Percent Native Hawaiian and Other Pacific Islander alone	Percen t Some other race alone	Percent Two or more races
Bayview Hunters Point	25.0%	7.8%	23.3%	0.0%	38.2%	1.9%	0.1%	3.8%
Bernal Heights	31.6%	40.6%	4.4%	0.2%	15.1%	0.0%	0.2%	8.0%
Castro/Upper Market	10.2%	67.0%	2.9%	0.5%	12.8%	0.3%	0.2%	6.3%
Chinatown	3.7%	7.0%	1.7%	0.5%	83.7%	0.0%	0.3%	3.2%
Excelsior	31.6%	15.2%	1.3%	0.2%	48.6%	0.5%	0.6%	2.0%

[11] San Francisco Health Improvement Partnership. "San Francisco Community Health Needs Assessment 2016: Appendices." San Francisco, CA: San Francisco Department of Public Health, 2016.
[12] ACS 2018-2022

Financial District/South Beach	8.8%	40.9%	1.3%	0.0%	44.6%	0.6%	0.3%	3.3%
Glen Park	11.5%	55.0%	6.5%	0.1%	13.9%	0.0%	0.9%	12.2%
Haight Ashbury	7.1%	71.3%	4.1%	0.0%	9.6%	0.0%	0.8%	7.1%
Hayes Valley	11.3%	55.0%	7.7%	0.1%	18.5%	0.2%	1.2%	5.9%
Inner Richmond	9.2%	46.3%	1.4%	0.2%	36.1%	0.4%	0.4%	5.9%
Inner Sunset	10.8%	45.2%	2.4%	0.1%	33.7%	0.1%	0.7%	6.9%
Japantown	18.2%	37.0%	3.9%	0.2%	32.7%	0.0%	1.4%	6.6%
Lakeshore	20.7%	27.8%	7.2%	0.1%	36.1%	0.1%	2.6%	5.4%
Lincoln Park	8.1%	35.5%	23.7%	0.0%	31.2%	0.0%	0.0%	1.6%
Lone Mountain/USF	13.9%	51.8%	4.4%	0.2%	19.9%	0.0%	3.3%	6.4%
Marina	9.1%	73.5%	0.4%	0.2%	10.0%	0.5%	0.3%	6.0%
McLaren Park	0.0%	0.0%	0.0%	0.0%	100.0 %	0.0%	0.0%	0.0%
Mission	31.8%	40.8%	5.0%	0.3%	15.7%	0.1%	0.7%	5.5%
Mission Bay	9.3%	33.4%	6.5%	0.0%	44.5%	0.8%	1.3%	4.3%
Nob Hill	12.0%	44.9%	4.6%	0.0%	31.5%	0.0%	1.4%	5.6%
Noe Valley	11.3%	61.4%	1.6%	0.0%	16.4%	0.0%	0.4%	8.8%
North Beach	12.2%	42.2%	5.1%	0.4%	34.4%	0.2%	0.5%	5.1%
Oceanview/ Merced/ Ingleside	15.6%	12.7%	7.2%	0.0%	60.2%	0.3%	0.4%	3.6%
Outer Mission	25.0%	13.7%	1.6%	0.0%	55.5%	0.4%	1.1%	2.7%
Outer Richmond	7.3%	40.0%	1.4%	0.1%	43.2%	0.0%	0.6%	7.4%
Pacific Heights	8.9%	63.9%	4.4%	0.1%	16.9%	0.0%	0.1%	5.6%
Portola	19.2%	14.0%	2.9%	0.0%	60.8%	0.0%	0.4%	2.7%

Potrero Hill	11.0%	51.5%	3.3%	0.0%	23.4%	0.0%	1.5%	9.3%
Presidio	24.5%	55.9%	1.4%	0.3%	7.0%	0.0%	0.4%	10.5%
Presidio Heights	10.4%	59.6%	0.4%	0.0%	23.4%	0.0%	0.3%	5.9%
Russian Hill	8.5%	61.1%	1.9%	0.0%	24.4%	0.1%	0.5%	3.6%
Seacliff	5.8%	57.5%	1.3%	0.0%	25.3%	0.0%	0.4%	9.7%
South of Market	15.1%	28.8%	7.6%	0.5%	42.8%	0.5%	0.7%	4.1%
Sunset/Parkside	8.2%	30.5%	1.3%	0.1%	52.5%	0.6%	0.4%	6.4%
Tenderloin	24.0%	29.7%	9.3%	1.7%	30.6%	0.0%	1.0%	3.8%
Treasure Island	31.0%	29.9%	15.9%	0.1%	10.4%	3.6%	1.9%	7.2%
Twin Peaks	14.6%	54.3%	4.6%	0.0%	22.3%	0.0%	0.6%	3.5%
Visitacion Valley	19.8%	8.5%	9.1%	0.3%	56.7%	1.5%	0.1%	4.0%
West of Twin Peaks	10.2%	43.5%	2.4%	0.2%	36.3%	0.0%	1.2%	6.1%
Western Addition	11.0%	37.3%	16.5%	0.1%	26.5%	0.7%	0.7%	7.2%
San Francisco	15.5%	38.3%	4.9%	0.2%	34.5%	0.4%	0.7%	5.5%

Housing Quality and Living Conditions

Housing has the ability to either contribute to, or protect against the health impacts, especially during or after hazard events. Housing can reduce a residents' exposure to hazard events. For example, residents living buildings without earthquake retrofits are significantly more vulnerable to geologic events while residents living in housing that has been properly protected against in-home dampness during precipitation events are more likely to be protected against flooding and mold exposure.

Housing Quality

Housing quality refers to a building's physical ability to protect the residents from exposure. Older, poorly maintained buildings are often substandard, and not fully safe for habitation. In addition, housing attributes such as ventilation, cool systems, and status can impact occupants' vulnerability to a hazard. For example:

- Housing without air conditioning or other cooling mechanisms may more easily overheat during extreme heat events. San Francisco has one of the lowest rates of air conditioning ownership in the United States.
- Soft-story buildings that have not undergone seismic retrofit are more vulnerable to severe damage during an earthquake.
- Housing without adequate ventilation or sealing may be vulnerable to smoke from urban conflagration due to inability to filter respiratory irritants. Similar to air conditioning prevalence in homes, San Francisco housing predominantly relies on passive cooling strategies, bringing cooler, outside air to cool down indoor temperatures. Poor air quality are more likely to occur during warmer temperature days, making it difficult to cool down indoor temperatures and maintain health air quality

Unhoused Population

Unhoused populations are among the most vulnerable San Franciscans. Without stable shelter options, this population is often more exposed to hazard events. During hazard events, this population has limited resources to evacuate, communicate, and shelter in place. This population is more likely to be impoverished, have lower educational attainment levels, and have higher rates of access and functional needs, all of which contribute to vulnerability. For example, during a heavy rainfall event in December of 2014, San Francisco's homeless population experienced a significant spike in Shigella cases. Heavy precipitation likely worsened poor sanitary conditions and increased crowding, contributing to shigellosis transmission among homeless persons.

In 2022, there were an estimated 7,754 sheltered and unsheltered homeless residents in San Francisco.[13] This population has been steadily rising since 2017, growing by almost a thousand individuals. Unsheltered homeless are concentrated in Supervisorial District Six and District Ten. Refer to Table A-8 for more information.

TABLE A-8: COMPLETE HOMELESS POINT IN TIME COUNT POPULATION BY DISTRICT, TOTAL, 2017-2022[14]

District	Unsheltered Homeless Count		
	2017	2019	2022
One	431	245	221
Two	53	171	158

13 Applied Survey Research "SAN FRANCISCO HOMELESS COUNT AND SURVEY", August 2022
14 Applied Survey Research "SAN FRANCISCO HOMELESS COUNT AND SURVEY", August 2022

Three	358	341	391
Four	31	34	81
Five	373	363	697
Six	3,324	3,656	3,848
Seven	91	168	163
Eight	260	317	287
Nine	523	643	664
Ten	1,208	1,841	1,115
Eleven	48	99	60
Confidential Scattered Site Locations in SF	158	157	69
Total	**6,858**	**8,035**	**7,754**

Housing Affordability

Housing affordability is a driver of vulnerability. When housing costs are high, households are less likely to afford necessary expenses such as food, heating, transportation, child care, and healthcare. According to the San Francisco Planning Department's 2022 Housing Element Update, San Francisco is "in the midst of a housing affordability crisis unprecedented in [San Francisco's] history".[15]. A household that spends over 30 percent of their pretax income on housing costs is considered burdened while a household that spends over 50 percent of their pretax income on housing costs is considered severely burdened. San Francisco rental prices increased by 22 percent between 2000 and 2012. By 2023, over 80% of very low-income renter households in San Francisco are rent burdened.[16] Research demonstrates that low-income households that can afford their housing are able to spend nearly five times as much on healthcare and a third more on food than those severely burdened with housing costs[17].

[15] San Francisco Planning Department, "San Francisco Housing Needs and Trends Report", July 2018
[16] San Francisco Planning Department
[17] Pew Research "American Families Face a Growing Rent Burden", April 2018. Retrieved from: www.pewtrusts.org/en/research-and-analysis/reports/2018/04/american-families-face-a-growing-rent-burden

Community Characteristics and Social Cohesion

A person's ability to prepare for or recover from disaster events is significantly influenced by their relationships with their neighbors, their community and community services, and their government and government services. A community with strong informal networks can work collectively to make sure residents quickly respond to hazard events, access emergency services, and have the resources to recover. The number and strength of community members' formal and informal social networks is often referred to as community and social cohesion. During a "social autopsy" of a 1995 Chicago Heatwave, researchers hypothesized that differences in mortality rates between neighborhoods were correlated with social isolation of senior citizens, access to government services, and neighborhood-level poverty.[18]

A neighborhood with easy access to community services is one that is either walkable or with adequate transportation access, especially to hospitals, health care centers, healthy food, and pharmacies. Social cohesion can enable individuals during a hazard event to draw on preexisting support networks for financial, information, and emotional assistance. When residents of a community are connected to each other through civic and voluntary associations, mobilizing in an emergency happens faster. Research has shown the communities with a higher density of civic organization predating a disaster are better prepared and quicker to recover.

Social Isolation

Social isolation is the experience of diminished social connectedness and typically refers to objective physical separation from other people. It is indicated by situational factors, like a small social network, living alone, infrequent social interaction, and lack of participation in social activities and groups. Social isolation can impact health and quality of life, ability to access adequate support for themselves, and the quality of the environment and community in which they live. Isolation can be a function of poverty that limits access to information technologies. It can be a function of limited literacy and/or linguistic isolation. It may be a function of disability, chronic or mental health conditions. Whatever the cause, when a hazard strikes, social isolation can increase vulnerability. During heat waves for example, one of the most vulnerable populations are elderly, especially those that live by themselves. In the 2003 Paris heat wave, 92% of all hospitalized lived alone. These individuals are less likely to trust their neighbors and have less social ties, resulting in not having someone check-in on them to make sure they're ok, increasing their risk during the event.

[18] . Klinenberg E. "Denaturalizing disaster: A social autopsy of the 1995 Chicago heat wave". Theory and Society. 1999;28:239-95.

Linguistic Isolation

Understand the linguistic environment within a community is essential for hazard planning. Households with limited English proficiency often face barriers to accessing community social services such as appropriate health care. Providing hazard warning and evacuation notices in multiple languages and accessible formats is imperative in ensuring these households are well informed during a hazard event.

Eighteen percent of San Francisco residents age five and older have Limited English Proficiency[19] Geographically, this most common in Chinatown, where 60 percent of the population does not speak English very well. Other neighborhoods with a high percentage of people who speak a language other than English at home and speak English less than very well include Visitacion Valley, Excelsior, Portola, the Outer Mission, and Oceanview/ Merced/Ingleside. However, it is important to note that linguistic isolation data may undercount this population as some undocumented residents and communities that may be less likely to engage with government census agencies. Residents in the undocumented community may be less likely to trust law enforcement which would impact outreach and engagement before, during, and after hazard events.

TABLE A-9: PERCENT OF POPULATION 5 YEARS AND OVER WITH LIMITED ENGLISH PROFICIENCY BY NEIGHBORHOOD, 2018-2022[20]

Neighborhood	Percent of residents with Limited English Proficiency	Count of residents with Limited English Proficiency
Bayview Hunters Point	31.9%	12,123
Bernal Heights	14.4%	3,328
Castro/Upper Market	3.2%	706
Chinatown	60.4%	8,081
Excelsior	31.9%	11,922
Financial District/South Beach	13.4%	3,016
Glen Park	5.7%	468
Golden Gate Park	-	-
Haight Ashbury	2.5%	437
Hayes Valley	5.6%	1,026

[19] ACS 2018-2022
[20] ACS 2018-22; *Indicates unstable data

Inner Richmond	16.7%	3,306
Inner Sunset	11.6%	3,060
Japantown	21.8%	793
Lakeshore	15.1%	1,860
Lincoln Park	*	*
Lone Mountain/USF	10.7%	1,714
Marina	2.7%	602
McLaren Park	*	*
Mission	15.9%	8,589
Mission Bay	15.8%	2,352
Nob Hill	15.7%	3,796
Noe Valley	3.6%	791
North Beach	19.3%	2,133
Oceanview/Merced/Ingleside	35.6%	8,460
Outer Mission	38.6%	8,414
Outer Richmond	19.7%	8,324
Pacific Heights	4.6%	1,010
Portola	36.0%	5,471
Potrero Hill	4.0%	567
Presidio	4.2%	147
Presidio Heights	7.7%	767
Russian Hill	7.8%	1,316
Seacliff	6.7%	149
South of Market	21.7%	5,142
Sunset/Parkside	25.0%	18,746
Tenderloin	29.1%	8,971

Treasure Island	18.7%	567
Twin Peaks	7.2%	563
Visitacion Valley	39.2%	6,803
West of Twin Peaks	12.2%	4,387
Western Addition	17.5%	3,814
San Francisco	18.9%	153,904

Evictions

Higher levels of housing unaffordability correspond with increasing levels of displacement (i.e. landlords increase evictions to try to free up their property for sale or secure new tenants who can pay higher rents), resulting in neighborhood turnover. This turnover impacts resiliency by weakening informal social networks as households that are displaced often experience loss of social relationships within a community. Additionally, as the cost of good quality housing rises relative to income, specific conditions that contribute to poor health are magnified. Conditions such as overcrowding, substandard construction and maintenance, the concentration of low-income households in neighborhoods, and homelessness are impacted. From March 1st 2022 to February 28th 2023, there were a total of 1197 Evictions in the city, according to the SF Rent Board[21]. According to a related analysis, the neighborhoods with the highest eviction incidences during that time were Mission, South of Market (SOMA), the Tenderloin, and the Financial District.

TABLE A-10: HIGHEST EVICTION NOTICE NEIGHBORHOODS, 2023[22]

Neighborhood	Evictions Instances
Mission	64
South of Market	61
Tenderloin	57
Financial District/South Beach	29
Outer Richmond	27
Nob Hill	26
Sunset/Parkside	24
Bayview/Hunters Point	16
Hayes Valley	11

[21]SFRB (2023). “2022-2023 Rent Board Annual Report on Eviction Notices (Revised)”. Retrieved from: https://www.sf.gov/sites/default/files/2023-06/Rent%20Board%20Annual%20Eviction%20Report%2022-23_Revised.pdf

[22] San Francisco Standard (2022). “Visualizing Evictions: See where San Francisco evictions are edging upward”. Retrieved from: https://sfstandard.com/2022/07/28/visualizing-eviction-see-where-san-francisco-evictions-are-edging-upwards/

Lakeshore	3

Pre-Existing Health Conditions

Populations with pre-existing health conditions are particularly vulnerable to hazard events. Pre-existing health conditions may impact a person's ability to access emergency response services. Hazard events may exacerbate certain pre-existing health conditions, or make pre-existing health conditions more difficult to manage. For example, extreme heat events exacerbate cardiovascular illness as temperature forces the heart to pump faster and harder in order to regulate body temperature.[23] Similarly, people with asthma may be particularly impacted by air quality impacts.

Disability and Functional Limitations

Hazard events such as fires, floods and earthquakes present a real challenge to individual with disabilities. Accommodations and assistance are needed for safe evacuations, including specialized transportation and shelter space. The needs of people with disabilities are often not adequately addressed in disaster relief and recovery plans, if they are addressed at all,[24] and people with disabilities often experience "invisibility" to decision-makers.[25] Communication materials and methods often do not adequately accommodate those with impaired cognitive function, hearing, or vision.[26] The U.S. Census defines six major categories of disabilities:

- Hearing difficulty deaf or having serious difficulty hearing
- Vision difficulty blind or having serious difficulty seeing, even when wearing glasses
- Cognitive difficulty Because of a physical, mental, or emotional problem, having difficulty remembering, concentrating, or making decisions
- Ambulatory difficulty Having serious difficulty walking or climbing stairs
- Self-care difficulty Having difficulty bathing or dressing
- Independent living difficulty Because of a physical, mental, or emotional problem, having difficulty doing errands alone such as visiting a doctor's office or shopping

[23] Skerrett, Patrick J. "Heat is hard on the heart; simple precautions can ease the strain" Harvard Health Blog, 22 July 2011, www.health.harvard.edu/blog/heat-is-hard-on-the-heart-simple-precautions-can-ease-the-strain-201107223180
[24] World Institute on Disability, 2016. *Climate Change and Disability: Existing Resources*
[25] Wolbring, G., and V. Leopatra, 2012: Climate change, water, sanitation and energy insecurity: Invisibility of people with disabilities. *Canadian Journal of Disability Studies*, 1, 66-90. doi:10.15353/cjds.v1i3.58
[26] Nick, G. A., and others, 2009: Emergency preparedness for vulnerable populations: People with special health-care needs. *Public Health Reports*, 124, 338-343. PMID: 19320378

Importance of Intersectional and Upstream Frameworks

The socioeconomic and demographic, housing quality and living conditions, community characteristics, and pre-existing health factors described throughout this section often co-occur, and cumulatively and interactively work to determine individual and community level vulnerability to hazard events. For example, not only do residents living in poverty have fewer resources to deploy in response to an event, but they are more likely to also have pre-existing health conditions that could make them more susceptible to injury during the event.

The intersectional nature of vulnerability creates deep and seemingly intractable inequities within and across communities. To understand, intervene in, and improve population inequities and vulnerability to hazard events requires more than just a selective list of "vulnerability factors". Even data is not sufficient to comprehensively represent a community. The causes of these factors, and their distribution, should be placed within a framework that identifies their economic and political determinants. Without addressing these structural factors, mitigation, prevention, and recovery activities will be unable to address the root causes on vulnerability, allowing for their continuation and reproduction.

Emergency Response Facilities Sector

Critical Response Facilities

Introduction to Asset Class

Critical response facilities are facilities that provide life safety and property and environmental protection services essential to a community during and after an incident such as an emergency or a disaster. For purposes of the Hazard and Climate Resilience Plan (HCRP), critical response facilities include:

- 11 San Francisco Police Department (SFPD) facilities in San Francisco: 10 District Stations (including the Police Headquarters at the new Public Safety Building) and the Regional Training Facility (the Academy).
- 50 San Francisco Fire Department (SFFD) facilities inside the city, including Fire Department Headquarters, and the Division of Training.
- The San Francisco Emergency Operations Center (EOC) and 9-1-1 Dispatch Center[27]; and
- 17 Primary Department Operations Centers (DOCs)[28]
- For facilities at the San Francisco International Airport, please see the Airport profile.

SFPD District Stations are locations where police personnel prepare for their shifts; manage investigations; securely store evidence; maintain weapons, ammunition, and other department resources; and temporarily house suspects. The stations also provide parking and maintenance for vehicle fleets. Police Headquarters houses department leaders who oversee the day-to-day operations of SFPD, and also serves as the home of the Police DOC, Special Operations, and the Forensic, Fiscal, Planning, and Crime Information Services Divisions. The Academy provides training to prepare recruit officers to perform the duties of a peace officer in our community, and also provides training to members of the public.

SFFD stations serve as homes for firefighters and paramedics while they are on duty, and thus include living, sleeping, and eating areas. Fire stations also store apparatus such as fire engines, fire trucks, ambulances, and related vehicles; personal protective equipment; fire hoses; and other specialized equipment and supplies. The headquarters building houses department leaders who oversee the day-to-day operations of the SFFD, and also serves as the location for the Fire DOC, the Bureau of Fire Prevention,

[27] And 1 alternative EOC, included in exposure analysis
[28] And 17 alternative DOCs, included in exposure analysis. 1 DOC and 1 ALTDOC not included in exposure assessment.

and Pump Station 1. The Division of Training (DOT) develops and provides fire suppression and emergency medical service instruction to all members of the Department. DOT is also home to the Neighborhood Emergency Response Team (NERT) Office and is a training site for NERT volunteers and members of the SFFD Fire Reserves.

The San Francisco EOC is a multi-agency coordination center that is used during incidents to coordinate response and initial recovery efforts above the field level. Common functions of the EOC include information gathering, analysis, and dissemination; incident priority determination; critical resource acquisition and allocation; policy making; and coordination with local, regional, state, and federal officials. DOCs are operated by city departments during incidents to manage their field response and recovery activities and resources, and to maintain continuity of operations for their departments. DOCs are also responsible for sharing information with the EOC regarding the status of their operations and resources. The 9-1-1 Dispatch Center is co-located with the EOC and acts as the communications hub for emergency services in San Francisco. Dispatchers answer calls from the public for emergency assistance and dispatch Police, Fire, and ambulance services to the scene of crimes, fires, accidents, and other types of incidents.

With the exception of Police and Fire facilities at the Airport, which is located in San Mateo County, critical response facilities are positioned throughout the City and County of San Francisco (CCSF). The facilities are owned by CCSF and are managed by their respective departments.

Issue Statement

Critical response facilities provide life safety and property and environmental protection during and after a hazard event. A number of police and fire stations are located in hazard areas with fire stations facing greater potential exposure to coastal flooding as sea level rises. Though the EOC, Police DOC, and several additional DOCs are located in seismically-advanced or retrofitted buildings, a number of DOCs are located in facilities that have not been recently retrofitted. Information on building type, build date, condition, retrofitting, air cooling, filtering, sensitive below grade components, back-up measures for utility outages, access to food and water, fuel for generators for all facilities is not easily accessible.

Exposure

Hazard Data Assumptions

This analysis was conducted in 2018 and 2019 using publicly-available data sources. In Table A-11, on the following page, shaking intensity is represented for two Earthquake scenarios: San Andreas Fault M7.8 and Hayward Fault M7.0 events. Accounts of assets subjected to varying levels of shaking intensity are cumulative for each scenario.

Asset Data Assumptions

Asset data originates from datasets maintained by SF Department of Emergency Management (2018).

TABLE A-11: EXPOSURE

Hazard	Police Assets 11 Total		Firefighting Assets 50 Total		EOC/DOC Assets 34 Total	
	#	%	#	%	#	%
Geologic						
San Andreas 7.8 - Violent	2	18%	12	24%	2	6%
San Andreas 7.8 - Very Strong	9	82%	38	76%	32	94%
Hayward 7.0 - Very Strong	0	0%	6	12%	4	12%
Hayward 7.0 - Strong	8	73%	34	68%	30	88%
Liquefaction Zone	3	27%	13	26%	18	53%
Flooding						
100-Year Coastal Flood Zone	0	0%	1	2%	0	0%
100-year storm + 24 inches SLR	1	11%	7	14%	1	3%
100-year storm + 66 inches SLR	1	11%	11	22%	3	8%
100-year stormwater flood	1	11%	4	8%	3	8%
Wildfire						
High	0	0%	0	0%	0	0%
Moderate	1	11%	0	0%	0	0%

Note: For an exposure table with additional hazards, please see Chapter 5.

Exposure Summary

Geologic: All of San Francisco would be exposed to violent or very violent shaking in a 7.9 earthquake on the San Andreas Fault, Including all critical response facilities. 38 firefighting assets and 36 EOC/DOC assets would be exposed to very strong shaking in a 7.0 Hayward fault event. Half of EOC/DOC assets are exposed to liquefaction hazard zones.

Flood: Few police facilities are exposed to flooding. However, the Public Safety Building that features the Police Headquarters, the Southern District Station, and Fire Station #4 may be exposed to coastal flooding during a 100-year storm with 24 inches of sea level rise. Compared to police, more fire facilities may be exposed to flooding. With 24 inches of sea level rise, 11 firefighting facilities may be exposed to flooding.

Fire: The only critical response facility exposed to moderate wildfire hazard is the Police Academy Building.

FIGURE A-6: CRITICAL RESPONSE AND LIQUEFACTION HAZARD

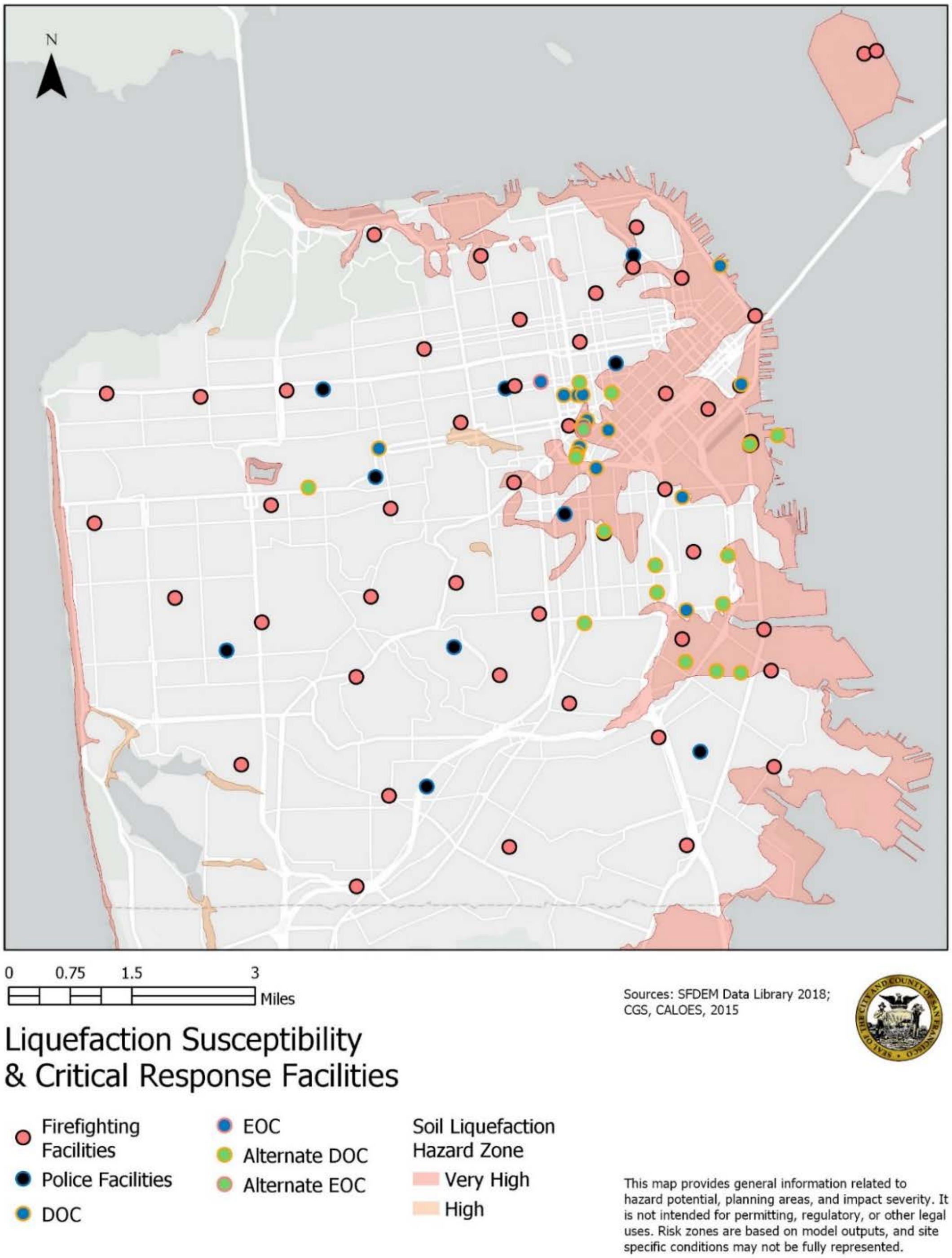
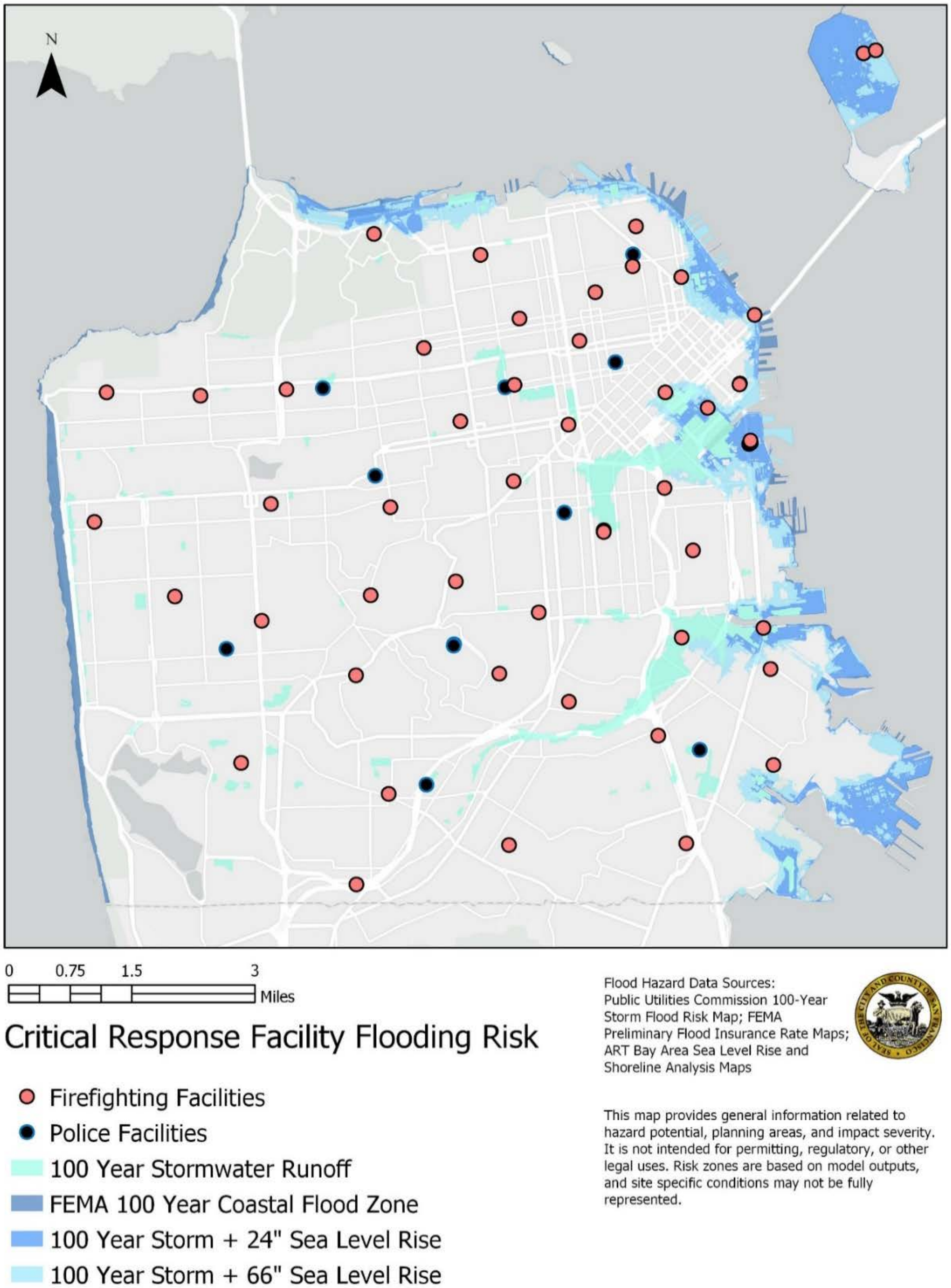


FIGURE A-7: CRITICAL RESPONSE AND FLOOD HAZARDS



VULNERABILITIES

Category	Vulnerability
Physical	Geologic: Most of the facilities in this asset class were built or have been retrofitted to withstand strong earthquake shaking. Additional seismic improvements are prioritized based on HAZUS and Seismic Hazard Ratings, described in greater detail in the informational section below. The bureau of equipment is another important facility housing the fire departments complete inventory of rescue tools and other important equipment. The building was built in 1907 with a brick foundation and is vulnerable to seismic damage. Flood: Several facilities in this class may be vulnerable to coastal flooding due to their location. These include Fire Station 35 on the Embarcadero in South Beach, Fire Station 48 and SFFD Training Center on Treasure Island, and the Police Headquarters/ Southern District Police Station in Mission Rock. The Southern District Police Station has sensitive equipment in the basement and first floor Extreme Heat: Though some of the newer facilities in this class have air conditioning, such as the EOC, most do not. Fire: Though some of the newer facilities in this class, such as the EOC, have air filtering, most do not.
Functional	Networks: Fire and police stations are "networked" in the sense of each station having distinct assignments and areas of responsibilities that combine to provide protection to the city as a whole. Thus, damage to one or more of these facilities will impact non-damaged facilities as they may need to assume responsibility for areas or assignments that would otherwise have been covered by damaged stations. If the EOC is damaged, citywide coordination of information and resources may suffer in a disaster. If a DOC is damaged, management of a department's continuity and field personnel may be adversely affected. The EOC and DOCs have alternate facilities that may be used if the primary facility is damaged. External Services: The facilities in this asset class rely on power, water, the 800 MHz public safety radio system, and internet services. The facilities also rely on outside fuel needs to power vehicles and generators. In

	addition, the departments with responsibility for these assets rely on the transportation network, including public transit, to bring personnel to their respective facilities. These facilities have the ability to run on generator power if needed, and most have short-term back-up water and food supplies (3 days to one week). The EOC, DOCs, and police and fire facilities have access to the Mayor's Emergency Telephone System, a hard-wired phone system that is expected to work when other phones do not. The EOC also has access to satellite phones and to amateur radio operators who can provide communication as needed. <u>Populations Served:</u> Police and Fire Stations provide assistance to anyone in their area of responsibility in need of life safety, incident stabilization, or property protection services. This includes services to people with disabilities or access and functional needs, including providing medical attention, search and rescue, and other protective care. The EOC and DOCs provide indirect services to all CCSF residents, day workers, and visitors by supporting field personnel with information and needed resources. <u>Unique or Critical Function:</u> Fire stations house personnel and apparatus used to provide fire suppression, emergency medical services to the community that are essential every day, and especially in a disaster. Police stations house personnel and resources to provide community safety and other protective services that are essential every day, and especially in a disaster. The EOC provides critical information, communications, and resource coordination services in support of first responders and other field personnel. DOCs provide support to field personnel and maintain their department's continuity of operations that are critical to maintain in a disaster.
Informational	<u>All-Hazard:</u> Francisco uses the HAZUS methodology at the individual building level, run first in 2013 and updated in 2017, to understand potential damage and losses in an earthquake. Seismic Hazard Ratings are used to assess risk and prioritize seismic-strengthening improvements for over 200 public buildings. Data on building type, build date, condition, retrofitting, air cooling, filtering, sensitive below grade components, back-up measures for utility outages, access to food and water, fuel for generators for all facilities is not easily accessible.

Governance	Geologic: The Earthquake Safety and Emergency Response (ESER) bond program continues to make improvements to firehouses and police district stations, including seismic improvements.

CONSEQUENCES

Category	Consequence
Society/Equity	All-hazards: Significant emergencies or disasters may result in the loss of facilities in this asset class as well as human casualties from building damage. This, in turn, would result in reduced ability to provide life safety, incident stabilization, and protection of property and the environment, which will prolong response and recovery times, leading to increased damage, casualties, and economic hardship. Geologic: Significant ground shaking and liquefaction may result in failure of facilities in this asset class as well as human casualties from building damage. This is turn would result in reduced ability to provide life safety, incident stabilization, and protection of property and the environment. Flood: Significant coastal or storm water flooding may result in building damage for facilities in this asset class as well as human casualties. This is turn would result in reduced ability to provide life safety, incident stabilization, and protection of property and the environment. Extreme Heat: Extreme heat may result in the need to close and relocate DOC facilities without air conditioning. This is turn may result in delayed or reduced ability to provide life safety, incident stabilization, and protection of property and the environment. Fire: Fire may cause damage or destruction of facilities in this asset class. Poor air quality from fires in CCSF or in the Bay Area may result in the need to close DOCs and other facilities in this asset class that do not have air filtering capability. This is turn would result in reduced ability to provide life safety, incident stabilization, and protection of property and the environment.
Economy	All-hazards:

	Without the life safety and protective services provided by Fire and Police in CCSF, one can assume the impacts to CCSF in terms of lost lives, infrastructure damage, loss or revenue, and interruption of economic activity would be substantial if not catastrophic. Losing the EOC and DOCs would also have substantial impacts, as these facilities provide incident coordination and management services, respectively. The loss of any of these facilities would result in longer response and recovery times, which in turn will negatively impact the city's economy. Cost to repair these facilities could be in the millions. Cost to replace would be in the billions. Fire: Without fire suppression abilities, fire could destroy large parts of the city (direct fire) or could cripple city functions (severe smoke impacts).
Environment	All-hazards: Police and Fire personnel may be among the first to learn of environmental impacts during an incident. Fire is the lead department with regard to land-based hazardous materials incidents in CCSF. Police take the lead in providing evacuation and protective services needed in an incident that impacts the environment. DOCs and EOC provide support to the field personnel in terms of information and resources needed to combat environmental impacts. The loss of this asset class would make containment and removal far harder, resulting in longer response and recovery times. Geologic: Earthquakes may result in hazardous debris and hazardous material spills. Loss of this asset class would make containment and removal of such hazardous materials far harder, resulting in longer response and recovery times. Flood: Floods may result in hazardous debris and hazardous material spills. Loss of this asset class would make containment and removal of such hazardous materials far harder, resulting in longer response and recovery times. Extreme Heat: Extreme heat events may result in heightened numbers of people seeking medical assistance and to infrastructure damage leading to power grid, traffic, and other types of disruptions. Fire is the lead provider of emergency medical assistance in CCSF. Police play an important role in resolving power, traffic, and other technological disruptions. DOCs and EOC provide support to the field personnel in

	terms of information and resources needed to address heat impacts. The loss of this asset class would result in longer response and recovery times. Fire: Fires result in toxic ash and other dangerous debris. Smoke events may result in heightened numbers of people seeking medical assistance. Fire is the lead provider of emergency medical assistance in CCSF. Police play an important role in limiting access to burn areas until toxic debris can be contained and removed. DOCs and EOC provide support to the field personnel in terms of information and resources needed to address fire impacts. The loss of this asset class would result in longer response and recovery times and increased danger to the public from potential exposure.

Hospitals

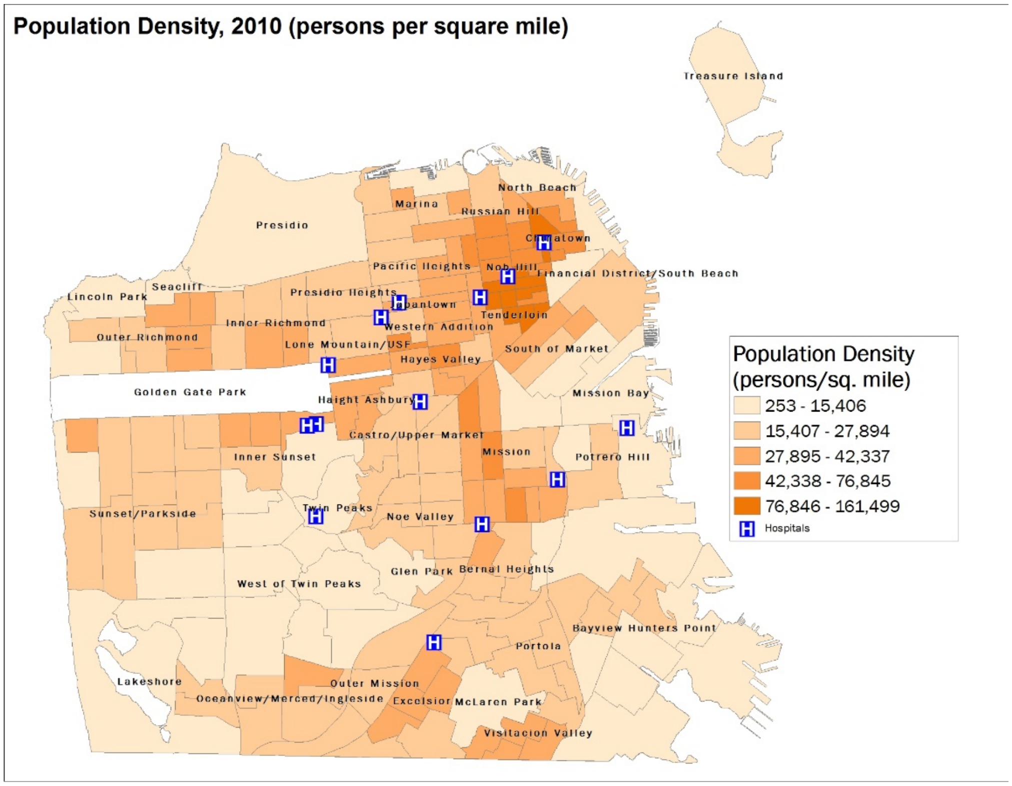
Introduction to Asset Class

Hospitals are institutions that provide life-saving and life-sustaining services to protect the health and wellbeing of all San Franciscans. They also play a critical role in responding to disaster events and providing medical surge capacity[29] to address the resulting influx of patients following an event. San Francisco's hospitals are licensed by the California Department of Public Health, and are required to provide 24-hour inpatient care, and include at the minimum the following eight basic services: medical, nursing, surgical, anesthesia, laboratory, radiology, pharmacy, and dietary services.[30] In addition to providing critical health care services, hospitals are also major employers and tend to be located on medical campuses with multiple other buildings housing related health care services, from pharmacies to doctors' offices.

San Francisco has 15 hospital facilities comprised of 56 buildings that are located across the city.[31] These facilities are concentrated in the city's northeast quadrant, which are also the city's most densely populated areas. For a map of hospital locations, refer to Figure A-8, on the following page. *Hospitals are often located in large, technically complex, multi-story buildings* that are comprised of a diverse set of services. In San Francisco, hospital buildings range from 1-15 stories tall, with the average building being five stories. In San Francisco, the three largest hospitals systems are UCSF, Dignity Health, and Sutter Health, accounting for 81% of the hospital beds in the City. Zuckerberg San Francisco General Hospital (ZSFG) is the city's primary safety-net hospital and the only Trauma Level I hospital in the county. ZSFGH and Laguna Honda hospital (primarily serves a long-term care facility, but is licensed as a hospital and skilled nursing facility) are owned and operated by the San Francisco Department of Public Health. Other hospitals in the City are either privately owned or owned by other public institutions, such as the University of California.

[29] Medical surge is defined as "the ability to provide adequate medical evaluation and care during events that exceed the limits of the normal medical infrastructure of an affected community" (e.g. a natural disaster or pandemic outbreak). US Department of Health and Human Services. Assistant Secretary for Preparedness and Response. Hospital Preparedness Program (HPP) Measure Manual: Implementation Guidance for the BP3 HPP Program Measurement Activities. July 1, 2014 – June 30, 2015. Retrieved from: http://www.phe.gov/Preparedness/planning/sharper/Documents/bp3-hpp-implementation-guide.pdf
[30] 22 CCR § 70005. General Acute Care Hospital.
[31] OSHPD/Facilities Development Division, Healthcare Construction Cost Data. September 2018

FIGURE A-8:
SAN FRANCISCO HOSPITALS AND POPULATION DENSITY, 2016



GENERAL ACUTE CARE HOSPITAL SYSTEMS:

- Chinese Hospital
- California Pacific Medical Center (CPMC; Davies, Mission Bernal, and Van Ness Campuses)
- Kaiser Permanente San Francisco Medical Center
- Zuckerberg San Francisco General Hospital & Trauma Center (ZGSF)
- Saint Francis Memorial Hospital
- St. Mary's Medical Center
- University of California, San Francisco (UCSF; Mission Bay, Mount Zion, and Parnassus Campuses)

OTHER HOSPITALS:

- Jewish Home (long-term care facility & acute psychiatric hospital)
- Laguna Honda Hospital (a long-term care facility)
- Langley Porter Psychiatric Hospital
- Kentfield Hospital San Francisco (long-term care)

- Laguna Honda Hospital (a long-term care facility)

Issue Statement

Hospitals provide life-saving and life-sustaining services to protect the health and wellbeing of all San Franciscans, and play a critical role in responding to disaster events. They are highly regulated entities governed by local, state, and federal level rules on building standards and operations, emergency preparedness, and assortment of other resilience focused standards. Hospital are especially vulnerable to impact from hazard events given the population they serve (medically and socially vulnerable community members), the complexity of services they provide, and their reliance on outside resources to function, including power, communications, food, fuel, routine shipments of equipment, and transportation access. Any significant damage or disruption to a hospital facility would have severe and cascading impacts to health, especially for San Franciscans without the means to find alternate care. Failure of a hospital facility could also impact surrounding hospitals during a hazard event and create a surge in patients that stress their medical capacity.

Exposure

Hazard Data Assumptions

This analysis was conducted in 2018 and 2019 using publicly-available data sources. In Table A-12, on the following page, shaking intensity is represented for two Earthquake scenarios: San Andreas Fault M7.8 and Hayward Fault M7.0 events. Accounts of assets subjected to varying levels of shaking intensity are cumulative for each scenario.

Asset Data Assumptions

Data was sourced from the SF Department of Public Health (SF DPH, 2019). Hospitals are broken into three sub-types based on specialization: Hospitals, Hospitals-Nursing, and Hospitals-Psychiatry.

TABLE A-12: EXPOSURE

Hazard	Hospitals 20 Total	
	#	%
Geologic		
San Andreas 7.8 - Violent	1	5%
San Andreas 7.8 - Very Strong	19	95%
Hayward 7.0 - Very Strong	0	0%
Hayward 7.0 - Strong	15	75%
Liquefaction Zone	2	10%
Flooding		
100-Year Coastal Flood Zone	0	0%
100-year storm + 24 inches SLR	0	0%
100-year storm + 66 inches SLR	1	5%
100-year stormwater flood	0	0%
Wildfire		
High	0	0%
Moderate	0	0%

Note: For an exposure table with additional hazards, please see Chapter 5.

Exposure Summary

Geologic: All of San Francisco would be exposed to violent or very violent shaking in a 7.9 earthquake on the San Andreas fault, including all of the hospitals. 14 hospitals would be exposed to violent shaking in a 7.0 earthquake on the Hayward fault. The San Francisco Sobering Center is the only hospital exposed to liquefaction hazard.

Flood: one of San Francisco's hospitals is exposed to projected future coastal flooding. None of the hospitals are in the stormwater flood risk zone.

Fire: None of San Francisco's hospitals are located in high or moderate wildfire zones.

FIGURE A-9: HOSPITALS AND LIQUEFACTION HAZARD

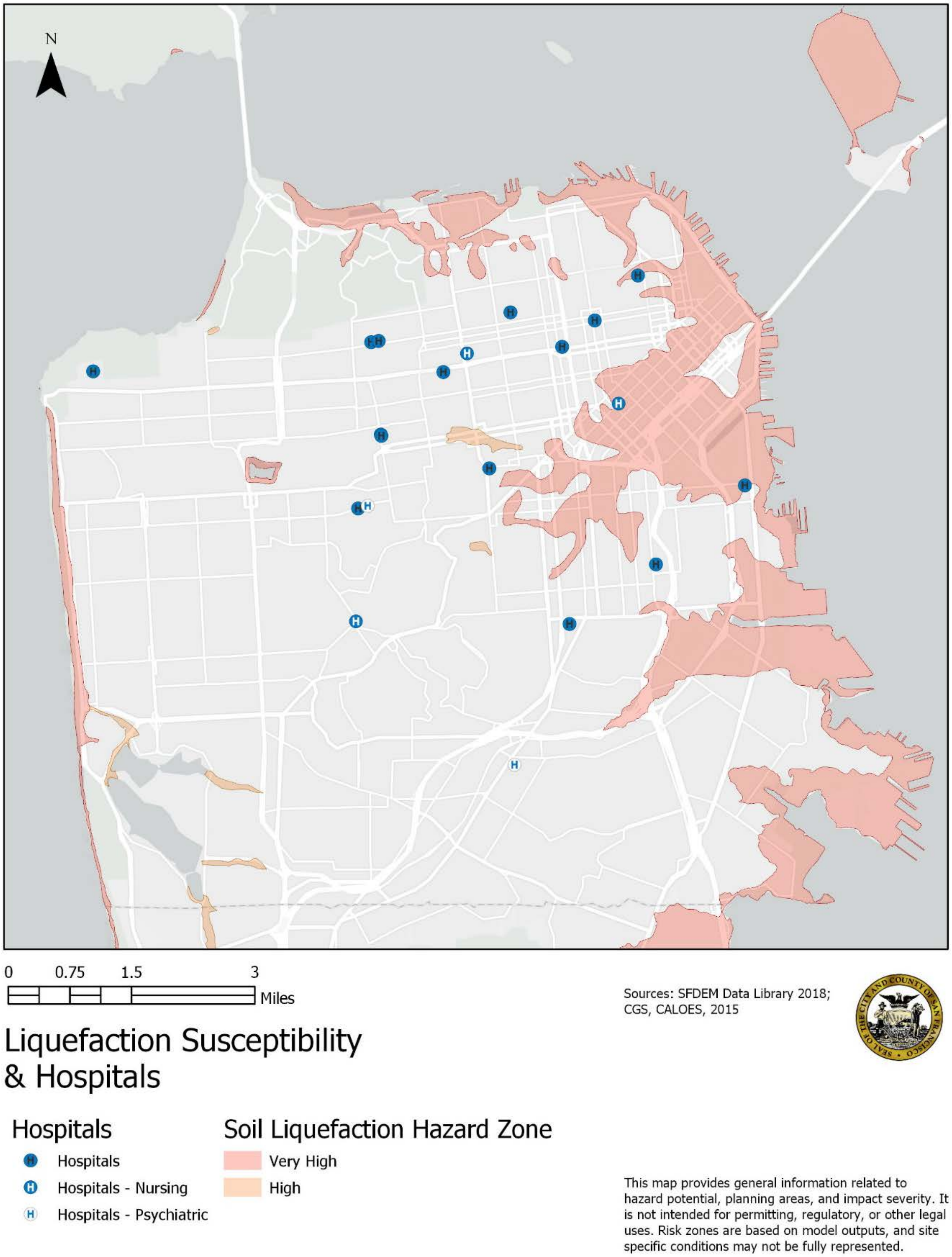
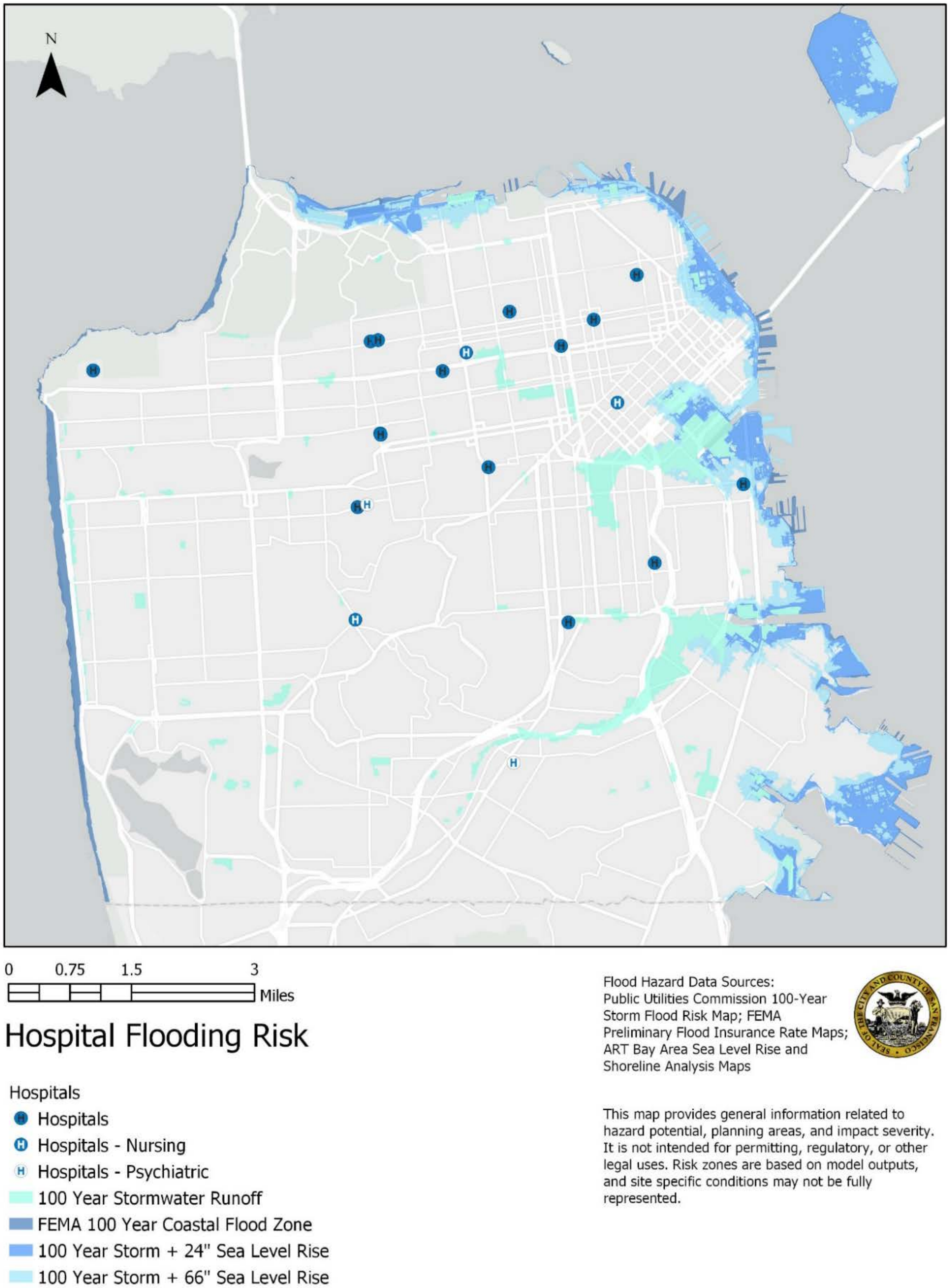


FIGURE A-10: HOSPITALS AND FLOOD HAZARDS



VULNERABILITIES

Category	Vulnerability
Physical	Geologic: Hospital buildings that are older (pre-1973) and non-retrofitted to meet current seismic standards are most at risk of serious damage during an earthquake. Under California law SB 1953, existing hospital acute care buildings must be retrofitted to adhere to certain seismic standards (or removed from general acute care service) by 2030. In San Francisco, 5 out of 15 facilities (33%) have met the 2030 deadline. Flood: Hospitals can experience site damage, structural and nonstructural building damage, destruction or impairment of utility service equipment, and damage to contents due to flooding. Hospitals without elevated generators may be vulnerable to power disruption in the event of flooding. Generators, or their supporting infrastructure (e.g. fuel tanks) are often below grade and are vulnerable if floodwater breaches the containment wall. Extreme Heat: Depending on the age of the building, the facility may have limited or substandard cooling systems. These cooling systems may not be sufficient during extreme heat events and place patients at increased risk of health impacts. Sensitive medical equipment stored in clinical labs are vulnerable to extreme temperatures. Additionally, older facilities may not have capacity (i.e. outlets) for temporary cooling equipment such as portable coolers. Fire: Hospitals are required to adhere to strict air filtration standards based on each area of the hospital's function.[32] Operating rooms, pharmacies, and sterile processing departments are required to meet stricter filtration requirements. In addition to filtration requirements, hospitals in California are required to use only outside air for ventilation, and cannot recirculate air. Therefore many buildings do not have the capacity to switch ventilations systems from bringing outside air in to recirculating inside air in the event of poor air quality due to smoke.
Functional	Networks: Damage or disruption at one hospital will significantly increase demand for services at other area hospitals as patients are rerouted. However, hospital networks have processes in place if one hospital is

[32] California Building Standards Code (California Code of Regulations/2016 California Mechanical Code/Title 24/Part 4/Chapter 3

	unavailable in order to mitigate disruption to the system. Hospitals also have the ability to expand their capacity to treat patients during hazard events through "medical surge." Zuckerberg San Francisco General Hospital is the only trauma center in the City, so any impact to ZSFG would have significant impacts in the ability to provide health services post-hazard in the City. <u>External Services:</u> Hospitals rely on power, communications, food, fuel, routine shipments of equipment, and transportation access to function. Hospitals are required to have a backup power generator on site with automatic restoration of power within 10 seconds. Current code requires existing acute care hospitals to have fuel supply on premises that is sufficient to provide 24 hours of full demand operation. [33] By 2030, acute care hospitals are required to have a minimum of 72 hours of fuel storage (newly constructed acute care hospital buildings must meet these requirements now).[34] Similar to power requirements, new acute care hospital facilities are required maintain an on-site water supply to support 72 hours of emergency operation (both potable and non-potable uses).[35] Existing buildings will need to comply with this requirement by 2030. Additionally, hospitals are required to have at least seven days' supply of staple foods (non-perishable) and two days' supply of perishable food on premises.[36] There is only one blood bank in the City, but each hospital has a cache of blood onsite. <u>Populations Served:</u> Hospitals provides life-saving and life-sustaining services to protect the health and wellbeing of all San Franciscans, regardless of citizenship or ability to pay. San Francisco hospitals are an integral public resource for vulnerable populations that may be disproportionately impacted during hazard events, including older adults during extreme heat events and unhoused populations or populations experiencing homelessness during extreme storm events. Hospitals serve those with access and functional needs, including those with pre-existing health conditions, medically dependent and mobility challenged individuals, and residents of all ages including pregnant women and young children. San Francisco hospitals serve San Francisco's ethnically and culturally diverse populations. As a

[33] According to 22 CCR § 70841 (b) "…The [emergency electrical system] shall serve all lighting, signals, alarms and equipment required to permit continued operation of all necessary functions of the hospital for a minimum of 24 hours.
[34] California Administrative Code, Chapter 6 and California Electrical Code Sections 517.25 and 700.12 (B))
[35] *California Plumbing Code Section 615.4* Emergency Water Supply
[36] *Title 22 – Section 70277*

	result, hospitals must tailor services to respond to multiple and simultaneous needs. <u>Unique or Critical Function:</u> Hospitals are a core component of the City emergency response apparatus and are expected to provide emergency medical services during and after disaster events. These facilities need to ensure continuity and quality of care for community members, even during emergency events. Hospitals can serve as a "teaching hospital", which provide medical education and training to future and current health professionals, and conduct medically-focused research. Teaching hospitals provide a unique educational role in our health care services system and would be difficult to replace.
Informational	<u>All-hazards:</u> All hospitals are required to submit data on health care financing and utilization to the Office of Statewide Health Planning and Development (OSHPD) on an annual basis. This information is publicly available for each facility. Information regarding building age, height, seismic risk, and compliance with state seismic rules is also collected and made publicly available. Hospitals are also required to develop hazards emergency operations plan and conduct an all-hazard risk assessment. Information developed through this planning document can be used to inform facilities planning for and response to hazard event. This plans are not hazard specific, and may leave gaps in understand facilities vulnerabilities to specific events.
Governance	<u>All-hazards:</u> Hospitals must comply with strict local, state, and federal laws and standards that govern building code, operation/maintenance, retrofit, and emergency preparedness requirements. California Department of Public Health (CDPH) is responsible for the licensure, regulation, inspection, and certification of general acute care hospitals. Office of Statewide Health Planning and Development (OSHPD) monitors the construction, renovation, and seismic safety of hospitals. In addition to state requirements, federal rules promulgated in 2016 by Center for Medicare & Medicaid Services (CMS) requires that all hospitals participating in Medicare and Medicaid develop an Emergency Operations Plan (EOP) which describes how a facility will respond to and recover from all hazards. Hospital revenue streams are varied and complex, and are often restricted in how they can be appropriated to address and prepare

	facilities for hazard events. Financing upgrades to meet the state's seismic safety requirements is especially hard for smaller and independent hospitals, some of which don't even have the credit to qualify for loans. The state mandate came with no state or federal money, so the cost has completely borne by the hospitals. For some, the only way to comply with the state requirement is to consolidate with larger hospitals.[37] Public hospitals in San Francisco have been successful in obtaining bond funding for complying state required seismic retrofits and other safety standards. In 2008, 84 percent of San Francisco voters approved Proposition A, which appropriated $887.4 million in general obligation bonds for the building of a new, seismically compliant, acute care hospital and trauma center at San Francisco General Hospital. In June 2016, 79 percent of San Francisco voters approved the $350 million Public Health and Safety bond to fund seismic upgrades in public health facilities (including hospital buildings) across the city. Additionally, San Francisco is proposing a $390 million Healthy, Safe, and Vibrant San Francisco Bond for the November 2024 ballot that would invest in critical hospital infrastructure.

CONSEQUENCES

Category	Consequence
Society/Equity	All-hazards: Any significant damage or disruption to a hospital facility would have severe and cascading impacts to health. Damage or disruption to a San Francisco hospital facility may directly increase morbidity and mortality, especially for San Franciscans without the means to find alternate care. If a hospital facility were to fail, the capacity surge on surrounding hospitals would impact care. Also as major employment centers, a disruption to a hospital would impact the workforce, particularly hourly workers who would lose wages. If a hospital is temporarily without power, it will rely on backup generation and must, at a minimum have fuel to provide power for the continued operation of all necessary functions of the hospital for at least 24 hours. Any power disruption would mandate the relocation of vulnerable patients. Extreme Heat:

[37] Ana B. Ibarra. "For California Hospitals That Don't Pass Quake Test, Money's Mostly At Fault." *California Healthline*. May 26, 2017. https://californiahealthline.org/news/for-california-hospitals-that-dont-pass-quake-test-moneys-mostly-at-fault/.

	High temperatures in hospital facilities without adequate cooling capacity may impact patients that are vulnerable to the health impacts of extreme heat, including children, the elderly, and people with pre-existing cardiovascular conditions or diabetes. Extreme heat may damage sensitive technological equipment which may either stall or slow certain medical processes. The surge in hospitalizations associated with extreme heat events may strain hospital capacity. Fire: Smoke from fires may impact facilities without adequate ventilation. Patients with respiratory illnesses would be especially impacted by impaired indoor air quality.
Economy	All-hazards: Significant damage to a hospital would require the immediate expenditure of resources to relocate vulnerable patients and medical equipment and would strain regional health care infrastructure. Hospitals have high capital requirements and house expensive medical equipment with high replacement costs. Any power disruption would mandate the relocation of vulnerable patients at moderate economic impact. Additionally, hospitals are important employment centers so disruption could affect related economic activity. Extreme Heat: An extreme heat event would not cause significant physical damage, but would increase power usage and utility costs and may damage sensitive equipment in buildings that haven't been adequately weatherized. If a heat event were severe enough to cause a hospital's temperature to be dangerously high, there would be economic costs associated with the relocation of vulnerable patients. Fire: If a smoke event were severe enough, there would be economic costs associated with the relocation of vulnerable patients and potential damage to medical equipment.
Environment	All-hazards: Hospitals store hazardous materials. Damage from an earthquake, flood, or fire could result in the release of hazardous materials.

Other Emergency Facilities

Introduction to Asset Class

Other emergency facilities are facilities or sites that provide supportive services essential to a community during and after an incident. They are located throughout San Francisco. For purposes of this assessment, other emergency facilities include:

- 102 indoor facilities and 5 outdoor sites that the City and County of San Francisco (CCSF) may rely on to provide sheltering services for people who are displaced or otherwise impacted in an incident. These sites include Moscone Center North, South, and West buildings.
- The San Francisco Animal Care and Control animal shelter, which would provide care and other services to displaced pets, service animals, and wild or exotic animals following an incident.
- 25 sites currently identified for use as potential resource staging areas following an incident impacting the city.

Potential shelter facilities included in this asset class are located primarily at public schools owned and operated by the San Francisco Unified School District (SFUSD), recreation centers owned and operated by the Recreation and Parks Department (RPD), and privately-owned places of worship. Each of these facilities is used during non-disaster periods to provide educational, recreational, religious, and other services to the community. Most of the facilities are open to the public, though some are privately owned and thus are typically available during daily operations to a more limited clientele. In general, before any of these facilities may be used as shelters following an incident, they must be inspected to ensure they are safe for use.

The San Francisco Department of Animal Care and Control (ACC) animal shelter is a taxpayer-funded, open-admission animal shelter. In its daily operations, the shelter provides housing, care, and medical treatment to domestic stray, lost, abandoned, sick, injured, and surrendered animals; and to wild and exotic animals. The shelter also serves as a headquarters for personnel who enforce state and local animal control and welfare laws in CCSF and act as first responders for animals during incidents. The ACC shelter is owned and operated by the San Francisco General Services Agency. The city has plans to thoroughly renovate an existing building in a different location for use as a new animal shelter, with relocation scheduled for the end of 2020.

Potential staging areas included in this asset class include vacant lots, parking lots attached to schools or recreation facilities, and playgrounds. Accordingly, most of the sites included in this category serve a daily function as a parking or recreational area. As with shelter facilities, before a staging area can be selected for service following an incident, it must be inspected to ensure it is safe for use.

Issue Statement

Other emergency sites play a critical role during and after a disaster for sheltering displaced persons, pets, and staging materials. Staging areas tend to be located in areas susceptible to liquefaction and coastal flooding. Disruption of lifelines, such as water, power, sewer, and communications would require that backup systems or supplies such as generators, portable toilets, or bottled water be brought onsite. The city lacks up-to-date data on privately-owned shelter facilities in terms of their vulnerability or resilience, such as retrofitting or air cooling and filtering. Loss of functionality of facilities in this asset class would increase response and recovery time

Exposure

Hazard Data Assumptions

This analysis was conducted in 2018 and 2019 using publicly-available data sources. In Table A-13, on the following page, shaking intensity is represented for two Earthquake scenarios: San Andreas Fault M7.8 and Hayward Fault M7.0 events. Accounts of assets subjected to varying levels of shaking intensity are cumulative for each scenario.

Asset Data Assumptions

Data was sourced from the SF Department of Emergency Management (SF DEM, 2019). The staging areas are mostly port properties along the Bay Shore, with the care and shelter locations being a mix of public/private buildings.

TABLE A-13: EXPOSURE

Hazard	Staging 25 Total		Care and Shelter 107 Total		Animal Care and Control 1 Total	
	#	%	#	%	#	%
Geologic						
San Andreas 7.8 - Violent or Very Strong	3	12%	80	75%	0	0%
San Andreas 7.8 - Very Strong	22	85%	22	21%	1	100%
Hayward 7.0 - Very Strong	23	88%	5	5%	0	0%
Hayward 7.0 - Strong	2	8%	82	77%	1	100%
Liquefaction Zone	25	96%	24	22%	1	100%
Flooding						
100-Year Coastal Flood Zone	8	31%	2	2%	0	0%
100-year storm + 24 inches SLR	8	31%	3	3%	0	0%
100-year storm + 66 inches SLR	24	92%	5	5%	0	0%
100-year stormwater flood	0	0%	6	6%	1	100%
Wildfire						
High	0	0%	0	0%	0	0%
Moderate	0	0%	3	3%	0	0%

Note: For an exposure table with additional hazards, please see Chapter 5.

Exposure Summary

Geologic: All of San Francisco would be exposed to violent or very violent shaking in a 7.9 earthquake on the San Andreas Fault, including all other emergency facilities. A significant proportion of staging areas and the current Animal Care and Control Center are exposed to liquefaction hazard zones.

Flood: Given the location of staging areas along eastern waterfront, they may potentially be exposed to flooding hazards. Eight staging sites are currently exposed to coastal flooding during a 100-year storm, and this increase to 24 sites with 66 inches of sea level rise. In addition, 25 staging sites are in the liquefaction zone. Notably, the current Animal Care and Control Center, the only facility of its kind, may be to be exposed to 100-Year stormwater flooding. Care and Shelter Facilities have limited exposure to potential flooding, however, the two Fort Mason Center Pavilions and one Treasure Island facility listed as possible shelters are located within the current 100-year coastal flood zone.

Fire: Three shelters are exposed to moderate wildfire hazard zones. However, in relation to the total number of shelters, this does not represent a significant amount of exposure.

FIGURE A-11: OTHER EMERGENCY SITES AND LIQUEFACTION HAZARD

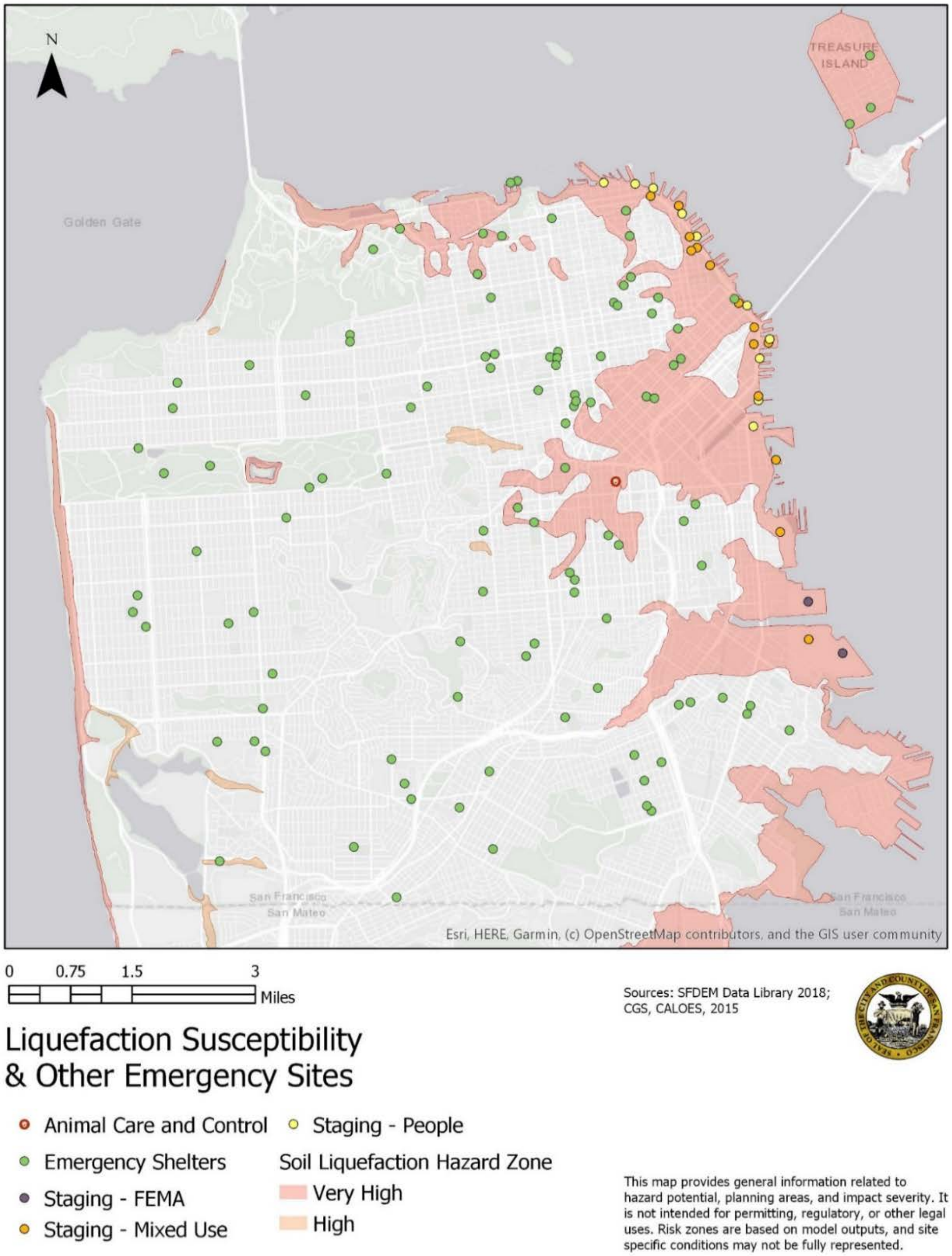
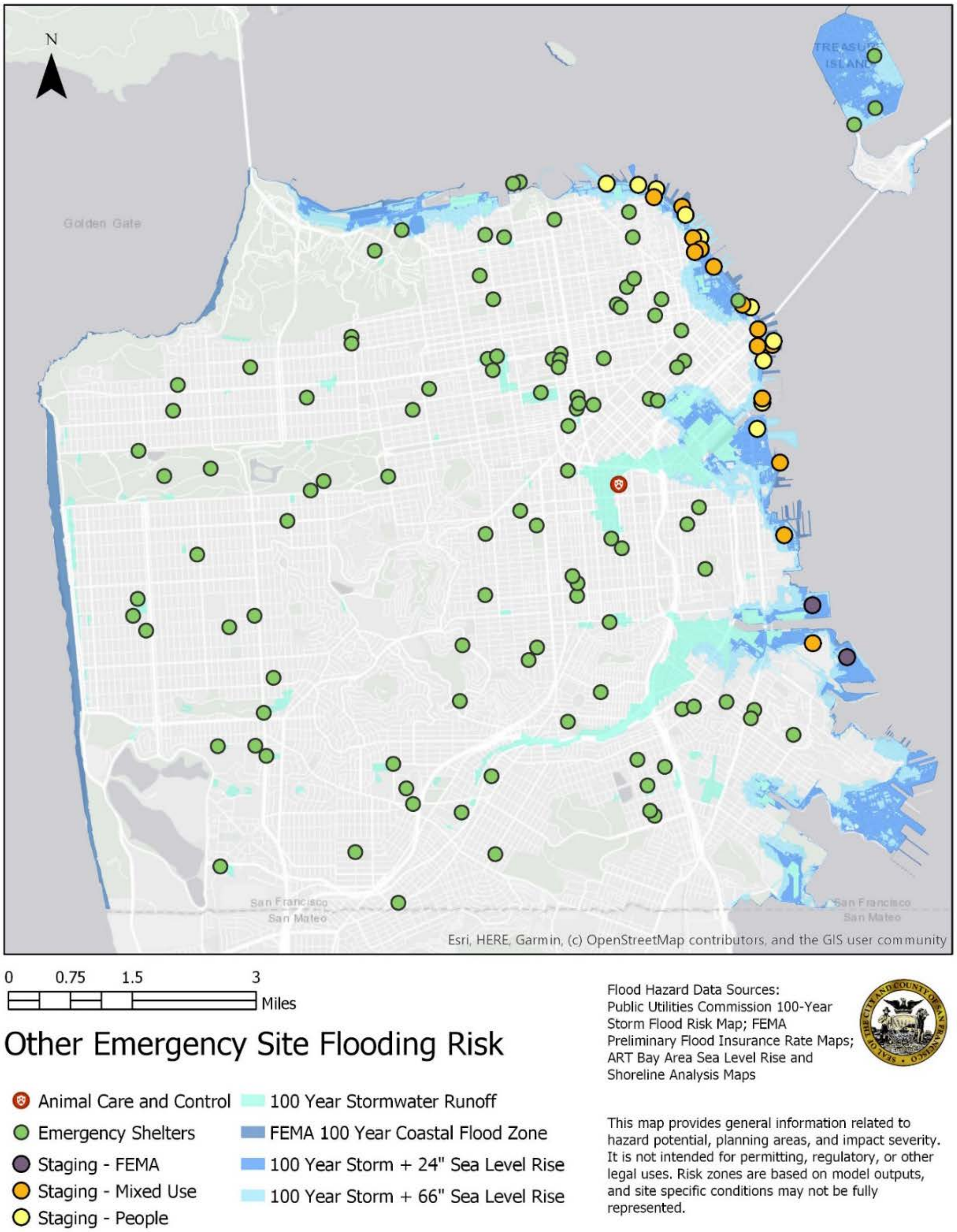


FIGURE A-12: OTHER EMERGENCY SITES AND FLOOD HAZARDS



Flood Hazard Data Sources: Public Utilities Commission 100-Year Storm Flood Risk Map; FEMA Preliminary Flood Insurance Rate Maps; ART Bay Area Sea Level Rise and Shoreline Analysis Maps

This map provides general information related to hazard potential, planning areas, and impact severity. It is not intended for permitting, regulatory, or other legal uses. Risk zones are based on model outputs, and site specific conditions may not be fully represented.

VULNERABILITIES

Category	Vulnerability
Physical	Geologic: At least 42 of the potential shelter facilities included in this asset class have received some retrofitting. Of these, 13 Recreation and Parks facilities have completed seismic renovations within the last ten years; these facilities would become operational first following a large earthquake. In addition, the City has built opened a new ACC shelter facility. The new facility is located in the liquefaction zone but has been designed to withstand strong earthquake shaking. Many of the staging areas are located on older piers that were not built to modern seismic standards and would be susceptible to damage in an earthquake. The piers in the northern waterfront are being studied as part of the Waterfront Resilience Program. The piers in the southern waterfront need to be evaluated individually to better understand their vulnerability and consequence of damage and identify specific work that is needed to improve their performance. Flood: Several facilities and sites in this asset class may be vulnerable to coastal flooding due to their location. Many of the piers in the southern waterfront are vulnerable to flooding, particularly where utilities exist under the piers, there is a need for space under the piers to maintain them, the condition of the pier aprons and fenders are already compromised, or where there is a need for access connections between the water and the land. The newly-renovated ACC shelter facility is located outside the 100-year storm risk zone and has an electrically-powered air conditioning system. Extreme Heat: Though most of the newer facilities in this asset class have air conditioning, older facilities do not. For example, six recently-renovated shelter sites have upgraded HVAC systems providing a climate-controlled environment. In contrast, many currently used facilities do not have air-conditioning. Resource staging areas included in this asset class are all located outside, which would potentially place personnel working in these areas at risk for heat or air quality-related complications during extreme-heat or wildfire smoke events. Fire:

	None of the facilities or sites included in this asset class are located in areas of very high or high fire risk as determined by the California Department of Forestry and Fire Protection (CAL FIRE). However, potential shelter facilities in Fort Mason are located in an area of moderate fire risk according to CAL FIRE. Most public schools and recreation centers included as potential shelter sites in this asset class have fire sprinkler systems installed. However, 15 of the possible shelter sites are wood-framed structures, which potentially increases their fire risk. In addition, all sites and facilities in this asset class may be susceptible to poor or unhealthy air quality stemming from fires located outside San Francisco. Though some of the newer facilities in this class have air filtering, most do not. Only three of the potential shelter facilities have filtered air. Both current and proposed ACC shelter facilities are designed to use 100-percent outside air circulation for disease control. During a fire or external smoke event, all ventilation would be shut down to minimize the spread of smoke into the building. In addition, both the current and renovated ACC facilities have older, historic windows that do not perform as well in preventing outside air infiltration. All of the resource staging areas included in this asset class are located outdoors, leaving personnel and other resources in these areas susceptible to impacts from smoke.
Functional	<u>Networks:</u> Potential shelter facilities are not networked in the sense of having discrete areas of responsibility. However, loss of a number of shelters would certainly impact the city's capability to provide shelter to displaced persons. Though the ACC animal shelter facility is a "stand-alone" facility, ACC's ability to respond in a disaster will heavily impact the city's human shelters, as ACC provides support for service animals in shelters serving humans, and provides emergency sheltering for household pets co-located with or within a short distance of human shelters. Similarly, the loss of multiple staging areas will impact the city's ability to locate needed resources close to areas where they are needed or near transportation routes for efficient dispersal. Thus, if one or more of these sites or facilities are unavailable, this will impact available sites or facilities, which may need to assume greater responsibility for unmet needs. <u>External Services:</u> Other emergency sites depend on water, sewer, gas, electricity, and telecommunications. Disruption of such lifelines would require that backup systems or supplies such as generators, portable toilets, or

bottled water be brought onsite. Interruption of the sewer system also would present disease control challenges.

ACC currently has no emergency water storage onsite, so a water tanker or hook-up to nearby fire hydrants may be required during an incident. A lack of electrical power could affect refrigeration capabilities, which may result in a loss of critical medical supplies such as vaccines. This, in turn, could impact the health of animals in ACC's care and potentially lead to disease outbreak.

Shelters rely on transportations systems as they require a high volume of commodities being delivered for effective operations, including food, cots, blankets, toiletries, and first aid supplies. As commodities become depleted locally, the city will depend on aid from other sources. If transportation corridors are temporarily unavailable or are damaged, this will further impact provisioning of these facilities.

ACC also relies on outside agencies for assistance with towing emergency trailers from storage location to a temporary shelter site or sites.

Shelter sites depend on trained building and health inspectors. Before any of the potential shelter sites can be occupied following an earthquake event, a safety assessment of the facilities must be conducted by trained building inspectors. Because CCSF has a large number of critical facilities that require similar inspections, and because the supply of local, trained building inspectors is limited, inspections of shelter facilities will need to be prioritized. Similarly, the Department of Public Health must conduct inspections of shelter facilities to ensure that they meet health and sanitation standards.

Populations Served:
Shelters provide temporary housing for displaced persons, though typically they serve a disproportionate number of people with fewer resources. This includes people who—because of age, disability, language barriers, or income—have limited housing options and require additional assistance to recover from an incident. For example, the city anticipates that a larger percentage of renters will seek shelter, as homeowners are more likely to remain with their property or have insurance to cover housing alternatives.

The ACC shelter is tasked with serving all populations within San Francisco, including people with disabilities, lower incomes, or people who are displaced. A major incident will result in an increase in the number of animals that need to be housed, fed, and cared for, including those needing medical attention. ACC is limited in its ability

	to support additional physical sheltering for stray animals without an owner or guardian, but is exploring obtaining additional equipment for this type of facility in austere conditions. Resource staging areas may be used to locate personnel, equipment, and supplies needed in an incident. These resources, in turn, support response and recovery personnel and the general population. Unique or Critical Function: Emergency shelters provide temporary accommodations to persons displaced from their homes by an incident. The ultimate goal of shelter operations is to help people to find the resources needed to leave the shelter. Shelters remain open until occupants can return home or find alternate housing. Because people often arrive at shelters without daily necessities, shelter staff work to identify and connect individuals with services or resources to meet basic needs. This includes access and functional needs such as obtaining personal care assistance, durable medical equipment, or needed medication. ACC is charged with providing rescue, emergency care, housing, and reunification services for animals that are lost, missing, or injured. ACC also provides support for service animals in human shelters and emergency household pet sheltering co-located with or near shelters for people. Staging areas serve as locations for emergency personnel waiting to be deployed, or for the storage of emergency supplies and equipment.
Informational	All-hazards: The city lacks up-to-date data on privately-owned shelter facilities in terms of retrofitting, air cooling and filtering, installation of sprinkler systems, sensitive below grade components, back-up measures for utility outages, access to food and water, and fuel for generators for all facilities. ACC is in the process of negotiating memoranda of understanding with other city agencies for assistance; however, options for trailering, water supply, and temporary shelter site locations remain unclear.
Governance	All-hazards: The Americans With Disabilities Act (ADA), 42 U.S. Code §§ 12101 et seq., requires shelters to provide equal access to benefits provided, including modifying “no pets” policies to allow people with disabilities to be accompanied by their service animals. See 28 C.F.R. § 35.130(b)(7)(i). Under the ADA, service animal means any dog that is individually trained to do work or perform tasks for the benefit of an

	individual with a disability. The work or tasks performed by a service animal must be directly related to the individual's disability. The Pets Evacuation and Transportation Standards (PETS) Act, P.L. 109-308 (H.R. 3858), requires FEMA to ensure that local and state emergency operations plans address the needs of individuals with household pets and service animals before, during, and after a major disaster or emergency. The PETS Act also authorizes FEMA to provide funding to local and state governments for animal emergency preparedness, including procurement, construction, leasing, or renovating of emergency shelter facilities and materials that would accommodate people with their pets and service animals following an evacuation. The Post-Katrina Emergency Response Act (PKEMRA), P.L. 109-295 (H.R. 5441), amended the Stafford Act to authorize search, rescue, care, and shelter of pets and service animals as a type of essential assistance to be provided after a major disaster declaration. All CCSF departments must abide by San Francisco Administrative Code Chapter 6, which governs public works or improvement contracting policies and procedures, including the procurement of professional design, consulting, and construction management services for public work or Improvement projects.

CONSEQUENCES

Category	Consequence
Society/Equity	All-hazards: Significant incidents may result in the loss of facilities in this asset class as well as human casualties from building damage. This would result in reduced ability to provide shelter for people and animals. It may also prevent or delay the use of certain staging areas, requiring the use of alternate sites. This, in turn, may increase response and recovery times. Geologic: Significant ground shaking and liquefaction may result in failure of facilities in this asset class as well as human casualties from building damage. This in turn would result in reduced ability to provide shelter for people and animals. Seismic impacts may also prevent or delay the use of certain staging areas, requiring the use of alternate sites. Collectively, such consequences may lengthen response and recovery times. Flood:

	Significant coastal or storm water flooding may result in building damage for facilities in this asset class as well as human casualties. This is turn would result in reduced ability to provide shelter for people and animals. Flooding may also prevent or delay the use of certain staging areas, requiring the use of alternate sites. Collectively, such consequences may lengthen response and recovery times. Extreme Heat: Extreme heat may result in the need to avoid using or to lessen reliance on shelter facilities without air conditioning. It may also require moving some outdoor staging sites to indoor facilities where the climate can be controlled, or to reducing the pace of work in outdoor staging area to lessen heat impacts to personnel at the site. Collectively, such consequences may result in reduced ability to provide shelter for people and animals, and to a reduction in the efficiency of staging areas, lengthening response and recovery times. Fire: Fire may damage or destroy facilities in this asset class. Poor air quality from fires in CCSF or in the Bay Area may result in a need to close shelter and ACC facilities that do not have air filtering capability, or to purchase filtering equipment, masks, and other supplies to lessen smoke impacts. This may result in reduced ability to provide shelter for people and animals and may prevent or delay the use of certain staging areas, requiring the use of alternate sites. Collectively, such consequences may increase response and recovery times.
Economy	All-hazards: The loss of, or delayed access to, the facilities or sites in this asset class would result in longer response and recovery times, which in turn will negatively impact the city's economy and ability to quickly recover. Costs to repair the facilities in this asset class could be in the millions or billions. Cost to replace would be in the trillions.
Environment	All-hazards: Staging areas provide support to department or field personnel by storing resources needed to combat environmental impacts, and by serving as locations where personnel may gather to prepare for deployment.

Public and Community Services Sector

Municipal Buildings

Introduction to Asset Class

This section includes municipal offices, jails, and publicly owned arts venues. Other types of public buildings are covered in different sectors of the assessment, such as emergency response facilities (e.g. police and fire stations), educational facilities, and health facilities (e.g. hospitals and clinics). The locations of buildings and exposure analysis calculations were made using data from the City's Facility System of Record.

- Municipal offices: Buildings where City employees work, members of the public receive services, and/or the combination of these two. Some City services focus on the unique needs of low-income and other sub-populations. For example, the Human Service Agency (HSA) administers many of these programs at its nine service center locations. Most municipal offices are clustered around City Hall, and several are located in the southeast. This analysis classifies 48 buildings as municipal office. Twenty-eight of these buildings house city departments, but are not owned by the City. Three private buildings which hold city departments are 240 feet or taller and therefore classified as a "Tall Building" in the City's Tall Building Inventory initial database.[38]
- Correctional facilities: There are three active County Jails at two facilities within San Francisco proper: County Jails #1 (Intake and Release) and #2 (Administrative Areas, Kitchen, Jail Pods and Medical/Psychology Ward) at 425 7th Street, and County Jail #4 at the Hall of Justice. The Hall of Justice also houses other justice-related staff offices, as well as San Francisco's criminal and traffic courts. There is also one active jail, County Jail #5, located in San Bruno (San Mateo County), which is mapped in Appendix B. There is a locked ward at Zuckerberg San Francisco General Hospital and two additional wards in the original San Francisco General Hospital building for inmates requiring hospitalization. The Juvenile Justice Center campus is located in the center of the city near Twin Peaks; that campus has a variety of on-site services, including a court, gymnasium, and administrative offices. The Log Cabin Ranch, a Santa Cruz Mountains facility for

[38] Tall Buildings Safety Strategy acknowledges that the 240-foot height criterion for the initial database was somewhat arbitrary. To the extent that the *San Francisco Building Code* imposes elevator, fire safety, and other requirements on high-rise buildings defined as those taller than 75 feet, it would be useful to expand the database to include at least all buildings above this height.

juveniles with violent or chronic offenses, had its operations suspended in June 2018 following repeated residents running away.

- City-owned cultural centers, museums, and performance halls: There are four major museums in the City's portfolio: The Asian Art Museum on Civic Center Plaza, the de Young Museum and the California Academy of Sciences in Golden Gate Park, and the Legion of Honor near Land's End lookout. The de Young and Legion of Honor are both managed by the city's Fine Arts Museums Department, which also maintains a warehouse in the Bayview neighborhood. The City's Arts Commission owns four cultural centers: Bayview Opera House, Mission Cultural Center for Latino Arts, SOMArts, and the African American Art and Culture Complex—located in the historic Fillmore Jazz District. The War Memorial Department holds three performance halls and one rehearsal hall, and the Real Estate Division owns one performance hall (Bill Graham Civic Auditorium); all five of these performance venues are located within one block of City Hall. There are many other museums in San Francisco which are privately owned and managed.

Issue Statement

Municipal buildings have diverse roles and needs. Municipal offices and service centers provide functions critical to the well-being and safety of San Francisco residents and visitors. Museums, performance halls, and historic buildings have unique cultural and economic value. These buildings range in their seismic safety and resilience to other hazards. Community members rely on services provided by the City and may not be able to locate replacement services. The consequences of municipal building disruption are more severe for residents who require public assistance to meet their basic needs, who are resource-constrained and experience other social vulnerabilities, including incarcerated populations.

Exposure

Hazard Data Assumptions

This analysis was conducted in 2018 and 2019 using publicly-available data sources. In Table A-14, on the following page, shaking intensity is represented for two Earthquake scenarios: San Andreas Fault M7.8 and Hayward Fault M7.0 events. Accounts of assets subjected to varying levels of shaking intensity are cumulative for each scenario.

Asset Data Assumptions

Asset data originates from the facility system of Record (FSR) dataset maintained by the Office of Resilience and Capital Planning and available through the San Francisco Open Data Portal.

TABLE A-14: EXPOSURE

Hazard	Municipal Office 42 Total		City-Owned Arts Institution 9 Total		Jail/Juvenile Detention Facilities 3 Total	
	#	%	#	%	#	%
Geologic						
San Andreas 7.8 - Violent	0	0%	3	33%	0	0%
San Andreas 7.8 - Very Strong	42	100%	6	67%	3	100%
Hayward 7.0 - Very Strong	4	10%	0	0%	0	0%
Hayward 7.0 - Strong	38	90%	9	100%	2	67%
Liquefaction Zone	23	55%	2	50%	2	67%
Flooding						
100-Year Coastal Flood Zone	1	2%	0	0%	0	0%
100-year storm + 24 inches SLR	2	5%	0	0%	0	0%
100-year storm + 66 inches SLR	8	19%	0	0%	2	67%
100-year stormwater flood	4	10%	4	44%	0	0%
Wildfire						
High	0	0%	0	0%	0	0%
Moderate	0	0%	1	11%	0	0%

Note: For an exposure table with additional hazards, please see Chapter 5.

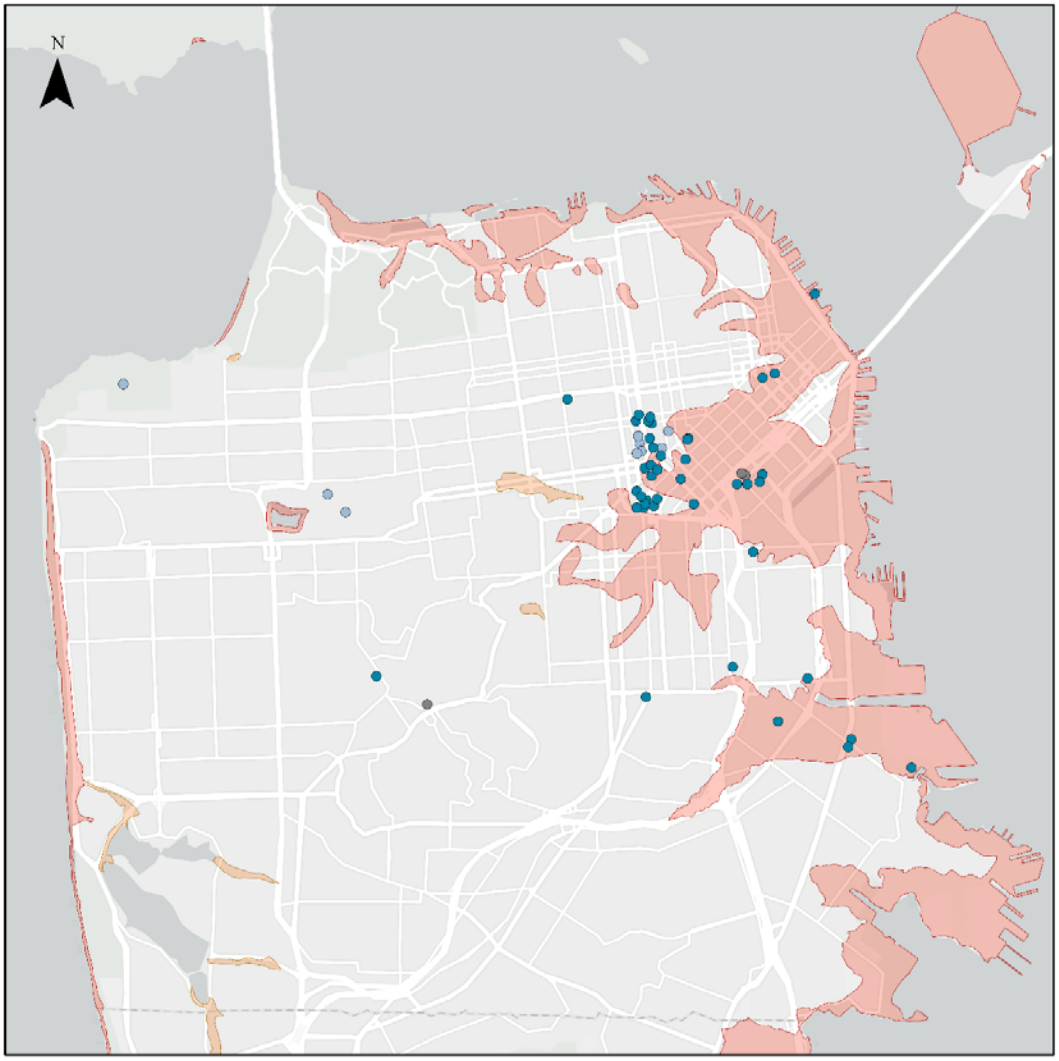
Exposure Summary

Geologic: All municipal buildings would be exposed to Violent or Very Strong shaking during a 7.8 earthquake on the San Andreas Fault. All municipal buildings except the juvenile detention facility would be exposed to Very Strong or Strong shaking during a 7.0 earthquake on the Hayward fault. The two County jail facilities in San Francisco, the Asian Art Museum, Bill Graham Civic Auditorium, and 23 municipal buildings are in the liquefaction zone.

Flood: The two County jail facilities in San Francisco and 8 municipal offices are in the 66" sea level rise zone. All War Memorial buildings and four municipal office buildings are in the 100-year stormwater flood zone.

Fire: The Legion of Honor is the only municipal building in a wildland-urban interface fire risk zone (Moderate).

FIGURE A-13: MUNICIPAL BUILDINGS AND LIQUEFACTION HAZARD



0 0.5 1 2 Miles

Sources: SFDEM Data Library 2018; CGS, CALOES, 2015; City of San Francisco Facility System of Record 2018

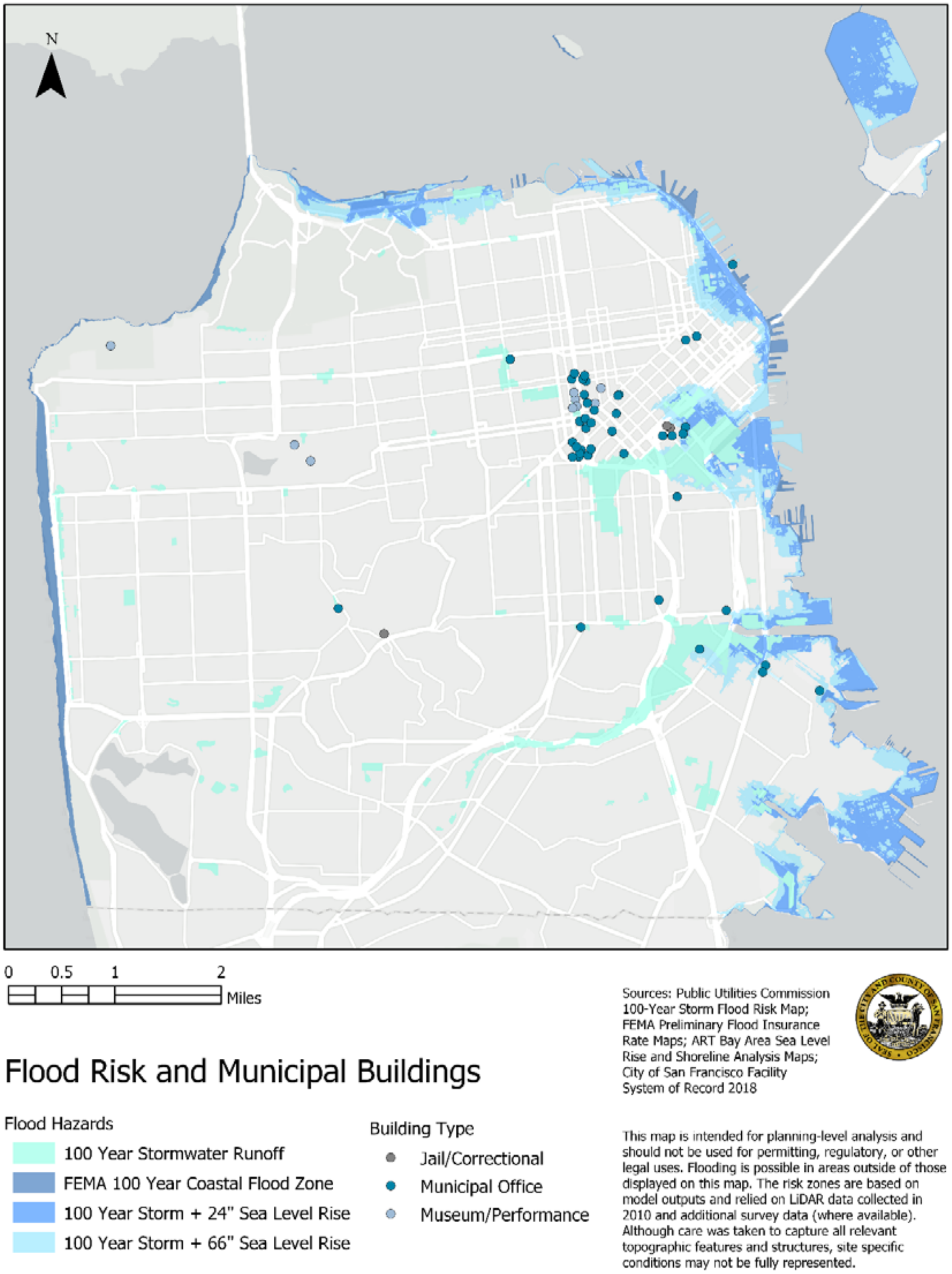
Liquefaction Susceptibility Municipal Buildings

Soil Liquefaction Hazard Zone
- Very High
- High

Building Type
- Jail/Correctional
- Municipal Office
- Museum/Performance

This map provides general information related to hazard potential, planning areas, and impact severity. It is not intended for permitting, regulatory, or other legal uses. Risk zones are based on model outputs, and site specific conditions may not be fully represented.

FIGURE A-14: MUNICIPAL BUILDINGS AND FLOOD HAZARDS



VULNERABILITIES

Category	Vulnerability
Physical	Geologic: Municipal buildings vary in their seismic soundness. Some have completed retrofits; in others the tenants have been partially or completely relocated. San Francisco uses seismic hazard ratings (SHRs) to assess risk and prioritize seismic-strengthening capital improvements. At present, the City has developed mitigation strategies for many of the buildings identified as SHR4 (worst performing), but resources are needed in order to deliver those mitigations. A top priority of the City's Capital Plan is to vacate, demolish, and rebuild the Hall of Justice. Though it is not an SHR4, a 2012 seismic evaluation of the Hall of Justice determined that "damage would be very severe and pose appreciable life hazards to occupants."[39] Some departments have been permanently relocated from the building, and additional mitigations are underway. There are certain building types in the municipal buildings asset category with structural vulnerabilities that make them high-priority for the City. Older non-ductile concrete frame buildings are brittle and vulnerable to extensive damage with significant life safety risk.[40] Approximately 3,400 such buildings exist in San Francisco (residential and nonresidential), but it is not yet known which of these pose a collapse risk in an earthquake. Steel frame structures built between approximately 1960 and 1994 are vulnerable to earthquakes if they use a welded steel construction method.[41] San Francisco's Earthquake Safety Implementation Program and Tall Buildings Safety Strategy recommend non-ductile concrete buildings and welded steel frame buildings be evaluated and retrofitted starting in 2020. Flood: Most buildings are not built to withstand any amount of flooding, as construction materials, siting and design standards do not require consideration of potential exposure to either water or salt. Buildings

[39] City Services Auditor 2013 Hall of Justice Replacement Jail http://www.sfsheriff.com/files/sf_jail_needs_8_2013.pdf

[40] "Guide to Earthquake Vulnerable Commercial Building Types," Association of Bay Area Governments Resilience Program, September 2016, http://resilience.abag.ca.gov/commercial-building-types/

[41] Detweiler, S.T., and Wein, A.M., eds., 2018, The HayWired earthquake scenario—Engineering implications: U.S. Geological Survey Scientific Investigations Report 2017–5013–I–Q, 429 p., https://doi.org/10.3133/sir20175013v2

	with at- or below-grade mechanical systems or equipment are vulnerable to flooding and groundwater intrusion. Extreme Heat: Older buildings with limited or substandard cooling systems are more vulnerable during extreme heat events. Fire: Buildings made with wood are highly susceptible to fire. Steel and concrete buildings are less vulnerable to fire damage, and steel buildings contain fire proofing materials to resist fire damage. Emergency plans and evacuation procedures are required by federal law. Populations with limited mobility or medical conditions are particularly at risk during evacuation. The *San Francisco Building Code* requires many buildings to have an in-building secondary water supply to operate the sprinkler system for 30 minutes. The Tall Buildings Safety Strategy recommends a study to evaluate whether (1) the in-building secondary water supply for automatic fire suppression in tall buildings is sufficient to inhibit fire spread and allow safe evacuation, and (2) the building code provisions that rely on elevators for evacuation during a fire emergency will be effective following an earthquake. Older buildings that do not have adequate HVAC and filtration technology may be more vulnerable to air quality impacts.
Functional	Networks: Municipal Buildings rely on each other in implementing programs, sharing data and information, and operating city services. Cross-department collaboration is highly dependent on functioning internet and telephones, and city IT systems are networked. The CCSF IT-focused Disaster Preparedness, Response, Recovery and Resiliency (DPR3) requires all departments to develop, test, and maintain departmental IT-focused Continuity of Operations plan (IT COOP) to meet the needs of critical system operations in the event of a disruption.[42] The War Memorial Veterans Building and Opera House share mechanical systems, as do the Hall of Justice and 425 7th Street, and Moscone Center North and South.[43] External Services: Municipal buildings rely on electricity delivery through PG&E's transmission and distribution system and all buildings have back up power sources to run emergency lighting and critical equipment. Municipal Buildings that house critical functions in the event of a power failure are equipped with backup generators to support those

[42] https://sfcoit.org/dpr3
[43] SFPUC 2017 Energy Benchmarking Report https://sfwater.org/Modules/ShowDocument.aspx?documentID=13356

	functions. Most of the solar installations on municipal buildings are tied to the grid without backup storage systems and the solar installation will not be able to be used in the event of a power failure: buildings with local storage systems can add to resilience if power from the grid is lost. Municipal buildings also rely on communications infrastructure, adequate air ventilation, potable water, and sewer to function normally. The functionality of municipal buildings is highly dependent on transportation access. The majority of City employees commute by transit, and resource-constrained residents are more likely to rely on transit to access city services. <u>Populations Served:</u> San Francisco's municipal buildings serve all San Franciscans and must be prepared to meet the needs of anyone who walks through the doors. American Community Survey 2017 estimates 20.3-20.9% of populations 5 years and older speak English less than "very well"[44] and 10.4-10.8% of noninstitutionalized population is with a disability.[45] Individual departments and facilities may also have particular service populations to consider. The Human Services Agency provides cash assistance, food and nutritional support, health insurance, employment training, child care, and specialized supportive care for low-income residents, who may have limited English proficiency or experience disability or homelessness. Forty percent of County Jail inmates seek mental health services at some point during their residency, and 53% of jail population is Black, which is almost 10 times higher than rates of Black population citywide.[46] Museums and performance halls attract visitors from all over the world, who may not speak English or may not know how to respond during an emergency. <u>Unique or Critical Function:</u> Municipal offices and service centers provide functions critical to the well-being and safety of San Francisco residents and visitors. Museums, performance halls, and historic buildings have unique cultural and economic value. Jails and juvenile detention facilities have specific design and staff requirements that cannot be replaced by other buildings. City workers are designated Disaster Service Workers and may be called upon to support emergency response and recovery efforts.
Informational	<u>All-hazards:</u>

[44] 2013-2017 American Community Survey 5-Year Estimates S1601: Language Spoken at Home
[45] 2013-2017 American Community Survey 5-Year Estimates S1810: Disability Characteristics
[46] https://www.sfdph.org/dph/files/jrp/BOS-Committee-Presentation-October-24-%202018.pdf

	While information about municipal building systems, components, and structure does exist, it is very high-level and of limited use for hazard mitigation planning. Building structural data and building occupancy are included as inputs in the City's HAZUS analysis, and the Public Utility Commission reports out information about certain components of buildings in their yearly Energy Benchmarking Reports. There is a directive to identify municipal facilities that can serve as locations of respite during poor air quality incidents.
Governance	All-hazards: The Real Estate Division is responsible for the management of municipal office buildings for General Fund Departments. Enterprise Departments have their own real estate management teams. For City departments occupying private buildings, the San Francisco Building Code regulates commercial building safety requirements. This includes soft story and masonry retrofit requirements, as well as HVAC, filtration, and fire requirements. San Francisco's Building Code also contains requirements for post-earthquake repair and retrofit of earthquake-damaged buildings. City Hall and surrounding buildings are contained in the Civic Center Historic District, and most of the Port's waterfront property is listed in the National Register of Historic Places.[47] Buildings in historic preservation districts have unique management needs and are subject to rigorous processes to make changes. New municipal buildings and major renovation projects that are 10,000 gross square feet or more are required to meet the Municipal Green Building Code, which in addition to requiring the building project to achieve a LEED Gold certification or higher, requires that an analysis be conducted to evaluate the costs and benefits of incorporating onsite batteries that store electricity from onsite solar photovoltaic systems that can be temporarily separated from the electricity grid to supply the community with electricity in the event of disaster.

Consequences

Category	Consequence
Society/Equity	All-hazards: Damage and disruption to municipal buildings impacts services provided to San Francisco residents. This is particularly impactful to residents who are resource-constrained or experience other social

[47] https://sfport.com/historic-preservation

	vulnerabilities. Persons housed at San Francisco's correctional facilities and rely on on-site services would likewise experience disproportionately strong impacts from facility disruption. Damage and disruption to municipal buildings impacts City employees' quality and timeliness of work, workplace social networks, and can even prompt short-term unemployment. This is particularly impactful to the lives of those who are non-salaried, who are low-income, and who are transportation- and housing-burdened. Museums, performance spaces, historical areas, and other buildings can provide cultural identity and their disruption could impact community identity. Tourists of these cultural areas may be limited English proficiency or have limited information available to them about emergency services. Geologic: Significant groundshaking and liquefaction can result in human casualties from building damage and significant property loss that would be difficult or impossible to redress. Persons with limited mobility could have difficulty evacuating. Flood: Significant flooding may result in human casualties if there is no second story. Populations with limited mobility or medical conditions are particularly at risk when coming into contact with even a small amount of floodwaters. Extreme Heat: Extreme heat may cause closures in non-weatherized buildings without cooling capabilities. Heat waves increase health risk for certain populations, such as the elderly, pregnant women, and those with medical conditions. Fire: Significant fire can result in human death or injury, especially in high rises. Poor air quality: Fire smoke in unfiltered buildings can result in increased rates of asthma attacks and other health risks. This is especially true for under-resourced communities and communities of color, which have significantly higher rates of bronchial disease.
Economy	All-hazards: Damages to buildings will require property owners to fund repairs, replacement, and interim facilities. Non-salaried employees face greater consequences, and will lose wages for each day of closure.

	Residents who rely on public assistance for their basic needs face greater consequences than the general public. City-owned properties that are leased to private tenants may lose sources of revenue if buildings are damaged or disrupted. Geologic: Depending on severity and building type, damage can lead to short- or long-term closure. Flood: Areas in coastal and storm water flood zones will see the most damage and economic impact. Extreme Heat: Depending on severity, heat events can lead to short term closure in older buildings that do not have adequate HVAC, which may be accompanied by relocation costs. Those with adequate HVAC will increase power use and see associated financial impact. This hazard will not cause permanent or indefinite closure. Fire: Damage from fire can lead to short to long term closure, which may be accompanied by relocation costs.
Environment	Geologic: Air quality could be temporarily impacted by the production of particulate matter from building damage. Reconstruction of damaged buildings may be material and energy-intensive, including emissions and air quality reduction from equipment and impacts from trucks supplying construction materials. Debris management and removal may have impacts, including truck traffic and exposure to harmful chemicals if not properly managed. Flood: Floods could mobilize debris and soil to move into and potentially degrade waterways. Floods could also mobilize hazardous waste that is improperly stored. Extreme Heat: Increased use of HVAC systems could increase GHG emissions if these are not efficient and using a clean energy source. Fire: Air quality would be temporarily reduced in the neighborhood, potentially regionally, if buildings are directly impacted by fire.

	Debris management and removal may have impacts, including truck traffic and exposure to harmful chemicals if not properly managed.

Municipal Maintenance and Operations Yards

Introduction to Asset Class

Some City departments have specialized storage and maintenance needs that require the use of municipal maintenance and operations yards. Municipal yards contain facilities necessary to sustain essential city services, including public transit and parks. This profile covers yards of the following departments:

- San Francisco Public Works (SFPW): one operations yard contains all the department's equipment and vehicle fleet
- San Francisco Municipal Transportation Agency (MTA): yards where vehicles and/or equipment are stored and/or are serviced. These include facilities for light rail vehicles, buses (electric trolley and motor coaches), cable cars, and historic streetcars
- Port of San Francisco: two maintenance facilities at Pier 50, Shed D and Pier 90
- Recreation and Park Department (RPD): two maintenance facilities in Golden Gate Park

Issue Statement

In addition to routine work, yards play an important role in disaster response. During and after an emergency, departments must work together to inspect city and private property, look for safety hazards, and clear debris. Most yards contain old buildings that are unsafe during an earthquake and unhealthy during an extreme heat or poor air quality event. Improving yards has been challenging. There is no horizontal space available for expansion and securing financing has proven difficult.

Inoperable or inefficient yards can disrupt city services. Disruptions in city services and delays in disaster response have the potential to exacerbate existing access, health, and mobility inequities.

Exposure

Hazard Data Assumptions

This analysis was conducted in 2018 and 2019 using publicly-available data sources. In Table A-15, on the following page, shaking intensity is represented for two Earthquake scenarios: San Andreas Fault M7.8 and Hayward Fault M7.0 events. Accounts of assets subjected to varying levels of shaking intensity are cumulative for each scenario.

Asset Data Assumptions

Asset data originates from the Facility System of Records maintained by the Office of Resilience and Capital Planning and available through the San Francisco Open Data Portal (2018).

TABLE A-15: EXPOSURE

Hazard	SFPW 1 Total		MTA 19 Total		Port 2 Total		PUC 1 Total		RPD 4 Total	
	#	%	#	%	#	%	#	%	#	%
Geologic										
San Andreas 7.8 - Violent	0	0%	0	0%	1	50%	0	0%	2	50%
San Andreas 7.8 - Very Strong	1	100%	19	100%	1	50%	1	100%	2	50%
Hayward 7.0 - Very Strong	0	0%	3	16%	2	100%	0	0%	0	0%
Hayward 7.0 - Strong	1	100%	13	68%	2	100%	1	100%	3	75%
Liquefaction Zone	1	100%	11	58%	2	100%	0	0%	0	0%
Flooding										
100-Year Coastal Flood Zone	0	0%	0	0%	1	50%	0	0%	0	0%
100-year storm + 24 inches SLR	0	0%	3	16%	1	50%	0	0%	0	0%
100-year storm + 66 inches SLR	0	0%	7	37%	2	100%	0	0%	0	0%
100-year stormwater flood	0	0%	2	11%	1	50%	0	0%	0	0%
Wildfire										
High	0	0%	0	0%	0	0%	0	0%	0	0%
Moderate	0	0%	0	0%	0	0%	0	0%	0	0%

Note: For an exposure table with additional hazards, please see Chapter 5.

Exposure Summary

Geologic: Around 90% of municipal yards will experience Very Strong or Strong ground shaking during an M7.0 earthquake on the Hayward fault. SFPW, Port, and MTA yards are in the liquefaction zone.

Flood: Only Port and MTA yards are in any flood zone, with about 40% of MTA yards in the 66” sea level rise zone.

Fire: No municipal yards are in a wildfire risk zone.

FIGURE A-15: MUNICIPAL YARDS AND LIQUEFACTION HAZARD

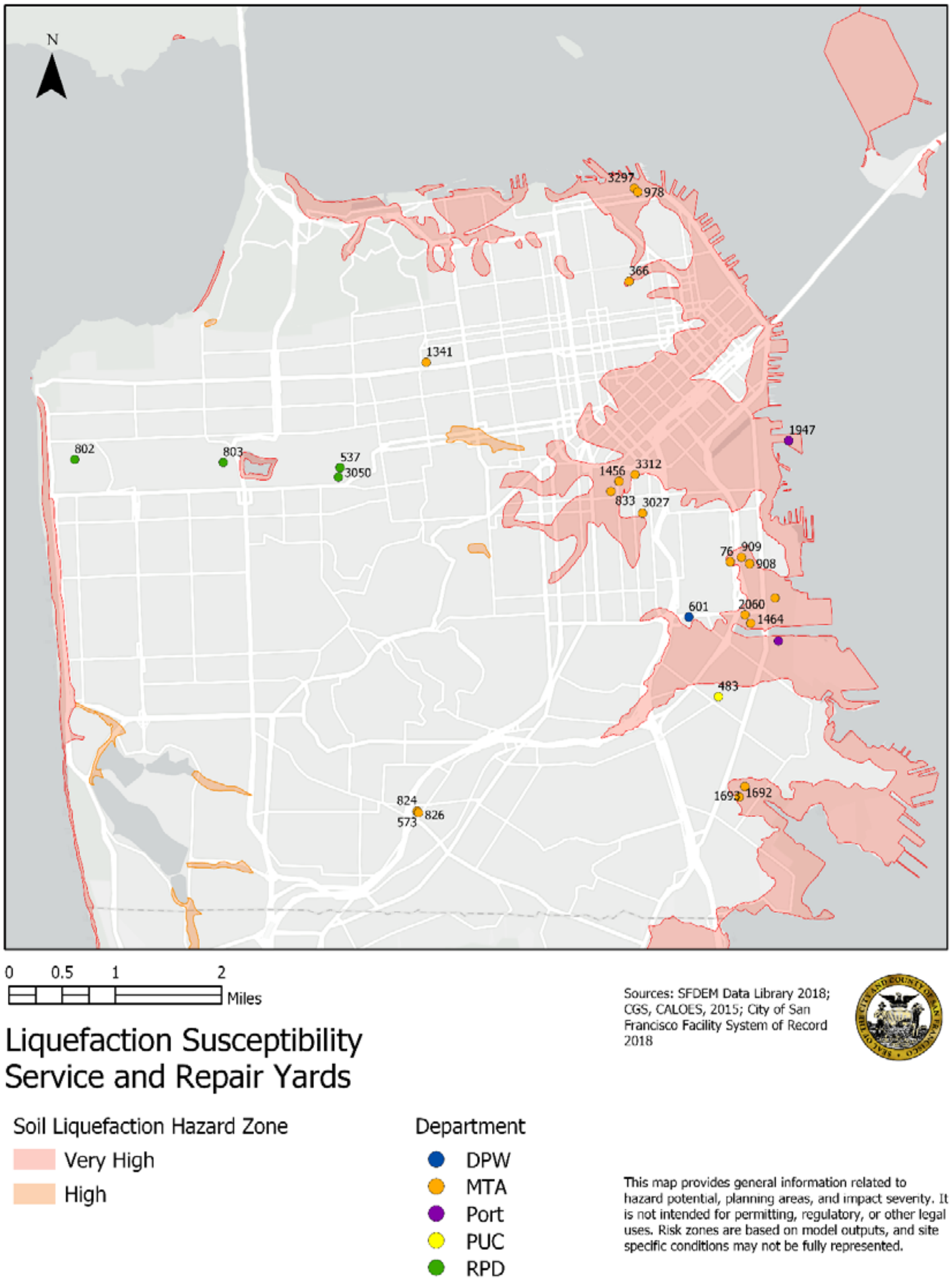
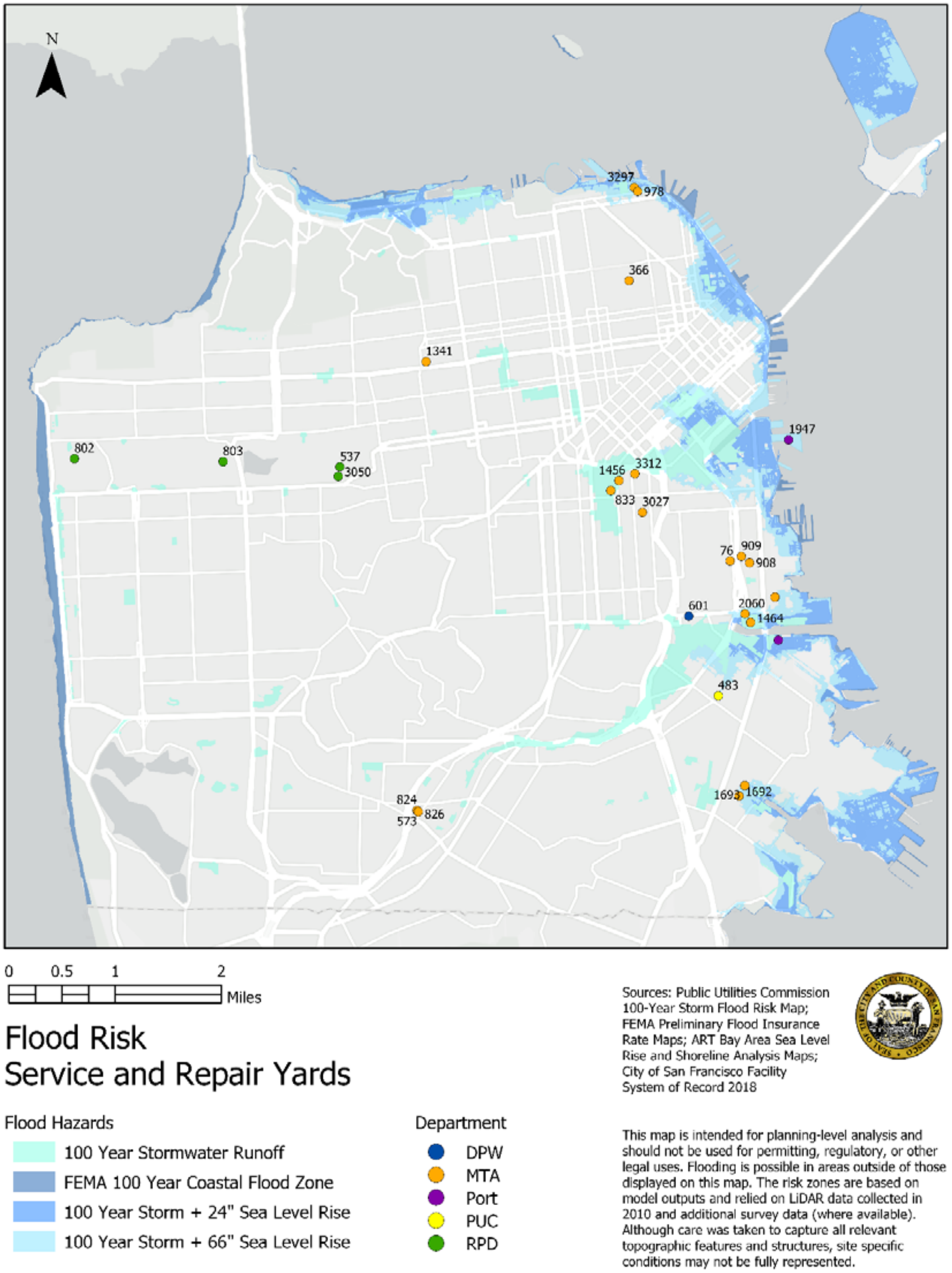


FIGURE A-16: MUNICIPAL YARDS AND FLOOD HAZARDS



VULNERABILITIES[48]

Category	Vulnerability
Physical	Geologic: The majority of buildings in municipal yards are un-retrofitted, and many structures were built during the 1940's and 50's. The MTA yard at Islais Creek was rebuilt in 2014, and MTA facilities at Bancroft, Burke, and Woods locations have also been retrofitted. Underground components at facilities could be damaged by liquefaction. Due to variances in topography, MTA yards at Presidio and Potrero locations were built into hills and have below-ground components. But these two facilities are not in a high liquefaction risk zone. Flood: Port yards at Pier 50 and Pier 90 are vulnerable to coastal flooding, and inundation of Bay waters into force main pipes affects functionality of restrooms at the piers. MTA yards at 1399 Marin and Islais currently experience flooding, and electrical exposure to flooding poses a safety hazard at these sites. RPD yards do have equipment on the ground, but are not located in areas with flood risk. Extreme Heat: Many buildings in municipal yards are open air, with no climate control. Many closed buildings take the form of garages, which may have overhead heaters but no cooling. Buildings at the SFPW yard do have central air conditioning but need upgrades. Facilities may not have capacity for temporary cooling equipment such as portable coolers. Fire: Many buildings are open air, or simple shed-like structures without filtration. Some facilities have HVAC systems are substandard or not operational and financing is not available to make improvements. In the SFPW buildings which do have filtration, air circulation was a problem during high smoke days in Fall 2018. Facilities may not have capacity for temporary equipment such as air scrubbers. Most RPD facilities are wood and therefore highly flammable, although not located in areas with wildland-urban interface fire risk. Sprinkler systems help mitigate fire risk.
Functional	Networks: Yards are formally linked during disaster response through Incident Command System (ICS). Debris clearance equipment is located at SFPW, RPD, PUC, and the Port. At other times, yards support each other's operations in ad hoc and informal ways. Services provided at yards are not redundant; if one yard becomes inoperable, the services

[48] Information collected during meeting with staff from SFPW, RPD, Port, MTA on February 6, 2019

	cannot be replicated at another yard. SFPW yard is currently over capacity, and MTA yards cannot move due to lack of space in the city to accommodate transit vehicle storage. Citywide, there is no room for horizontal growth. <u>External Services:</u> Yards rely on electrical power, water, sewage, internet, fuel, and some gas. Electricity is particularly critical for MTA functions. RPD vehicles require fuel, which are co-located at its central gas station in Golden Gate Park. Not all yards have emergency backup power. Two MTA motor coach facilities have backup power, and all motor coach facilities have underground storage tanks for fuel. However, the duration of the fuel supply is currently unknown.[49] The only RPD emergency backup power is located at its Department Operations Center (DOC). The Port's entire facility has backup generator power. Staff rely on regional transportation, as many workers at municipal yards live outside city limits. <u>Populations Served:</u> Municipal maintenance and operations yards sustain San Francisco's public transit, roads, and open spaces, which serve the city's diverse populations. Some sub-populations would be more impacted by a disruption in services (e.g. low-income and mobility challenged individuals are especially dependent on public transportation). City staff working at municipal yards may face greater risks to hazard events as many positions require outdoor labor. <u>Unique or Critical Function:</u> Yards play essential roles in City emergency response. After the Police and Fire Departments, SFPW is third in line for response following a disaster event. SFPW has a responsibility for road clearance and structure assessment. The SFPW yard becomes a DOC, and other departments follow ICS protocols to support SFPW's operations. RPD operates its own DOC. SFPW logistics requests are submitted to the citywide Emergency Operations Center (EOC), which forwards these logistic requests to the RPD DOC for support. Crews inspect for damaged overhead lines, which pose immediate safety hazard. All SFPW vehicles are in one location, and satellite yards could help improve response. Most of DPW vehicle fleet is Priuses, which are low to the ground and will be difficult to drive on streets with debris. SFPW fleet does not include bulldozers and will rely on contractors to complete debris removal.[50] MTA fleet vehicles are used in inspection, and yards must be accessible for the fleet to be

[49] Interviews with MTA staff for the Lifelines Restoration Performance Project, October 9, 2018
[50] Interviews with SFPW staff for the Lifelines Restoration Performance Project, August 23, 2018

	deployed. Before the Port supports citywide operations, it conducts its own facility inspection with staff engineers.
Informational	All-hazards: Historically, information collected for MTA yards is based on service requests, but the department plans to shift to a more proactive approach over the next few years. To meet Federal Transit Administration Transit Asset Management compliance, MTA completes a 10-year asset management plan that contains condition assessment on all yards and replacement costs. SFPW recently changed their work order program so that outstanding tasks are stored with an estimated cost, for use in funding requests in the Capital Plan. RPD has completed a conditions assessment for use in preventative maintenance planning, containing indices on all facilities to monitor when replacements are needed. Port uses the citywide capital management tool for work orders and management.
Governance	All-hazards: Very few city policies exist to prompt repairs and improvement. Financing repairs and improvements is also a challenge. SFPW has made requests in the Capital Plan to improve its yard improvements—which needs a major renovation. MTA resilience improvements occur when other major capital work must be conducted at a facility, and there is no specific fund to do this. The Port received Homeland Security funding to establish backup generator power for its entire facility. Flood: MTA uses SLR capital planning checklist when designing or upgrading a facility. MTA is the lead department in implementing transportation strategies to reduce citywide greenhouse gas emissions[51] and is conducting an assessment on sea level rise vulnerabilities and consequences.

CONSEQUENCES

Category	Consequence
Society/Equity	All-hazards: Disruptions to roads and public transit operations impact residents and visitors to San Francisco, and have the potential to exacerbate existing access/mobility inequities. Disruptions to park maintenance is most detrimental in RPD-designated equity zones where park access is limited, and for residents without private outdoor space and/or air-conditioning.

[51] https://www.sfmta.com/sites/default/files/reports-and-documents/2017/12/cap_draft_full_document-final1.pdf

	Geologic: Un-retrofitted structures at yards are dangerous for onsite workers. Flood: Floodwater contact with electrical components is dangerous for onsite workers. Extreme Heat: Absent cooling systems at municipal yards will increase health risks for onsite workers during extreme heat events. Outdoor workers will be particularly vulnerable. Fire: Absent filtration systems at municipal yards will increase health risks for onsite workers during poor air quality events. Outdoor workers will be particularly vulnerable.
Economy	All-hazards: Damages to facilities will require funding repairs, replacement, and/or interim alternatives. If yard damage leads to service disruption, economic impacts would disproportionately impact communities who rely on transit for mobility. If the transit system is impacted, MTA could lose substantial funds from missing fares. Non-salaried employees face greater consequences, and will lose wages for each day of closure.
Environment	All-hazards: Disruptions to transit service may cause an increase in private vehicle use and greenhouse gas emissions. Road closures and re-routing may increase traffic and congestion. Geologic: Air quality could be temporarily impacted by the production of particulate matter from structure damage. Flood: Floods could mobilize debris, soil, or wastewater to move into and potentially degrade waterways. Floods could also mobilize hazardous waste that is improperly stored, including leaking underground storage tanks. Extreme Heat: Increased use of cooling systems could increase GHG emissions if not efficient and using a clean energy source. Air Quality:

	Air quality could be temporarily reduced in the neighborhood, potentially regionally, if structures are directly impacted by fire.

Health Care Facilities

Introduction to Asset Class

Health care facilities provide life-saving and life-sustaining services. All health care facilities are important resources for disaster response. For the purpose of this assessment, the 'Health Care Facilities' asset class is defined as any of the following medical or nonmedical use facilities.

- Primary Care Clinics, or community and free clinics/sites, offer a range of primary care services to uninsured and underinsured populations. The majority of primary care clinics in California are operated by public agencies, including public hospitals and health systems, health care districts, or nonprofit corporations. Primary care clinics operate in a wide variety of building types, including as part of a large hospital or school campus, or as a multi-story commercial building. There are 64 primary care clinics in San Francisco, which predominantly located in the city's northeast and southeast quadrants, mirroring population density.
- Skilled-Nursing Facilities provide supportive medical care on an extended basis.46 In San Francisco, skilled nursing facilities vary by both building type, neighborhood location, and size. Standalone skilled nursing facilities can range from 30 to 180 beds and operate in both high density and low-density neighborhoods. Skilled nursing facilities may be on the same campus as a Residential Care Facility for the Elderly (RCFE). There are 15 standalone skilled nursing facilities in San Francisco, and facilities at San Francisco General, CPMC, and the Veteran's Administration Community Living Center.
- Pharmacies are defined by the California State Board of Pharmacies as a licensed place where "controlled substances, dangerous drugs, or dangerous devices are stored, possessed, prepared, manufactured, derived, compounded, or repackaged, and from which the controlled substances, dangerous drugs, or dangerous devices are furnished, sold, or dispensed at retail".[52] According to the Department of Consumer Affairs, there are 201 pharmacies in San Francisco. Pharmacies operate as both part of larger hospital complexes, as the first floor of a commercial building, or as a standalone building. Pharmacies provide medicine that can reduce morbidity and mortality in the aftermath of disaster events. Pharmacies are required to have a detailed plan for disasters and other disruption of normal business operations.[3]

[52] California State Board of Pharmacy Business and Professions Code 4015

- Residential Care Facilities for the Elderly (RCFEs) are non-medical facilities that offer important supportive residential living for individuals age 60 and over who are no longer able to live safely independently. They provide room, meals, housekeeping, supervision, storage and distribution of medication, and personal care assistance with basic activities like hygiene, dressing, eating, bathing and moving. There are 64 RCFEs in San Francisco, and 4 RCFEs as continuing care at retirement communities. These facilities may be adjacent to skilled nursing facilities and vary by both building type and size. Many RCFEs are single family homes in primarily residential neighborhoods with fewer residents, while other RCFEs are in larger complexes with many beds and employees. While not technically a medical facility, RCFE house very vulnerable older adults.
- End Stage Renal Disease (ESRD) facilities, or dialysis facilities, are "a free-standing specialty clinics, which provides less than 24-hour care for the treatment of patients with ESRD."[53] The free-standing component of California's definition makes it more restrictive than the federal definition, which includes hospital-based dialysis".[54] These facilities part of a larger hospital, in a larger commercial building or office complex, or a standalone facility. There are 14 dialysis clinics in San Francisco.

Note that there are several other types of health care facilities that operate in San Francscico, including an array of behavioral health specific service sites. These sites have similar attributes to facilties outlined above, provide services to similar populations, and have similar distributions across the city.

Issue Statement

Health care facilities provide vulnerable populations with life-saving and life-sustaining services. All health care facilities have important roles in disaster response and recovery. For example, primary care clinics can scale to provide urgent care services in an event with a significant medical surge, while skilled nursing facilities and residential care facilities may be tasked with administering services during shelter-in-place events. The continuity of these services is important, and any disruption to health facilities would

[53] CA Health and Safety Code (HCS). Division 2: LICENSING PROVISIONS; CHAPTER 1. Clinics; ARTICLE 1. Definitions and General Provisions

[54] "A Review of Regulatory Standards, Quality of Care Concerns, and Oversight of Ambulatory Surgery Clinics, Comprehensive Outpatient Rehabilitation Facilities, and End-State Reginal Disease Facilities" California Department of Public Health, June 2017. https://www.cdph.ca.gov/Programs/CHCQ/LCP/Pages/ReviewofRegulatoryStandards.aspx

strain the services they provide and disproportionately impact populations without access to alternate forms of care or who are unable to travel to an alternate facility. Exposure to groundshaking from the Hayward fault affects 90% of the city's clinics, skilled nursing facilities, and dialysis facilities, and the entire city of San Francisco is exposed to groundshaking from the San Andreas Fault. Skilled nursing facilities and residential care facilities provide 24/7 residential and medical care for vulnerable populations. Any disruption to these facilities from a hazard would require evacuation and additional medical and housing resources.

TABLE A-16: EXPOSURE

Hazard	Clinics 97 Total		Skilled Nursing Facilities 18 Total		Pharmacies 201 Total		RCFEs 63 Total		Dialysis Facilities 14 Total	
	#	%	#	%	#	%	#	%	#	%
Geologic										
San Andreas 7.8 - Violent	12	12%	2	11%	25	12%	28	42%	1	7%
San Andreas 7.8 - Very Strong	85	88%	16	89%	176	88%	38	57%	13	93%
Hayward 7.0 - Very Strong	3	3%	0	0%	12	6%	0	0%	0	0%
Hayward 7.0 - Strong	84	87%	16	89%	153	76%	45	67%	13	93%
Liquefaction Zone	23	24%	0	0%	50	25%	1	1%	1	7%
Flooding										
100-Year Coastal Flood Zone	0	0%	0	0%	0	0%	0	0%	0	0%
100-year storm + 24 inches SLR	2	2%	0	0%	7	3%	0	0%	0	0%
100-year storm + 66 inches SLR	2	2%	0	0%	11	5%	0	0%	1	7%
100-year stormwater flood	2	2%	0	0%	5	2%	0	0%	0	0%
Wildfire										
High	0	0%	0	0%	0	0%	0	0%	0	0%
Moderate	1	1%	1	6%	0	0%	0	0%	0	0%

Exposure Summary

Geologic: All health care facilities would be exposed to violent or very strong shaking during a 7.8 earthquake on the San Andreas fault. Around 90% of the city's clinics, skilled nursing facilities, and dialysis facilities would be exposed to very strong or strong shaking during a 7.0 earthquake on the Hayward fault. Liquefaction exposure is lower than groundshaking, around one quarter of the city's clinics and pharmacies are in the liquefaction zone; other health care facilities have minimal liquefaction risk.

Flood: Eleven pharmacies, two clinics, and one dialysis clinic are in the 66" sea level rise zone. Five pharmacies and two clinics are in the 100 year stormwater zone. Altogether, only around 5% of all health care facilities are in any flood zone.

Fire: One clinic and one skilled nursing facility have moderate wildfire risk.

FIGURE A-17: HEALTH CARE FACILITIES AND LIQUEFACTION HAZARD

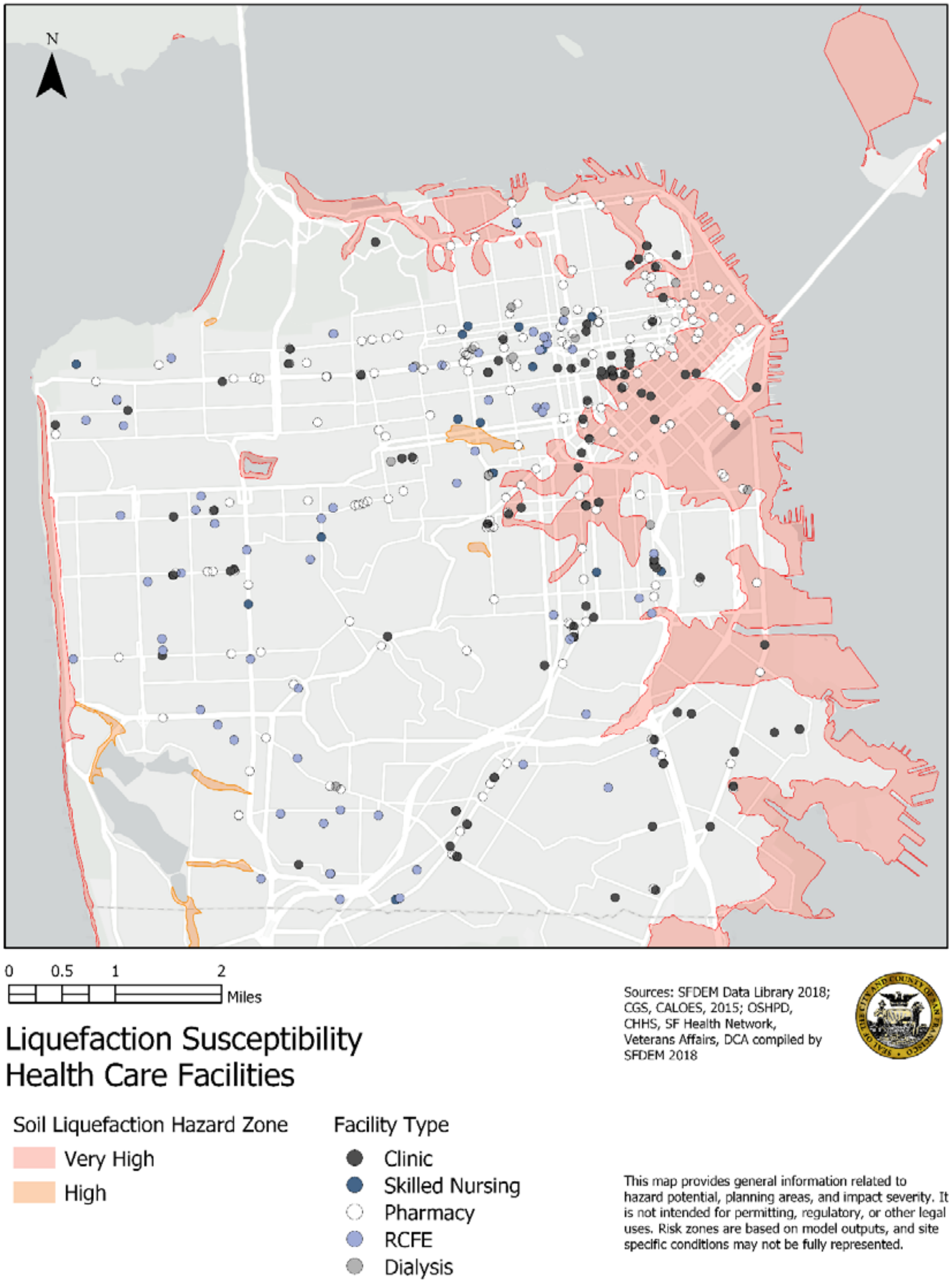
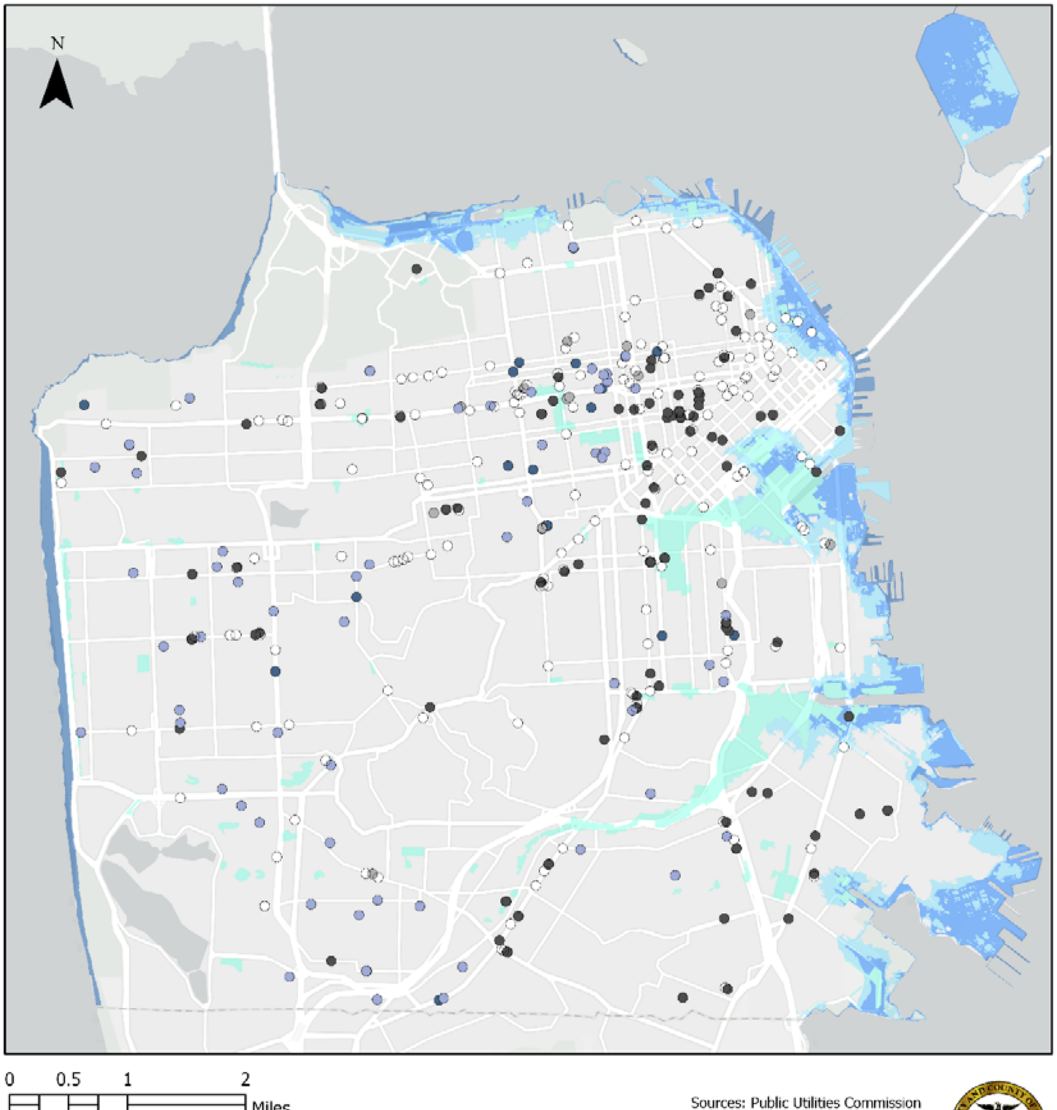


FIGURE A-18: HEALTH CARE FACILITIES AND FLOOD HAZARDS



Flood Risk and Health Care Facilities

Flood Hazards
- 100 Year Stormwater Runoff
- FEMA 100 Year Coastal Flood Zone
- 100 Year Storm + 24" Sea Level Rise
- 100 Year Storm + 66" Sea Level Rise

Facility Type
- Clinic
- Skilled Nursing
- Pharmacy
- RCFE
- Dialysis

Sources: Public Utilities Commission 100-Year Storm Flood Risk Map; FEMA Preliminary Flood Insurance Rate Maps; ART Bay Area Sea Level Rise and Shoreline Analysis Maps; OSHPD, CHHS, SF Health Network, Veterans Affairs, DCA compiled by SFDEM 2018

This map is intended for planning-level analysis and should not be used for permitting, regulatory, or other legal uses. Flooding is possible in areas outside of those displayed on this map. The risk zones are based on model outputs and relied on LiDAR data collected in 2010 and additional survey data (where available). Although care was taken to capture all relevant topographic features and structures, site specific conditions may not be fully represented.

VULNERABILITIES

Category	Vulnerabilities
Physical	All Hazards: The diversity of health care facilities creates a wide variety of physical vulnerabilities dependent on the building type, density, equipment stored in the building, and the specific regulations of the body that governs it. Geologic: There is significant overlap in the physical attributes between health care facilities and residential and commercial buildings. Please refer to the Housing and Commercial Vulnerability and Consequence Profiles for details for seismic vulnerability. Of note, skilled nursing facilities and RCFEs are not required to meet the same safety seismic standards as hospitals as outlined in California SB 1953.[55] Flood: Depending on building design, facilities may be vulnerable to flood events. Facilities either located at or below grade or with equipment stored on the ground floor adjacent to entryways may be impacted by flood events and experience building damage, destruction of equipment or other materials, or disruption of power and other utility services. Extreme Heat: Depending on building age and structural design, the facility may have limited or substandard cooling systems. These cooling systems may not be sufficient during extreme heat events and residents most vulnerable to the health impacts of extreme heat may be at increased risk of morbidity and mortality. Fire: Buildings made with wood are highly susceptible to fire. Steel and concrete buildings are less vulnerable to fire damage and steel buildings contain fire proofing materials to resist fire damage.
Functional	Networks: Primary care facilities are indirectly and directly networked (e.g. San Francisco Health Network, DPH Healthcare Coalition, Community Clinic Consortium). If a primary care were to shut down, it may impact patient access to other facilities (e.g. longer wait times for appointments), as they become the health home for more patients.

[55] Office of Statewide Health and Planning Department (OSHPD)

	Any disruption to skilled nursing facilities, RCFEs, or ESRDs would necessitate the relocation of vulnerable patients to other available facilities. <u>External Services:</u> All health care facilities rely on power, natural gas, water, communications, and transportation access to function. Primary care facilities are likely to have some backup power. Because skilled nursing facilities and RCFEs house populations are likely to have access and functional needs, access to medical equipment and adequate transportation are especially important in hazard events. RCFEs are required to plan for self-reliance for up to 72 hours. Pharmacies depend on temperature control for certain medications. <u>Populations Served:</u> Health care facilities provide public life-sustaining services. Primary care facilities serve all San Franciscans regardless of citizenship or the ability to pay. Skilled nursing facilities and RCFEs house populations with access and functional needs, including those with pre-existing health conditions, medically dependent and mobility challenged individuals, and elderly populations. ESRDs serve populations with end stage renal disease. <u>Unique or Critical Function:</u> Primary Care: These facilities will respond to the medical surge immediately post hazard event and are located in neighborhoods with limited access to other urgent health care services. Skilled Nursing Facilities and RCFEs: These facilities provide a unique and critical service by providing 24/7 residential care and in the case of Skilled Nursing Facilities – medical care for vulnerable populations. These facilities need to ensure quality of care in emergency events. Pharmacies: These facilities provide life-sustaining medications for residents across the city. ESRDs: For patients with end stage renal disease and on dialysis, ESRDs are critical life-sustaining services. Patients must visit ESRDs multiple times a week and any disruption in service would require patients to find alternative services.
Informational	Primary Care and Skilled Nursing Facilities: All primary care clinics and skilled nursing facilities are required to submit data on health care financing and utilization to Office of Statewide Health Planning and Development (OSHPD) on an annual basis. This information is publicly available for each facility.

	Pharmacy: Pharmacy facilities must obtain a license through the California Board of Pharmacy. Contact information for all licensed facilities is publicly available online. RCFEs: Data on RCFEs are collected by the California Department of Social Services and includes contact information, capacity, and inspections and citations.
Governance	Primary Care: The OSHPD regulates structural development primary care clinics. The California Department of Public Health regulates the operation of community clinics and free clinics. Skilled Nursing Facilities: OSHPD regulates structural development of skilled nursing facilities. The California Department of Public Health (CDPH), Health and Human Services (HHS), and Centers for Medicare and Medicaid Services (CMS) regulates emergency preparedness in skilled nursing facilities. These facilities are required to have an emergency plan based on an established risk assessment that addresses the special needs of client populations.[56] RCFE: In 2008, California passed AB 479, which addressed emergency preparedness in RCFEs and added a section to the California Health and Safety Code that mandates RCFEs have evacuation procedures, plans for the community to be self-reliant for at least 72 hours, an emergency transportation plan, emergency power, a communication plan, an emergency plan for the storage of medications, and an emergency plan for electronically dependent populations.[57] Pharmacies: Pharmacies are regulated by the California State Board of Pharmacy. The California State Board of Pharmacy and the California Business and Professions Code adopted a policy to "encourage and permit emergency provision of care to affected patients and areas by waiver of requirements that it may be implausible to meet under these circumstances, such as prescription requirements, record-keeping requirements, labeling requirements, employee ratio requirements, consultation requirements, or other standard pharmacy practices and duties that may interfere with the most efficient response to those affected."[58]

[56] CMS Code of Federal Regulations https://www.cdph.ca.gov/Programs/CHCQ/LCP/Pages/EPRR.aspx#
[57] California Assembly Bill 479 https://leginfo.legislature.ca.gov/faces/billCompareClient.xhtml?bill_id=201720180AB3098
[58] Disaster Response Policy Statement, California Board of Pharmacy http://www.pharmacy.ca.gov/publications/disaster_policy.pdf

	ESRDs: ESRDs are regulated by the Centers for Medicare and Medicaid Services (CMS). These regulations require that ESRDs develop emergency preparedness procedures and review these procedures annually.[59]

CONSEQUENCES

Category	Consequence
Society/Equity	<u>All Hazards:</u> Any significant impact to health care facilities will have cascading impacts on society and equity and the populations served by these facilities. These impacts could be as significant as loss of life as health care facilities often serve some of San Francisco's most vulnerable populations. Primary Care: Any disruption to primary care clinics would have inequitable impacts as it would most severely affect populations without access to alternative sources of health care. Residents that live far away from transit corridors and are served by neighborhood primary care clinics may have difficulty accessing a different clinic. Skilled Nursing Facilities and RCFEs: Any significant structural damage that disrupts these facilities would have significant impacts. Damage to skilled nursing facilities and RCFEs would mandate permanent relocation of many vulnerable residents. Residents without other support systems may have a difficult time finding the same level of care. Pharmacies: Any disruption in services would have inequitable impacts for populations with access or functional needs or without access to transportation, who would have more difficulty obtaining medications. ESRDs: Geographic distribution of ESRD incidence indicates that social determinants influence which populations suffer from ESRD.[60] In San Francisco, the underlying causes of renal disease, like Type 2 Diabetes and High Blood Pressure, disproportionately impact low-income communities, and communities of color.[61] Data indicates that these communities are therefore more likely to have higher incidences of ESRDs. Any impact to dialysis facilities would increase this unequal health burden. Populations without adequate

[59] Centers for Medicare and Medicaid Services https://www.cms.gov/Regulations-and-Guidance/Legislation/CFCsAndCoPs/ESRD.html
[60] Nicholas SB, Kalantar-Zadeh K, Norris KC. Socioeconomic disparities in chronic kidney disease. *Adv Chronic Kidney Dis.* 2015;22(1):6-15.
[61] San Francisco Health Improvement Partnership. "San Francisco Community Health Needs Assessment 2016: Appendices." San Francisco, CA: San Francisco Department of Public Health, 2016.

	medical care or alternative resources would be especially impacted by any disruption in dialysis services. Geologic: Seismic impacts are more widespread and can result in more permanent health, society, and equity impacts. Any significant structural damage that results in the permanent disruption of service by health care facilities would have significant impacts. Flood: Flood impacts would be geographically limited, but could impact society and equity if there were significant disruption of transportation, power, or health care services. Extreme Heat: The health impacts of extreme heat is influenced by social determinants. Populations most vulnerable to extreme heat events include elderly populations and patients with renal disease. These populations rely heavily on healthcare facilities. Fire: Fire could disproportionately burden residents in residential care facilities with access or functional needs who need assistance in evacuations.
Economy	All Hazards: All Types: Medical facilities are employment centers and any impact could affect economic activity. There may be economic costs associated with any building repairs or replacement of damaged or destroyed equipment or supplies. Primary Care: Depending on the severity of the event, and subsequent disruption to primary care clinics, economic impacts could demand the immediate expenditure of resources to relocate patients and medical supplies. Skilled Nursing Facilities and RCFEs: Depending on the severity of the hazard, impacts could include displacement from skilled nursing facilities or RCFEs. Reduction in the number of available beds in these facilities could increase cost and price new tenants out of the market. Beds in these facilities are already in high demand. ESRDs: Depending on the severity of the hazard, there could be economic costs for patients forced to find new ways to receive treatment. There could also be economic costs for the facilities from building repairs or damaged or destroyed medical equipment. Geologic:

	Geologic impacts are more widespread and can result in more significant economic impacts. Flood: Although flood impacts are geographically limited in scope, any water damaged equipment or medicine would have to be replaced. In a power outage, pharmacies must have backup power to refrigerate medicine that must be chilled. Extreme Heat: Although an extreme heat event would not cause significant structural damage, it could increase power and utility costs. If a residential facility is not prepared for an extreme heat event, relocation of residents may be necessary at additional costs. Fire: If smoke from a fire impacts vulnerable residents at a residential facility, relocation of residents may accrue additional costs.
Environment	All Hazards: Many health facilities store hazardous materials that may be released in an earthquake, flood, or fire event.

Food Distribution

Introduction to Asset Class

Food distribution assets include wholesale suppliers, grocery stores, and charitable food distribution. Wholesale food distribution companies provide fresh and processed food products to grocery stores and restaurants that serve local communities. Charitable food distribution centers serve a number of functions. Many centers offer hot and cold meals on site, while others act as a food pantry site. Both provide meals and groceries for those who are low income, elderly, disabled, and/or critically ill. Many organizations provide food delivery services that additionally offer wellness checks and referrals specifically for the elderly and critically ill. The SF-Marin Food Bank is a critical networked distribution asset for these charitable organizations, supplying food to nearly 400 non-profit partners, including 278 local food pantries.[62]

Grocery stores and corner stores are spread widely throughout the city, though the Bayview Hunters Point area was designated by the USDA as a food desert in 2011[63], and continues to have few high quality grocery options. Wholesale distributions centers and the SF-Marin Food Bank are largely located in the industrial sections of the southeast quadrant of the city. The Real Estate Division owns the property for the San Francisco Wholesale Produce Market as well as several wholesale produce market buildings and facilities in Bayview Hunters Point and Bernal Heights areas. Many other food distributors have clustered near that facility.

Food distribution centers have a variety of build forms. Corner stores are small commercial storefronts while grocery stores are typically large commercial buildings that rely on temperature control and loading infrastructure for trucks. Wholesale suppliers are housed in industrial warehouses and similarly rely on temperature control and loading infrastructure. Farmers markets are open air temporary marketplaces. The SF-Marin Food Bank has a large modern warehouse in the Potrero Hill neighborhood that services City of SF. Centers that provide full meal services are larger buildings with commercial kitchens and large areas for dining. Other food distribution centers have a variety of built forms that are not consistent across this asset class. Centers vary in property ownership status, but typically manage their own facilities.

[62] "Community Partners," SF-Marin Food Bank, 2018, https://www.sfmfoodbank.org/programs/community-partners/.
[63] "Food Access Research – Go to the Atlas," United States Department of Agriculture Economic Research Service, 2017, https://www.ers.usda.gov/data-products/food-access-research-atlas/go-to-the-atlas/.

Issue Statement

Food distribution centers are critical, life sustaining resources for all community members. Charitable food distribution centers are especially important for highly vulnerable populations. While city regulations require that certain building types are retrofitted, there continue to be numerous types of built forms that are vulnerable in a Geologic event and it is unclear how many of these are food distribution centers. Access to power supply is important for centers to keep their perishable food supply fresh and safe to eat. It is unclear how many centers have contingency plans for power outages that can be caused by geologic, storm, and heat events. Transportation access is another point of vulnerability for food distribution centers. Losing transportation roadways or vehicles due to geologic, flood, or fire can have detrimental impacts to food supply, especially those who rely on mobile food deliveries. In emergency scenarios, detailed contingency food supply plans are enacted by the Department of Emergency Management in partnership with a number of charitable food distribution centers.

Exposure

Hazard Data Assumptions

This analysis was conducted in 2018 and 2019 using publicly-available data sources. In Table A-17, on the following page, shaking intensity is represented for two Earthquake scenarios: San Andreas Fault M7.8 and Hayward Fault M7.0 events. Accounts of assets subjected to varying levels of shaking intensity are cumulative for each scenario.

Asset Data Assumptions

Asset data is originates from the Dunn and Bradstreet (2017) dataset obtained from SFGIS.

TABLE A-17: EXPOSURE

Hazard	Grocery Stores 761 Total		Wholesale Merchants 101 Total	
	#	%	#	%
Geologic				
San Andreas 7.8 - Violent	113	15%	9	9%
San Andreas 7.8 - Very Strong	648	85%	92	91%
Hayward 7.0 - Very Strong	51	7%	52	51%
Hayward 7.0 - Strong	613	81%	45	45%
Liquefaction Zone	196	26%	68	67%
Flooding				
100-Year Coastal Flood Zone	10	1%	20	20%
100-year storm + 24 inches SLR	26	3%	26	26%
100-year storm + 66 inches SLR	43	6%	50	50%
100-year stormwater flood	24	3%	8	8%
Wildfire				
High	0	0%	0	0%
Moderate	4	1%	0	0%

Note: For an exposure table with additional hazards, please see Appendix X.

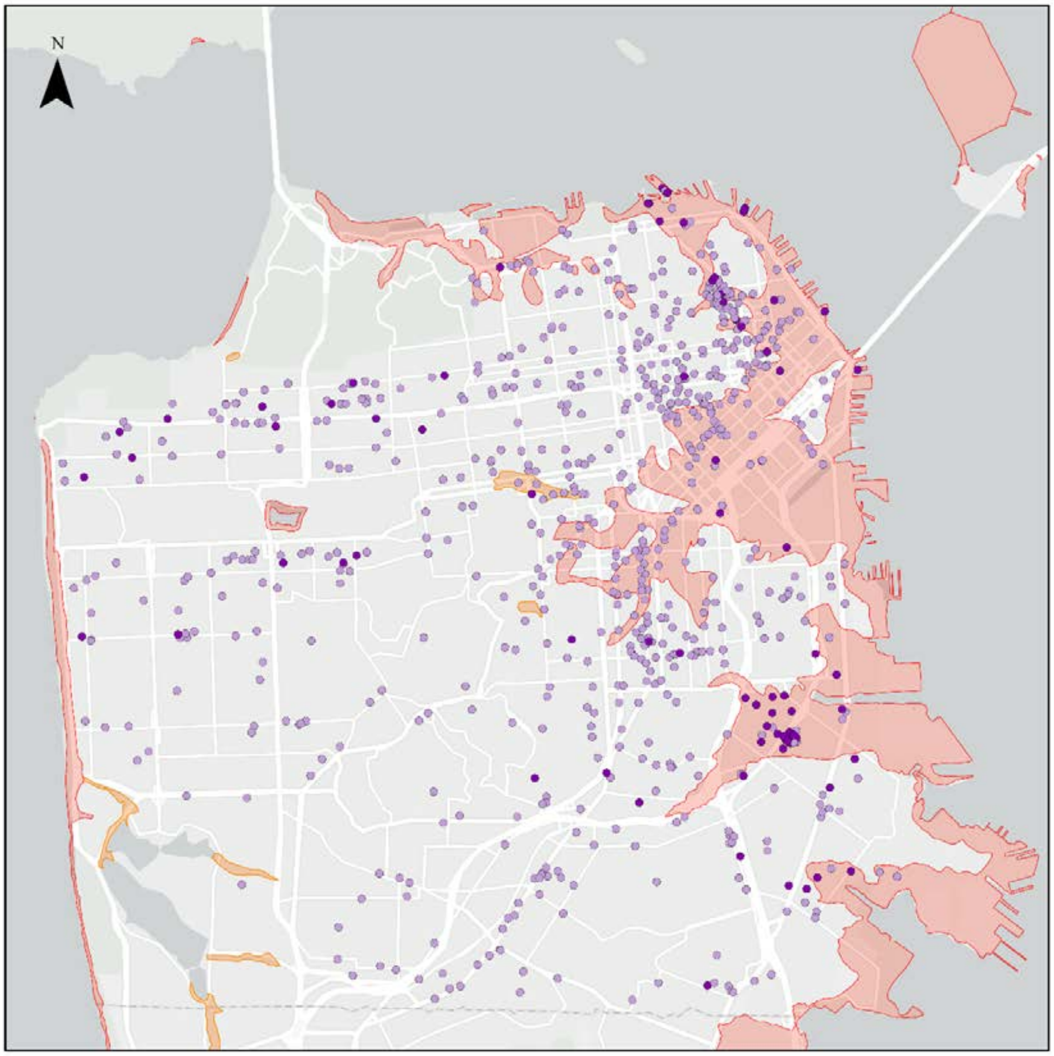
Exposure Summary

Geologic: All food distribution assets are at risk of either Violent or Very Strong groundshaking during a M7.8 earthquake along the San Andreas Fault. 90% of both grocery stores and wholesale merchants are at risk of Very Strong or Strong groundshaking during a Hayward M7.0 earthquake. Two thirds of the city's wholesale merchants are in either Very High or High liquefaction zones. Chinatown, Mission, and South of Market neighborhoods have several grocery stores in liquefaction zones.

Flood: Wholesale merchants experience greater exposure than grocery stores to flood zones, particularly coastal flooding, with many located along the waterfront. A quarter of the city's wholesale merchants are within the 24" sea level rise zone, and half within 66" sea level rise.

Fire: Food distribution has low exposure, with virtually no assets in the wildland-urban risk zones

FIGURE A-20: FOOD DISTRIBUTION AND LIQUEFACTION HAZARD



0 0.5 1 2
Miles

Sources: SFDEM Data Library 2018; CGS, CALOES, 2015; SFGIS Program Dun and Bradstreet 2017

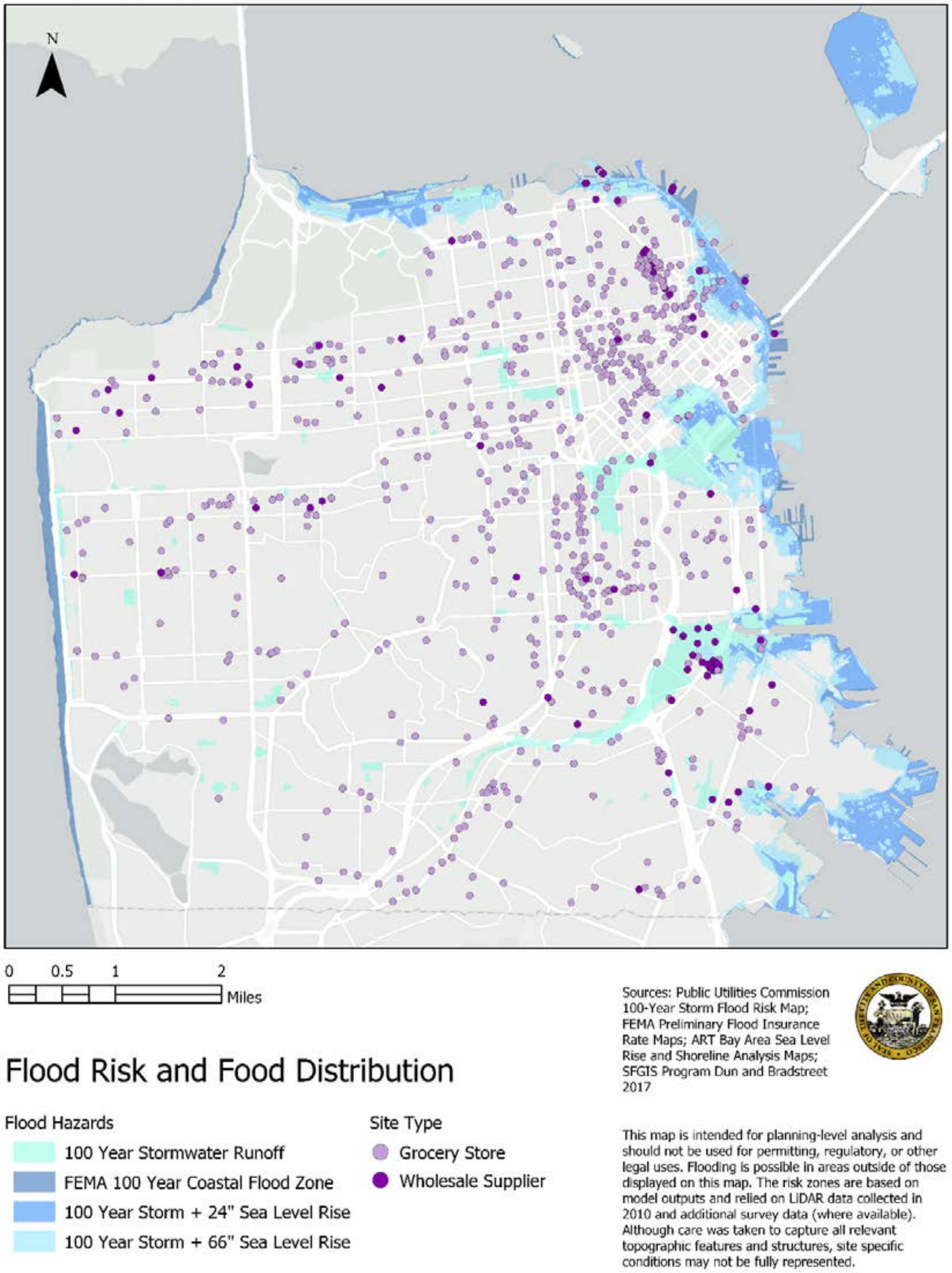
Liquefaction Susceptibility
Food Distribution

Soil Liquefaction Hazard Zone
- Very High
- High

Site Type
- Grocery Store
- Wholesale Supplier

This map provides general information related to hazard potential, planning areas, and impact severity. It is not intended for permitting, regulatory, or other legal uses. Risk zones are based on model outputs, and site specific conditions may not be fully represented.

FIGURE A-21: FOOD DISTRIBUTION AND FLOOD HAZARDS



VULNERABILITIES

Category	Vulnerability
Physical	Geologic: Pre-1978 soft story buildings are vulnerable to extensive damage. This impacts centers that are housed in store fronts underneath multi-unit residential buildings. Regulation requires these buildings (with 5+ units, and with 2+ stories over a soft story) to be retrofitted by 2020. Unreinforced masonry buildings that have not been retrofitted are more vulnerable to damage. Regulation required non-residential buildings (<5 units) to be retrofitted by 2006, so these should be rare. Pre-1995 tilt-up industrial buildings and pre-1980 non-ductile concrete frame buildings are vulnerable to extensive damage. Which building types are prevalent among food distribution centers is not readily available. Many older and legacy food distribution businesses are in buildings that are not very resilient (e.g. out of date and leaky refrigeration systems, few upgrades over time, inefficient energy/water use). The San Francisco Wholesale Produce Market and the nearby cluster of food distribution related business are located in an area that is susceptible to liquefaction in an earthquake as well as flooding. Flood: Flooding above the finished floor causes damage to the building materials and contents. Distribution centers may experience structural or nonstructural building damage, and impairment or destruction of utility service equipment. Extreme Heat: The building itself would have low vulnerability to heat. In non-weatherized buildings without cooling capabilities (e.g. air conditioning), services could shut down during high heat events. High heat events can cause power outages, which could spoil refrigerated food products. Many older and legacy food distribution businesses are in buildings that are not very resilient (e.g. out of date and leaky refrigeration systems, few upgrades over time, inefficient energy/water use). These facilities likely struggle during extreme heat days. Fire: Food distribution buildings may be more or less vulnerable to fire due to exposure based on proximity to hazard areas/zones. Buildings with metal frames are especially vulnerable to building collapse in the event of fire. Reduced air quality due to fire smoke causes increased

	health risks for employees and customers in buildings that do not have proper air filtration.
Functional	<u>Networks:</u> Grocery stores are not directly networked to each other, but damaged grocery stores can lead strained functioning of other nearby grocery stores, which may not have resources needed to meet extra demand. In an emergency event, grocery stores are hit hard and food shortages are possible. Damage to wholesale suppliers can exacerbate food shortages. The SF-Marin Food Bank is a food supplier to nearly 400 non-profit partners, including 278 local food pantries.[64] This building appears to be recently built and is not a seismically vulnerable commercial building type. It is outside of the 100 year flood plain. Most charitable food distribution centers are not networked with each other. However, if a building is too damaged to be used, the users of the center may redistribute to other centers while the building is repaired. This may strain functionality of these services. While impacts on the emergency/charitable food network are critical, longer-term impacts on the overall food distribution supply and networks are important since everyone (food banks included) relies on these facilities. In an emergency situation, there are numerous plans in place for mass feeding. The Tenderloin Hunger Task Force successfully conducted an emergency mass feeding drill and created a mutual assistance agreement between CBOs and the government, requiring food distributors to share information with each other in an emergency.[65] The SF Emergency Plan contains operations for mass feeding, including mobile operations. MREs and other similar shelf stable meals are available in widespread emergency situations from military bases.[66] <u>External Services:</u> Transportation is critical for food distributors, especially for suppliers and for delivery services. Impacts to transportation can leave food supply chains vulnerable to disruption. Power is necessary to maintain temperature control in food storage facilities, and to refrigerate and prepare food. Pantries have increased

[64] "Community Partners," SF-Marin Food Bank, 2018, https://www.sfmfoodbank.org/programs/community-partners/.
[65] Cissie Bonini, "San Francisco Disaster Good System Report," Walter and Elise Haas Fund, September 2014, http://www.haassr.org/wp-content/uploads/2014/10/wehfDisasterFoodSystems.pdf.
[66] "Emergency Support Function #6 Mass Care, Housing, and Human Services Annex," City and County of San Francisco Department of Emergency Management, May 2017, https://sfdem.org/sites/default/files/FileCenter/Documents/837-ESF%206%20-%20Mass%20Care%2C%20Housing%2C%20and%20Human%20Services%20Annex.pdf.

	the proportion of fresh food and reduced the proportion of canned foods, creating more reliance on power. <u>Populations Served:</u> Grocery stores are the primary food distribution centers for most people. These stores accept SNAP/CalFresh and WIC, important monetary supplements that enable food access to those who are low income, pregnant/nursing, and very young. Charitable food distribution centers provide meals and groceries for those who are low income, elderly, isolated, mobility challenged, health impaired/medically dependent, and housing insecure/burdened. On site services provide meals and social bonding for these groups. Delivery services are especially important for the elderly, mobility impaired, and critically ill. These services often provide daily wellness checks, nutrition counseling, social work, and home safety and urgent needs services. <u>Unique or Critical Function:</u> The asset class is critical in its function as a provider of food, a basic necessity, especially in emergency situations. Charitable food distribution services provide important free social services, such as food provision/delivery, wellness checks, social services referrals, and social events. These centers can also function as nodes of community based political power, advocating for food access among vulnerable populations. In major emergencies, food pantries and meal service centers may function as emergency staging and distribution centers. This is arranged through SF Community Agencies Responding to Disaster (SF CARD), the SF Fire Dept's Neighborhood Emergency Response Team (NERT), and/or SF Voluntary Organizations Active in Disasters (SF VOAD).
Informational	<u>All-hazards:</u> A draft vulnerability and consequence assessment exists for sea level rise threat. DEM has detailed emergency response protocol that includes how non-profits contribute their services to mass care. However, data on building type/condition, retrofitting, air cooling, filtering, sensitive below grade components, back-up measures for utility outages, and contingency/emergency plans for all food distribution centers is not easily accessible.
Governance	<u>All-hazards:</u> AB 903 requires reimbursement of emergency response costs to nonprofits. SF CARD, NERT, and SF VOAD regulate emergency response coordination among participating community centers.

CONSEQUENCES

Category	Consequence
Society/Equity	All-hazards: Significant damage to charitable food distribution structures can create long term disruptions to the normal social structures and supports of community members, especially those who are highly vulnerable and who receive targeted social, health, and wellness services. These populations would have to find other means of obtaining food, and for some this could mean a reduction in food quality and caloric intake. Damage to wholesale distribution centers and grocery stores can result in disruption to food supply, from days to months. This is impactful for all community members. Long term disruptions of grocery stores may reduce the accessibility of fresh food in neighborhoods. There may be equity impacts if groceries within low income/highly diverse neighborhoods have more vulnerable building types or are within more hazard vulnerable zones. Food distribution and retail businesses tend to provide jobs for people with lower educational attainment, and the distribution sector in particular can provide a pathway to more skilled / better paid jobs (this is less true of food retail jobs, as well as other low-skilled sectors like retail, hospitality, etc.). Disruptions to this sector would have a negative impact on our economic diversity. Geologic: Significant groundshaking can result in human casualties from building damage, and can result in the reduction of food supplies citywide Flood: Significant stormwater flooding may result in human casualties if there is no 2nd story. Extreme Heat: Extreme heat increases health risk for employees and customers who are elderly, pregnant, children, and/or have medical conditions. Fire: Significant fire can result in human casualties. Reduced air quality in unfiltered buildings can result in increased rates of asthma attacks. This is especially true in under-resourced communities and communities of color, which have significantly higher rates of bronchial disease.

Economy	All-hazards: Any damage to the facility will require centers to fund repairs or replacement. Additionally, non-salaried employees will lose wages for each day of closure and permanent closures will result in loss of employment. Wholesale suppliers, grocery stores and farmers markets receive revenue from the services they provide. Each day of closure or limited facility use will reduce or eliminate daily revenue. As for customers, populations that rely on free and subsidized meal/grocery services may have to utilize traditional grocery stores, reducing available personal income. Geologic: Neighborhoods with un-retrofitted buildings will see the most damage and economic impact. Flood: Neighborhoods in coastal and storm water flood zones will see the most damage and economic impact. Extreme Heat: This hazard will not cause permanent or indefinite closure. Air Quality: Air quality reduction from fire will not cause permanent or indefinite closure.
Environment	Geologic: Air quality could be impacted by the production of particulate matter from building damage. Flood: If food distribution facilities are near to the coast, flooding may cause debris from the building and soil from around the building to move into waterways. Fire: Air quality would be reduced in the neighborhood, and potentially citywide, if the building is directly impacted by fire.

Education Institutions

Introduction to Asset Class

Educational institutions include public and private K-12 schools, as well as public and private colleges and universities. K-12 institutions provide education, nutrition, and basic health care to children and youth, including those who may be more vulnerable to climate impacts because of existing disparities (see Vulnerable Populations profile). Higher education institutions provide career services, confer degrees, and foster research, in addition to providing nutrition, housing, and health services to many of their students. Education institutions are major employers, especially large universities.

Educational facilities are dispersed widely throughout the City. Analysis was conducted on 124 public K-12 San Francisco Unified School District schools, 127 private K-12 schools, and 50 higher education institutions, including colleges, universities, and community colleges. City College of San Francisco operates on 11 sites, UCSF operates education services in two main locations (the Parnassus campus and Mission Bay), UC Hastings and SFSU each operate on central campuses, and there are 21 private universities and colleges. Private schools provide services to a third of K-12 students in San Francisco[67].

Educational facilities are generally situated on a campus, with one or several buildings and open/recreational space. K-12 education facilities generally include classrooms, gymnasium/cafeteria, library, and recreational space. SFUSD owns and manages K-12 public facilities, while private schools operate independent of each other unless they are part of a larger religious or nonprofit network. College facilities are typically campuses with multiple buildings dedicated to specific disciplines. UCSF is a medical university that operates facilities dedicated to medical care and biotech research, in addition to classroom functions. College facilities also often include residential units in addition to medical, retail, cultural, recreational, and dining services for its students. Colleges and universities own or rent and manage their own facilities.

[67] *Earthquake Risk and San Francisco's Private Schools*, December 31, 2013

Issue Statement

Educational institutions provide important services in addition to the provision of basic and continuing education, including housing, medical care, employment, child care, nutrition, social services, and emergency shelter. They serve a large population, and tailor services specific to the needs of many disadvantaged and sensitive groups. K-12 school populations are particularly sensitive to health risks from heat and smoke from fire, though many facilities do not have air cooling or filtration technology. Public K-12 school buildings are required to be resistant to earthquakes by the Division of State Architects, but this policy does not apply to private schools (which serve approximately 33% of the City's school-aged children). Private schools are likely to perform significantly worse in earthquakes than public school buildings.[68] Structural damages to K-12 buildings from earthquake, flooding, or fire can cause citywide social and economic impacts if students need to be redistributed to other schools. Short term closures can impact facility employee and parent wages, and can impact a child's performance in school.

Exposure

Hazard Data Assumptions

This analysis was conducted in 2018 and 2019 using publicly-available data sources. In Table A-11, on the following page, shaking intensity is represented for two Earthquake scenarios: San Andreas Fault M7.8 and Hayward Fault M7.0 events. Accounts of assets subjected to varying levels of shaking intensity are cumulative for each scenario.

Asset Data Assumptions

Asset data originates from DEM, DataSF Open Data Portal, and National Center of Education Statistics.

[68] *Earthquake Risk and San Francisco's Private Schools*, December 31, 2013

TABLE A-18: EXPOSURE

Hazard	Public K-12 124 Total		Private K-12 127 Total		University/College /Community College 50 Total	
	#	%	#	%	#	%
Geologic						
San Andreas 7.8 – Violent	29	23%	31	24%	4	8%
San Andreas 7.8 - Very Strong	95	77%	96	76%	46	92%
Hayward 7.0 - Very Strong	1	1%	3	2%	7	14%
Hayward 7.0 - Strong	95	76%	98	77%	40	80%
Liquefaction Zone	14	11%	29	23%	27	54%
Flooding						
100-Year Coastal Flood Zone	0	0%	0	0%	1	2%
100-year storm + 24 inches SLR	1	1%	2	2%	5	10%
100-year storm + 66 inches SLR	4	3%	6	5%	9	18%
100-year stormwater flood	7	6%	3	2%	4	8%
Wildfire						
High	0	0%	0	0%	0	0%
Moderate	3	2%	4	3%	3	6%

Note: For an exposure table with additional hazards, please see Chapter 5

Exposure Summary

Geologic: All of San Francisco would be exposed to Violent or Very Strong shaking in a 7.8 earthquake on the San Andreas fault, including all educational institutions. 244 institutions would be exposed to Very Strong or Strong shaking in a 7.0 earthquake on the Hayward fault. 70 institutions are in the liquefaction zone, including over half of the city's universities/colleges/community colleges.

Flood: 19 of San Francisco's educational institutions, including five SFUSD schools, are exposed to current and projected future coastal flooding; 13 of the institutions, including seven SFUSD schools, are in the storm water flood risk zone.

Fire: Educational exposure to wildland-urban fire zones is limited to moderate risk, and 10 educational institutions are in this zone.

FIGURE A-22: EDUCATIONAL INSTITUTIONS AND LIQUEFACTION HAZARD

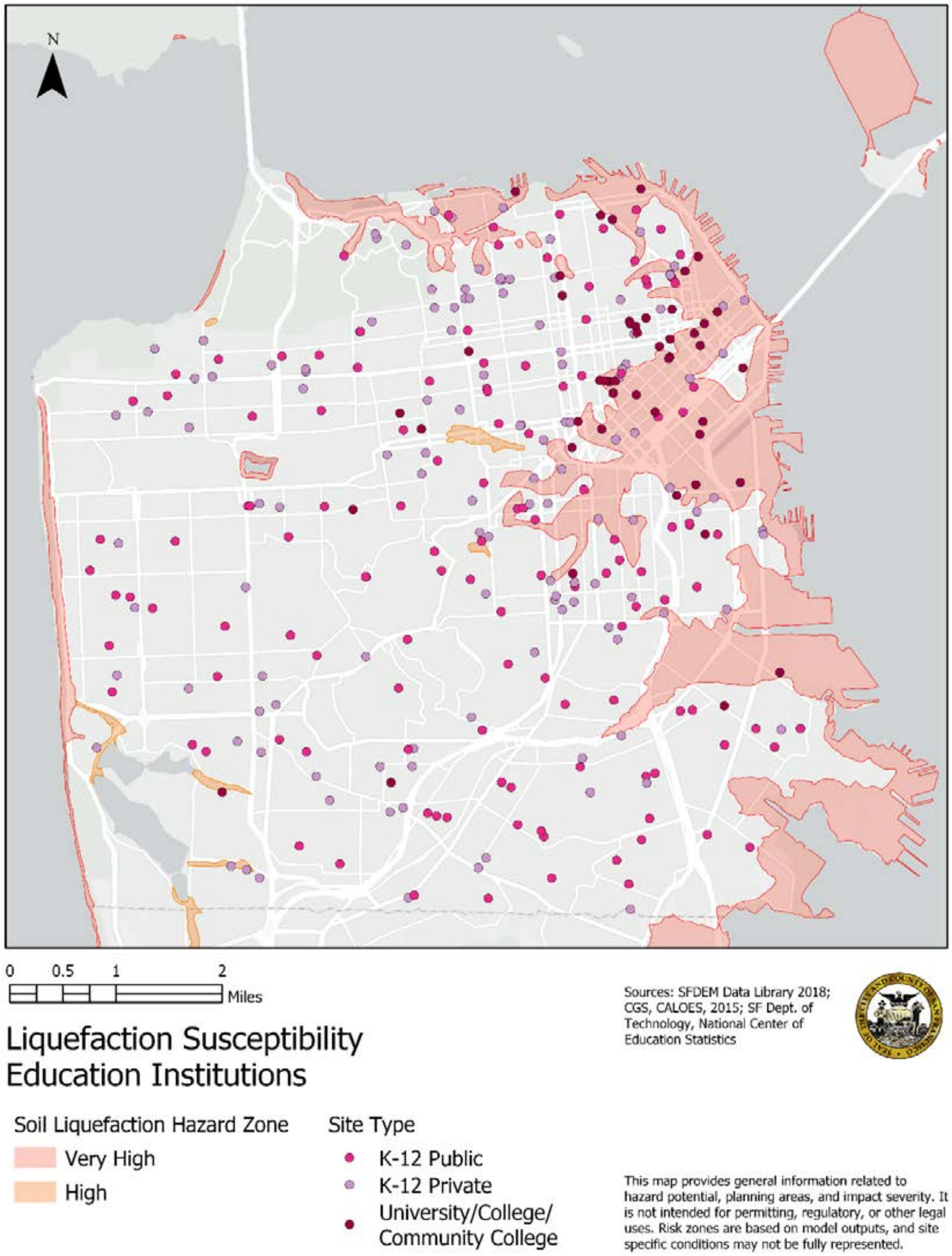
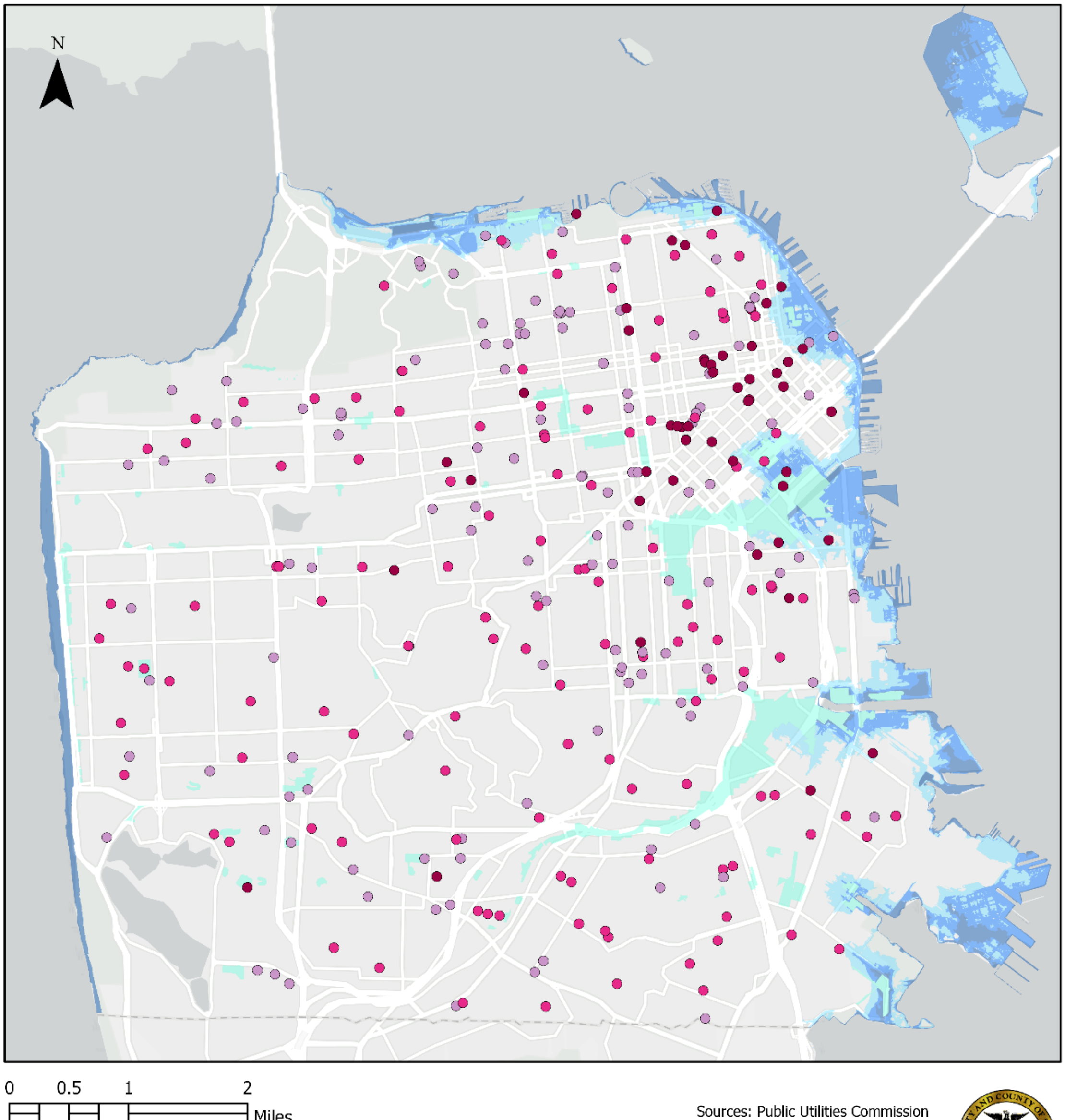


FIGURE A-23: EDUCATIONAL INSTITUTIONS AND FLOOD HAZARDS



Flood Risk
Educational Institutions

Flood Hazards

- 100 Year Stormwater Runoff
- FEMA 100 Year Coastal Flood Zone
- 100 Year Storm + 24" Sea Level Rise
- 100 Year Storm + 66" Sea Level Rise

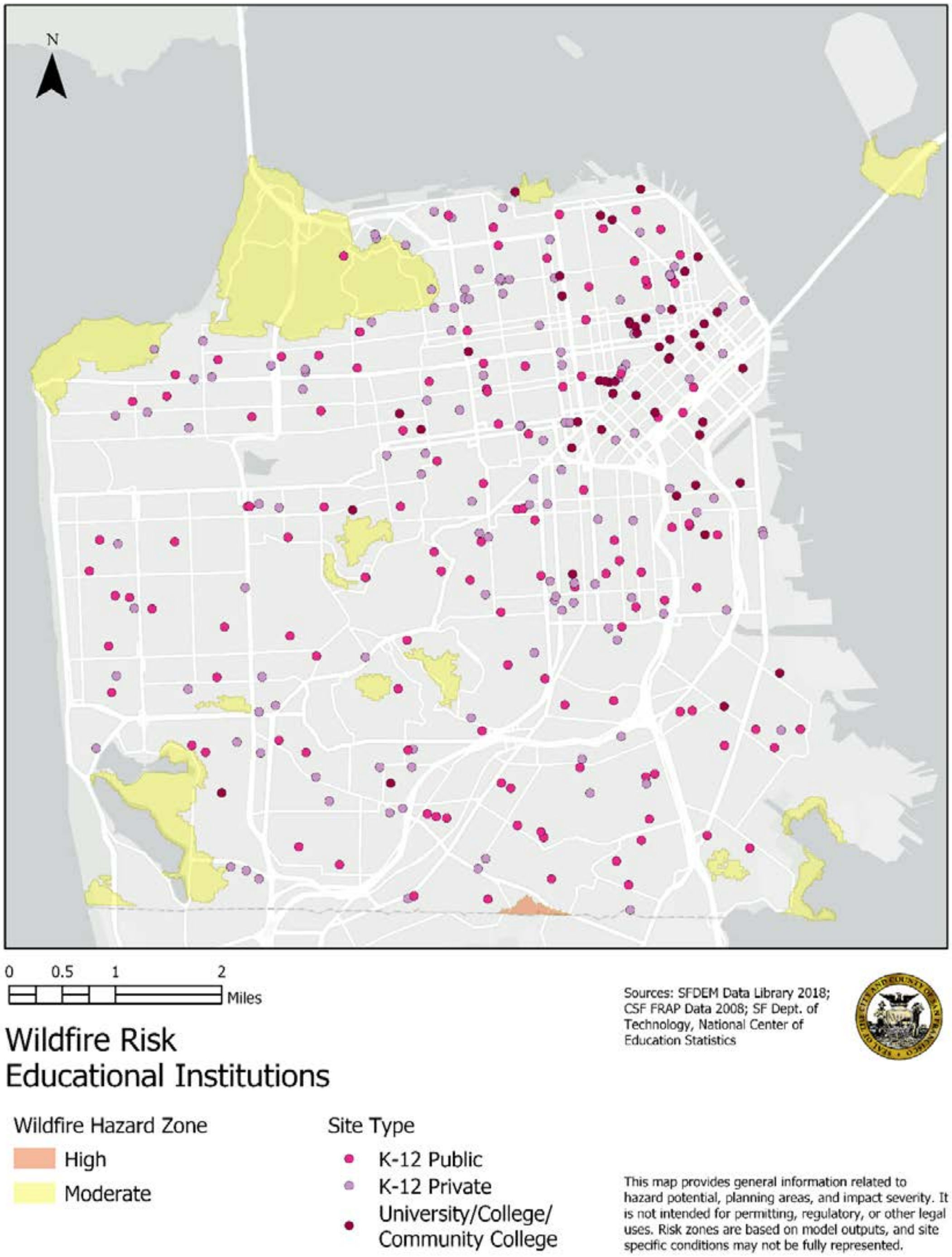
Site Type

- K-12 Public
- K-12 Private
- University/College/ Community College

Sources: Public Utilities Commission 100-Year Storm Flood Risk Map; FEMA Preliminary Flood Insurance Rate Maps; ART Bay Area Sea Level Rise and Shoreline Analysis Maps; SF Dept. of Technology, National Center of Education Statistics

This map is intended for planning-level analysis and should not be used for permitting, regulatory, or other legal uses. Flooding is possible in areas outside of those displayed on this map. The risk zones are based on model outputs and relied on LiDAR data collected in 2010 and additional survey data (where available). Although care was taken to capture all relevant topographic features and structures, site specific conditions may not be fully represented.

FIGURE A-24: EDUCATIONAL INSTITUTIONS AND WILDLAND URBAN INTERFACE FIRE HAZARD



VULNERABILITIES

Category	Vulnerability
Physical	Geologic: According to the 2004 Seismic Safety Commission's report on schools in CA, "public schools constructed under the Field Act after 1978 are likely to be among the safest buildings in which to experience a major earthquake."[69] Pre-1978 public school buildings that have not been retrofitted will be vulnerable to damage in the event of a seismic event. SFUSD has identified seismic retrofitting and upgrades as a high priority, and as part of its Prop A Bond Program all schools are assessed for seismic needs. In 2013, 12% of public school buildings and 33% of private school buildings had characteristics that "indicate they might perform poorly in future earthquakes." 24% of private schools did not have enough information to know. This is significant considering that San Francisco has a high private school enrollment (33% in 2013).[70] DBI has a private school seismic program that required private schools to perform an earthquake evaluation of their buildings by 2017 (final report publication, TBD). Flood: Flooding above the finished floor of schools damages building materials and contents. Schools may experience structural or nonstructural building damage, and impairment or destruction of utility service equipment. Flooding in SFUSD basements may damage boilers. SFUSD schools that have experienced flooding have sump pumps installed. Extreme Heat: Colleges and universities may have sensitive equipment that could be impacted by heat events. SFUSD keeps its IT equipment in actively cooled data closets. In non-weatherized school buildings without adequate cooling systems (e.g. air conditioning), students are at increased risk of health impacts. The vast majority of SFUSD facilities do not have air conditioning, and only certain sites have mechanical ventilation. Schools may shut down in extreme heat events at the discretion of the SFUSD Board of Education.

[69] "Seismic Safety in California Public Schools," California Seismic Safety Commission, 2004, http://ssc.ca.gov/forms_pubs/cssc_2004-04_school_safety.pdf.
[70] Earthquake Risk and San Francisco's Private Schools, December 31, 2013

	<u>Fire:</u> Fire impact to air quality is a concern for educational facilities, especially those serving children. Neither California nor San Francisco has regulations that requires the use of air filtration. Many SFUSD schools do not have mechanical ventilation and air filtration systems. In the event of very poor air quality, schools may shut down at the discretion of the SFUSD Superintendent. The Division of the State Architect oversees a rigorous Fire and Life Safety program governing the design of public schools and community colleges for onsite fire prevention.
Functional	<u>Networks:</u> SFUSD has an IT network that is currently supported by backup generators. This is important to maintain communication because Additionally, if a K-12 school building is too damaged to be used, the students will need to be distributed to other area schools while the building is reconstructed or repaired. This may strain the services provided by the receiving schools. <u>External Services:</u> Education facilities rely on transportation access, power, water, and food. They also rely on communications (i.e. phone and internet) to maintain safety (communication with parents and emergency services) and for lesson requirements (internet research/media use). SFUSD, UCSF, SFSU, CCSF all have emergency plans. Some SFUSD school sites have backup generators, such as school sites with IT networks. SFUSD has transportation services and radio communication for use in an emergency. SFUSD also requires food and water storage for emergency use. <u>Populations Served:</u> Educational institutions serve nearly all school aged children in San Francisco. Public institutions (SFUSD and San Francisco City College) serve young people and adults regardless of income or citizenship status. Public education facilities also provide programming and/or services for those who have physical and intellectual disabilities. Some educational facilities serve significant populations of ethnically/culturally diverse populations. K-12 public schools in particular have English language learner (ELL) programs to accommodate non-native English speakers. SFUSD also provides newcomer program supports, newcomer student linkages, and sanctuary education supports.

	<u>Unique or Critical Function:</u> Public K-12 schools are critical community institutions that provide basic education in addition to social work for highly sensitive, low income, and otherwise disadvantaged populations. Public K-12 schools provide subsidized meals for low income students through the free breakfast and lunch programs, they interface with the foster system and social workers, and they provide sanctuary education supports. Universities and colleges provide unique services to the city in the form of research development, in addition to medical and professional training. These institutions, in particular SFUSD, are critical for emergency services. SFUSD staff members are designated emergency workers, and the School District partners with the Department of Emergency Management to coordinate mass sheltering and feeding at its facilities.
Informational	<u>All-hazards:</u> Data on building type/condition, retrofitting, air cooling, filtering, sensitive below grade components, back-up measures for utility outages, and contingency/emergency plans for *all* educational institutions (including private and higher education institutions) is not easily accessible. SFUSD and DEM have detailed emergency response protocols. SFUSD has data on school facilities, and DBI has records on private school facility seismic resilience.
Governance	<u>All-hazards:</u> The Field Act and subsequent state legislation requires that public schools are built to be earthquake resistant and older buildings be retrofitted. No such requirements exist for private schools. Private schools in San Francisco were mandated to conduct an earthquake resistance report by 2017. Public schools have mandated earthquake and fire drills to mitigate human casualties. The SFUSD superintendent is responsible for cancelling school services in the event of extreme heat or poor air quality. SFUSD has a detailed School Site Emergency Plan and partners with Department of Emergency Management to coordinate mass housing and care in the case of an emergency. The Division of the State Architect oversees a rigorous Fire and Life Safety program governing the design of public schools and community colleges.

CONSEQUENCES

Category	Consequence
Society/Equity	All-hazards: In the event that students need to be evacuated from a damaged building, families may be unable to immediately reunite with students. SFUSD emergency protocol has a detailed reunification strategy to ensure students are cared for until they are reunited with family. Any significant damage to the facility building may result in indefinite redistribution of students, which separates students from their normal social structures and supports (peers and teachers). Students may also have to travel for long distances to get to their newly assigned school. Significant damage and health hazards can result in the shutdown of school services from days to weeks. This results in students' education being disrupted (with each day lost tied to test score reductions). The scale of impact depends on the time of year (there is low student attendance during the summer months). Geologic: Significant ground shaking and liquefaction can result in human casualties from building damage. Flood: Significant storm water flooding may result in human casualties if there is no second story. Extreme Heat: Extreme heat may cause facilities without air conditioning to close, keeping students at home, though most SF homes also do not have cooling capabilities. Students and schools in urban heat island areas (such as Chinatown, Potrero Hill-Dogpatch, and Bayview neighborhoods) will be particularly vulnerable. Fire: Building fires can result in human casualties, though this is mitigated by emergency protocols (e.g. fire drills). Poor air quality from fire may cause school closures. If schools do not close and do not have filtering technology, poor air quality will increase health risks to students. Air quality reduction from fire will not result in building damage or redistribution of students, although it can impede learning if schools must close.
Economy	

	All-hazards: Any damage to the facility will require schools to fund repairs or replacement. In the event of major damage, schools will also have to fund interim costs during rebuilding such as portable classrooms and transportation. Additionally, non-salaried facilities employees will lose wages for each day of closure. Parents of young children will lose wages for each day they need to stay home for child care purposes. This may be mitigated by employee protections (e.g. use of sick days). Hourly employees and single parent households, which are also likely to be low income, are most impacted. Indefinite closures will result in loss of employment. Short-term construction employment will gain jobs. The scale of impact depends on the time of year (there is low student attendance during the summer months). Flood: This hazard can cause indefinite closure in coastal and storm water flood zones. Geologic: Neighborhoods with un-retrofitted school buildings (mostly private school buildings) will see the most damage and impact. Extreme Heat: This hazard will not cause indefinite closure. Fire: Air quality reduction from fire will not cause indefinite closure.
Environment	Geologic: Air quality could be temporarily impacted by the production of particulate matter from building damage. Flood: If school facilities are near to the coast, flooding may cause debris from the building and soil from around the building to move into waterways. Fire: Air quality would be reduced in the neighborhood, and potentially citywide, if the building is directly impacted by fire or from smoke from regional fires.

Community Centers

Introduction to Asset Class

Community centers provide a location where community members can obtain resources and information, and participate in spiritual, educational, recreational, and/or political activity. These include libraries, recreation centers, senior centers, youth centers, neighborhood centers, and faith-based centers. SF Human Services Agency outlines more than 40 centers that offer services for the elderly across the city.[1] A 2010 list from the Office of Assessor-Recorder identifies 530 spiritual centers citywide.[2] It is challenging to find specific data on youth and neighborhood centers. Community centers are run by the City, NGOs and places of worship, and many are a part of organizational networks, such as the YMCA.

Community centers vary in form. Some are large facilities that contain fitness, open space, and kitchen amenities. Others operate in small to medium sized commercial properties or in traditional building types for places of worship. The building age, materials, and forms are not consistent across this asset class. Centers vary in property ownership status, but typically manage their own facilities.

Issue Statement

Community centers are critical in their function as a community convener that enables social networking and bonding, as well as the provision of important free or low cost social services. Centers also may function as shelters, air quality respite centers, and cooling centers during emergency events. The services these institutions provide are especially important to vulnerable populations. However, data on how vulnerable community centers are to climate and seismic hazards is not well understood. In addition, community centers rely on power and communication, but how many centers have contingency plans for power outages that can be caused by seismic, storm, and heat events is unknown. This is especially important for centers that play a role as an emergency shelter or cooling center.

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[1] "Senior Centers and Activity Centers," City and County of San Francisco Human Services Agency, 2018, https://www.sfhsa.org/services/connection-community/senior-centers-and-activity-centers.

[2] SF Planning GIS data library (2018)

Exposure

Hazard Data Assumptions

This analysis was conducted in 2018 and 2019 using publicly-available data sources. In the table on the following page, shaking intensity is represented for two Earthquake scenarios: San Andreas Fault M7.8 and Hayward Fault M7.0 events. Accounts of assets subjected to varying levels of shaking intensity are cumulative for each scenario.

Asset Data Assumptions

Asset data originates from the San Francisco Facilities System of Record (2018). Although there is a wide range of community centers as described above, given data availability, the exposure assessment focuses on three representative community center types found in the City and County of San Francisco's Facility System of Record database: libraries, recreation centers, and other community centers.

Exposure Summary

Geologic: All of San Francisco would be exposed to Violent or Very Strong shaking in a 7.8 earthquake on the San Andreas Fault, including all community centers. 49 centers would be exposed to Very Strong or Strong shaking in a 7.0 earthquake on the Hayward fault. 13 centers are in the liquefaction zone.

Flood: One library in the 24” sea level rise zone represents the extent of community center exposure to current and future coastal flooding. There are 5 community centers in the 100 year stormwater flood zone.

Fire: One recreation center in the Moderate wildland-urban interface fire zone represents the extent of community center exposure to wildfire.

TABLE A-19: EXPOSURE

Hazard	Libraries 29 Total		Recreation Centers 20 Total		Other Community Centers 11 Total	
	#	%	#	%	#	%
Geologic						
San Andreas 7.8 - Violent	9	31%	4	20%	1	9%
San Andreas 7.8 - Very Strong	20	69%	16	80%	10	91%
Hayward 7.0 - Very Strong	0	0%	0	0%	2	18%
Hayward 7.0 - Strong	23	79%	16	80%	8	73%
Liquefaction Zone	6	21%	5	25%	2	18%
Flooding						
100-Year Coastal Flood Zone	0	0%	0	0%	0	0%
100-year storm + 24 inches SLR	1	3%	0	0%	0	0%
100-year storm + 66 inches SLR	1	3%	0	0%	0	0%
100-year stormwater flood	2	7%	2	10%	1	9%
Wildfire						
High	0	0%	0	0%	0	0%
Moderate	0	0%	1	5%	0	0%

Note: For an exposure table with additional hazards, please see Chapter 5.

FIGURE A-25: COMMUNITY CENTERS AND LIQUEFACTION HAZARD

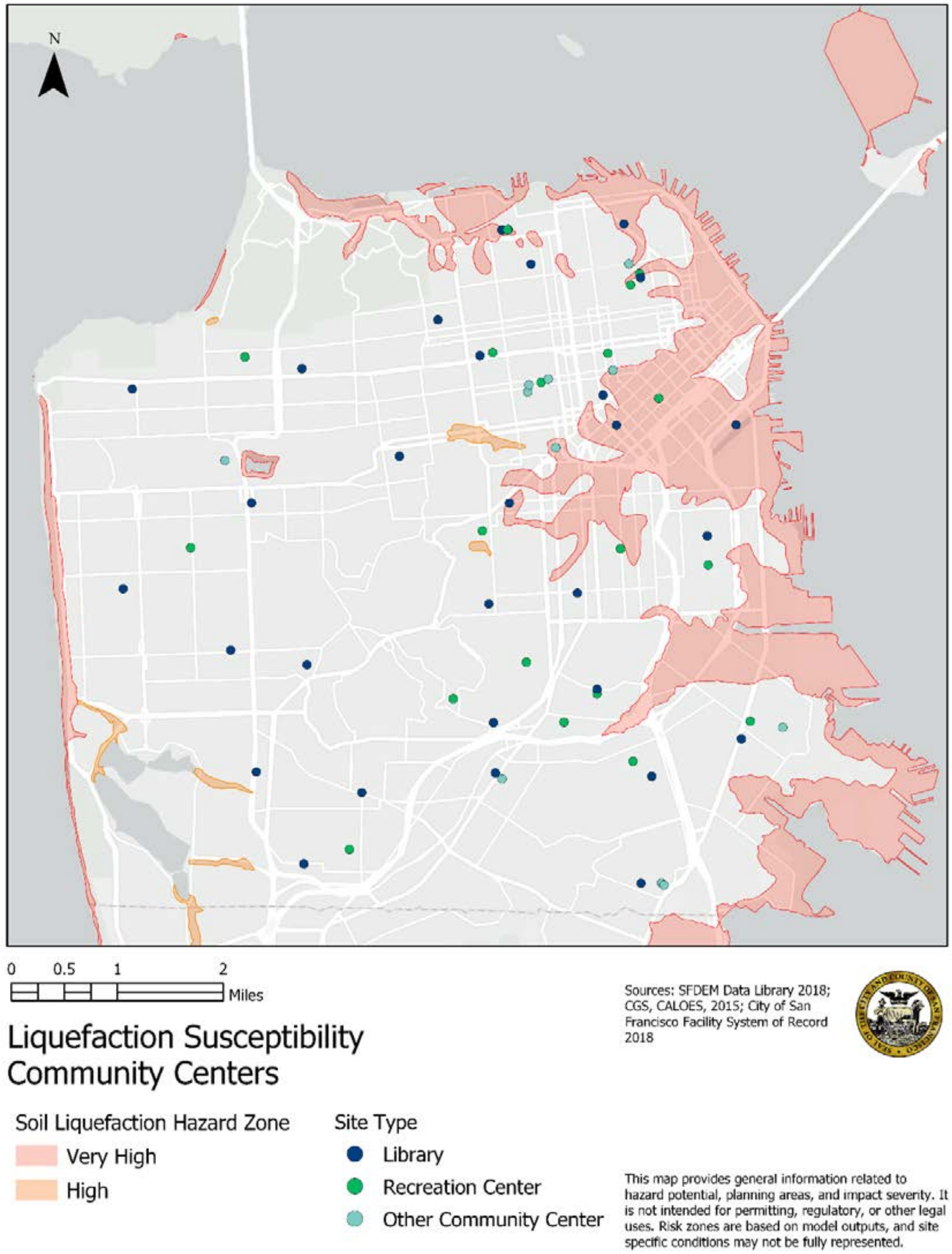
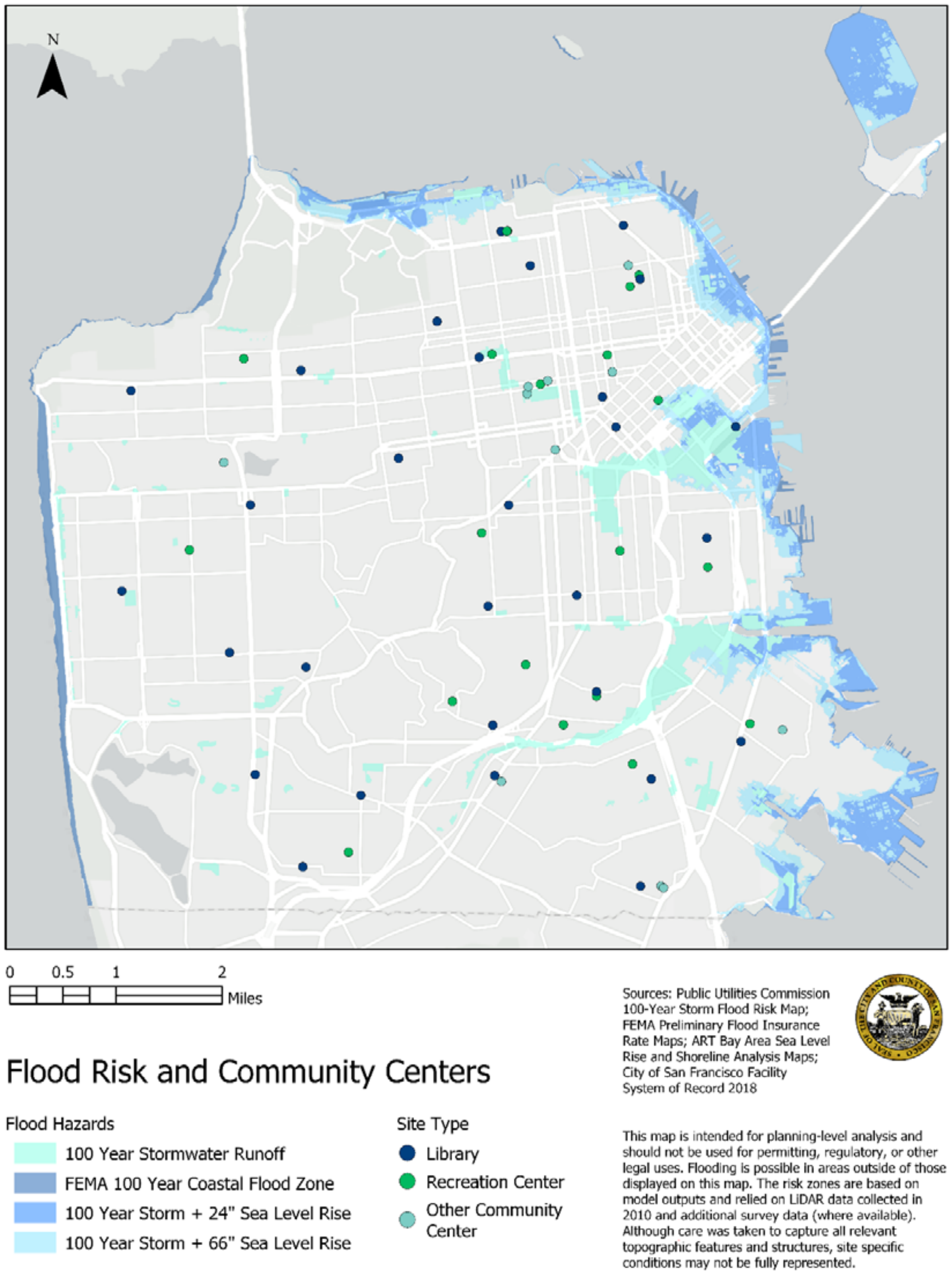


FIGURE A-26: COMMUNITY CENTERS AND FLOOD HAZARDS



VULNERABILITIES

Category	Vulnerability
Physical	Geologic: Pre-1978 soft story buildings are vulnerable to extensive damage. This impacts centers that are housed in store fronts underneath multi-unit residential buildings. Regulation requires these buildings (with 5+ units, and with 2+ stories over a soft story) to be retrofitted by 2020. Unreinforced masonry buildings that have not been retrofitted are more vulnerable to damage. Regulation required non-residential buildings (<5 units) to be retrofitted by 2006, so these should be rare. Pre-1995 tilt-up industrial buildings and pre-1980 non-ductile concrete frame buildings are vulnerable to extensive damage. Which building types are prevalent among community centers, especially those owned or managed by private entities, is not readily available. Flood: Flooding above the finished floor causes damage to the building materials and contents. Distribution centers may experience structural or nonstructural building damage, and impairment or destruction of utility service equipment. Extreme Heat: In non-weatherized buildings without cooling capabilities (e.g. air conditioning), services could shut down during high heat events. High heat events can cause power outages for centers without backup power sources. Fire: Community center buildings may be more or less vulnerable to fire due to exposure based on proximity to hazard areas/zones. Buildings with metal frames are especially vulnerable to building collapse in the event of fire. Reduced air quality due to fire smoke causes increased health risks for employees and members in buildings that do not have proper air filtration.
Functional	Networks: The community centers are not directly networked. All branch libraries are connected to the Main Library data center, some by City Fiber, however, if a building is too damaged to be used, the members of the center may redistribute to other centers while the building is reconstructed/repaired. This may strain functionality of the services provided by the asset class. For example, day care use of a YMCA may be redistributed to other similar centers in the area, or to other YMCAs. Library collections are networked and damage to one or more facilities could impact citywide service.

	External Services: Community center facilities rely on transportation access for members and staff. Centers rely on power and water to deliver services within sanitary and functional buildings. They also rely on communications (i.e. phone and internet) to maintain safety (communication with guardians and emergency services) and for service delivery (internet research/media use, emails). Food access becomes important if a community center is turned into an emergency shelter. Some centers have food pantry programs that serve as backup food supplies. Large community service providers, such as YMCA or Girls and Boys Club, have emergency plans and training, but it is unclear if these include contingency plans for back up external services (like off grid power, water/food supply, communications). This is likely highly variable among organizations and dependent on available resources. Populations Served: Community centers often primarily serve those with access or functional needs. Senior centers provide specific services to the elderly, who are often medically dependent, transit dependent, require mobility aids, and are low income. Youth centers are important resources for low income families to be able to afford daycare and enrichment for their children. Neighborhood and faith-based centers often provide services that target low income, at-risk community members. In addition, many neighborhood community and faith centers operate in ethnically diverse areas and cater to those populations. These centers offer services in non-English languages, provide ELL courses, and provide important services to members who are linguistically isolated. Unique or Critical Function: The asset class is critical in its function as a community convener that enables the development of social networking and bonding, as well as the provision of important free or low cost social services such as daycare, youth enrichment, drug-violence-mental illness prevention/counseling, employment preparation services, and recreation. In major emergencies centers may function as mass care staging centers. Many faith-based and neighborhood organizations have protocols for volunteering their services and buildings for use during emergencies. These protocols are often arranged through SF Community Agencies Responding to Disaster (SF CARD), the SF Fire Dept's Neighborhood Emergency Response Team (NERT), and SF Voluntary Organizations Active in Disasters (SF VOAD). Centers may also function as official and unofficial cooling centers during a heat emergency. These centers especially serve those who are most

	vulnerable and mobility challenged, such as the elderly, low income, and disabled.
Informational	All-hazards: A draft vulnerability and consequence assessment exists for sea level rise threat. DEM has detailed emergency response protocol that includes how non-profits contribute their services to mass care. However, data on building type/condition, retrofitting, air cooling, filtering, sensitive below grade components, back-up measures for utility outages, and contingency/emergency plans for all community centers is not easily accessible.
Governance	All-hazards: AB 903 requires reimbursement of emergency response costs to nonprofits. SF CARD, NERT, and SF VOAD regulate emergency response coordination among participating community centers.

CONSEQUENCES

Category	Consequence
Society/Equity	All-hazards: Significant damage to community centers can create long term disruptions to the normal social structures and supports of community members, especially those who are highly vulnerable and who receive targeted social, health, and wellness services. There may be inequitable impacts if older, fragile, non-retrofitted buildings and buildings without cooling and filtration capabilities are located in or serve disadvantaged communities. A long term closure results in community members having to find other centers that provide similar services at similar prices within a reasonable travel distance. This might be impossible, especially for populations with limited mobility, and for populations with highly specific needs, leaving these members temporarily, and potentially permanently, disconnected from important social, health, wellness, and/or life skills services. Disruption to these facilities could also have ripple impacts on family members who take on caregiving. Geologic: Significant groundshaking can result in human casualties from building damage.

	Flood: Significant stormwater flooding may result in human casualties if there is no 2nd story. Extreme Heat: Heatwaves may cause closures in non-weatherized buildings without cooling capabilities. For centers providing daycare and education services, this keeps students at home. As SF is typically cool and many residences do not have air conditioning, community centers can act as important places for people to get out of dangerous heat. This is especially important for sensitive populations such as the elderly, disabled, and very young. Should these cooling centers lose power, vulnerable populations may be at greater health risk, especially those who have limited mobility. Fire: Significant fire can result in human casualties. Reduced air quality in unfiltered buildings can result in increased rates of asthma attacks. This is especially true in under-resourced communities and communities of color, which have significantly higher rates of bronchial disease.
Economy	All-hazards: Any damage to the facility will require centers to fund repairs or replacement. For community centers that receive revenue from the services they provide, each day of closure or limited facility use will reduce or eliminate daily revenue. In addition, non-salaried employees will lose wages for each day of closure. Permanent closures will result in loss of employment. For centers that provide early education and daycare services, guardians of young children will lose wages for each day they need to stay home for childcare purposes. Similarly, disruption to eldercare facilities will impact family members who need to provide the care instead. Hourly employees and single parent households are most impacted-- these are most likely to be low income households. Geologic: Neighborhoods with un-retrofitted buildings will see the most damage and economic impact. Flood: Neighborhoods in coastal and storm water flood zones will see the most damage and economic impact. Extreme Heat: This hazard will not cause permanent or indefinite closure.

	Fire: Air quality reduction from fire will not cause permanent or indefinite closure.
Environment	Geologic: Air quality could be impacted by the production of particulate matter from building damage. Flood: If facilities are near to the coast, flooding may cause debris from the building and soil from around the building to move into waterways. Fire: Air quality would be reduced in the neighborhood, and potentially citywide, if the building is directly impacted by fire.

Housing

Introduction to Asset Class

San Francisco's housing stock, developed and maintained over more than one and a half centuries, includes many building and unit types. The city's housing serves a diverse set of household types—including families with and without children, roommates, single individuals, and multi-generational households—from a wide range of incomes. Some rental units are under rent control, some are restricted to low- and moderate-income households, while others are rented at market rates.

Compared to the rest of the Bay Area, San Franciscans are much more likely to live in multifamily housing, with a fairly even distribution of households living in single family homes and buildings with 2-4 units, 5-19 units and 20 units or more.[3] Housing is distributed across the city with more single family homes in the southern and western portions of the city and more large multifamily housing in the northeastern quadrant of the city. Increasingly, residential high rise towers are being constructed in the northeast portion of the city using new concrete design and construction technologies. 40% of the city's tall buildings have residential occupancies.[4] Homes in San Francisco are constructed with a wide variety of materials. Smaller structures tend to be wood-framed or, less-commonly, constructed with masonry materials. Concrete residential structures tend to be mid-rise buildings. Housing is critical for residents' health and safety. Housing may be resident owned, privately owned and rented, privately-owned subsidized, or publicly-owned and operated public housing.

The continuing high cost of housing in San Francisco amplifies the need for providing affordable housing to all household income levels, especially low and very low income levels. The provision of adequate affordable housing remains a significant challenge for San Francisco. From 1990 to 2015, the number of renter households experiencing severe rent burden (> 50% of income on housing costs) increased from 38,000 to 49,000. Currently, the majority of low income renters and homeowners (< 80% AMI) are cost burdened (> 30% of income on housing costs).[5] Citywide, there are 33,661 subsidized affordable housing units, restricted for use by individuals and families below

[3] "2017 San Francisco Housing Inventory," San Francisco Planning Department, 2018, http://default.sfplanning.org/publications_reports/2017_Housing_Inventory.pdf.
[4] "SF Tall Buildings Study," San Francisco Office of Resilience and Capital Planning, unpublished.
[5] "San Francisco Housing Needs and Trends Report," San Francisco Planning Department, July 2018, http://default.sfplanning.org/publications_reports/Housing-Needs-and-Trends-Report-2018.pdf

certain income thresholds. Sixty percent of these affordable units are located in 5 neighborhoods: Bayview Hunter's Point, Mission, South of Market, Tenderloin, and Western Addition.[6] Of those 33,000 units, approximately 2,250 are in private developments and approximately 31,400 are in public on non-profit developments.

Housing services available to people experiencing or transitioning out of homelessness include shelters, navigation centers, and permanent supportive housing. Temporarily shelters house some of San Francisco's most vulnerable residents, providing a variety of health and case management services; access to laundry facilities and hygiene products; assistance with benefits enrollment; and meals and safety. Homelessness and Supportive Housing Temporary Shelter Capacity is currently 1700 shelter beds for adults and families, 500 Navigation Center beds for adults, 450 transitional housing beds for adults and families, and 100 stabilization units for adults. In addition to HSH facilities, master-leased buildings house some of San Francisco's most vulnerable residents, providing a variety of health and case management services; access to laundry facilities; comfort and safety. The City has master leases with the owners of SROs which house HSH clients. HSH also provides operating funds to third-party service providers that have master leased SRO buildings to house clients. This portfolio in comprised of over 35 buildings and more than 3000 units located throughout the city.

Issue Statement

Housing is a daily necessity for all residents in San Francisco. Depending on the construction type, housing can be severely damaged by hazards and can result in injury, health impacts, or death for residents. Housing supply is limited, particularly for low and moderate income residents. This shortage would be exacerbated by natural hazards and climate change impacts and could lead to significant displacement for vulnerable residents. New models predict that in a M7.8 San Andreas earthquake, 18,300 residential buildings could be damaged in San Francisco, temporarily or permanently displacing 69,600 households (20% of all households).

[6] "San Francisco Housing Needs and Trends Report," San Francisco Planning Department, July 2018, http://default.sfplanning.org/publications_reports/Housing-Needs-and-Trends-Report-2018.pdf

Exposure

Hazard Data Assumptions

This analysis was conducted in 2018 and 2019 using publicly-available data sources. In the table on the following page, shaking intensity is represented for two Earthquake scenarios: San Andreas Fault M7.8 and Hayward Fault M7.0 events. Accounts of assets subjected to varying levels of shaking intensity are cumulative for each scenario.

Asset Data Assumptions

Asset data is originates from datasets maintained by SF Planning, and SF DEM (2018).

Exposure Summary

Geologic: All housing will experience Violent or Very Strong groundshaking during a 7.8M earthquake on the San Andreas Fault. Around 40% of single family units are in the Violent zone, the highest percentage across all housing assets. Almost 90% of multifamily housing units will experience Very Strong or Strong groundshaking during a 7.0M earthquake on the Hayward fault. The Hayward Very Strong and Strong zones also contain 98% of all subsidized affordable housing units and 99% of all permanent supportive housing sites.

Flood: Single family homes have low exposure to all types of flooding, but around 800 homes are in the 100-year stormwater flood zone. Around 12,000 multifamily units are exposed in both the stormwater and 24” sea level rise zones. The proportion of affordable housing exposed to all types of flooding is higher than rates for other housing types. The 66” sea level rise zone contains over 4,000 affordable units. The MSC South Shelter is within the 24” sea level rise zone, and the Division Circle Navigation Center is within the stormwater risk zone.

Fire: Citywide residential exposure to WUI fire is limited, less than 3,000 housing units are in the Moderate risk zone. Most recently, with the wildfires engulfing Northern California, air quality in San Francisco has been a major concern for residents. Because of the nature of prevailing winds in the region and the proximity to traffic congestion and emissions, notwithstanding the exacerbating impact of the fires, many neighborhoods in the City have air quality levels considered dangerous for vulnerable and low-income communities with multifamily and affordable housing (for example, Bayview/Hunter's Point.) Air quality should play a role in how we build and where we build housing.

TABLE A20: EXPOSURE

Hazard	Single Family Units 95,700 Total		Multi-Family Units 288,800 Total		Subsidized Affordable Units 33,800 Total		Permanent Supportive Housing 122 Total		Navigation Center & Shelter Sites 27 Total	
	#	%	#	%	#	%	#	%	#	%
Geologic										
San Andreas 7.8 - Violent	37500	39%	41000	14%	3100	9%	7	6%	0	0%
San Andreas 7.8 - Very Strong	58200	61%	247800	86%	30700	91%	115	94%	27	100%
Hayward 7.0 - Very Strong	1300	1%	23600	8%	3700	11%	5	4%	3	11%
Hayward 7.0 - Strong	56900	60%	231700	80%	29300	87%	116	95%	23	85%
Liquefaction Zone	1500	2%	73500	25%	13800	41%	47	39%	15	56%
Flooding										
100-Year Coastal Flood Zone	0	0%	1000	0%	400	1%	1	1%	0	0%
100-year storm + 24 inches SLR	100	0%	12100	4%	1800	5%	7	6%	1	4%
100-year storm + 66 inches SLR	400	0%	21800	8%	4300	13%	8	7%	2	7%
100-year stormwater flood	800	1%	11600	4%	2200	7%	6	5%	1	4%
Wildfire										
High	100	0%	100	0%	100	0%	0	0%	0	0%
Moderate	1100	1%	1600	1%	300	1%	0	0%	0	0%

Note: For an exposure table with additional hazards, please see Chapter 5.

FIGURE A-27: RESIDENTIAL PARCELS AND LIQUEFACTION HAZARD

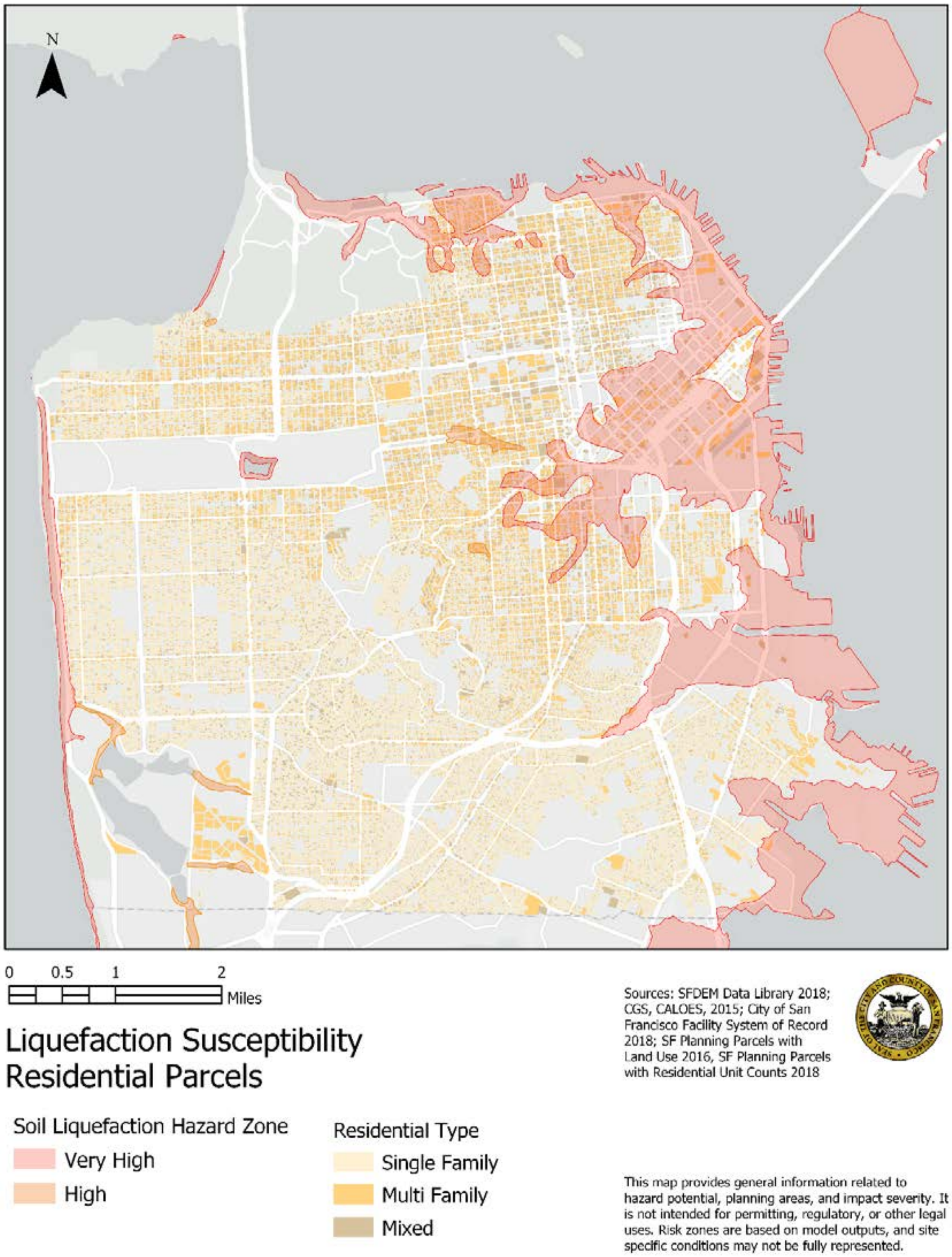
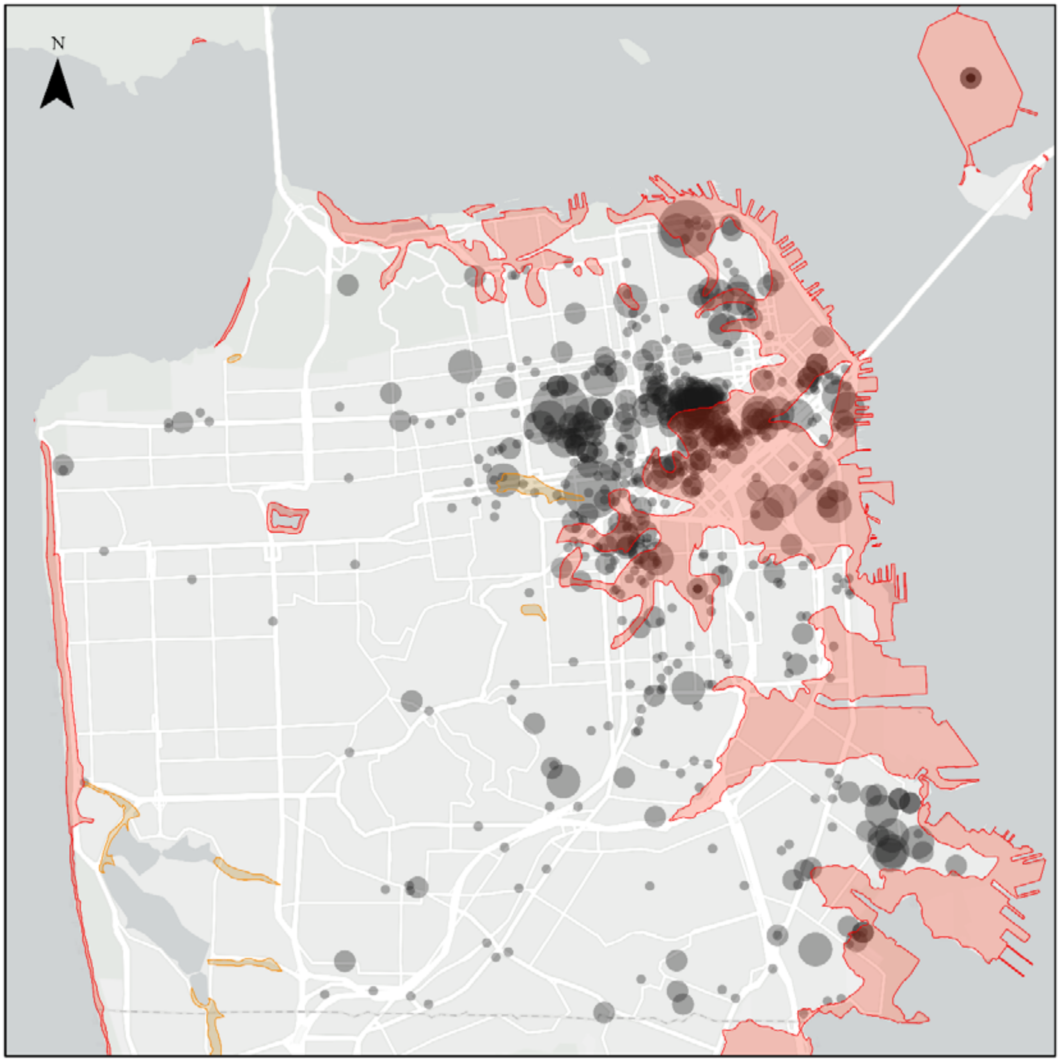


FIGURE A-28: AFFORDABLE HOUSING AND LIQUEFACTION HAZARD



0 0.5 1 2 Miles

Liquefaction Susceptibility
Subsidized Affordable Housing

Soil Liquefaction Hazard Zone
- Very High
- High

Number of Low Income Units
- 1 - 49
- 50 - 149
- 150 - 449
- 450 - 766

Sources: SFDEM Data Library 2018; CGS, CALOES, 2015; City of San Francisco Facility System of Record 2018; Affordable Housing data compiled by SF Planning in 2018 from CHPC, HUD, MOHCD

This map provides general information related to hazard potential, planning areas, and impact severity. It is not intended for permitting, regulatory, or other legal uses. Risk zones are based on model outputs, and site specific conditions may not be fully represented.

FIGURE A-29: RESIDENTIAL PARCELS AND FLOOD HAZARD

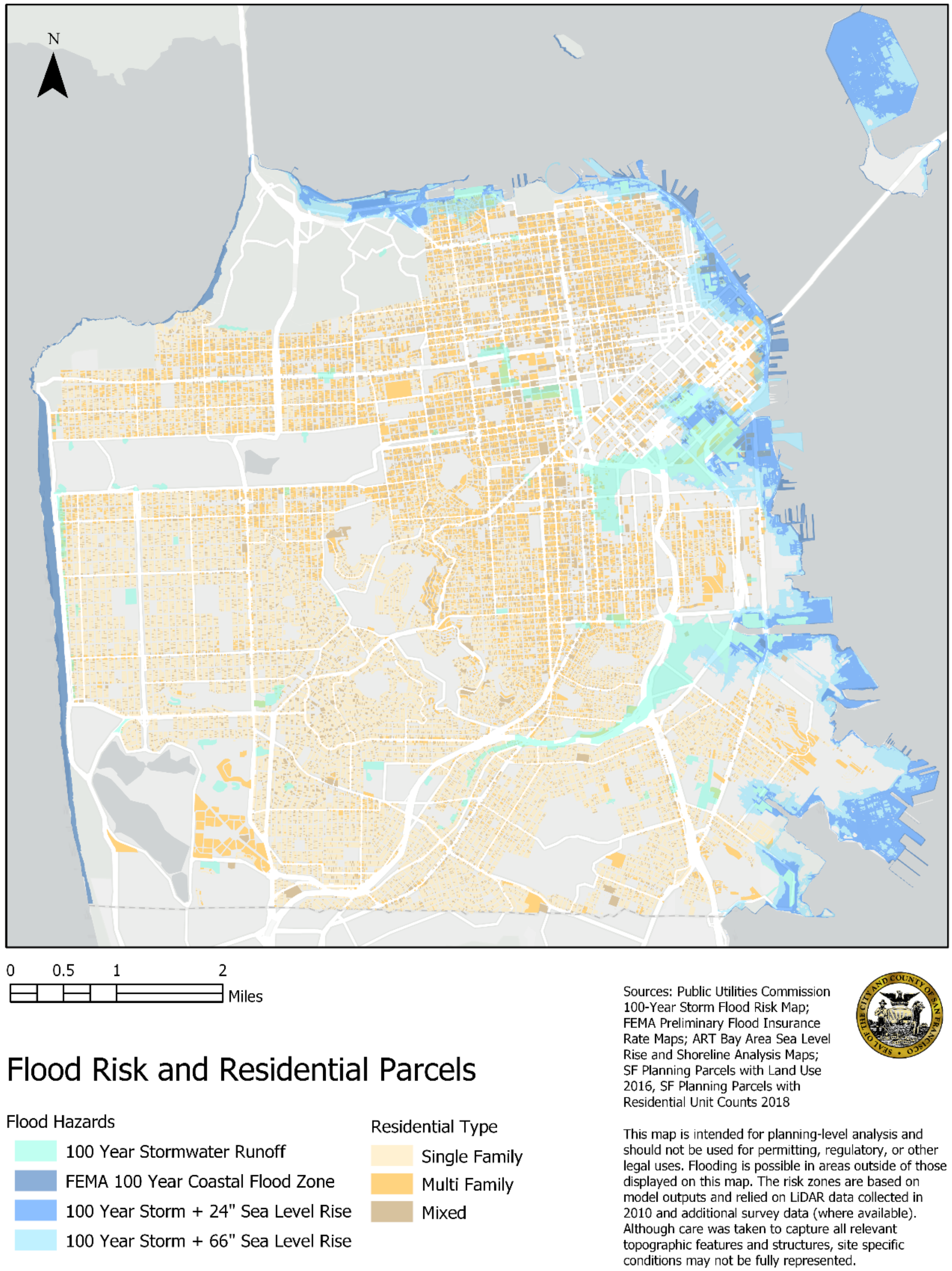
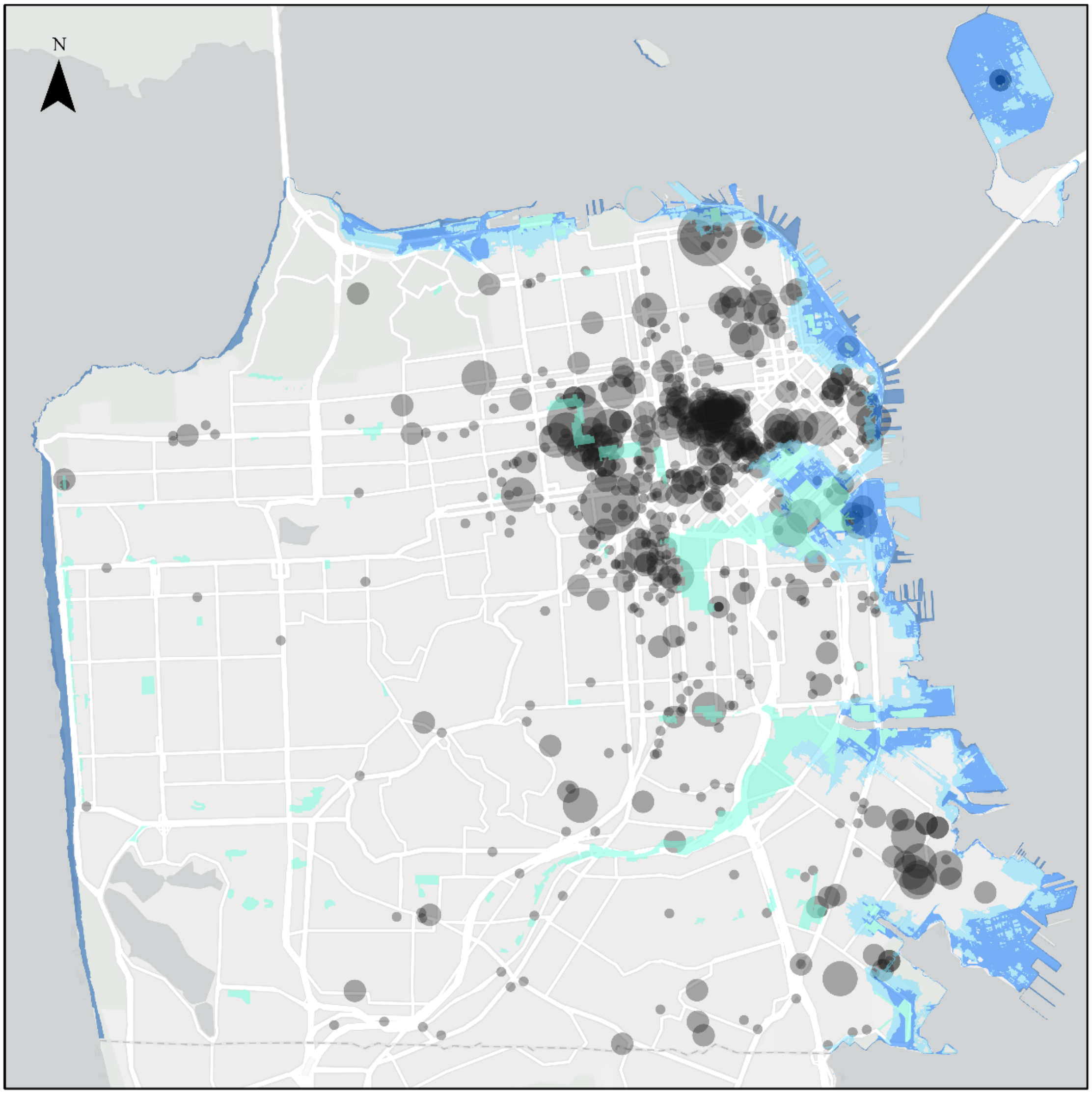


FIGURE A-30: AFFORDABLE HOUSING AND FLOOD HAZARD



0 0.5 1 2
Miles

Flood Risk
Subsidized Affordable Housing

Flood Hazards

- 100 Year Stormwater Runoff
- FEMA 100 Year Coastal Flood Zone
- 100 Year Storm + 24" Sea Level Rise
- 100 Year Storm + 66" Sea Level Rise

Number of Low Income Units

- 1 - 49
- 50 - 149
- 150 - 449
- 450 - 766

Sources: Public Utilities Commission 100-Year Storm Flood Risk Map; FEMA Preliminary Flood Insurance Rate Maps; ART Bay Area Sea Level Rise and Shoreline Analysis Maps; Affordable Housing data compiled by SF Planning in 2018 from CHPC, HUD, MOHCD

This map is intended for planning-level analysis and should not be used for permitting, regulatory, or other legal uses. Flooding is possible in areas outside of those displayed on this map. The risk zones are based on model outputs and relied on LiDAR data collected in 2010 and additional survey data (where available). Although care was taken to capture all relevant topographic features and structures, site specific conditions may not be fully represented.

FIGURE [XX-XX]: WELL-RESOURCED NEIGHBORHOODS

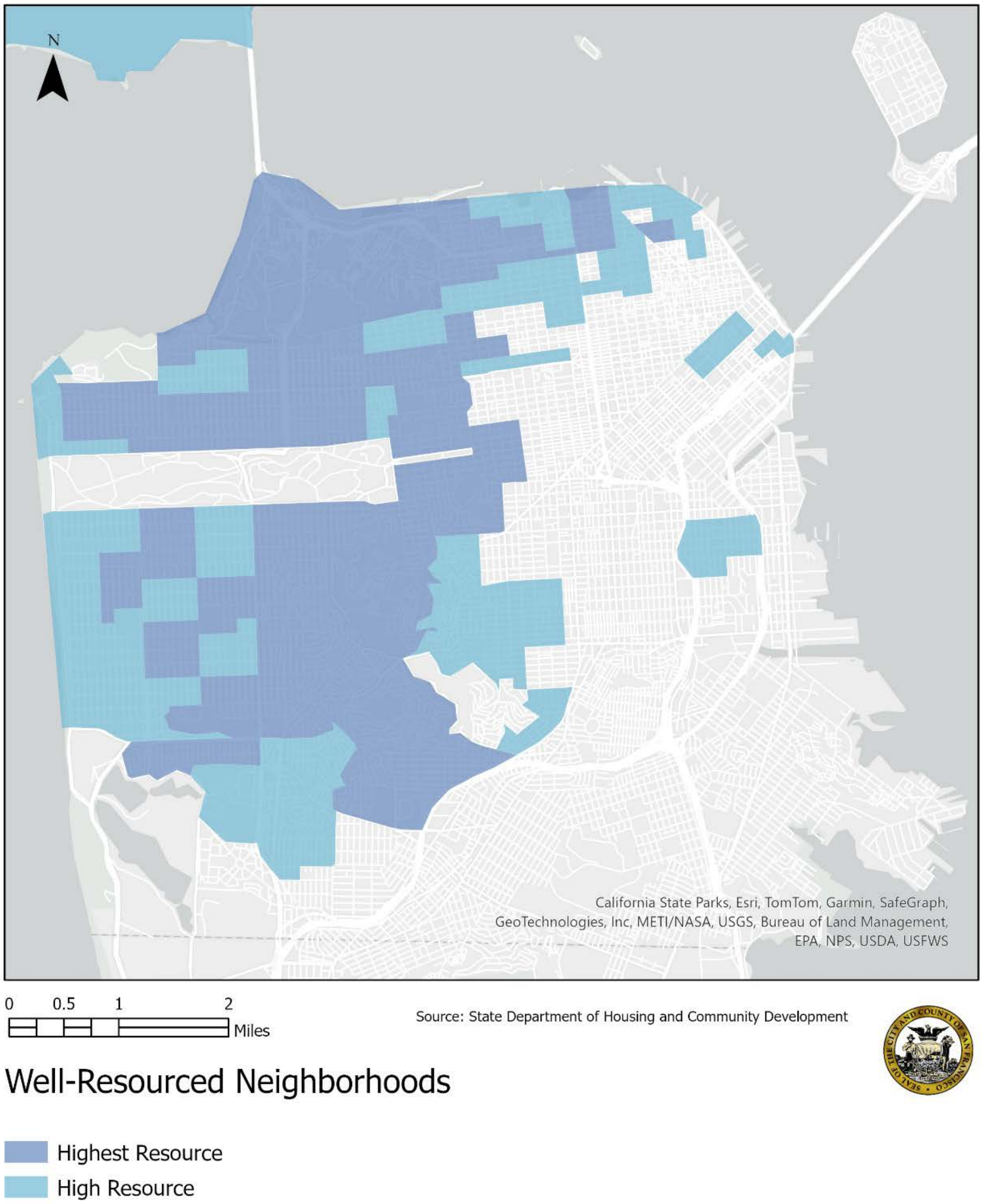
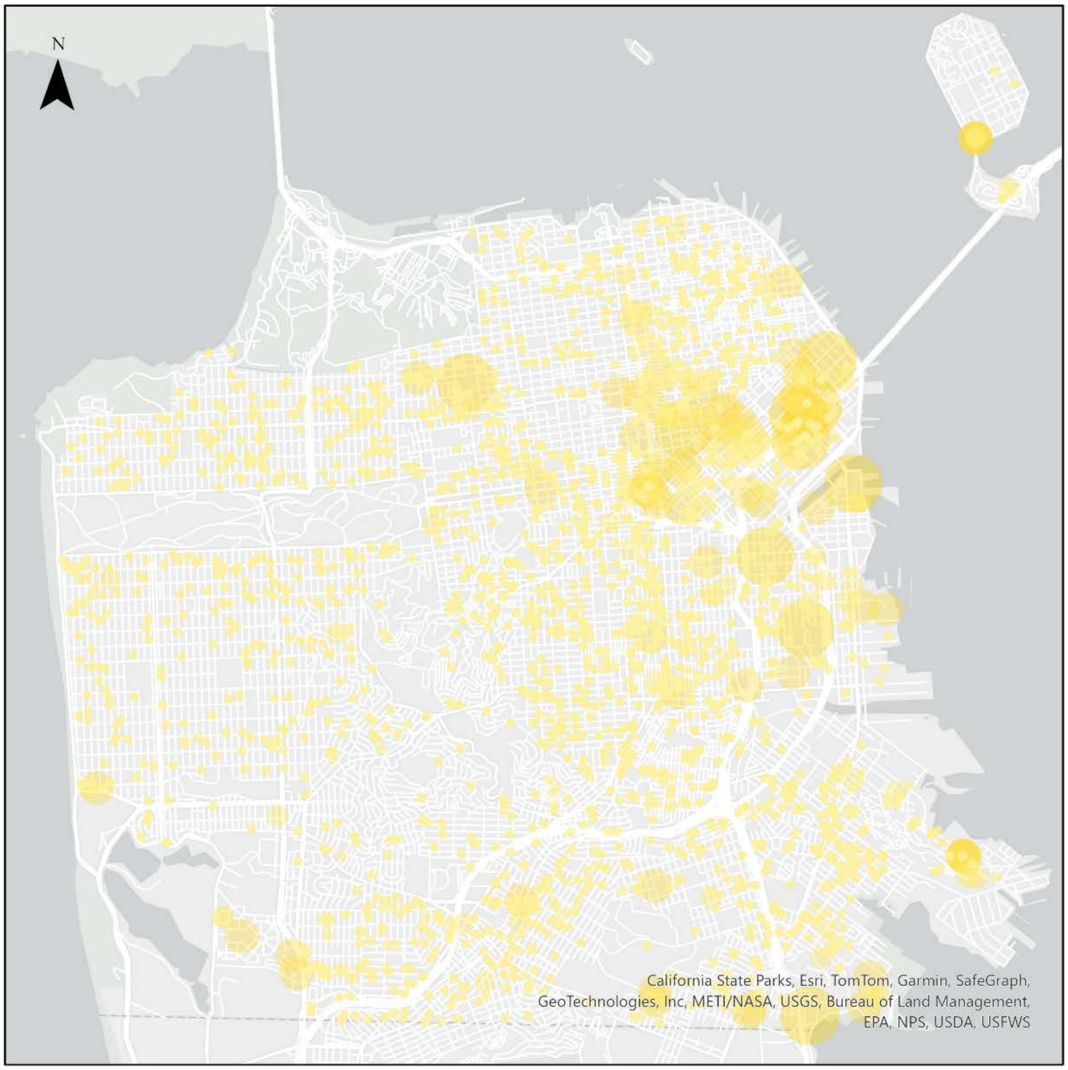


FIGURE [XX-XX]: 2022 SF DEVELOPMENT PIPELINE



0 0.5 1 2 Miles

Source: State Department of Housing and Community Development

2022 SF Development Pipeline

Number of Residential Units in Development

- 1 - 49
- 50 - 149
- 150 - 449
- 450 - 766

VULNERABILITIES

Category	Vulnerability
Physical	Geologic: Ground shaking and liquefaction can damage vulnerable housing types:[7] Older single family homes: Un-retrofitted older single family homes with cripple walls (short unreinforced walls that raise the first floor 1-5 feet above ground level for a crawl space or above ground basement), that are split level, and that have living spaces over an attached garage. Homes built before the 1940s on flat sites and those built in any year on sloped sites are particularly vulnerable. Homes not bolted to their foundation can slide off and the cripple wall or garage walls can collapse. Hillside homes can collapse down the hill with inadequate anchorage. Soft-story buildings: Wood frame multi-family buildings built before 1995 with parking or retail on the ground floor are known to experience ground floor collapse or tilt in an earthquake, as was seen in the Marina District in the Loma Prieta earthquake. More than 2,000 of the city's 4,908 soft-story buildings have been retrofitted to date and work is scheduled to be completed on the remaining buildings by 2020.[8] Older concrete buildings: Concrete buildings constructed prior to 1980 are likely to have nonductile detailing and other deficiencies that have resulted in building collapse in previous earthquakes around the world. These buildings tend to be midrise buildings. Approximately 3,300 such buildings exist in San Francisco (residential and nonresidential), but it is not known which percentage of these pose a collapse risk in an earthquake.[9] Newer construction: Modern building codes are meant to ensure that buildings have low life-safety risks from falling hazards and collapse. However, modern building codes do not provide minimum requirements for controlling earthquake damage that may require extensive repair with extended downtime.[10] Other less common vulnerable housing types include unreinforced masonry, and mobile or manufactured homes. Nonstructural

[7] "Guide to Earthquake Vulnerable Housing Types," Association of Bay Area Governments Resilience Program, December 2016, http://resilience.abag.ca.gov/housing/vulnerable_types/.
[8] "Mandatory Soft Story Program," San Francisco Department of Building Inspection, 2018, https://sfdbi.org/softstory.
[9] "SF Tall Buildings Study," San Francisco Office of Resilience and Capital Planning, unpublished.
[10] "SF Tall Buildings Study," San Francisco Office of Resilience and Capital Planning, unpublished.

	elements such as water heaters and brick chimneys may also cause damage and injury in an earthquake. New models predict that in a M7.8 San Andreas earthquake, 18,300 residential buildings of any size could be damaged in San Francisco, temporarily or permanently displacing 69,600 households (20% of all households) with 16,500 people seeking privately or publicly provided short term shelter. Residential building losses could top $8 billion in San Francisco alone.[11] Voluntary and mandatory retrofit programs for residential property protects residential investments, keeps residents in their homes and neighborhoods intact. Flood: Most homes are not built to withstand any amount of flooding, as current construction materials, siting and design standards do not consider potential exposure to either water or salt. San Francisco does not have an adopted FEMA flood plain with building code requirements but both coastal floodplains (through FEMA) and urban flood zones (through SFPUC) are under development. Extreme Heat: Residential buildings are not physically damaged by heat, but older and un-weatherized buildings or those without air conditioning can lead to unhealthy conditions for occupants, particularly the elderly, children, and those with illnesses that make them more sensitive to heat. Given the usually mild conditions in San Francisco, most housing does not have air conditioning. Fire: Buildings made with wood are highly susceptible to fire. Steel and concrete buildings are less vulnerable to fire damage, and steel buildings contain fire proofing materials to resist fire damage. Because of varying prevailing winds across San Francisco, and the proximity to freeways and other pollution-producing sources, and as serious fire events increase across Northern California, some neighborhoods and households are more adversely affected by poor air quality than others. Most housing in the City does not have HVAC systems or window insulation to mitigate the risks.
Functional	Networks:

[11] "Expected Housing Losses in an Earthquake," Association of Bay Area Governments Resilience Program, September 2018, http://resilience.abag.ca.gov/housing/losses/.

	Although housing is not networked, housing supply is limited and affordable housing is even more limited[12]. Any damage to housing stock could lead to the displacement of residents from the City or region if they cannot find alternative and affordable housing. <u>External Services:</u> Housing relies on power, natural gas, sewer and water systems, and access to food, communications, and transportation for full function. Homes are unlikely to have independent back up power. Many households do not have emergency gas shut-off valves. Residents are encouraged to have earthquake kits including water and food for 72 hours after an event. The Neighborhood Emergency Response Teams (NERTS) and Neighborhood Empowerment Network (NEN) program aim to help empower residents to prepare themselves for disasters. <u>Populations Served:</u> Everyone needs housing, but some residents are already in overcrowded or poor condition housing. (Some are also unhoused, see Populations profile). Low income residents are particularly vulnerable to housing damage because they are more likely to rent, more likely to spend a high percentage of their income on housing and may not have the financial resources to find replacement housing. Structural racism and enduring impacts of exclusionary zoning make these vulnerabilities even more acute for communities of color who face displacement pressure under normal conditions. Natural disasters and/or climate change impacts could worsen this pressure and accelerate displacement without proactive strategies from the City and Community Based Organizations. Older housing without adequate HVAC puts residents at higher risk of heat and air quality health impacts from fire. This has a particular impact on sensitive populations, such as children, the elderly, those who are pregnant, and those with medical conditions. This can be particularly acute in Single Room Occupancy buildings (SROs), as well as Skilled Nursing Facilities (SNFs), which both house highly vulnerable populations. <u>Unique or Critical Function:</u> Housing is limited in supply and provides a critical function for residents. Loss of housing could lead to permanent displacement of residents given low vacancy rates and high rents and property values.
Informational	

[12]"Housing Needs and Trends Report" San Francisco Planning Department, July 2018, https://sfplanning.org/resource/san-francisco-housing-needs-and-trends-report

	<u>All-hazards:</u> ABAG has resources on seismic vulnerable housing types, as well as expected housing losses during a seismic event. The SF Department of Building Inspection maintains data on mandated seismic reporting and retrofitting. The SF Office of Resilience and Capital Planning will soon publish a report on tall buildings and their vulnerability in a seismic event. The USGS HayWired report also outlines SF high rise vulnerabilities during a seismic event. Additionally, a draft vulnerability and consequence assessment exists for sea level rise
Governance	<u>All-hazards:</u> Housing has many individual, private and public owners so hazard mitigation and adaptation action require many different implementation and funding mechanisms. San Francisco has established voluntary and involuntary seismic retrofit programs and is developing a similar program for urban flooding. Building code, planning code, and green building code are important regulatory tools that may be leveraged for developing climate and hazard resilience for housing.

CONSEQUENCES

Category	Consequence
Society/Equity	<u>All-hazards:</u> Low income residents are particularly vulnerable to housing damage because they are more likely to rent, more likely to spend a high percentage of their income on housing, and they may not have the financial resources to find replacement housing. Structural racism and enduring impacts of exclusionary zoning make these vulnerabilities even more acute for communities of color who face displacement pressure under normal conditions. Displacement can result in longer commuters and separation from social connections and resources, affecting families and mental health. Without proactive strategies from the City, companies, foundations, and Community Based Organizations, natural disasters and/or climate change impacts could worsen this pressure and accelerate displacement. Below is more detail on specific housing challenges faced by San Francisco households as well as information on particular types of housing that are more likely to serve low and moderate income people and therefore have special social and equity importance. Rent Controlled Housing: According to data compiled for the Housing Needs and Trends Report an estimated 40% of San Francisco's total housing and nearly 70% of the rental stock are subject to rent control, an estimate of over 160,000 units. As of 2015, an estimated 68,000 low income renters and 24,000

	moderate income renters lived in rent-controlled units and many were paying rents significantly below market. If tenants are forced to relocate after a disaster it could be difficult to find homes at an affordable price and they may be forced to leave the city. In addition, rent controlled housing is mostly multi-unit buildings which may require more time-consuming and costly repair than single family homes. Cost burdened Renters: 2013-2017 ACS data shows over 87,000 renters in San Francisco who are cost burdened, spending more than 30% of income on rent. Of these, over 42,000 are severely cost burdened or paying more than 50% of income on rent. Renter cost burden is concentrated in low- and moderate-income households and severe cost burden is concentrated among extremely low and very low income households who earn up 30% and 50% of area median income, respectively. Many of these households are already taxed financially and dislocation from their housing could make it difficult to remain in the city during recovery and special focus and investment will be needed to help retain these households. Communities of color, including African Americans and Latinos along with seniors and people with disabilities are face higher rates of severe rent burden. Cost Burdened Owners: 2013-2017 ACS data shows over 41,000 owner households are cost burdened spending more than 30% of income. Of these, over 18,000 are severely cost burdened spending more than 50% of income on housing costs. While homeowners have more security of tenure and are likely to have more wealth in home equity, lower income homeowners who are the majority of owners with severe cost burdens, are likely to be least equipped to recover from a disaster with less savings and less capacity to navigate bureaucracy to access recovery funds. Additional services and programs may be needed to reach vulnerable, low income homeowners. Overcrowding: 2013-2017 ACS data shows 6% of all households or 22,000 households are overcrowded, meaning there are more than one person per habitable room and more than half of these households are severely overcrowded with more than 1.5 people per room. Overcrowding is problem overwhelmingly faced by families with children and is mostly a problem for low income households. It is also more pronounced among people of color especially Asians and Latinos. Many families with children who are overcrowding will struggle to find housing that can accommodate their families should they be displaced due to disaster. Services to help accommodate these households in the event of an emergency will help to retain them in the city.

	Subsidized affordable housing: There are approximately 33,000 housing units in San Francisco that have been built or preserved with public subsidy to be affordable to people with low and moderate incomes. This housing has been built and preserved with a range of local, state, and federal sources as well as inclusionary housing policies that require affordable units as part of market rate development. Some buildings that serve low income tenants may have maintenance and modernization needs that could affect recovery or resiliency after a disaster. Because affordable housing financing depends on many sources including tax credits, local public loans, private loans, and state funding, re-financing for repair or rebuilding could be more complex than average for a multifamily building. The need for relocation assistance could be particularly strong for affordable housing tenants during rebuilding or repair. Some publicly funded developments also house people with physical, mental, and developmental disabilities who need special attention. In the event of evacuation, these populations need additional oversight and assistance in the event of displacement. SROs: There are approximately 19,000 single room occupancy (SRO) units in hundreds of buildings around the city. According to San Francisco's Planning code, an SRO unit can be no more than 350 square feet. These small units tend to be more affordable than other housing and disproportionately serve lower income people including many seniors, people with disabilities, people of color, and immigrant families. Most SROs were built in the nine years following the 1906 earthquake and many are nearly 100 years old. As a result, many buildings may have significant maintenance needs, need adaptations for changing weather, and could need significant repairs following a disaster. San Francisco regulates SROs to preserve this housing stock through the Residential Hotel Unit Conversion Ordinance (HCO). Over 12,000 SRO units are privately owned while more 6,500 are nonprofit owned (and are included in the 33,000 affordable units described above). Skilled Nursing Facilities (SNFs), SNFS are often located in residential buildings and serve medically-vulnerable residents who need daily care. Any impacts to residential buildings that include SNFs would have severe impacts on residents who are unable to evacuate and need consistent access to medical care. Geologic: Seismic impacts would be the most widespread and therefore affect more people than other predicted hazards. Low income residents

	and renters may be disproportionately impacted because they may not have insurance or the financial means to seek alternative housing after a seismic event. Flood: Flood impacts to housing would be geographically limited, but historically have been most severe in low-income communities of color (Inner Mission and Cayuga). Flooding can result in mold conditions and adverse health impacts without appropriate cleanup and remediation. Extreme Heat: Heat impacts could disproportionately burden residents in overcrowded or substandard housing who have few resources for weatherproofing or retrofitting. Fire: Fire impacts could disproportionately burden residents in overcrowded or substandard housing. Poor air quality disproportionately affects the health of low-income communities concentrated in areas around freeways and those lacking the favorable prevailing winds (such as Bayview Hunter's Point). During prolonged fire seasons, residents have needed a safe haven from dangerous particulates, but in some neighborhoods, the interiors of residents' homes do not provide that safety. Households and owners in these neighborhoods often do not have the means to install HVAC systems or to seal their windows to mitigate the risks in the homes.
Economy	All-hazards: Depending on the scope of the hazard, impacts could range from individual households or neighborhoods to the region. Homeowners could lose equity in their homes. Both renters and owners would face direct costs like rent for alternative housing and repair/replacement of damage to the house itself and contents. Secondary economic impacts could include lost work time due to displacement and health impacts, and potential disinvestment in vulnerable neighborhoods if mortgage companies refuse loans or other market factors. Housing recovery post-disaster can take weeks to years depending on damage type and funding availability. Housing may or may not be habitable during recovery depending on the severity of the impact and what repairs are necessary. According to the 2018 Housing Needs and Trends Report, majority of lower wage workers in San Francisco also live in the city but the rate of lower wage workers living in the city has been declining and these workers may have higher vulnerability to displacement during

	a major disaster, given high market housing prices. San Francisco's post-disaster economic recovery could be hindered without plan to temporarily house and permanently re-house these workers. Geologic: Seismic hazards are the most widespread and could lead to regional impacts on housing supply in a large event with 68,900 residential buildings uninhabitable and 198,700 households potentially displaced across the Bay Area in a M7.8 San Andreas earthquake.[13] Most households do not carry earthquake insurance. Flood: Economic impacts from flood events on housing are likely to be limited to specific neighborhoods. FEMA flood insurance is not required in San Francisco which may lead to more severe economic impacts for homeowners and renters in the flood zone. Extreme Heat: Increased HVAC use can lead to higher operational costs for building owners. Recurring heat events could lead to increased medical costs and lost wages for outdoor workers. Fire: Fire events could result in direct economic impacts like damaged or destroyed homes and businesses. Without mitigations, poor air quality may result in extreme and costly health outcomes, with the attendant loss of economic vitality in the City. The key mitigation -- HVAC systems -- are costly for property owners.
Environment	Geologic: Reconstruction of damaged housing may be material and energy intensive and include emissions from equipment and impacts from trucks supplying construction materials. Temporary or interim housing may face challenges with management of wastewater and solid waste and may temporarily occupy open space. Displacement could cause longer commutes, which increases congestion and GHG emissions. Debris management and removal may have impacts, including truck traffic, and exposure to harmful chemicals. Flood: Floods could mobilize household hazardous waste that is improperly stored leading to water quality impacts. Extreme Heat:

[13] "Expected Housing Losses in an Earthquake," Association of Bay Area Governments Resilience Program, September 2018, http://resilience.abag.ca.gov/housing/losses/.

	Increased use of HVAC systems could increase GHG emissions if these are not efficient and using a clean energy source. Fire: Debris management and removal has the potential to expose humans and the environment to harmful chemicals if not properly managed. The use of HVAC systems to mitigate the hazard may have the unintended consequence of increased GHG emissions.

Business and Industry Sector

Commercial Buildings

Introduction to Asset Class

For this assessment, commercial buildings are classified as office, retail, hotels, and mixed use property types. San Francisco has a high number of office properties, making up 55% of total commercial floor area (including hotels and industrial) and 37% of all commercial buildings in 2014. All other non-hospitality and warehouse properties (including retail) make up 27% of total commercial floor area and 43% of all commercial buildings.[14] There were 218 hotels counted in 2017, with more than 34,000 rooms.[15] San Francisco's commercial properties house the economic engine of San Francisco, supporting the City's tech and finance industries.

Commercial buildings are found throughout the city, but are densely concentrated in the northeast quadrant. Nearly 60% of hotel rooms in San Francisco are located within walking distance of the Moscone Center in the South of Market neighborhood.[16] The northeast quadrant features a variety of commercial building types, from small wood frame and masonry buildings to concrete and steel frame skyscrapers. Neighborhood commercial properties are prevalent throughout the city and concentrated along commercial corridors. These commercial buildings are smaller, usually 1-5 stories, and are often mixed use properties with retail use on the ground floor and residential or office use above. These properties are largely privately owned and managed.

Issue Statement

Commercial buildings are critical infrastructure for one of the largest job centers in the Bay Area. These buildings have a variety of built forms, and some have been identified as significantly vulnerable in a seismic and/or fire event. Pre-1978 wood frame buildings with residential units over commercial or retail spaces, known as soft-story buildings, are vulnerable to collapse in earthquakes. Older steel frame buildings constructed between the 1960s and 1990s have known deficiencies, including welded steel connections that have fractured in strong shaking during the 1994 Northridge

[14] "San Francisco Existing Commercial Buildings Performance Report," SF Environment and ULI Greenprint Center for Building Performance, 2015, http://uli.org/wp-content/uploads/ULI-Documents/SFenergybenchmarkingreport.pdf.
[15] "2017 Lodging Statistics," San Francisco Travel, March 2018, https://sftravel.ent.box.com/s/qjchpspcuabqx400kp64yf4lqvtmbngw.
[16] "San Francisco Visitor Industry Statistics," San Francisco Travel, 2018, https://www.sftravel.com/san-francisco-visitor-industry-statistics-1.

earthquake. Older concrete buildings constructed before 1980 (a common building type in San Francisco) are likely to have non-ductile construction and other detailing that have led to collapse in past earthquakes. San Francisco's Earthquake Safety Implementation Program calls for older concrete buildings to be evaluated starting in 2020 and for older steel frame buildings to be evaluated starting in 2030. Soft-story buildings are required to be retrofitted by 2020.

Hotels are a unique asset in the commercial category, providing overnight housing for City visitors, who are particularly vulnerable in a hazard event. In the event of an evacuation due to earthquake or fire, the length of time necessary to evacuate large volumes of people who work in high rises coupled with the potentially short period of time available to safely evacuate makes populations who work in high rises particularly at risk, especially those with limited mobility or medical conditions. Many businesses in San Francisco handle highly sensitive data, information, or capital that could impact the national and global economy if operations are disrupted.

Exposure

Hazard Data Assumptions

This analysis was conducted in 2018 and 2019 using publicly-available data sources. In Table A-11, on the following page, shaking intensity is represented for two Earthquake scenarios: San Andreas Fault M7.8 and Hayward Fault M7.0 events. Accounts of assets subjected to varying levels of shaking intensity are cumulative for each scenario.

Asset Data Assumptions

Asset data originates from datasets maintained by SF Planning.

Exposure Summary

Geologic: During a 7.8M earthquake on the San Andreas Fault, all commercial parcels are at risk of either Violent or Very Strong groundshaking. During a 7.0M earthquake on the Hayward fault, over 90% of office and commercial parcels are at risk of Very Strong or Strong groundshaking, retail parcels face slightly less risk citywide. Over 40% of office and hotel parcels are in the liquefaction zone, compared to 35% of mixed commercial parcels, and 22% of retail parcels.

Flood: Commercial asset exposure to flooding is minimal, but 13% of office parcels and 9% of mixed commercial parcels are in areas which may be exposed to 66 inches of future sea level rise, if protective measures are not taken.

Fire: Commercial assets not exposed

TABLE A-21: EXPOSURE

Hazard	Office Parcels 1300 Total		Mixed Commercial Parcels 1900 Total		Retail Parcels 2700 Total		Hotel Parcels 300 Total	
	#	%	#	%	#	%	#	%
Geologic								
San Andreas 7.8 - Violent	100	8%	300	13%	500	18%	-	3%
San Andreas 7.8 - Very Strong	1,200	92%	1,700	87%	2,200	82%	300	97%
Hayward 7.0 - Very Strong	200	16%	200	8%	100	5%	-	9%
Hayward 7.0 - Strong	1,000	76%	1,600	83%	2,200	80%	200	88%
Liquefaction Zone	600	44%	700	35%	600	22%	100	42%
Flooding								
100-Year Coastal Flood Zone	-	0%	-	0%	-	0%	-	0%
100-Year Storm + 24 inches SLR	100	5%	100	4%	-	2%	-	3%
100-Year Storm + 66 inches SLR	200	13%	200	9%	100	4%	-	7%
100-Year Stormwater Flood	100	5%	100	5%	100	4%	-	4%
Wildfire								
High	-	0%	-	0%	-	0%	-	0%
Moderate	-	0%	-	0%	-	0%	-	0%

Note: For an exposure table with additional hazards, please see Chapter 5.

FIGURE A-31: COMMERCIAL USES AND LIQUEFACTION HAZARD

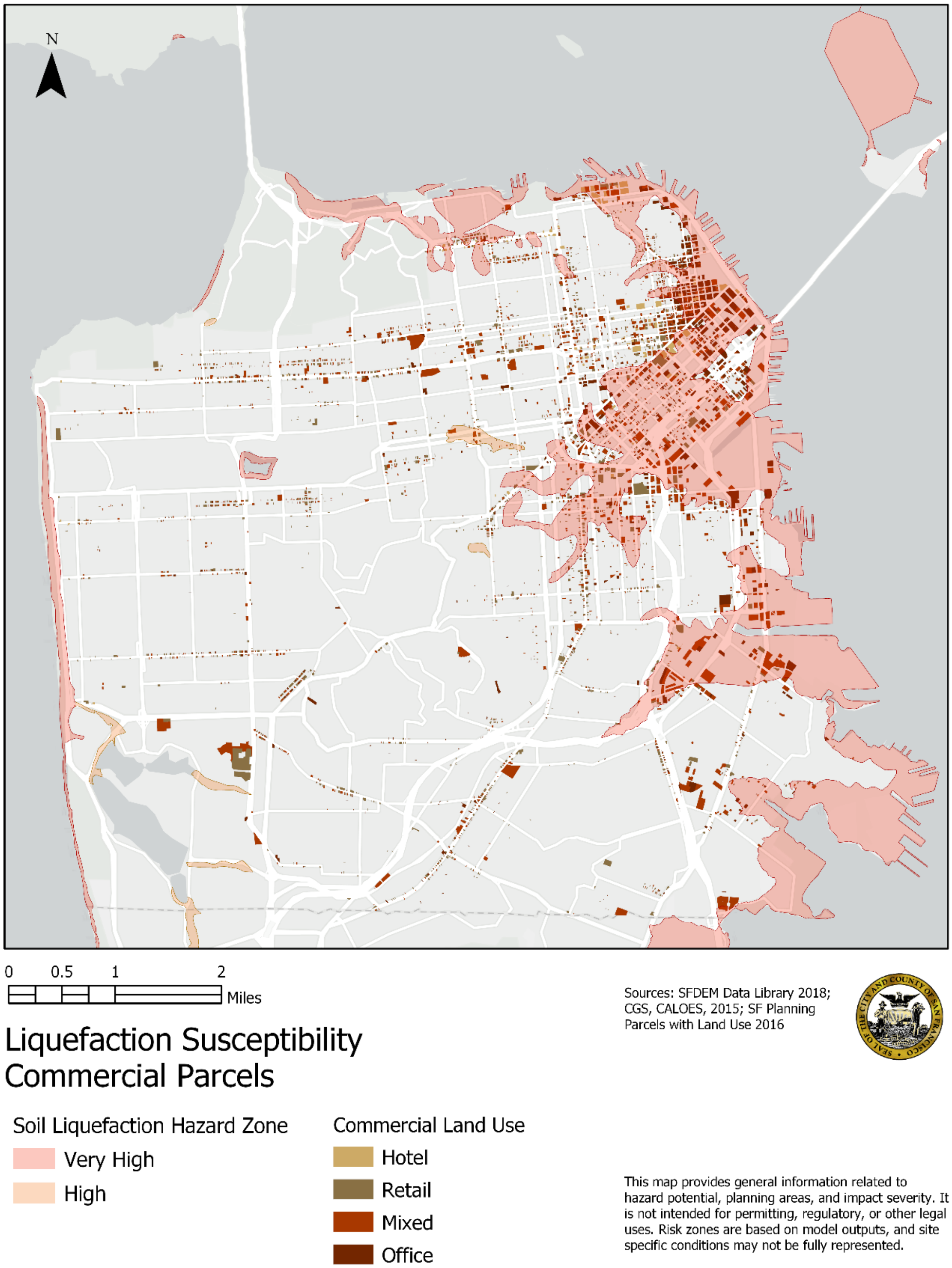
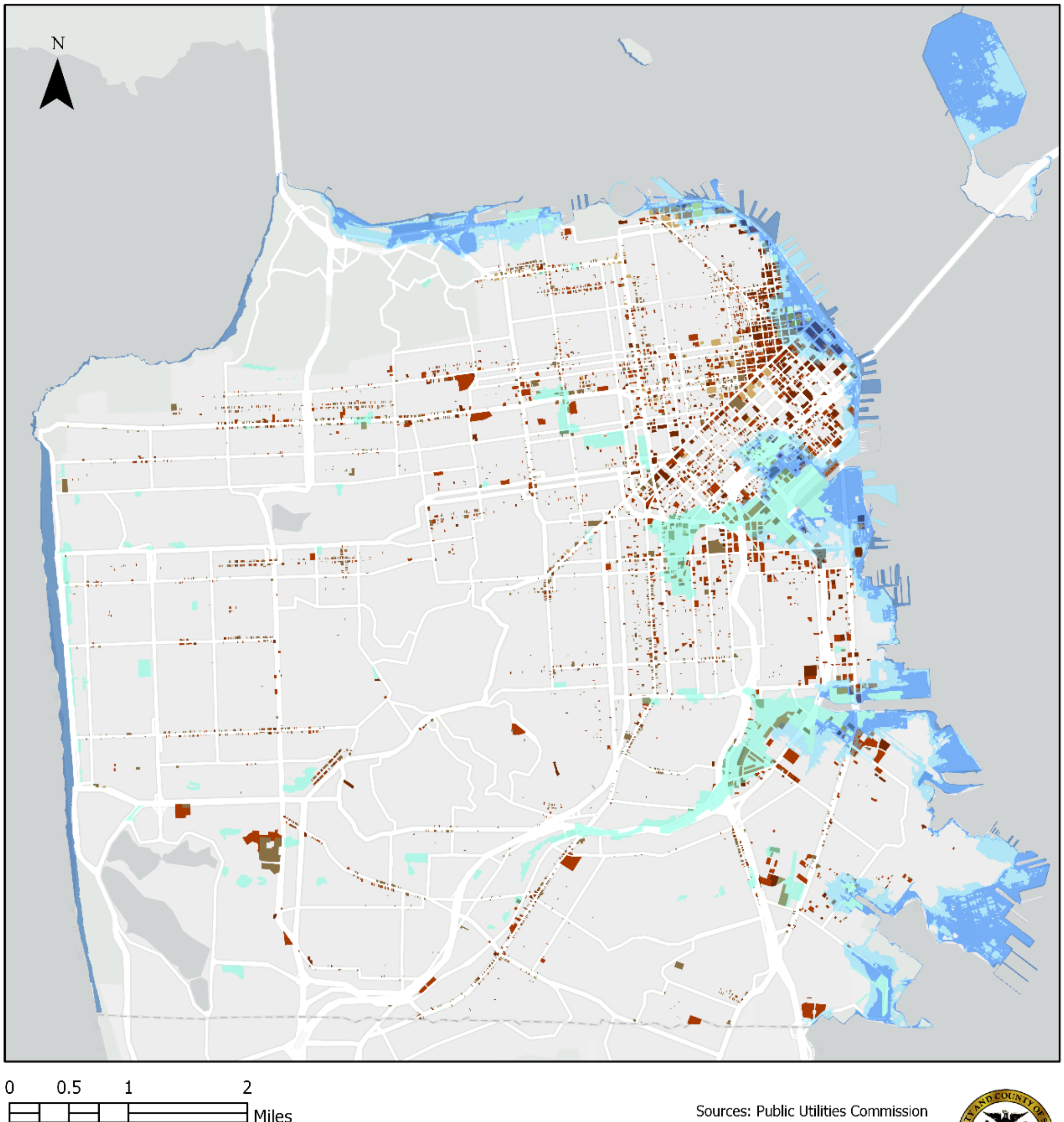


FIGURE A-32: COMMERCIAL USES AND FLOOD HAZARDS



Flood Risk and Commercial Parcels

Flood Hazards
- 100 Year Stormwater Runoff
- FEMA 100 Year Coastal Flood Zone
- 100 Year Storm + 24" Sea Level Rise
- 100 Year Storm + 66" Sea Level Rise

Commercial Land Use
- Hotel
- Retail
- Mixed
- Office

Sources: Public Utilities Commission 100-Year Storm Flood Risk Map; FEMA Preliminary Flood Insurance Rate Maps; ART Bay Area Sea Level Rise and Shoreline Analysis Maps; SF Planning Parcels with Land Use 2016

This map is intended for planning-level analysis and should not be used for permitting, regulatory, or other legal uses. Flooding is possible in areas outside of those displayed on this map. The risk zones are based on model outputs and relied on LiDAR data collected in 2010 and additional survey data (where available). Although care was taken to capture all relevant topographic features and structures, site specific conditions may not be fully represented.

VULNERABILITIES

Category	Vulnerability
Physical	Geologic: Pre-1978 soft story buildings are vulnerable to extensive damage. This impacts commercial or retail spaces housed underneath multi-unit residential buildings or offices. Regulation requires these buildings (with 5+ units, and with 2+ stories over a soft story) to be retrofitted by 2020. Unreinforced masonry buildings that have not been retrofitted are also vulnerable to damage, but existing retrofit regulation should make these examples rare. Pre-1980 non-ductile concrete frame buildings are brittle and vulnerable to extensive damage with significant life safety risk.[17] Approximately 3,400 such buildings exist in San Francisco (residential and nonresidential), but it is not yet known which small percentage of these pose a collapse risk in an earthquake. Steel frame structures built between 1960 and 1994 are vulnerable to earthquakes if they use a welded steel construction method.[18] San Francisco's Earthquake Safety Implementation Program and Tall Buildings Safety Strategy recommend non-ductile concrete buildings and welded steel frame buildings be evaluated starting in 2020. Flood: Most commercial properties are not built to withstand any amount of flooding, as construction materials, siting and design standards do not require consideration of potential exposure to either water or salt. Extreme Heat: Older buildings that do not have adequate weatherization or HVAC may be more vulnerable to heat impacts. Fire: Buildings made with wood are highly susceptible to fire. Steel and concrete buildings are less vulnerable to fire damage and steel buildings contain fire proofing materials to resist fire damage. Older buildings that do not have adequate HVAC and filtration technology may be more vulnerable to air quality impacts.
Functional	Networks: Commercial buildings themselves are not networked, however, businesses may have important supply, information, or capital networks between them. Businesses that handle highly sensitive

[17] "Guide to Earthquake Vulnerable Commercial Building Types," Association of Bay Area Governments Resilience Program, September 2016, http://resilience.abag.ca.gov/commercial-building-types/

[18] Detweiler, S.T., and Wein, A.M., eds., 2018, The HayWired earthquake scenario—Engineering implications: U.S. Geological Survey Scientific Investigations Report 2017–5013–I–Q, 429 p., https://doi.org/10.3133/sir20175013v2

	data/capital may have detailed contingency plans if their operations are disrupted or shut down. <u>External Services:</u> Office and retail businesses rely on power, water, communications, and transportation access for full functioning. Buildings that have sensitive components (such as life and sciences commercial uses) may be more likely to have back up power. <u>Populations Served:</u> Commercial buildings house businesses that employ residents of SF and the greater Bay Area. These are typically those of working age, and include those who are physically disabled, low income, housing and transportation cost burdened, non-English speakers, renters, and those without cars. Hotels serve visiting populations overnight. Visitors may not speak English as a first language, have fewer back-up resources available to them, and may not know how to access important information or emergency service. Businesses and nonprofits that use commercial properties may be a part of the Neighborhood Emergency Response Team that aids in emergency response efforts. <u>Unique or Critical Function:</u> Commercial buildings in SF house one of the largest job centers in the Bay Area. These facilities are necessary for the Bay Area's primary industries to function. Many of these facilities house companies that could impact the global economy if their services are disrupted. Hotels house tens of thousands of visitors overnight daily.
Informational	<u>All-hazards:</u> ABAG has resources on seismic vulnerable commercial building types. The SF Department of Building Inspection maintains data on mandated seismic reporting and retrofitting. The SF Office of Resilience and Capital Planning published a report on tall buildings and their vulnerability in a seismic event, and strategies to reduce vulnerability. The USGS HayWired report also outlines SF high rise vulnerabilities during a seismic event. Additionally, a Regional Vulnerability and Consequence Adaptation Study exists for sea level rise threat.
Governance	<u>All-hazards:</u> SF building code regulates commercial building safety requirements. This includes soft story and masonry retrofit requirements, as well as HVAC, filtration, and fire requirements. San Francisco's building code also contains requirements for post-earthquake repair and retrofit of earthquake damaged buildings (AB-098, AB-099, AB-100).

CONSEQUENCES

Category	Consequence
Society/Equity	<u>All-hazards:</u> SF's commercial buildings provide places of work for San Franciscans and for a large proportion of Bay Area residents. Damage and disruption to these buildings can disrupt these residents' work, their workplace social networks, and can even prompt widespread short term unemployment. This is particularly impactful to the lives of those who are non-salaried, who are low-income, and who are transportation and housing burdened. Hotels also provide overnight housing for tens of thousands of San Francisco visitors daily. These guests may not speak English as a primary language, they will have fewer resources available to them, they may not know how to access important information or emergency services, and they are heavily reliant on hotel emergency procedures for their safety. Many commercial buildings are also important to the cultural identity of the surrounding neighborhood or city. These businesses can provide places for community members to gather and socialize, they can provide a unique neighborhood function, or they can serve as a community symbol. The destruction of these landmarks and nodes can have significant impacts to community identity and can disrupt local social networks. <u>Geologic:</u> Significant groundshaking can result in human casualties from building damage. In a large seismic event, populations in high rises are especially vulnerable in the event of an emergency evacuation, due to the short time available to safely evacuate, the large volume of people who need to evacuate, and the long distances many people will need to travel to evacuate. Populations with limited mobility or medical conditions are particularly at risk. Emergency plans and evacuation procedures are required by federal law. <u>Flood:</u> Significant stormwater flooding may result in human casualties if there is no 2nd story. Populations with limited mobility or medical conditions are particularly at risk. <u>Extreme Heat:</u> Heatwaves may cause closures in non-weatherized buildings without cooling capabilities. Heat waves increase health risk for medically sensitive populations, such as the elderly, pregnant women, and those with medical conditions.

	Fire: Significant fire can result in human death or injury, especially in high rises. Populations in high rises are especially vulnerable in the event of an emergency evacuation, due to the short time available to safely evacuate, the large volume of people who need to evacuate, and the long distances many people will need to travel to evacuate. Populations with limited mobility or medical conditions are particularly at risk. Emergency plans and evacuation procedures are required by federal law. The *San Francisco Building Code* requires many buildings to have an in-building secondary water supply to operate the sprinkler system for 30 minutes. The Tall Buildings Safety Strategy recommends a study to evaluate whether (1) the in-building secondary water supply for automatic fire suppression in tall buildings is sufficient to inhibit fire spread and allow safe evacuation, and (2) the building code provisions that rely on elevators for evacuation during a fire emergency will be effective following an earthquake. Air Quality: Reduced air quality from fire smoke in unfiltered buildings can result in increased rates of asthma attacks. This is especially true in under-resourced communities and communities of color, which have significantly higher rates of bronchial disease. Smoke impacts will not cause building damage or long term closure.
Economy	All-hazards: Any damage to the facility will require property owners to fund repairs or replacement. Businesses owners will have to bear the cost of relocating or otherwise accommodating its employees in the event of structural building damage. Each day of closure or limited facility use can reduce or eliminate daily revenue. In addition, non-salaried employees will lose wages for each day of closure. Hourly employees and small business employees/owners are most impacted by these events. Permanent closures will result in loss of employment. Many commercial building owners participate in DBI's Building Occupancy Resumption Program (BORP), which allows San Francisco building owners to pre-certify private post-earthquake inspection of their buildings by qualified engineers and specialty contractors to help speed re-occupancy of these buildings. Geologic: Depending on severity and building type, damage can lead to short to long term closure. The shutdown of many financial institutions and other global companies in the event of severe shaking and liquefaction may have economic impacts that are felt worldwide. Construction investment in the event of widespread destruction

	may have positive economic effects as well ("Creative Destruction" effect). Flood: Neighborhoods in coastal and storm water flood zones will see the most damage and economic impact. Extreme Heat: Depending on severity, health hazard can lead to short term closure in older buildings that do not have adequate HVAC. Those with adequate HVAC will increase power use and see associated financial impact. This hazard will not cause permanent or indefinite closure. Fire: Damage from fire can lead to short to long term closure. Air quality reduction from fire will not cause permanent or indefinite closure.
Environment	Geologic: Air quality could be temporarily impacted by the production of particulate matter from building damage. Reconstruction of damaged buildings may be material and energy intensive, including emissions from equipment and impacts from trucks supplying construction materials. Debris management and removal may have impacts, including truck traffic, and exposure to harmful chemicals. Flood: Flooding may cause debris from the building and soil from around the building to move into waterways. Floods could mobilize hazardous waste that is improperly stored leading to water quality impacts. Extreme Heat: Increased use of HVAC systems could increase GHG emissions if these are not efficient and using a clean energy source. Fire: Air quality would be reduced in the neighborhood, potentially regionally, if commercial buildings are directly impacted by fire. Debris management and removal has the potential to expose humans and the environment to harmful chemicals if not properly managed.

Industrial Buildings

Introduction to Asset Class

Industrial buildings are classified as production, distribution, repair (PDR) property types, housing industries such as construction, utilities, transportation, warehousing, fleet lots, wholesale, light manufacturing. Industrial buildings may also include more intensive uses, such as waste management or Port facilities. These properties house an important part of San Francisco's economy, with PDR jobs making up 14% of total employment and 8% of establishments in 2018.[19] PDR industries are especially important employers for low income families, with 70% of manufacturing employees coming from low income households.[20] The 2016 industrial inventory counts nearly 4,800 PDR establishments.[21] Around 2,100 parcels in San Francisco are for PDR use.

These buildings are densely concentrated in the east and southeast neighborhoods, including SOMA Showplace Square, Potrero Hill, Central Waterfront, and Bayview Hunters Point. PDR and waste management properties often take a warehouse building form (including tilt-up construction), but smaller industries may be found in a variety of commercial building types, such as masonry buildings and soft stories. These properties are largely privately owned and managed, though the City owns several maintenance and operations facilities, described in the Municipal Buildings section.

Issue Statement

Industrial buildings are critical infrastructure for job centers in the Bay Area that are especially important for low income households and for individuals without a post-secondary degree. These buildings often use old concrete, concrete tilt-up, and masonry construction, which are particularly vulnerable building types in a seismic event.[22] Smaller industrial companies may also use soft story building types. There is currently no mandatory retrofit regulation for tilt-up building forms. These buildings are

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[19] "2018 San Francisco Commerce and Industry Inventory," San Francisco Planning Department, 2020 http://commissions.sfplanning.org/cpcpackets/2016CII.pdf.
[20] "Make to Manufacture: Advanced Manufacturing Playbook," Office of Economic and Workforce Development, 2016, https://oewd.org/sites/default/files/Documents/Make_to_Manufacture%20%282%29.pdf.
[21] "2016 San Francisco Commerce and Industry Inventory," San Francisco Planning Department, 2016, http://commissions.sfplanning.org/cpcpackets/2016CII.pdf.
[22] "San Francisco's Earthquake Risk," Department of Building Inspection, 2009,
https://sfdbi.org//sites/default/files/Documents/Boards_and_Commissions/Agenda_Attachments/Task_2_Report_apr8DRAFT.pdf

concentrated in low-lying neighborhoods with significant flood and liquefaction risks. Industrial buildings are important to maintain regional supply chains, distribution, and logistics, as well as citywide waste management.

TABLE A-22: EXPOSURE

Hazard	Industrial Parcels 2,100 Total	
	#	%
Geologic		
San Andreas 7.8 – Violent	200	7%
San Andreas 7.8 - Very Strong	1,900	93%
Hayward 7.0 - Very Strong	300	15%
Hayward 7.0 - Strong	1,700	81%
Liquefaction Zone	1,200	58%
Flooding		
100-Year Coastal Flood Zone	100	3%
100-Year Storm + 24 inches SLR	200	10%
100-Year Storm + 66 inches SLR	500	22%
100-Year Stormwater Flood	300	14%
Wildfire		
High	-	0%
Moderate	-	0%

Note: For an exposure table with additional hazards, please see Chapter 5.

Exposure Summary

Geologic: All industrial parcels are within Violent or Very Strong groundshaking zones during a 7.8M earthquake on the San Andreas Fault. Ninety-six percent of industrial parcels are within Very Strong or Strong groundshaking zones during a 7.0M earthquake on the Hayward fault. Nearly sixty percent of industrial parcels are in a liquefaction risk zone.

Flood: Currently, three percent of industrial parcels have some portion in FEMA's 100-year coastal flood zone, and fourteen percent in the SFPUC's 100-year stormwater flood zone. In the future, ten percent of industrial parcels may be exposed to 24 inches of sea level rise, and 22% may be exposed to 66 inches.

Fire: Limited to no exposure.

FIGURE A-33: INDUSTRIAL USES AND LIQUEFACTION HAZARD

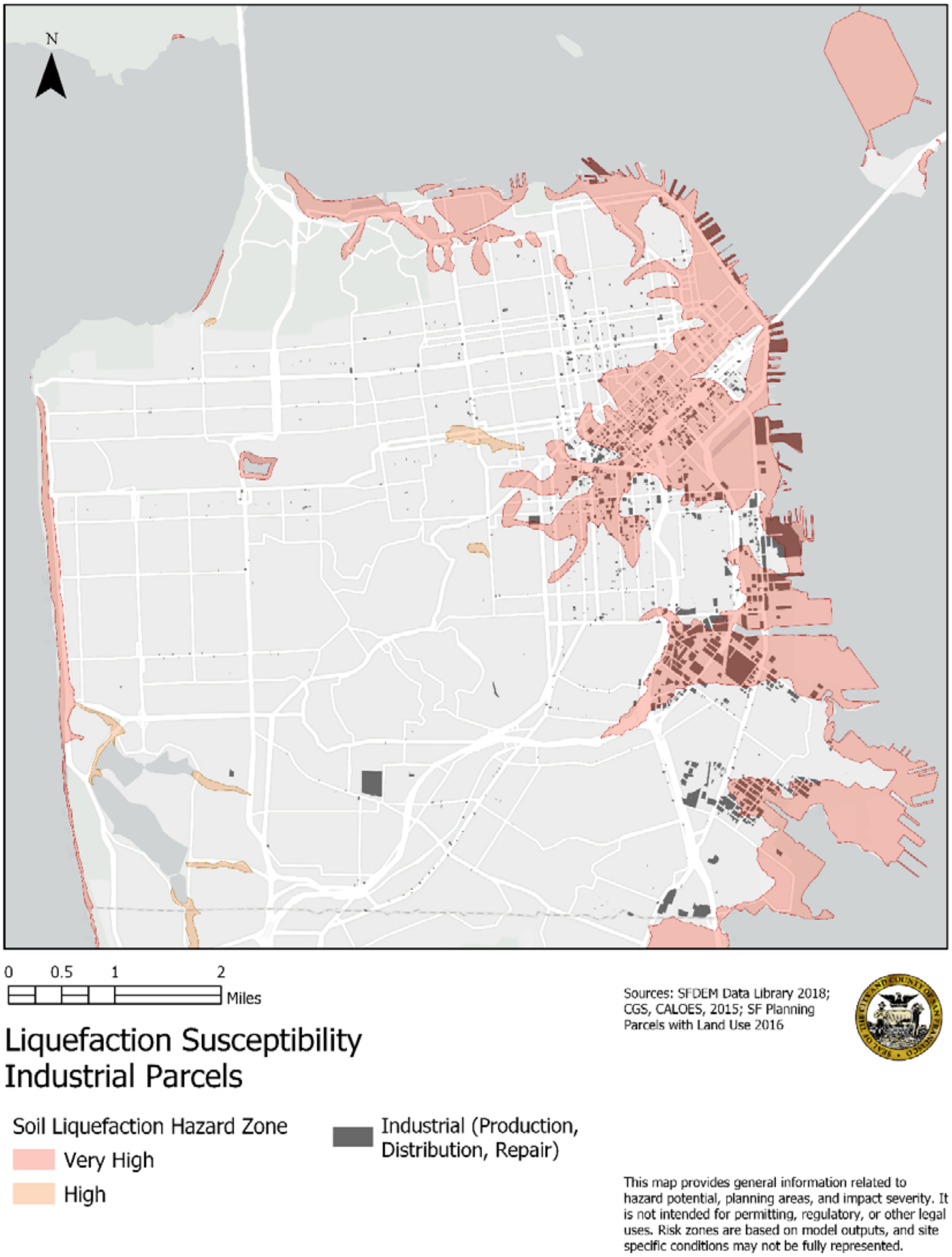
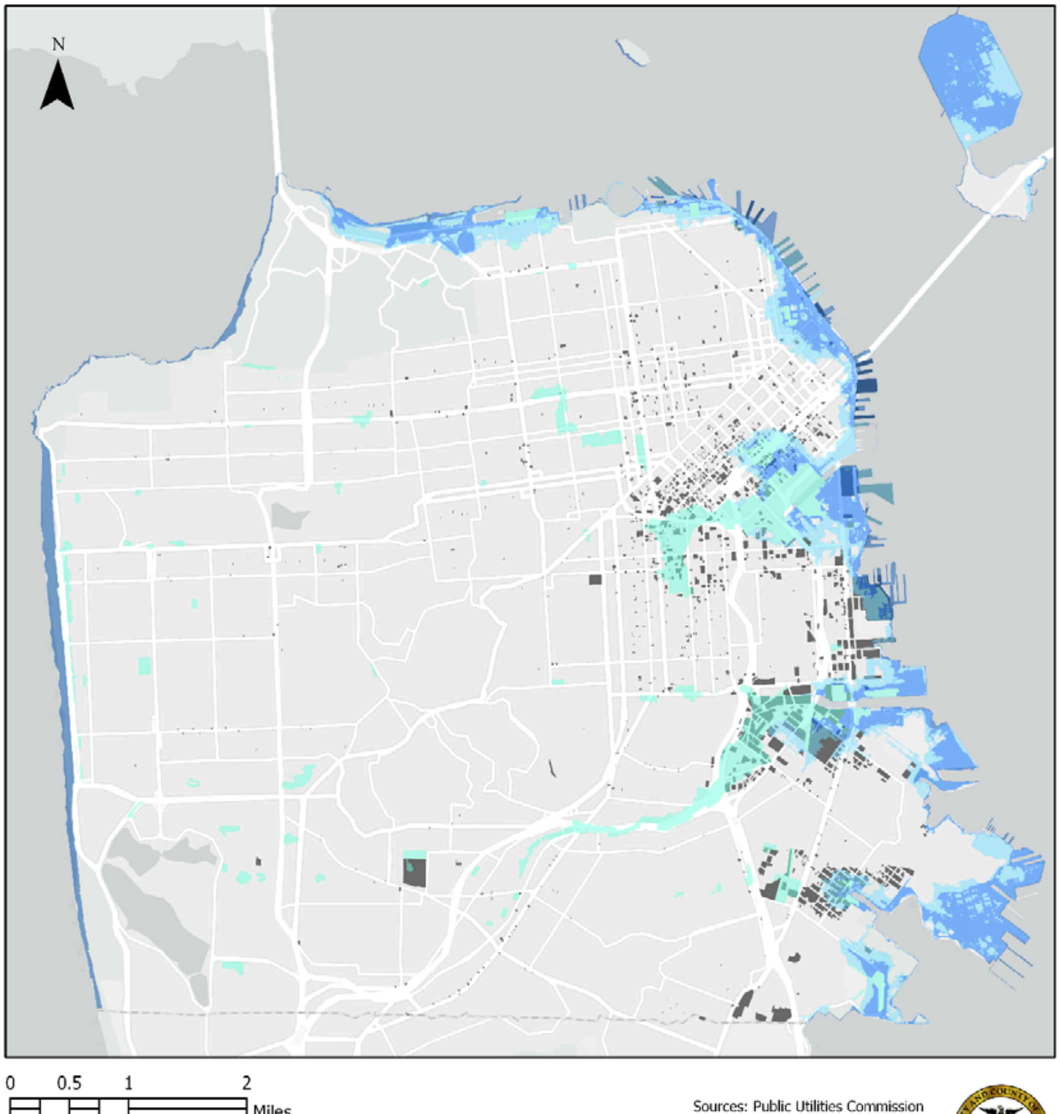


FIGURE A-34: INDUSTRIAL USES AND FLOOD HAZARDS



Flood Risk and Industrial Parcels

Flood Hazards

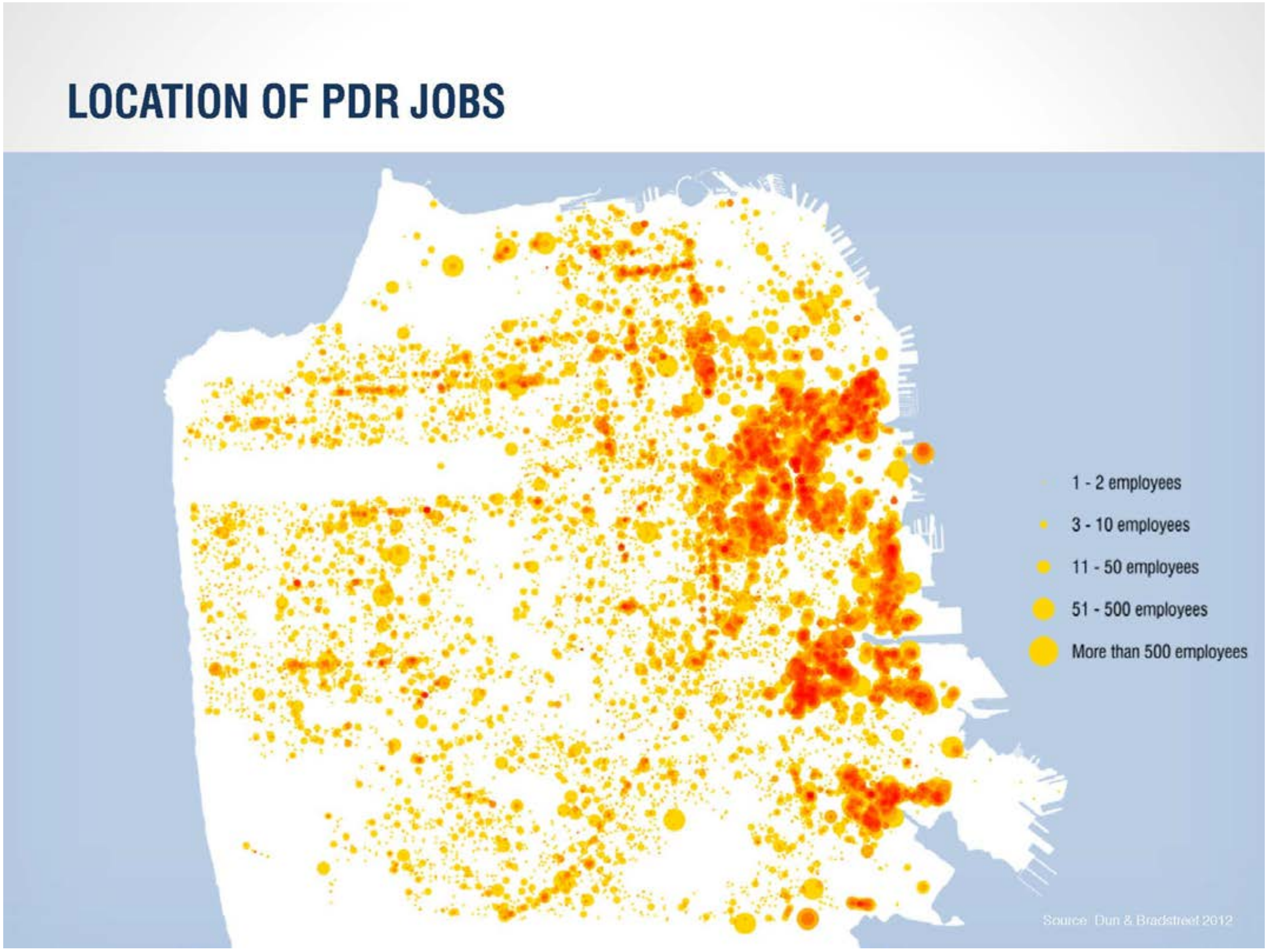
- 100 Year Stormwater Runoff
- FEMA 100 Year Coastal Flood Zone
- 100 Year Storm + 24" Sea Level Rise
- 100 Year Storm + 66" Sea Level Rise

Industrial (Production, Distribution, Repair)

Sources: Public Utilities Commission 100-Year Storm Flood Risk Map; FEMA Preliminary Flood Insurance Rate Maps; ART Bay Area Sea Level Rise and Shoreline Analysis Maps; SF Planning Parcels with Land Use 2016

This map is intended for planning-level analysis and should not be used for permitting, regulatory, or other legal uses. Flooding is possible in areas outside of those displayed on this map. The risk zones are based on model outputs and relied on LiDAR data collected in 2010 and additional survey data (where available). Although care was taken to capture all relevant topographic features and structures, site specific conditions may not be fully represented.

FIGURE A-35: LOCATION OF PDR JOBS



VULNERABILITIES

Category	Vulnerability
Physical	Geologic: Pre-1978 soft story buildings are vulnerable to extensive damage. This impacts small industrial businesses housed underneath multi-unit residential buildings or offices. Regulation requires these buildings (with 5+ units, and with 2+ stories over a soft story) to be retrofitted by 2020. Unreinforced masonry buildings that have not been retrofitted are also vulnerable to damage, but existing retrofit regulation should make these examples rare. Pre-1995 tilt-up buildings are vulnerable to extensive damage, but are not regulated. Tilt-up construction is a common industrial building type. In 2009 there were about 200 of these extant in San Francisco.[23] Flood: Most industrial properties were built before 1940 (40.3%) and in the decades immediately after World War II.[24] They were not built to withstand any amount of flooding, as construction materials, siting and design standards do not require consideration of potential exposure to either water or salt. These buildings are concentrated in low-lying neighborhoods with significant flood and liquefaction risks. Extreme Heat: Older buildings that do not have adequate HVAC may be more vulnerable to heat and air quality impacts. Fire: Older buildings that do not have adequate HVAC and filtration technology be more vulnerable to heat and air quality impacts.

[23] DBI (https://sfdbi.org//sites/default/files/Documents/Boards_and_Commissions/Agenda_Attachments/Task_2_Report_apr8DRAFT.pdf) Search "industrial"

[24] Bay Area Economics, 2018. "Port of San Francisco, Piers 90-94 Backlands Market Assessment: Draft Report." P.25

Functional	Networks: Industrial buildings themselves are not networked, however, many distribution yards or fleet lots have an office building that may be networked. These businesses have important supply, information, or capital networks between them. Industrial uses in particular are critical for business supply chains, construction, transportation (e.g. shuttles) and maintenance/operation of infrastructure equipment. External Services: Industrial businesses rely on power, fuel, water, communications, and transportation access for full function. Buildings that have sensitive operations may be more likely to have backup power. For example, operations that require temperature control (such as food processing facilities) may have generators. Populations Served: Industrial buildings house businesses that employ residents of SF and the greater Bay Area. These are typically those of working age, and include those who are low income, housing and transportation cost burdened, renters, and those without cars, as well as those who are ethnically and culturally diverse and/or have limited English speaking capacity. Unique or Critical Function: Industrial buildings in SF house many large employers in the Bay Area. Many of these facilities are necessary for the supply chain, distribution, and operation of Bay Area businesses and industries. For example, Recology's Recycle Central on Pier 96 is critical for SF waste management operations.
Informational	All-hazards: SF Department of Building Inspection put out an earthquake risk report in 2009 that provides an industrial building inventory, and outlines how these buildings would fare in different earthquake scenarios. Additionally, SF Planning published a 2016 Commercial and Industrial Inventory. A draft vulnerability and consequence assessment exists for sea level rise threat.
Governance	All-hazards: SF building code regulates commercial building safety requirements. This includes soft story and masonry retrofit requirements, as well as to HVAC, filtration, and fire requirements.

CONSEQUENCES

Category	Consequence
Society/Equity	All-hazards: SF's industrial buildings and facilities provide places of work for San Franciscans and for many Bay Area residents. Damage and disruption to these buildings can disrupt these residents' work, their workplace social networks, and can even prompt short term unemployment. This is particularly impactful to the lives of those who are non-salaried, who are low-income, and who are transportation and housing burdened. In manufacturing, 70% of employees come from low income households.[25] The destruction of industrial building landmarks might also have impacts to community identity in the surrounding neighborhood. Geologic: Significant groundshaking can result in human casualties from building damage. Populations with limited mobility or medical conditions are particularly at risk. Flood: Significant stormwater flooding may result in human casualties if there is no 2nd story. Populations with limited mobility or medical conditions are particularly at risk. Debris or contaminated soils could especially affect under-resourced communities and communities of color, many of which are adjacent to or mixed with industrial areas. Extreme Heat: Heatwaves may cause closures in non-weatherized buildings without cooling capabilities. Heat waves increase health risk for medically sensitive populations, such as the elderly, pregnant women, and those with medical conditions. Fire: Significant fire can result in human casualties. Populations with limited mobility or medical conditions are particularly at risk. Reduced air quality from fire smoke in unfiltered buildings can result in increased rates of asthma attacks. This is especially true in under-resourced communities and communities of color, many of which are adjacent to or mixed with industrial areas, and have significantly

[25] "Make to Manufacture: Advanced Manufacturing Playbook," Office of Economic and Workforce Development, 2016, https://oewd.org/sites/default/files/Documents/Make_to_Manufacture%20%282%29.pdf.

	higher rates of bronchial disease. Smoke impacts will not cause building damage or long term closure.
Economy	All-hazards: Any damage to the facility will require property owners to fund repairs or replacement. Businesses owners will have to bear the cost of relocating or otherwise accommodating its employees in the event of structural building damage. Each day of closure or limited facility use can reduce or eliminate daily revenue. In addition, non-salaried employees will lose wages for each day of closure. Hourly employees and small business employees/owners are most impacted by these events. Permanent closures will result in loss of employment. Industrial business slow-downs or closures can result in loss of revenue to upstream businesses (for example, supply shortages or logistics delays). Geologic: Depending on severity and building type, damage can lead to short to long term closure. The shutdown of many supply chain and logistics companies in the event of severe shaking and liquefaction may have regional economic impacts. Construction investment in the event of widespread destruction may cause positive economic effects ("Creative Destruction" effect). Flood: Neighborhoods in coastal and storm water flood zones will see the most damage and economic impact. The flooding of shuttle or other transportation facilities could also limit the ability of employees in all sectors of San Francisco to get to or from work. Extreme Heat: Depending on severity, health hazard can lead to short term closure in older buildings that do not have adequate HVAC. Those with adequate HVAC will increase power use and see associated financial impact. This hazard will not cause permanent or indefinite closure. Fire: Damage from fire can lead to short to long term closure. Air quality reduction from fire will not cause permanent or indefinite closure.
Environment	Flood: If commercial buildings are near to the coast, flooding may cause debris from the building and soil from around the building to move into waterways. This is especially a concern in older industrial areas

	where known or unknown contaminated soils from former uses could further pollute waterways and San Francisco Bay. Fire: Air quality would be reduced in the neighborhood, potentially regionally, if commercial buildings are directly impacted by fire.

Maritime

Introduction to Asset Class

The Port of San Francisco was created by the State of California to develop a Port within the State. Maritime uses depend on a waterfront location to operate. Since the 1960s, maritime needs have evolved and the demands for Port facilities and landside transportation changed with more focus on containerized cargo. In response, the Port has diversified its uses, including its maritime uses. The Port's maritime functions remain a critically important asset for the Port, the City, the region and the State. The importance of the Port's maritime functions is apparent from the range of activities that span its waterfront. These range from the fishing, police and recreational maritime uses in Fisherman's Wharf area, the cruise ship terminals, research vessel berths, Bar Pilots and fireboats in the Central Waterfront, and the cargo, ship repair and heavier industrial/maritime uses in the Southern Waterfront. Maintaining and enhancing the Ports maritime uses is important to the economy, safety, and job diversity of not only the Port itself but the rest of the City and County of San Francisco as well as the region.

There are unique physical characteristics of a number of Maritime assets that affect their vulnerability. All of the Port's maritime assets sit on or adjacent to the water and require shoreline access. The water dependency of the assets means that they were constructed to be durable given a certain amount of contact with water. However, Port facilities were constructed for lower water levels than those experienced today or those projected for the future. Additionally, many of the Port's maritime facilities are in need of additional maintenance and were constructed over 50 years ago. Many piers are served by utilities under them and this utility infrastructure are some of the Port's most vulnerable assets. The maritime assets at the Port also rely on shoreline transportation and utility network connections to function. The Port's maritime assets are constructed of a variety of materials including concrete, wood, covered asphalt, wood and steel piles, steel sheet piles and rely on piles, fendering, functioning aprons and floats. Many of the Port's assets, including its maritime assets are designated as historic and the Port is home to several historic districts-including the Embarcadero Historic District, the Northeast Waterfront Historic District and the Union Iron Works Historic District.

The Port holds the property within its jurisdiction in trust for the State of California. As a trustee, the Port must ensure that projects and leases within its jurisdiction are consistent with the public trust and the Port works closely with the other trustees (the

State Lands Commission and the Bay Conservation and Development Commission) to ensure that uses are advancing the trust. The Port is also an enterprise agency within the City and County of San Francisco and is governed by a Commission of five members appointed by the Mayor. The Port leases include over 550 ground, commercial, retail, office, industrial and maritime industrial leases including cargo shipping, ship repair, excursion boats, ferry boats, fishing and fish processing/distribution, tourism, filming, harbor services, and cruise-shipping. The in-water and shoreline work that the Port and its leases must conduct also requires a number of permits that are project-specific and must be obtained from agencies such as the Water Quality Control Board, NOAA Fisheries, the Bay Conservation and Development Commission, the Army Corps, the EPA and Fish and Wildlife.

Issue Statement

Maritime uses hold a unique and critical role in the city's economy and since they depend on water access, cannot be relocated or easily replaced. The facilities tend to be older and some are historic, which increases their vulnerability to earthquakes, flooding, and extreme heat. Many maritime uses are built on fill, which has higher susceptibility to liquefaction, which could cause significant damage to facilities and infrastructure. Piers are particularly vulnerable to flooding, especially where water-sensitive utilities are located under the piers. Damage and disruption of maritime uses would have far reaching consequences, but especially to the economy and workforce, given the diversity of well-paying and often unionized jobs in maritime businesses.

Exposure

Hazard Data Assumptions

This analysis was conducted in 2018 and 2019 using publicly-available data sources. In the table on the following page, shaking intensity is represented for two Earthquake scenarios: San Andreas Fault M7.8 and Hayward Fault M7.0 events. Accounts of assets subjected to varying levels of shaking intensity are cumulative for each scenario.

Asset Data Assumptions

Asset data originates from datasets maintained by SF Port (2018).

Exposure Summary

Geologic: All piers are in the Violent or Very Strong groundshaking zones during a 7.8M earthquake on the San Andreas Fault. Most piers are in the Very Strong groundshaking zone during a 7.0M earthquake on the Hayward fault. All piers are in the liquefaction zone.

Flood: All piers have some portion in the current 100-year coastal flood zone. Stormwater flooding analysis was not conducted in areas which are not served by the SFPUC's combined sewer and stormwater collection system, therefore the Port's property was not analyzed.

Fire: No piers with maritime assets are in a wildland-urban interface fire zone

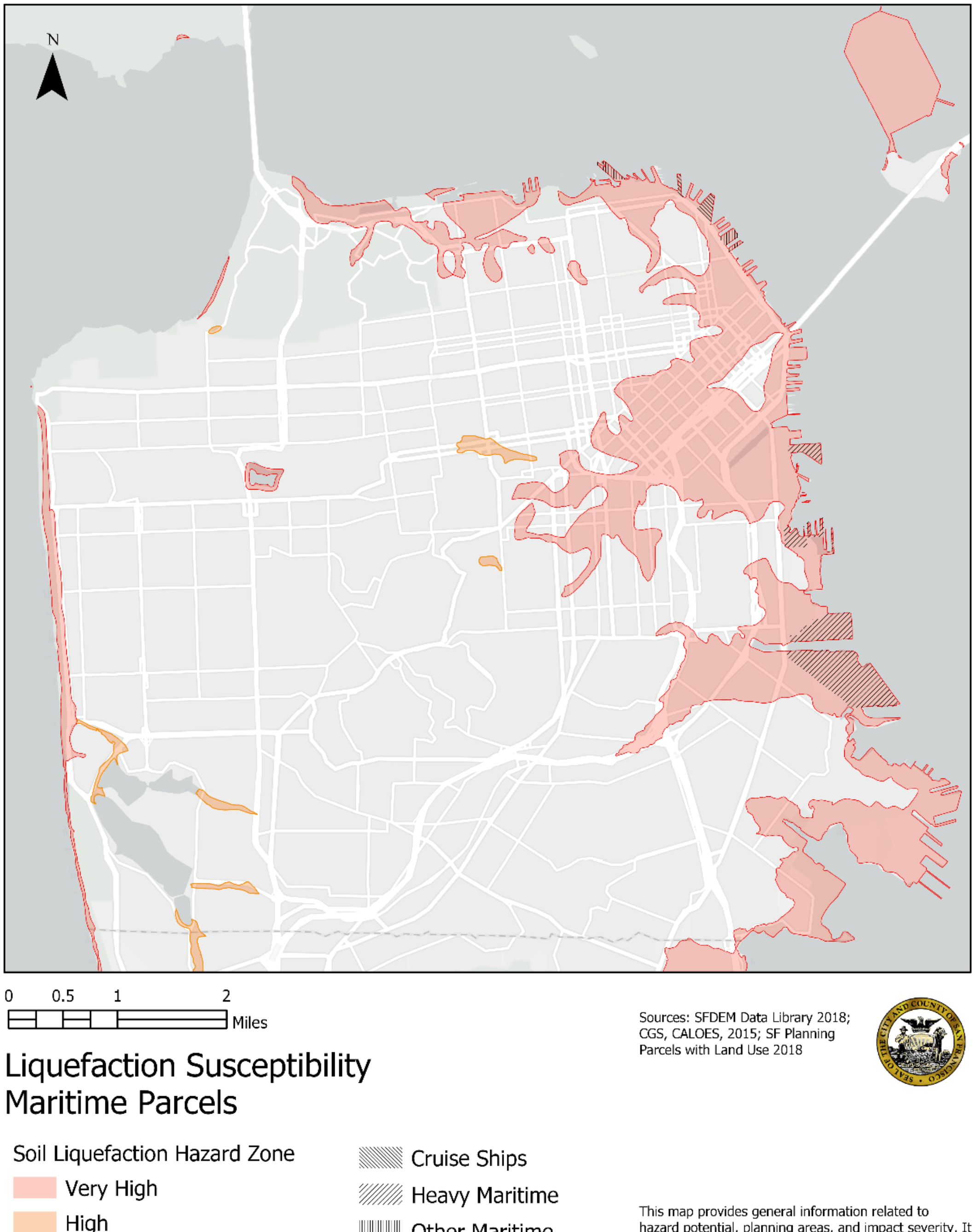
TABLE A-23: EXPOSURE

Hazard	Cruise Terminal Piers (27*, 29, 35*)		Heavier Industrial/ Maritime Piers (50*, 68, 70, 80*, 90*, 92*, 94*, 96*)		Other Maritime - Bar Pilots, Research Vessel Berths, Commercial Fishing (9, 15*, 17, 45)	
	#	%	#	%	#	%
Geologic						
San Andreas 7.8 - Violent	0	0%	4	50%	0	0%
San Andreas 7.8 - Very Strong	3	100%	4	50%	4	100%
Hayward 7.0 - Very Strong	3	100%	7	88%	4	100%
Hayward 7.0 - Strong	0	0%	1	13%	0	0%
Liquefaction Zone	3	100%	8	100%	4	100%
Flooding						
100-Year Coastal Flood Zone	3	100%	8	100%	4	100%
100-year storm + 24 inches SLR	3	100%	8	100%	4	100%
100-year storm + 66 inches SLR	3	100%	8	100%	4	100%
100-year stormwater flood	N/A	N/A	N/A	N/A	N/A	N/A
Wildfire						
High	0	0%	0	0%	0	0%
Moderate	0	0%	0	0%	0	0%

* Indicates active deep-water berths at the time of this publication

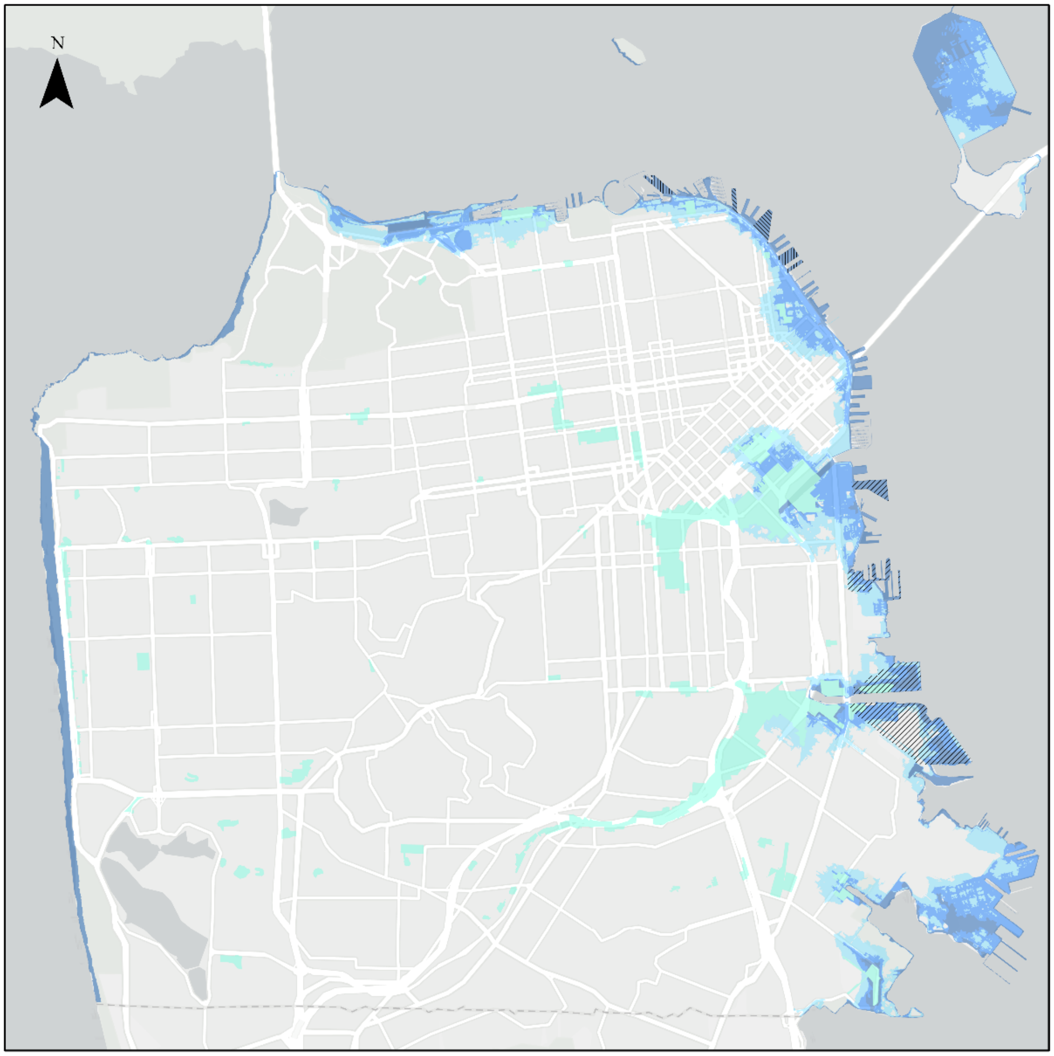
Note: For an exposure table with additional hazards, please see Chapter 5.

FIGURE A-36: MARITIME USES AND LIQUEFACTION HAZARD



This map provides general information related to hazard potential, planning areas, and impact severity. It is not intended for permitting, regulatory, or other legal uses. Risk zones are based on model outputs, and site specific conditions may not be fully represented.

FIGURE A-37: MARITIME USES AND FLOOD HAZARDS



0 0.5 1 2 Miles

Flood Risk
Maritime Parcels

Flood Hazards

- 100 Year Stormwater Runoff
- FEMA 100 Year Coastal Flood Zone
- 100 Year Storm + 24" Sea Level Rise
- 100 Year Storm + 66" Sea Level Rise

- Cruise Ships
- Heavy Maritime
- Other Maritime

Sources: Public Utilities Commission 100-Year Storm Flood Risk Map; FEMA Preliminary Flood Insurance Rate Maps; ART Bay Area Sea Level Rise and Shoreline Analysis Maps; SF Planning Parcels with Land Use 2018

This map is intended for planning-level analysis and should not be used for permitting, regulatory, or other legal uses. Flooding is possible in areas outside of those displayed on this map. The risk zones are based on model outputs and relied on LiDAR data collected in 2010 and additional survey data (where available). Although care was taken to capture all relevant topographic features and structures, site specific conditions may not be fully represented.

VULNERABILITIES

Category	Vulnerability
Physical	Geologic: Most of the Port's maritime facilities are vulnerable to seismic hazards due to both construction and location. The Port, and much of downtown San Francisco, was constructed on Bay fill, which is susceptible to liquefaction. In addition to location, the majority of the Port's facilities were constructed prior to current seismic safety standards and many have not been seismically retrofit. Flood: Piers have physical characteristics that make them more vulnerable to flooding, including where utilities exist under the piers, the need for space under the piers to maintain them, the condition of the pier aprons and fendering and the need for access connections between the water and the land. Some piers have utilities and infrastructure with salt sensitive components that would either need to be raised or made water proof. Hazardous materials that are stored on the piers will need to be secured to ensure there is no release into waterways or community spaces. The historic nature of many of the Port's assets also increases their vulnerability and could reduce adaptation options. Extreme Heat: A majority of the Port's buildings are in older, historic building stock and only a few of them have been weatherized. Additionally, the Port has a number of warehouse and industrial areas that are not easy to cool and employees in operations and maintenance who work outside. Fire: The majority of the Port's buildings lack air filtration and outside air quality has impacts on the quality of air inside of many of the Port's buildings. Additionally, many of the Port's buildings and assets are warehouses and industrial sites that are difficult to filtrate and a number of our employees work outside in maintenance and operations and are exposed to air quality conditions.
Functional	Networks: Redundant systems and services at the Port or elsewhere in the region could help ensure continuity of critical systems. External Services: Maritime uses depend on power, communications, fuel supplies and transportation access. Goods and materials are also important to some of the assets and services.

	The Port has backup power and pumping capacity at some of its facilities. Pier 1, the JOS Building, Illinois Street Bridge, AT&T Park, and Ferry terminals have standby power capabilities. All other port facilities lack backup power. An assessment of this capacity should be conducted to ensure that the measures are capable of maintaining critical operations regarding other facilities. <u>Populations Served:</u> The Port's maritime assets increase the diversity of employment in San Francisco and provide well paying, often unionized, jobs in the city. The assets and services are also important to the local economies where they are located, which includes Bayview-Hunter's Point, as well as small businesses in the northern waterfront that rely on the cruise industry. The fishing industry provides a cultural and economic connection to the Bay and aquatic resources that have been important to San Franciscans since the City's founding. <u>Unique or Critical Function:</u> The maritime assets and services provide recreational benefits, such as excursion trips to Alcratraz, whale watching, and tours to other destinations. The Port has a number of educational and interpretive materials throughout its jurisdiction (including the Bayside History Walk) which interpret and educate people on the history of maritime assets and the current maritime assets that can be found along the Port. Most of the Port's maritime assets are unique and would be difficult to replace in the region and impossible to replace in the City. The deep-water berthing sites for military and research ships is a unique asset and service found along the Port, the Cruise ship terminals are also unique to the region, the commercial fisheries facilities are unique and difficult to replace as well.
Informational	<u>All-hazards:</u> There are some existing studies including several flood risk studies conducted specifically for Port assets that were completed in 2016, a seismic vulnerability analysis that was conducted at a high level for the three mile seawall, a currently underway Multi-Hazard Risk Assessment for the three mile Seawall segment that assesses seismic and flood risk, a study of the flood risk at Mission Creek, a study of the flood risk (and a little seismic) at Islais Creek and a Citywide SLR study.
Governance	<u>All-hazards:</u> The Port must work with a number of regulatory and resource agencies to maintain, repair or improve maritime assets. These agencies include the Regional Water Quality Control Board, US Fish

	and Wildlife, California Fish and Wildlife, State Lands, Bay Conservation and Development Commission, State Historic Preservation Office and the Army Corps and their regulations and policies are numerous and depend upon the specifics of the project proposed. Anything associated with dredging and filling the Bay is heavily regulated. The Port currently has access to several funding sources to assess risks and vulnerabilities and improve resilience, including a San Francisco General Obligation Bond, City Capital Planning funding, a Caltrans resilience grant, Army Corps General Investigation, Port Capital Planning funding.

CONSEQUENCES

Category	Consequence
Society/Equity	All-hazards: The most significant impacts related to society and equity due to the disruption of the Port's Maritime assets would be related to a loss of industrial and maritime jobs, impacts to the safety of vessel travel on the Bay, reduced access to the Bay and its resources, local businesses would lose jobs that rely on, and provide service to, the Port's maritime assets and services, which include trucking, restaurants, etc. Disruption or loss of maritime uses would exacerbate existing inequities in the Port's southern waterfront area.
Economy	Geologic: The economic impact of groundshaking and liquefaction is currently being assessed from Fisherman's Wharf to Mission creek. The impacts of disruption of maritime assets due to a seismic event would range from citywide to regional to state-level. Flood: This is currently being assessed by two studies: the Multi-Hazard Risk Assessment for the Seawall Program and the Army Corps Flood Study. The impacts of disruption of Maritime assets due to flooding would range from citywide to regional to state-level.
Environment	Geologic: Seismic events that damage the Port's maritime facilities could result in contamination of the Bay, debris in the Bay, the need for in water construction repairs which would have ecological impacts, potential air quality impacts if facilities need to move further away, impacts to public access and parks that rely on or are enhanced by access to the water. Flood: Flood risks could release contamination into the Bay, could result in debris in the Bay, could reduce public access and could negatively impact habitats and species.

Contaminated Lands

Introduction to Asset Class

Historic land uses prior to the adoption of current environmental regulations left a legacy of contaminated land sites across San Francisco. Contaminated soil, groundwater, and soil vapor can negatively impact human health and environmental quality, and can limits future productive use of the land, unless proper cleanup and remediation actions have been taken. The City and County of San Francisco recognizes the importance of evaluating soil condition in advance of development. Sites requiring grading or building permit may be regulated under the Maher Ordinance, which covers areas with current or historical industrial use or zoning, areas within 100 feet of current or historical underground tanks, filled former Bay, marsh or creek areas and areas within 150 feet of a current or former elevated highway.[26] San Francisco Health Code Article 22a includes areas where UST were once leaking, resulting in potential for legacy contamination. Around 1800 Maher cases have been completed or are in progress. The San Francisco Department of Public Health's Local Oversight Program (LOP) oversees leaking underground storage tank remediation, over 3000 sites have been successfully remediated. Properties with known or potential chemical contamination outside the Maher area may be administratively added to the Maher Program or included in the Voluntary Remedial Action Program. Cleanups involve excavating contaminated source materials from the site to be stored in an engineered containment area. In some cases, contaminants cannot be removed and must be stabilized in place. Engineering techniques to prevent movement of contaminants include covers and vertical barriers made of clay or cement slurry.[27]

This assessment uses data from the Department of Toxic Substances Control (DTSC) to identify locations of ongoing cleanup activities. The mapping and analysis does not represent the location of every contaminated site in need of remediation; as demonstrated by the Maher map area,[28] potential to encounter contaminated soil exists across broad areas of the city. Nor does the DTSC data represent the full environmental burden that communities face. Four cleanup status categories were included:

- Active: investigation and/or remediation currently in progress

[26] https://data.sfgov.org/Energy-and-Environment/Maher/hqsk-4xmh
[27] https://www.epa.gov/sites/production/files/2018-08/documents/landfills_and_containment_as_an_element_of_site_remediation.pdf
[28] https://data.sfgov.org/Energy-and-Environment/Maher/hqsk-4xmh

- **Certified with land use restrictions**: the completed remedy resulted in hazardous substances remaining on site, and so future uses are restricted and long-term monitoring is required
- **Certified with ongoing operation and maintenance**: remedial activities (such as pumping and treating contaminated groundwater) must be continued for many years before completed cleanup will be achieved
- **Inactive with action required**: sites where DTSC has identified the need for a removal or remedial action, or extensive investigation

Federal Superfunds have a specific designation as heavily contaminated, underutilized and undeveloped land sites where hazardous waste is possibly affecting the health and safety of local communities and ecosystem. Superfunds are listed under the National Priorities List through the federal Superfund cleanup program. There is one Superfund site in San Francisco, located in the southeast area of the City in the Bayview Hunters Point neighborhood.

Issue Statement

It is in the interest of public health and safety to effectively and efficiently remediate contaminated land sites, and/or mitigate human health exposure, and/or mitigate human health exposure. Contaminated land sites are disproportionately located near low-income and communities of color, and any release of hazardous substances burdens communities which are already disproportionately burdened. Many sites undergoing remediation and/or mitigation have plans for new housing development. San Francisco is experiencing an affordable housing crisis, and there is a limited amount of undeveloped land to meet housing needs. Loss of land for new housing will have negative impacts citywide. Cleanup, remediation, and/or mitigation processes are extremely cost and time intensive, where encountering financial and/or regulatory obstacles can result in years-long delays. Sites that become exposed to flooding and rising groundwater in the future may not have been remediated to an aquatic standard, with potential negative impacts to health and the natural environment. Integrating adaptive site management into cleanup activities is a step towards equity and resilience.

Exposure

Hazard Data Assumptions

This analysis was conducted in 2018 and 2019 using publicly-available data sources. In the table on the following page, shaking intensity is represented for two Earthquake scenarios: San Andreas Fault 7.8M and Hayward Fault 7.0M events. Accounts of assets subjected to varying levels of shaking intensity are cumulative for each scenario.

Asset Data Assumptions

Asset data originates from datasets maintained by the SF DEM (2018) and the California State Department of Toxic Substances Control (EnviroStor, 2018)

Exposure Summary

Geologic: Two thirds of parcels with ongoing cleanup activities are in a liquefaction zone. Ninety-eight percent of parcels are at risk of very strong or strong groundshaking during a 7.0M Hayward fault earthquake. All parcels are at risk of violent or very strong groundshaking during a 7.8M San Andreas Fault earthquake.

Flood: Fifteen percent of parcels with ongoing cleanup activities have a portion in the FEMA 100-year coastal flood zone, and one third of parcels are at risk of flooding from 66 inches of sea level rise. Two parcels are at risk of a 100-year stormwater flood.

Fire: There is moderate wildfire risk in four parcels.

TABLE A-24:
EXPOSURE

Hazard	Parcels with DTSC Cleanup Activities 59 Total	
	#	%
Geologic		
San Andreas 7.8 - Violent	8	14%
San Andreas 7.8 - Very Strong	51	86%
Hayward 7.0 - Very Strong	15	25%
Hayward 7.0 - Strong	43	73%
Liquefaction Zone	39	66%
Flooding		
100-Year Coastal Flood Zone	8	14%
100-year storm + 24 inches SLR	11	19%
100-year storm + 66 inches SLR	19	32%
100-year Stormwater Flood	2	3%
Wildfire		
High	0	0%
Moderate	4	7%

Note: For an exposure table with additional hazards, please see Chapter 5.

FIGURE A-38: ACTIVE CLEANUP ACTIVITIES AND LIQUEFACTION HAZARD

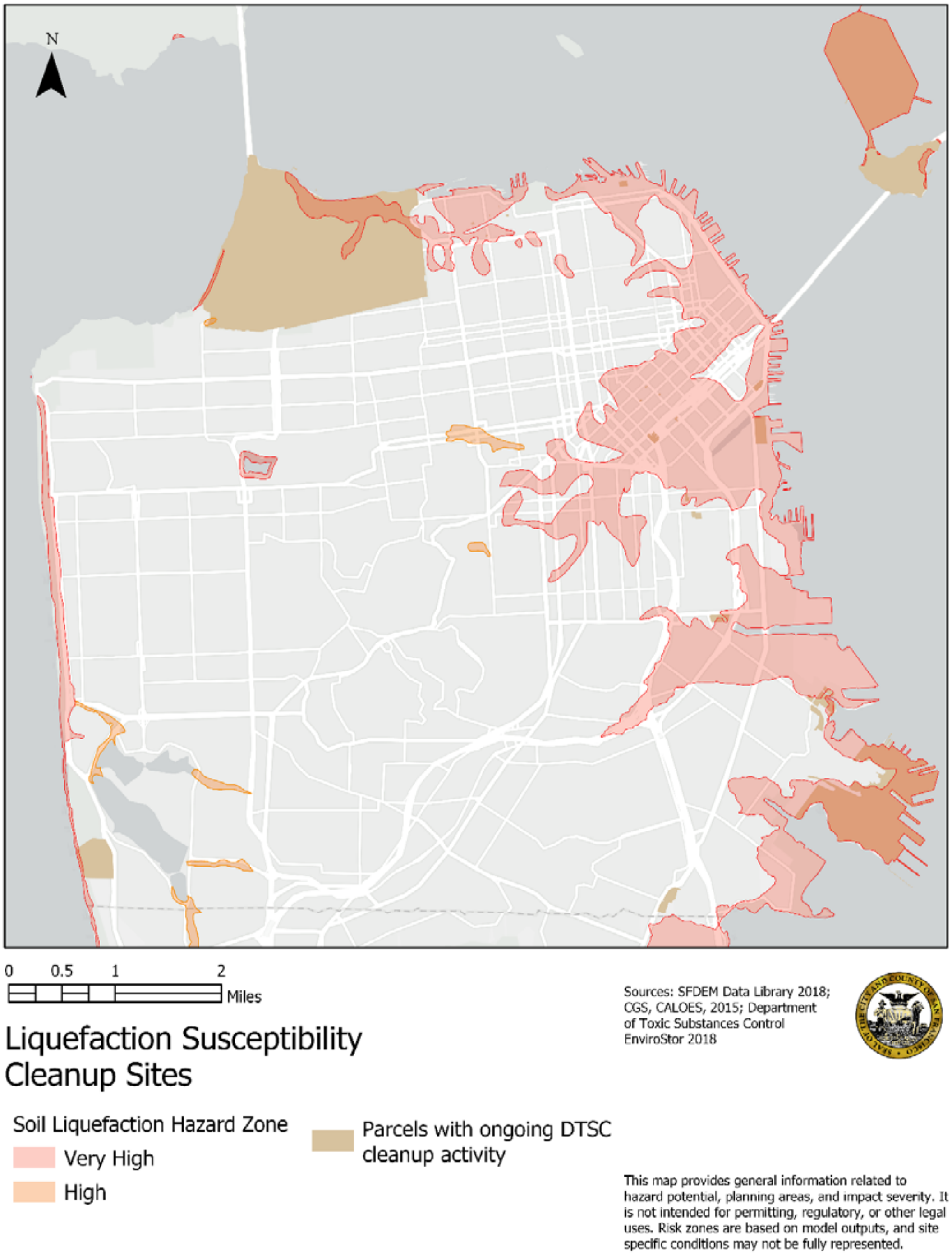
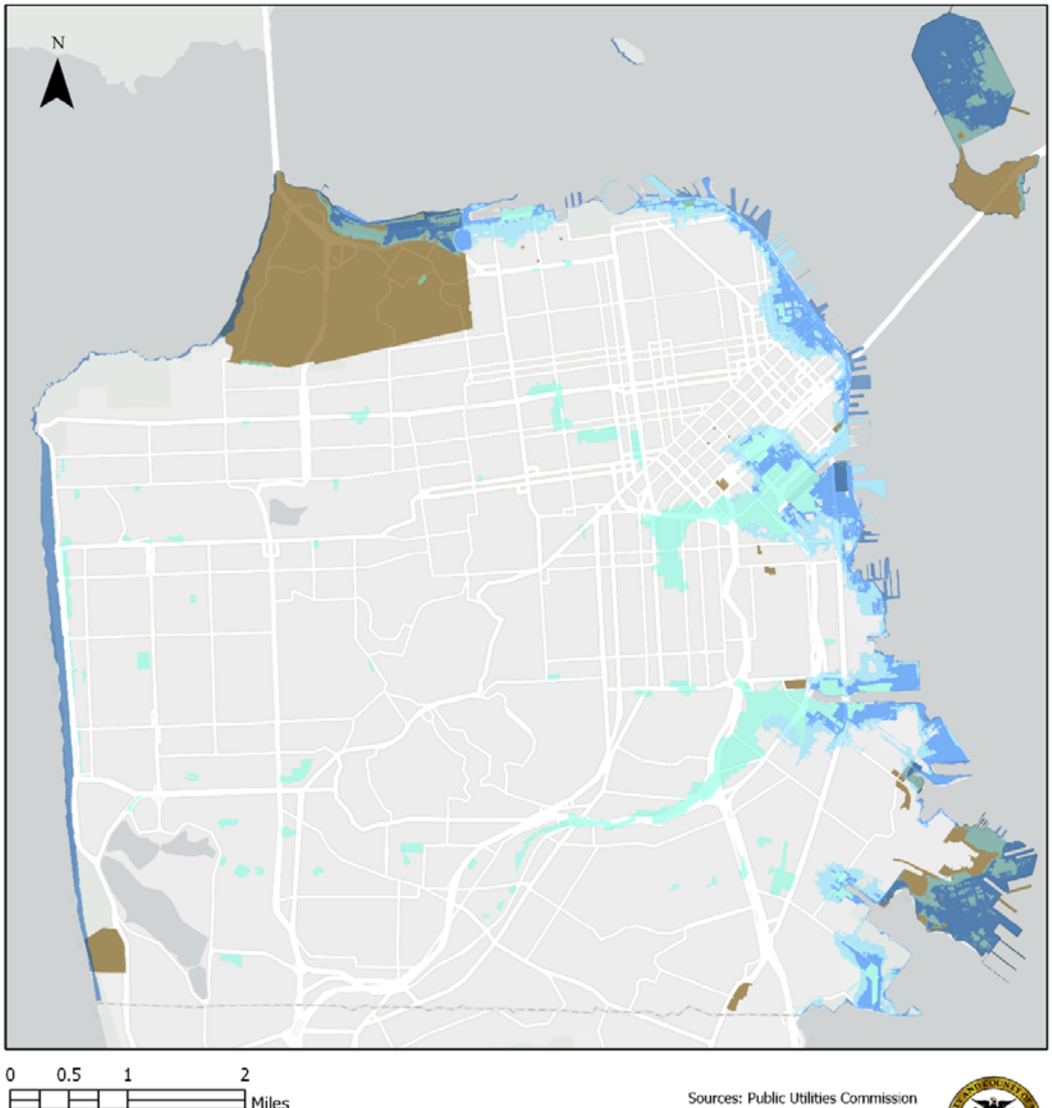


FIGURE A-39: ACTIVE CLEANUP ACTIVITIES AND FLOOD HAZARD



Flood Risk and Cleanup Sites

Flood Hazards

- 100 Year Stormwater Runoff
- FEMA 100 Year Coastal Flood Zone
- 100 Year Storm + 24" Sea Level Rise
- 100 Year Storm + 66" Sea Level Rise
- Parcel with ongoing DTSC cleanup activity

Sources: Public Utilities Commission 100-Year Storm Flood Risk Map; FEMA Preliminary Flood Insurance Rate Maps; ART Bay Area Sea Level Rise and Shoreline Analysis Maps; Department of Toxic Substances Control (DTSC) EnviroStor 2018

This map is intended for planning-level analysis and should not be used for permitting, regulatory, or other legal uses. Flooding is possible in areas outside of those displayed on this map. The risk zones are based on model outputs and relied on LiDAR data collected in 2010 and additional survey data (where available). Although care was taken to capture all relevant topographic features and structures, site specific conditions may not be fully represented.

VULNERABILITIES

Category	Vulnerability
Physical	Geologic: Ground shaking could compromise the integrity of caps and liners. Liquefaction could compromise the stability of waste containment facilities, such caps over remediated sites, and slurry walls that contain contaminants. Flood: The sensitivity varies by site and contaminant type, as well as the contaminant's mobilization pathways, and the degree of remediation. Contaminants that are bound to sediments are vulnerable to erosion and could be mobilized into the Bay. Other contaminants could dissolve in the water if exposed to rising groundwater during high tides or storms and contaminate soil and groundwater. Saltwater could also corrode cleanup equipment. Floodwater that remains for a long time period could infiltrate through the soil and become contaminated. Remediation standards for aquatic uses are more stringent than upland uses. Cleanups completed for upland standards may be unsatisfactory if sites become exposed to flooding. Residents in buildings located on remediated land rely on engineering control methodologies and technologies for protection, in particular where groundwater drives soil vapors up and into occupied spaces. These protective technologies may not be in place in areas newly exposed to flooding or groundwater changes.[29] Vapor barriers protect from fumes/contaminants. Cleanups in San Francisco receive a vapor barrier regardless of future use. Sites may need to mitigate exposure to vapor due to a variety of causes. For example, Mission Bay area has high methane soil vapor due to industry and bay muds, and uses a methane mitigation system – systems pull vapors from underneath and the building and release them through the roof (then need a permit from the Air Board). Many buildings operate groundwater pumping systems. Extreme Heat: Limited to none. Most cleanup sites are in different remediation stages and monitoring is done daily. In case of heatwave alerts, there is enough time available to take adaptive actions in advance. Extreme heat may lead to malfunction of equipment or communication

[29] 2017 Adapting to Rising Tides (ART) Contra Costa County: http://www.adaptingtorisingtides.org/wp-content/uploads/2017/03/Contra-Costa-ART-Project-Report_Final.pdf#page=42

	systems.[30] Extreme heat poses a risk to the health of remediation professionals on-site. SFDPH requires vapor systems, which can protect against increased vapor release during extreme heat. Fire: Closed permanent contaminated lands are generally capped by an impermeable or low permeability layer, such as clay, and underlain by the native geologic material. The damp clay is resistant to fire. However, surrounding areas that may be on fire, could pose fire hazard to cleanup site equipment and remediation systems, as well as any supporting structures.
Functional	External Services: Contaminated lands management relies on robust communication and emergency response channels, as well as a reliable power supply network for the timely execution of cleanup activities. Power outages may not cause immediate threats to public health, but will slow down cleanup activities and incur additional cleanup costs. Populations Served: The assets in this class do not serve vulnerable populations. However, contaminated sites are disproportionately located in or adjacent to low-income and communities or color. Unique or Critical Function: Cleanup activities are initiated on sites that are underutilized, and San Francisco has very limited undeveloped land area. Without proper cleanup, contaminated lands are left undeveloped which hinders the ability of the city to meet its pressing housing needs. Contaminated lands located in open space areas can be redesigned to provide recreational and habitat benefits. Closed landfills have to monitor methane for explosion hazard. Former landfill in presidio, hunter's point, treasure island. Capping is soil and other vegetative cap. There is a closed landfill by SF State. Required to monitor methane for explosion hazard.
Informational	All-hazards: Information on active cleanup activities and contaminated lands sites location is publicly available and updated regularly. Information on sites overseen by DTSC, Water Board and the City and County of San Francisco is available from the State's online CERS database. However, land remediation is a multi-stakeholder process and since

30 https://www.nema.org/Standards/SecureDocuments/NEMA%20GD%202-2016%20Evaluating-Fire-and-Heat-Damaged-Electrical-Equipment-Guide.pdf

	most contaminated land sites are privately owned, the pace of cleanup depends on being able to locate property owners and discuss legal liability issues. Detailed research is needed to examine the risk of groundwater flooding of contaminated land sites for the City and County of San Francisco.
Governance	<u>All-hazards:</u> Cleanup activities are overseen by a number of agencies. US EPA is the lead regulatory agency for Superfund sites, along with the Navy, Department of Toxic Substances Control (DTSC), and the Regional Water Quality Control Boards (RWQCB); DPH-Environmental Health and City Planning Department. Site mitigation, the cleanup or management of chemical contaminants in soil, vapor, or groundwater is regulated per one or more programs within the San Francisco Department of Public Health's Hazardous Materials and Waste Program (HWMP), Local Oversight Program (LOP), and the Maher Program (SFHC Article 22a) and Voluntary Remedial Action Program (VRAP). Conducting a preliminary environmental assessment, carrying out a remedial investigation to determine the extent of contamination, and developing a cleanup plan is costly and timely process. Cleanup costs vary depending on contaminant type, and encountering unanticipated contaminants during cleanup can result in significant cost increases. The cleanup itself can take many years, depending on the nature and extent of the contamination, cooperation of site owner(s), and resources available. Property owners responsible for site cleanup, community groups, state and federal regulators, and technology developers may have different perspectives on how remediation technologies should be evaluated and selected. Reconciling the differing expectations of these stakeholders can add to delays in site remediation. Remediation and/or mitigation is addressed by the project proponent in the Site Mitigation Plan. While regulators have a different perspective than developers, the basis for remediation and/or mitigation activities is to protect the public's health during and after development. The State Water Resources Control Board (SWRCB) requires site owners to plan for sea level rise under the Waste Discharge Requirements (WDRs), which adds to adaptive capacity and may prioritize cleanup among the sites under their purview. While there are no WDR sites in San Francisco, this program demonstrates SWRCB's awareness of sea level rise risk. Infrastructure Plans for developments at Hunter's Point Shipyard and Candlestick point included sea level rise studies and design criteria for 100 year tide and future sea level rise.

	Cleanups can be led by local agencies, the Water Board, DTSC, or CalRecycle—although this last option is not common in San Francisco. Large cleanup projects can choose their regulatory lead; the lead will communicate with other agencies involved. Standards for cleanup are different if housing or park space. Regional Board, DTSC, SFDPH all environmental screening levels, must be below screening levels or mitigate exposure. The City and County of San Francisco and SFDPH requires a stamp of approval from licensed engineer or licensed geologists, can report abuses/violations of the professional with the potential to have their license revoked. The agency overseeing the cleanup has administrative oversight, and ability to deploy more inspectors if needed. The agency overseeing the cleanup has discretion. SFDPH knowledge of contractors with poor reputations will administer more frequent inspections. Shipyard has its own Article in the health code, Article 31. City accepts land from navy after it has been cleaned. Standards driven by federal requirements/numbers.

CONSEQUENCES

Category	Consequence
Society/Equity	<u>All-hazards:</u> The actual health consequences of a release of contaminants would depend on the substances released and the proximity of the sites to sensitive receptors, such as residential areas, schools, hospitals, and housing for the elderly. Radioactive contamination presents the greatest health threats. Site Mitigation Plans required by the Maher Ordinance address these potential health threats during and after development. Proximity to Nationwide, superfund sites has been associated with cancer, low infant birth weights, and liver disease.[31] The one Superfund site in San Francisco is located in the Bayview Hunters Point neighborhood. The percent of Bayview Hunters Point residents who are Black/African American is significantly higher than citywide rates—28% vs. 5%. Across the country, contaminated sites are disproportionately located in communities of color.[32]

[31] Ala A, Stanca CM, Bu-Ghanim M, Ahmado I, Branch AD, Schiano TD, et al. (2006). Increased prevalence of primary biliary cirrhosis near Superfund toxic waste sites. Hepatology 43(3):525-31
[32] Brown, P. Race, Class, and Environmental Health: A Review and Systematization of the Literature. Environmental Research
Volume 69, Issue 1, April 1995, Pages 15-30. https://doi.org/10.1006/enrs.1995.1021

	San Francisco has a significant shortage of housing, particularly affordable housing. The City plans to build new housing to address this shortage. Site remediation must be completed before housing development can begin, and delays in remediation impacting housing production. Additionally, delays in cleanup could result in longer endured health burdens for the surrounding community. A study which compared birth outcomes before and after Superfund site cleanups found an association of up to 25% increased risks of congenital abnormalities.[33] Flood: Contaminated substances, if suspended in the water column, can be consumed by fish and lead to food chain contamination that consequently affects human health. While San Francisco does not rely on groundwater for drinking water supply, contaminants that come into contact with groundwater would pose an additional threat to human health if the water were used for drinking.[34]
Economy	All-hazards: Direct consequences include the costs of remediation, mitigation, and/or cleanup of damaged property. Indirect consequences include economic losses to affected secondary industries. If human health is affected, productivity losses, increased health care costs, or liability claims could also occur. Human health effects may be acute or chronic. A longer-term economic impact could occur if contaminants are redistributed onto new sites, reducing the availability of productive, usable land and increasing the number of sites requiring cleanup. Cost is also a concern for the regulatory agencies, especially at the state level. If responsible parties are local industries, extraordinarily high remediation costs may result in a threat to shut down operations, resulting in loss of jobs and tax base, and delay in the usability of the site. State agencies can provide reimbursement for cleanup to developers if certain thresholds are met.
Environment	All-hazards: Contaminated land sites contain hazardous materials that pose risk to the environment and certain pollutants, such as polychlorinated biphenyls (PCBs), affect the health of wildlife as well as people.

[33] Currie, Janet, Michael Greenstone, and Enrico Moretti. 2011. "Superfund Cleanups and Infant Health." American Economic Review, 101 (3): 435-41. DOI: 10.1257/aer.101.3.435
[34] ART

	Flood: Contaminants released into the Bay could have significant adverse impacts on aquatic species, and potentially make their way into the food chain. Fire: Potential air pollution of surrounding urban areas and risk of toxic fumes that affect the local flora and fauna.

Hazardous Materials Facilities

Introduction to Asset Class

The San Francisco Department of Public Health (SFDPH) defines a hazardous material as any material that because of its quantity, concentration, or physical or chemical characteristics, poses a significant present or potential hazard to human health and safety, or to the environment. Hazardous materials include those which are radioactive, flammable, explosive, toxic, corrosive, or unsafe in other ways. Exposure to hazardous materials can occur through accidental release.

Hazardous materials facilities include businesses or institutional facilities that generate, store, transport or treat hazardous materials. Such facilities include research laboratories, manufacturing facilities, gas stations, dry cleaning services, paint supply stores, auto body shops, transportation maintenance facilities, among others. The types of facilities which use hazardous substances vary widely, providing community a wide range of services and employment and educational opportunities. Hazardous materials facilities provide unique functions and services, and support the business operations of other entities throughout the City and County of San Francisco. Hazardous materials facilities can be both publicly or privately owned.

Over the past decades, federal, state, and local regulations have been developed to protect human health and the environment from hazardous materials. The San Francisco Department of Public Health Hazardous Materials and Waste Program is the local enforcement agency which regulates hazardous materials facilities registered within the City and County of San Francisco. The program implements six state environmental mandates and two local mandates. Approximately 2,700 hazardous materials facilities operate in the City and County of San Francisco, the majority located in the east and southeast areas.

These facilities include:

- 2585 that store hazardous chemicals, 238 that store hazardous materials in underground storage tanks (USTs) and 156 that store petroleum in aboveground storage tanks (ASTs)
- 1341 that generate hazardous waste, 40 of which are classified as Large Quantity Generators (LQGs) by the USEPA's Resource Conservation and Recovery Act (RCRA) Program
- 1235 of these facilities both store hazardous chemicals and generate hazardous waste.

Issue Statement

Regulations and robust inspection practices work to prevent accidental release of hazardous materials. Technology improvements, such as alarms and automatic shutoff devices, also prevent releases. Even with existing precautionary measures, hazardous materials facilities may be vulnerable to climate-related hazards, due to their precarious physical and functional characteristics. Depending on the hazardous material present, facilities may be required to prepare emergency and/or risk reduction plans; however, preventing hazardous materials release ultimately depends on the day-to-day practices of each individual facility. Hazardous materials facilities are reliant on external services, including power, communications systems, emergency response systems, transportation routes, and the municipal sewer system.

Exposure

Hazard Data Assumptions

This analysis was conducted in 2018 and 2019 using publicly-available data sources. In the table on the following page, shaking intensity is represented for two Earthquake scenarios: San Andreas Fault M7.8 and Hayward Fault M7.0 events. Accounts of assets subjected to varying levels of shaking intensity are cumulative for each scenario.

Asset Data Assumptions

Asset data is from California Environmental Reporting System (CERS) as collected on the CalEPA Regulated Site Portal, 2019.

Exposure Summary

Geologic: All hazardous materials facilities are in the Violent or Very Strong groundshaking zones during a 7.8M San Andreas earthquake. Ninety percent of facilities that store hazardous chemicals and store hazardous are in the Very Strong or Strong groundshaking risk zones during a 7.0M Hayward earthquake. Nearly half of both facility types are in the liquefaction risk zone.

Flood: Two percent of chemical storage facilities and three percent of hazardous waste generators are in the FEMA 100-year coastal flood zone. Eleven percent of chemical storage facilities and twelve percent of hazardous waste generators are in the 100-year stormwater flood zone. Nearly twenty percent of both types of facilities are in the 66” sea level rise zone.

Fire: Wildfire risk is limited to 16 facilities that store hazardous chemicals in the moderate risk zone.

TABLE A-25: HAZARDOUS MATERIALS FACILITIES EXPOSURE

Hazard	Chemical Storage Facilities (2585 Total)		Hazardous Waste Generator (1341 Total)	
	#	%	#	%
Geologic				
San Andreas 7.8 - Violent	301	12%	143	11%
San Andreas 7.8 - Very Strong	2281	88%	1197	89%
Hayward 7.0 - Very Strong	443	17%	201	15%
Hayward 7.0 - Strong	1899	73%	1009	75%
Liquefaction Zone	1188	46%	642	48%
Flooding				
100-Year Coastal Flood Zone	64	2%	36	3%
100-year storm + 24 inches SLR	218	8%	112	8%
100-year storm + 66 inches SLR	500	19%	260	19%
100-year Stormwater Flood	274	11%	163	12%
Wildfire				
High	0	0%	0	0%
Moderate	16	1%	0	0%

Note: For an exposure table with additional hazards, please see Chapter 5.

FIGURE A-40: HAZARDOUS MATERIALS FACILITIES AND LIQUEFACTION HAZARD

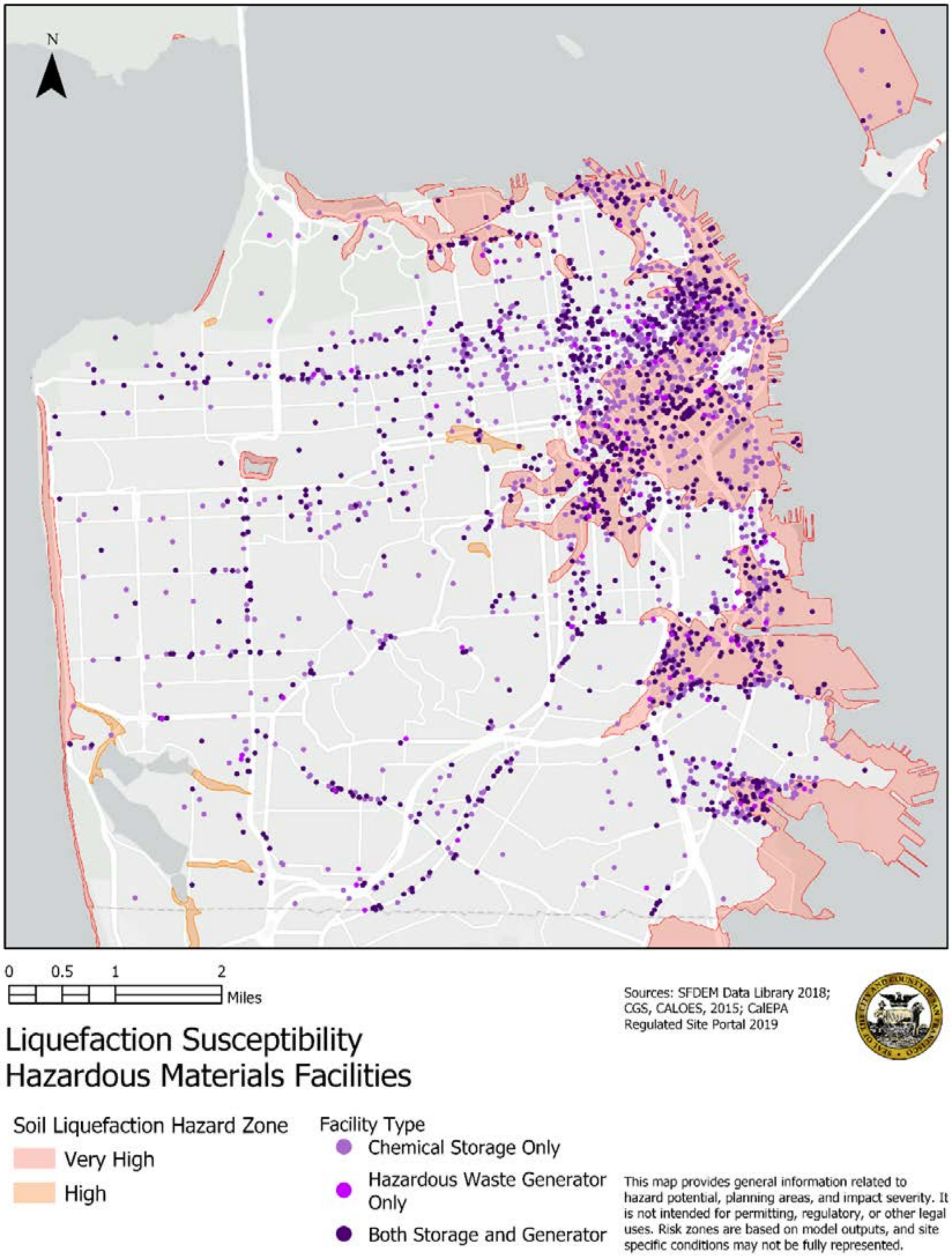
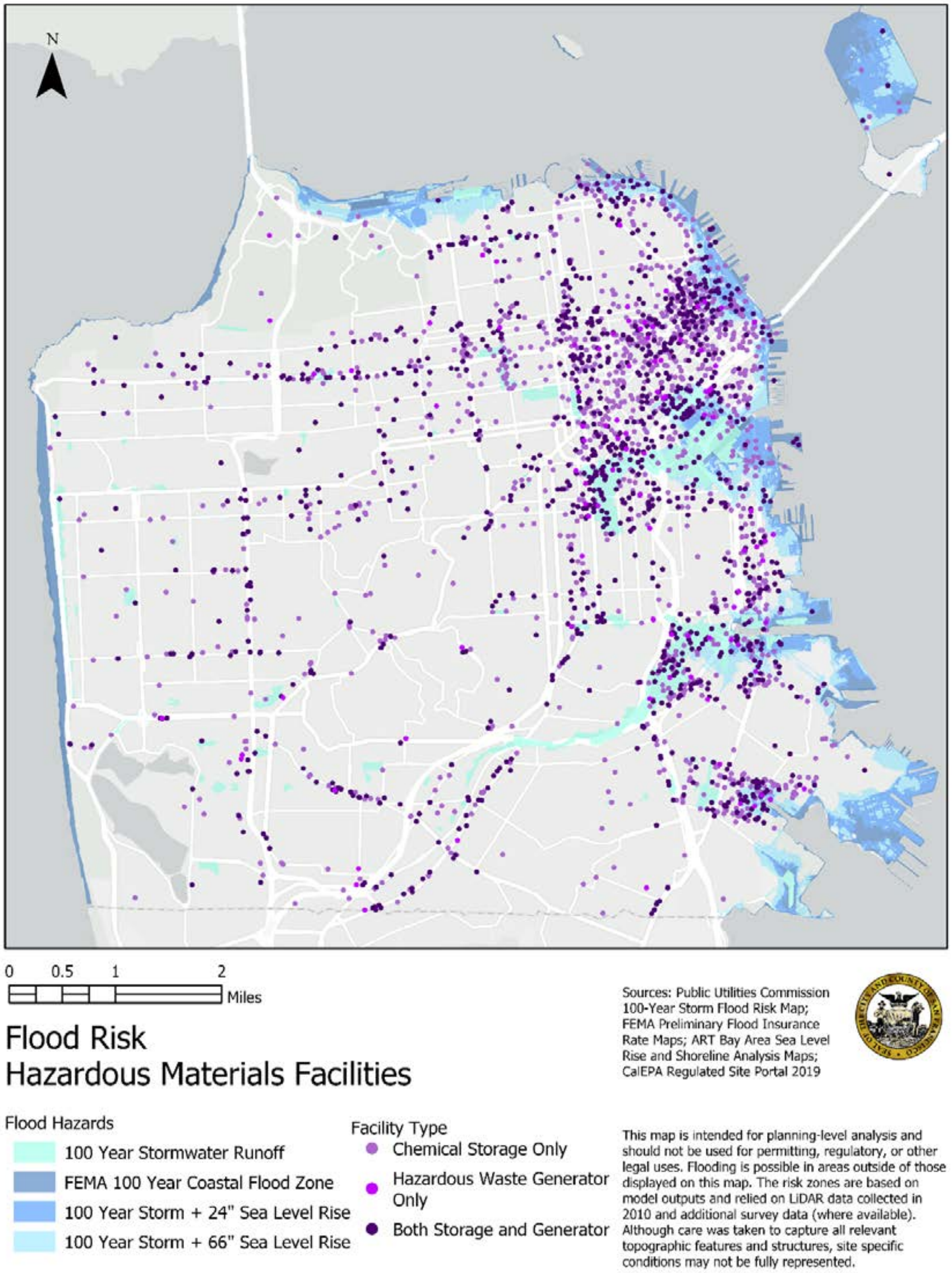


FIGURE A-41: HAZARDOUS MATERIALS FACILITIES AND FLOOD HAZARD



VULNERABILITIES

Category	Vulnerability
Physical	Geologic: Hazardous materials facilities are vulnerable to seismic hazards, especially if stored underground. Historically dozens of hazardous materials releases have occurred as a result of seismic activity. Liquefaction can compromise the integrity of storage tanks and operating systems. Gaseous hazardous materials pose the greatest hazard during an earthquake due to their volatility and ease of spread. In facilities holding multiple hazardous material types, mixing upon release can result in secondary chemical reactions. Facilities located on hillsides generally perform worse during large-scale seismic activities. Flood: Facilities exposed to coastal flooding could result in hazardous materials release into the Bay. Industrial facilities containing hazardous materials are not generally designed to withstand flooding. If flooding damages electrical equipment, power disruption may lead to containment system failure and subsequent hazardous materials release. Secondary chemical reactions can also occur with highly soluble hazardous materials. Facilities with a history of improper storage or malfunction of containment systems or operations are at higher risk. Poor business practices can be prevented by the robust inspection frequency of SFDPH's Hazardous Materials and Waste Program. Vulnerability can be reduced by continued monitoring and maintenance of any on-site flood, erosion protection and lifeline infrastructures, as well as monitoring of storage tanks for potential leachates. In the long term, facilities located along the Bay may require intervention, mitigation, or relocation. Extreme Heat: Vulnerability to extreme heat depends on type of storage, cooling system capacity, and chemical characteristics impacting reactivity to extreme heat. Products with lower ignition points—such as gasoline and solvents—can be flammable if spilled to open air. Diesel and motor oil are combustible but have higher ignition points. Facilities that rely on cooling for operation face greatest risks, especially during a power outage. Fire: Hazardous materials can be highly flammable or unstable when mixed with other chemicals. SFDPH's Hazardous Materials and Waste Program inspections ensure that incompatible materials are segregated and secondarily contained. Fire could lead to depressurization of hazardous materials containment and increase the risk of explosions. Hazardous materials inventory statement and

	management plan required by the Fire Department includes addressing flammable storage risk. Deliberate fires and terrorism also pose a risk and it is difficult to predict such occurrences. Operational capabilities include employee training, evacuation plans, employee support system. Employees would be the first line of response to control any on-site fire before it damages hazardous materials containment tanks. Some businesses and institutions store hazardous materials in above ground storage tanks (ASTs) or underground storage tanks (USTs). ASTs and USTs may contain flammable liquids or other petroleum products. ASTs and USTs have alarms and automatic shutoff devices to prevent releases.
Functional	Networks: While hazardous waste facilities are not formally networked in an industrial system, they do rely on each other for continued operation. For example, a disruption in transporter service could result in storage overcapacity at generator facilities. Contingency plans are required of all certified hazardous materials businesses. External Services: Clear and reliable transportation routes, communication systems, and power are necessary to the operations of hazardous materials facilities. Transport of hazardous materials to San Francisco is predominantly via maritime or ground transportation. Some facilities are permitted to discharge waste to the sewer system. Hazardous materials facilities also rely on external response operations during an emergency. In the event of a hazardous materials release, facility operations must halt until emergency response and cleanup activities are completed. Additional regulatory requirements exist post-disaster before operations may continue. Populations Served: Hazardous materials facilities provide community a wide variety of services and employment and educational opportunities, with facility type ranging from vehicle repair to research institutions. Healthcare centers and hospitals, among other facility types, provide services to vulnerable populations. Unique or Critical Function: Permission to operate hazardous materials business is limited and facility-specific. The construction industry relies heavily on hazardous materials wholesalers, and other businesses may require certain hazardous materials in their industrial production processes. Gas stations are essential to certain vehicle operation, and support population mobility. There are a wide variety of entities that use hazardous materials, and some may be unexpected. For example,

	some restaurants are classified as hazardous materials facilities if they use compressed gas tanks for soda or frozen desserts.
Informational	<u>All-hazards:</u> Businesses that store, handle, or use hazardous materials must obtain and maintain a valid Hazardous Materials Certificate of Registration, and submit information to the California Environmental Reporting System (CERS). Facilities develop a site map, an emergency response and contingency plan, hazardous materials inventory and hazardous waste inventory statements, a training program for employees, and a hazardous materials reduction plan. The public has a right to review most of the information reported. However, the release of confidential and trade secret information to the public is regulated by state and federal law. SFDPH Hazardous Materials and Waste Program provides information, such as chemical inventory, to SFDPH Emergency Response teams to provide to the Fire Department for use during a hazardous material emergency. San Francisco residents can dispose of certain hazardous wastes—oil-based paints, solvents, cleaning products, pesticides, fertilizers, automotive products, photo chemicals, mercury thermometers and non-empty aerosols—at retail collection facilities or at through a free curbside pickup service. The pickup service is currently underutilized. If not disposed of properly, old containers of household chemicals can deteriorate and leak, causing fumes and fires, or polluting runoff. Improperly disposed chemicals can leach into the soil and groundwater, or pose risks to waste collection workers.
Governance	<u>All-hazards:</u> Under the Federal Code of Regulations, Title 13, the San Francisco Department of Public Health (SFDPH) Hazardous Materials and Waste Program (formerly known as the Hazardous Materials Unified Program Agency) is the local enforcement agency certified by the State's Department of Toxic Substances Control (DTSC) to regulate hazardous materials facilities registered within the City and County of San Francisco. SFDPH's Hazardous Materials and Waste Program implements six state environmental mandates and two local mandates.[35] Article 21 of the Health Code requires businesses that store, handle, or use hazardous materials must obtain and renew annually a Hazardous Materials Certificates of Registration (COR). While regulated facilities are inspected at least once every three years, preventing hazardous materials release ultimately depends on the practices of the

[35] Aboveground Petroleum Storage; California Accidental Release Prevention Program; Chlorofluorocarbon Recycling; Hazardous Materials Storage and Use; Hazardous Waste Generation; Hazardous Waste Treatment; Medical Waste Generation; Underground Storage Tanks

	individual facilities. The California Accidental Release Prevention (CalARP) Program is intended to reduce the likelihood and severity of consequences of extremely hazardous materials releases. CalARP requires that businesses handling more than a threshold quantity of a regulated substance develop a Risk Management Plan (RMP) with a detailed engineering analysis of the risks and mitigation actions needed to prevent an accidental release. RMPs must also consider external events such as natural disasters. Chemicals regulated under the CalARP are a subset of the hazardous materials which require a COR. The work of the SFDPH Hazardous Materials and Waste Program also includes regulating petroleum storage, hazardous wastes (Health Code Article 22), chlorofluorocarbon recycling (Health Code Article 24), medical waste (Health Code Article 25), and Underground Storage Tanks (USTs). The Fire Code regulates and governs the safeguarding of life and property from fire and explosion hazards arising from the storage, handling, and use of hazardous materials. The Stafford Act, as amended by the Disaster Management Act of 2000, does not require local hazard mitigation plans to cover human-caused hazards. LQGs are required to follow seismic and stormwater flooding compliance for management of above ground storage tanks (ASTs) and underground storage tanks (USTs), and secondary containment.[36] SQGs and VSQGs only have to comply with basic code requirements, reducing prevention of accidental release.

CONSEQUENCES

Category	Consequence
Society/Equity	<u>All-hazards:</u> Serious health issues (acute, delayed, chronic) may occur, including skin damage or death. Vulnerable populations with pre-existing health conditions face greater impacts. Risk Management Plans must consider the proximity to sensitive populations such as schools, residential areas, general acute care hospitals, long-term health care facilities, and child day care facilities. Hazardous materials facilities located in or near communities of color and/or low-income neighborhoods pose a threat to already marginalized populations. Depending on the scale of a hazardous material release, communities may also be cut off from emergency response.

[36] Secondary containment is a means of surrounding one or more primary storage containers to collect any hazardous material spillage in the event of loss of integrity or container failure

	Geologic: Earthquakes can result in the release of hazardous dust, surface water runoff, or toxic vapors. The associated public health risk depends upon the materials released during an accident, the toxicity of the materials, and the wind or water direction that may carry the emissions from the release. In highly elevated areas and hill locations prone to mist, toxic fumes may persist longer in the air and cause health risks to local population. Flood: Hazardous materials can be released into the waterways and/or groundwater if they are improperly stored and carried by flood flows. Plumes can spread reaching areas remote to the release, contaminating the soil or sedimentation that remains once water levels return to normal. This poses a risk of direct contact to people, plants and animals, especially to workers involved in response and recovery. Extreme Heat: Hazardous material release into air can increase heat-related health issues. Contaminated air can infiltrate residential and commercial facilities and create additional indoor air quality issues. Facility overheating can result in heat-related health risks to hazardous materials facility employees. Failure of hazardous materials facility containment, transport, or cooling systems due to over exposure to heat could result in loss of life. Fire: Some hazardous materials upon burning may release highly poisonous byproduct gases and disperse in the air, causing inhalation problems and cascading health risks to the public.
Economy	All-hazards: Economic impacts vary depending on type of hazardous material released and the extent of response needed for cleanup. Release of hazardous materials will result in loss of facility raw materials and products, consequently increasing material and operational costs and loss of profits. There are additional costs associated with required cleanup activities and necessary actions to restore facility operations. Any hazardous material release will pose a strain on local agency resources to respond to the emergency. Cleanup operations may lead to lost wages and harm the economic health and livelihood of the surrounding community. Damages to surrounding private and public property (temporary, repairable, permanent), including essential support systems (water, food), and damages to employee health (acute, delayed, chronic) are to be expected.

	Flood: Depending on their location, hazardous materials facilities may need to be relocated as their main function would be difficult to maintain with periodic flooding or elevated groundwater. Release of contamination into the sewer system could pose long-term operational damage to wastewater treatment facilities, depending on the hazardous material reactivity and flammability. Extreme Heat: Failure of hazardous materials facility containment, transport, or cooling systems due to over exposure to heat could result in loss of life or asset damage. Heat can result in increased electricity costs for running cooling systems, and there are cost associated with weatherization of critical equipment, building envelope and lifeline equipment. Fire: Possible superficial damage to facility equipment and surrounding structures due to damage by toxic fumes. Risk of fire spreading out to surrounding areas and causing damage to property (temporary, repairable, permanent) and spread of contamination. A fire routinely follows an explosion, which may cause further damage to surrounding property/assets and inhibit emergency response.
Environment	All-hazards: Significant environmental impacts can result from the release of hazardous materials having long-lasting and far-reaching consequences on plants, wildlife, unique habitats, and water quality. Contamination of water supply is possible via damaged water supply pipe or damaged pipeline transporting natural gas. Leaking from industrial or commercial uses (including gas stations, car washes, etc.) may result in the release of toxic substances on or below the ground surface, contaminating soil and groundwater with long-lasting negative impacts to ecosystem health and biodiversity. Geologic: In highly elevated areas and hill location prone to mist, any fumes may persist longer in the air, settle on plants and animals impacting local habitat quality, as well as city parks and open spaces. Flood: Highly persistent hazardous materials can remain active within an ecosystem (e.g. organic compounds that bind to biomass, soluble chemicals, suspended solids). Highly mobile hazardous materials can spread for long distances from their release point and cause unforeseen consequences to habitat and local resources with a

	long-lasting, far-reaching effect on the environment (e.g. eutrophication or die-offs). Extreme Heat: Heat events that result in the release of toxic fumes or waterborne contaminants would be harmful to plants and wildlife and could result in long-term ecosystem damage and reduced habitat productivity. Fire: During a fire, volatile hazardous materials could exacerbate local fire intensity and cause additional complexities for emergency response.

Transportation Sector

Roadways

Introduction to Asset Class

Roadways facilitate residents, workers, and visitors traveling within and through San Francisco, which supports economic activity, goods movement, and quality of life. The roadway network links people with community facilities and services, jobs, family and friends, recreation, and other destinations within the city and throughout the Bay Area region. For this assessment, roadways include roadways, bicycle and pedestrian infrastructure, on-street parking, and bridges. Other elements found in the roadway not assessed in this profile include transit services (see public transit profile) underground utilities (see utilities and infrastructure profiles) street furnishings, planting strips, and lighting.

- Roadways are a system of interstates, freeways, major and minor streets that provide the main pathway for vehicle traffic throughout the city. Of San Francisco's, 1,088 miles of roadways, 946 miles are surface streets. Privately owned streets and park streets make up an additional 83 miles, and 59 miles are limited-access freeways.
- San Francisco's bicycle network is composed of 434 miles of bicycle facilities, 213 miles of which are signed bicycle routes that share right-of-way with motor vehicles, 125 miles are standard bikeways, and 13 miles are protected bikeways. The right-of-way also includes sidewalks that allow pedestrian travel and provide access to buildings, open space, roadways, and public transit. San Francisco sidewalks are typically 6-12 feet wide, elevated 6-8 inches above the roadway surface and have curb ramps that provide disability access in compliance with the Americans with Disabilities Act.
- On-street parking is also part of the roadway. SFMTA currently manages 23,000 metered on-street spaces, 12,000 signed or colored on-street curb spaces, and 94,000 on-street spaces in neighborhoods through the city as part of the Residential Permit Program.
- City-owned bridges: Public Works inspects and maintains 98 bridges, including vehicular bridges, pedestrian bridges, movable bridges, overpasses over freeways/train tracks, and two tunnels. The City owns four drawbridges, including three bascule bridges that were constructed in the early-to mid-19th century and eligible for listing with the National Register of Historic Places.
- State-owned bridges: Caltrans owns and maintains state and federal highways, roads, and bridges in San Francisco, including US-101 (Van Ness Ave and

Lombard Street), CA Highway 1 (19th Ave, Cross Over Drive and Park Presidio Boulevard), CA Highway 35 (Skyline Blvd/Sloat Blvd), US-80, US-280, and CA 82 San Jose Avenue. The Bay Bridge is the primary connector between San Francisco and the East Bay. The Bay Bridge approach is a one-mile stretch of US-80 that leads to the Bay Bridge, supporting approximately 270,000 vehicles daily between San Francisco and the East Bay, and supporting commuter and goods movement for the region.

San Francisco's roadway network is overseen with shared responsibilities by the San Francisco Municipal Transportation Agency (SFMTA), San Francisco Public Works (Public Works), the San Francisco County Transportation Authority (SFCTA), California Department of Transportation (Caltrans) and, to a lesser extent, the Port of San Francisco and the Department of Recreation and Parks

Public Works inspects city-owned bridges on a bi-annual basis to note and address deficiencies and maintenance issues. A number of these bridges cross over freeways and are jointly inspected by Caltrans and Public Works. In addition, Caltrans also inspects a number of our local bridges including those over the Caltrain right-of-way. Because the drawbridges cross waterways that are designated as navigable waterways, the U.S. Coast Guard regulates the drawbridge operations and requires the drawbridges to remain in operational condition. Public Works operates and lifts the drawbridges as needed. Caltrans is responsible for inspection, maintenance and repairs for state and federal roadways and bridges, but has Delegated Maintenance Agreements with San Francisco Public Works to perform minor repairs of surface roadways.

Issue Statement

Roadways are integral to transportation, access, and connectivity throughout the City. There are a wide-range of users of the roadways, from drivers to bicyclists to public transportation riders. The roadway is vulnerable to significant damage and disruption from liquefaction, particularly if underground utilities rupture. The roadway has reduced accessibility and safety during flood events, but can usually be returned to functionality relatively quickly once waters recede. Roadways in San Francisco are already in high demand and key thoroughfares have little to no space capacity, particularly during commute times. The consequences of disrupted roadways can cascade to citywide or regional congestion especially if major arterials are disrupted, impacting access to homes and businesses, goods movement, and local air quality. Even the disruption of local streets can have profound impacts to residents and businesses in affected neighborhoods.

Exposure

Hazard Data Assumptions

This analysis was conducted in 2018 and 2019 using publicly-available data sources. In the table on the following page, shaking intensity is represented for two Earthquake scenarios: San Andreas Fault 7.8M and Hayward Fault 7.0M events. Accounts of assets subjected to varying levels of shaking intensity are cumulative for each scenario.

Asset Data Assumptions

State bridges include their on and off ramps as part of their structures. Roadway and bikeway network data originates from the SF Open Data Portal (2018). Local and state bridges originate from the California Department of Transportation (Caltrans) GIS data library (2018).

Exposure Summary

Geologic: All roadway assets are exposed to violent or very violent shaking in a 7.9M earthquake on the San Andreas Fault. Most roadway assets are exposed to strong shaking in a 7.0M earthquake on the Hayward fault. 18% of roadways and 24% of bikeways are in the liquefaction zone. In addition, about a quarter of all bridges are located in the liquefaction zone.

Flood: Very limited roadway assets are exposed to the current 100-year coastal flood. However, with 66 inches of SLR, up to 8 percent of roadways and 11 percent of bikeways would be exposed to coastal flooding in a 100-year storm.

Fire: Five percent of roadways and 12% of bikeways are exposed to moderate wildland-urban interface fire risk, primarily in the Park Presidio.

TABLE A-26: EXPOSURE

Hazard	Roadways: 1,117 miles total		Bikeways: 233 miles total		Local Bridges: 53 total		State Bridges: 104 total	
	#	%	#	%	#	%	#	%
Geologic								
San Andreas 7.8 - Violent or Very Strong	321	29%	82	35%	6	11%	14	13%
San Andreas 7.8 - Very Strong	796	71%	151	65%	47	89%	90	87%
Hayward 7.0 - Very Strong	82	7%	19	8%	10	19%	11	11%
Hayward 7.0 - Strong	752	67%	164	70%	28	53%	62	60%
Liquefaction Zone	201	18%	56	24%	14	26%	23	22%
Flooding								
100-Year Coastal Flood Zone	12	1%	3	1%	1	2%	2	4%
100-year storm + 24 inches SLR	50	4%	14	6%	7	13%	2	4%
100-year storm + 66 inches SLR	92	8%	26	11%	7	13%	2	4%
100-year stormwater flood	38	3%	11	5%	11	21%	20	19%
Wildfire								
High	1	0%	0	0%	0	0%	0	0%
Moderate	56	5%	27	12%	0	0%	15	14%

Note: For an exposure table with additional hazards, please see Chapter 5.

FIGURE A-42: ROADWAYS AND LIQUEFACTION HAZARD

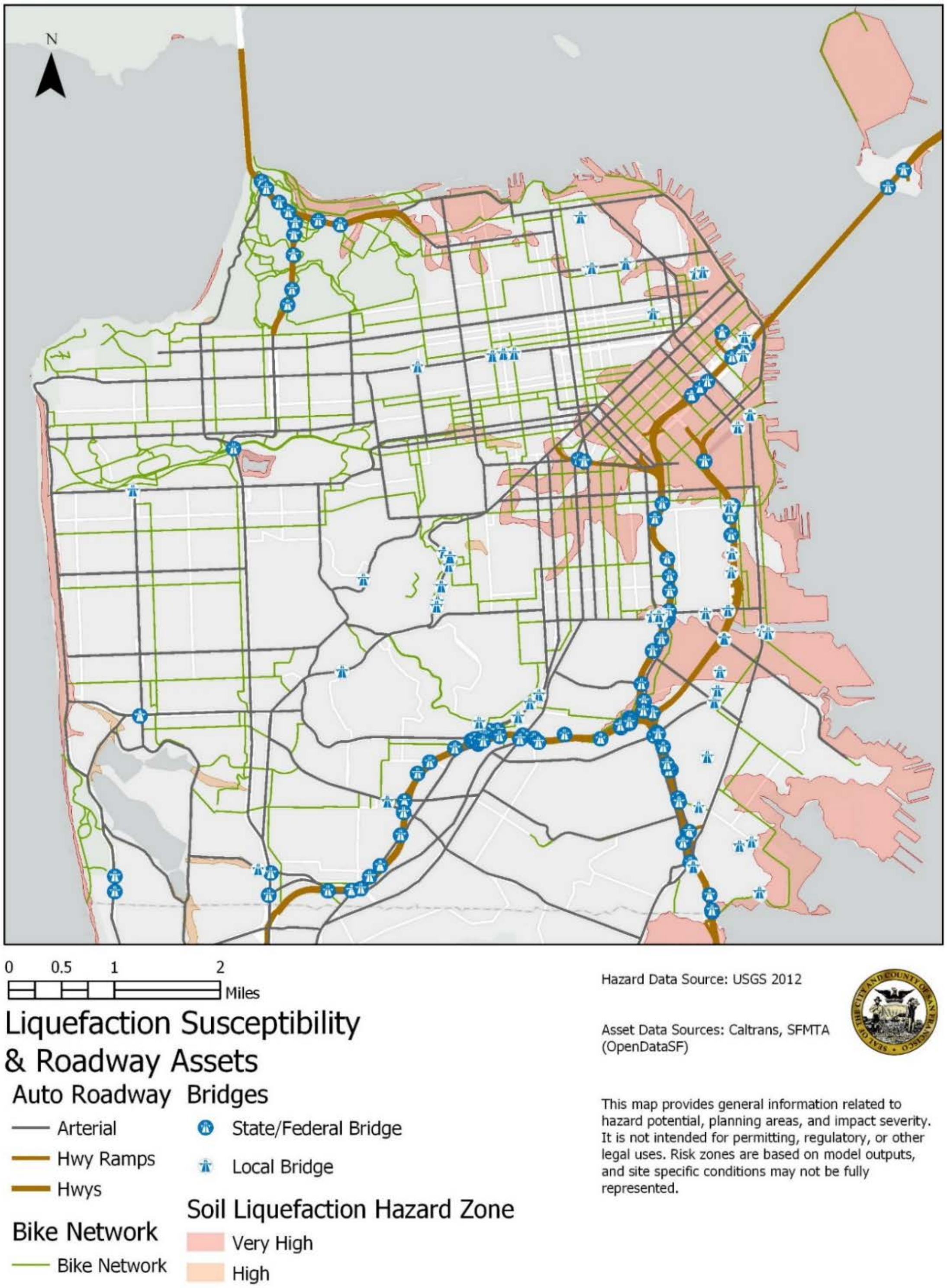


FIGURE A-43: ROADWAYS AND FLOOD HAZARDS

0 0.5 1 2 Miles

Roadway Flooding Risk

- Arterial
- Hwy Ramps
- Hwys
- Bike Network
- State/Federal Bridge
- Local Bridge
- 100 Year Stormwater Runoff
- FEMA 100 Year Coastal Flood Zone
- 100 Year Storm + 24" Sea Level Rise
- 100 Year Storm + 66" Sea Level Rise

Flood Hazard Data Sources: Public Utilities Commission 100-Year Storm Flood Risk Map; FEMA Preliminary Flood Insurance Rate Maps; ART Bay Area Sea Level Rise and Shoreline Analysis Maps

This map provides general information related to hazard potential, planning areas, and impact severity. It is not intended for permitting, regulatory, or other legal uses. Risk zones are based on model outputs, and site specific conditions may not be fully represented.

VULNERABILITIES

Category	Vulnerability
Physical	Geologic: Liquefaction may damage roadways, especially if underground pipes break. Most streets damaged during the Loma Prieta earthquake were damaged as a result of failing infrastructure – sewer, water, and gas breaks. Roadway damage impacts all uses of the roadway, including autos, public transit, bicycle facilities, and on-street parking. Liquefaction may also damage sidewalks, impacting pedestrian mobility.[37] Falling debris from buildings can temporarily disrupt roadways until cleared. Damaged buildings that have been cordoned may also disrupt access to the right-of -way.[38] In the 1990's following the Loma Prieta earthquake, City bridges were seismically analyzed and, if necessary, retrofitted to meet the standards of the era. Public Works is in the process of developing a plan to identify the most important bridges within the City and to perform a new seismic analysis to make sure that these structures meet modern code requirements. Flood: Although new roadways are designed to carry the 100-year flood event without flooding the adjacent sidewalk and structures, many roadways in San Francisco were constructed before this design criteria became mainstreamed, many roadways and sidewalks have subsided and impacted their drainage potential, and in some areas roadways repairs and re-grading efforts have reduced floodway capacity of the street.[39] Roadways that are exposed to more frequent flooding as sea level rises are likely to erode and subside.[40] When roadways are flooded, all users of the roadway (e.g., autos, public transit, bicycles, and on-street parking are affected by impacts to safety, accessibility, and increased congestion. Roadways can generally gain functionally shortly after floodwaters recede.[41]

[37] Lifelines Restoration Timeline Projection (forthcoming)
[38] Ibid.
[39] San Francisco Sea Level Rise Vulnerability & Consequences Assessment (forthcoming)
[40] Ibid.
[41] Ibid.

	Electrical components such as traffic signals, lighting, and control systems are particularly sensitive to any inundation and may take longer to regain functionality than roadways.[42] Interstate 80 and 280 are both elevated in areas of potential sea level rise exposure and thus less vulnerable to flooding. However, the footings of the elevated structures may be impacted by exposure to salt water (e.g., concrete structures may experience enhanced degradation and/or scour). In addition, the on and off ramps that connect with surface streets could be impacted through surface flooding.[43] Sidewalks are generally not sensitive to flooding and can resume their function once floodwaters recede; however, during flood events, accessibility and safety are issues. Sidewalks have minimal adaptive capacity for flooding as they cannot be easily raised and need to consider ADA accessibility and maximum slope restrictions when meeting the roadway. Although bridges are generally elevated structures, and vehicular traffic flow on the bridges may be above the floodwaters, the bridge supports (e.g., pilings, steel trusses), abutments, and bridge on and off ramps may be impacted by flooding at ground level or by an elevated water surface within the waterway itself. The equipment room at the Islais Creek Bridge may be subject to flooding with sea level rise. Extreme Heat: Pavement exposed to high temperatures over long periods of time may deform (such as pavement heave).[8] However, high temperatures can be considered in pavement design to avoid deterioration. Given the relatively short lifespan of pavement (20-25 years) and the relatively low incidence of extreme heat given San Francisco's climate, the adaptive capacity is relatively high. Workers, such as construction and repair crews, spending considerable time in the roadway may be vulnerable to extreme heat. People, especially sensitive populations such as the elderly, young, and ill, that are waiting in the right-of-way for transit services may be impacted by extreme heat, especially if there is not shading from trees or protective transit facilities. Bridges are generally not sensitive to extreme heat, but they can expand in the heat and potentially face difficulty closing properly. The

[42] Ibid.
[43] Ibid.

	mechanical and electrical equipment for drawbridges could potentially be damaged by extreme heat conditions necessitating increased maintenance. <u>Fire:</u> While the roadway itself is not sensitive to fire, elements of the right-of-way can be damaged or destroyed including railings and electrical equipment. Fire can increase the risk of erosion and landslides which can damage roadways. Damaged or clogged drainage systems can also contribute to potential damage during rainfall events. Bridges are sensitive to fire as the extreme temperatures could reduce the performance of the bridge. Roadways and bridges are not sensitive to smoke.
Functional	<u>Networks:</u> Roadways function as a network. Disruption to the highest capacity roadways, such as interstates and arterials could affect the overall function of the network with substantial congestion because there are limited alternatives. Although alternative on and off ramps can be used to access the freeways, re-routing traffic increases traffic congestion on city streets. There is limited redundancy for bridges. Inland roadways can provide alternative routes for street traffic. However, Third Street, with two bascule bridges, is one of the primary north-south corridors on the southeast side of the city. <u>External Services:</u> The roadway depends on electric power for lights and signals and for the overhead power lines of the electric trolley system. If electric power is disrupted, then traffic control may be handled by SFPD officers and SFMTA parking control officers. Drawbridges also depend on electric power. Roadways depend on the combined sewer system to remove runoff and maintain accessibility during precipitation events. Roadway repair depends on two Granite Rock Asphalt plants located in Redwood City and South City which may be damaged after an earthquake and have high demand from other cities. <u>Populations Served:</u> Roadways serve all San Franciscans, commuters, and visitors. The transit, biking, and pedestrian facilities are especially important for

	those without a personal vehicle or not capable of driving, such as the elderly and disabled. <u>Unique or Critical Function:</u> Roadways in San Francisco are often very congested and there are competing demands for the space from different users. The roadway serves a critical function to provide access and mobility to all. Roadways are also critical for emergency responders to access those in need, and critical facilities, such as hospitals. Public Works has an Emergency Priority Routes Map to assist in conducting damage assessment and street clearance functions. More recently, a multi-agency work group has developed an Emergency Route Reopening Standard Operating Procedure to create tailored priority route maps following a disaster as pre-planned maps will not accurately reflect damage assessment information. Bridges are especially important for communities with limited access or communities in which freeways are a barrier to accessibility to the remainder of the City. The Bay Bridge plays an especially critical function providing connectivity to the East Bay.
Informational	<u>All-hazards:</u> Public Works is in the process of developing a plan to identify the most important bridges within the City and to perform a new seismic analysis to make sure that these structures meet modern code requirements.
Governance	<u>All-hazards:</u> Public Works is responsible for approximately 13,000 blocks within San Francisco. Approximately 1/3 of the streets are arterial or collector streets and approximately 2/3 are residential. Public Works is constantly resurfacing and repairing surface roads. Generally, six criteria (in no particular order) determine the priority for resurfacing in normal conditions: • Pavement Condition Index (scoring 0-100) • Geographic equity • Project readiness and coordination with private and public agencies • Inquiries • Mode(s) of transportation • Availability of funding

	The City has committed to Vision Zero with a goal of zero traffic fatalities and critical injuries in San Francisco by 2024. This has implications for the design and maintenance of streets, bicycle, and pedestrian infrastructure. SFMTA has its own capital program dedicated to the multimodal transportation system; however, the short-and long-term adaptation needs of the multimodal transportation system often require coordination with other agencies such as the SFCTA, the Port, and Public Works. The City is committed to safe and accessible travel for people with disabilities, making capital improvements and enhancing services across the City. Bridges in California are designed per the American Association of State Highway and Transportation Officials (AASHTO) Bridge Design Specifications with Caltrans Interims and Revisions. In addition, Caltrans has developed a Seismic Design Criteria document which defines the seismic design spectrum to be used. The Design Spectrum (DS) is defined as the greater of a probabilistic design spectrum based on a 5% probability of exceedance in 50 years or a deterministic spectrum based on the largest median response resulting from the maximum rupture of any fault in the vicinity of the bridge site. These design levels can also be increased in order to achieve a higher level of performance on important lifeline structures. The U.S. Coast Guard regulates drawbridge operations over navigable waterways and requires the drawbridges to remain in operational condition. Public Works lifts the bridges when notified by the U.S. Coast Guard.

CONSEQUENCES

Category	Consequence
Society/Equity	<u>All-hazards:</u> Disruption to roadways during a hazard event could affect health and safety if people cannot access medical treatment or first responders cannot access an area. Nevertheless, priority lifeline routes are intended to maintain emergency access for first responders and critical medical care. Increased congestion and re-routing could increase collisions and related injuries/fatalities. Increased congestion and re-routing may be especially difficult for vulnerable populations, such as children and the elderly.

	Rerouting of traffic, especially truck traffic, could further impact communities that are already burdened by air pollution.
Economy	All-hazards: Increased congestion may result in the loss of economic productivity and the loss of economic activity if some businesses are not accessible. Many businesses rely on just-in-time goods movement deliveries that could be impacted by disrupted roadways. Small business are particularly vulnerable if access is comprised as they may have fewer resources to withstand a loss of business activity. This can impact the ability of community residents to purchase groceries, gas, and other necessities. If major arterials are disrupted, the impacts could quickly become citywide or regional. If local streets are disrupted the impacts may be neighborhood or citywide. If a major bridge were disrupted, such as the Bay Bridge, alternate routes would be extremely lengthy and heavily impacted with additional vehicles. The time-of-day and day-of-week of a hazard disruption can play a major role in the scale of consequences. A hazard event during working hours will likely result in greater congestion and disruption as hundreds of thousands of commuters would be trying to use the right of way. Geologic: The cost to repair roadways damaged by liquefaction would be significant. Flood: Increased coastal flooding could increase roadway maintenance costs. Extreme Heat: Increased extreme heat events could increase roadway maintenance costs and could reduce the lifespan of some electrical equipment. Fire: Exposure of roadways to fire can cause the closure of these routes with impacts for traffic circulation
Environment	All-hazards: Increased air pollution due to congestion. Flood: Abandoned vehicles may pose an environmental threat due to contamination from fuel and other chemicals.

Parking Garages

Introduction to Asset Class

City owned public parking garages are typically multi-story concrete parking structures. They are primarily concentrated in the Northeastern part of the city. They are a source of revenue for the City, offering short-term or monthly public parking for private vehicles. These assets are primarily owned and managed by SFMTA. If a parking facility is owned by Real Estate (RED), then a third party vendor is normally contracted to manage the garage. Some parking assets are owned by other city agencies, such as Recreation and Parks, and management varies from department to department.

Exposure

Hazard Data Assumptions

This analysis was conducted in 2018 and 2019 using publicly-available data sources. In the table on the following page, shaking intensity is represented for two Earthquake scenarios: San Andreas Fault 7.8M and Hayward Fault 7.0M events. Accounts of assets subjected to varying levels of shaking intensity are cumulative for each scenario.

Asset Data Assumptions

Data on public parking garage assets was sourced from the Facility System of Record map found on the SF Open Data Portal. This was then cross checked using the list of parking garages found on the SFMTA website.

TABLEA-27: EXPOSURE

Hazard	Parking Structures: 19 Total	
	#	%
Geologic		
San Andreas 7.8 - Violent or Very Strong	19	100%
San Andreas 7.8 - Very Strong	0	0%
Hayward 7.0 - Very Strong	1	5%
Hayward 7.0 - Strong	18	95%
Liquefaction Zone	6	32%
Flooding		
100-Year Coastal Flood Zone	0	0%
100-year storm + 24 inches SLR	1	5%
100-year storm + 66 inches SLR	1	5%
100-year Stormwater Flood	1	5%
Wildfire		
High	0	0%
Moderate	0	0%

Note: For an exposure table with additional hazards, please see Chapter 5.

Dataset does not include: Japan Center Annex Garage

Exposure Summary

Geologic: All public parking structures will be exposed to violent or very strong shaking in a 7.8M earthquake on the San Andreas Fault. However, only one structure will be subject to violent or very strong shaking in a 7.0M earthquake on the Hayward fault.

Flood: Public parking assets are not expected to see significant exposure to flooding hazards. However, there is one facility (Golden Gateway Parking Garage) that will see exposure to flooding given both SLR scenarios as well as during 100-year storm water events.

Fire: Public parking assets do not see exposure to wildland-urban interface fire hazards

FIGURE A-44:PARKING ASSETS AND LIQUEFACTION HAZARD

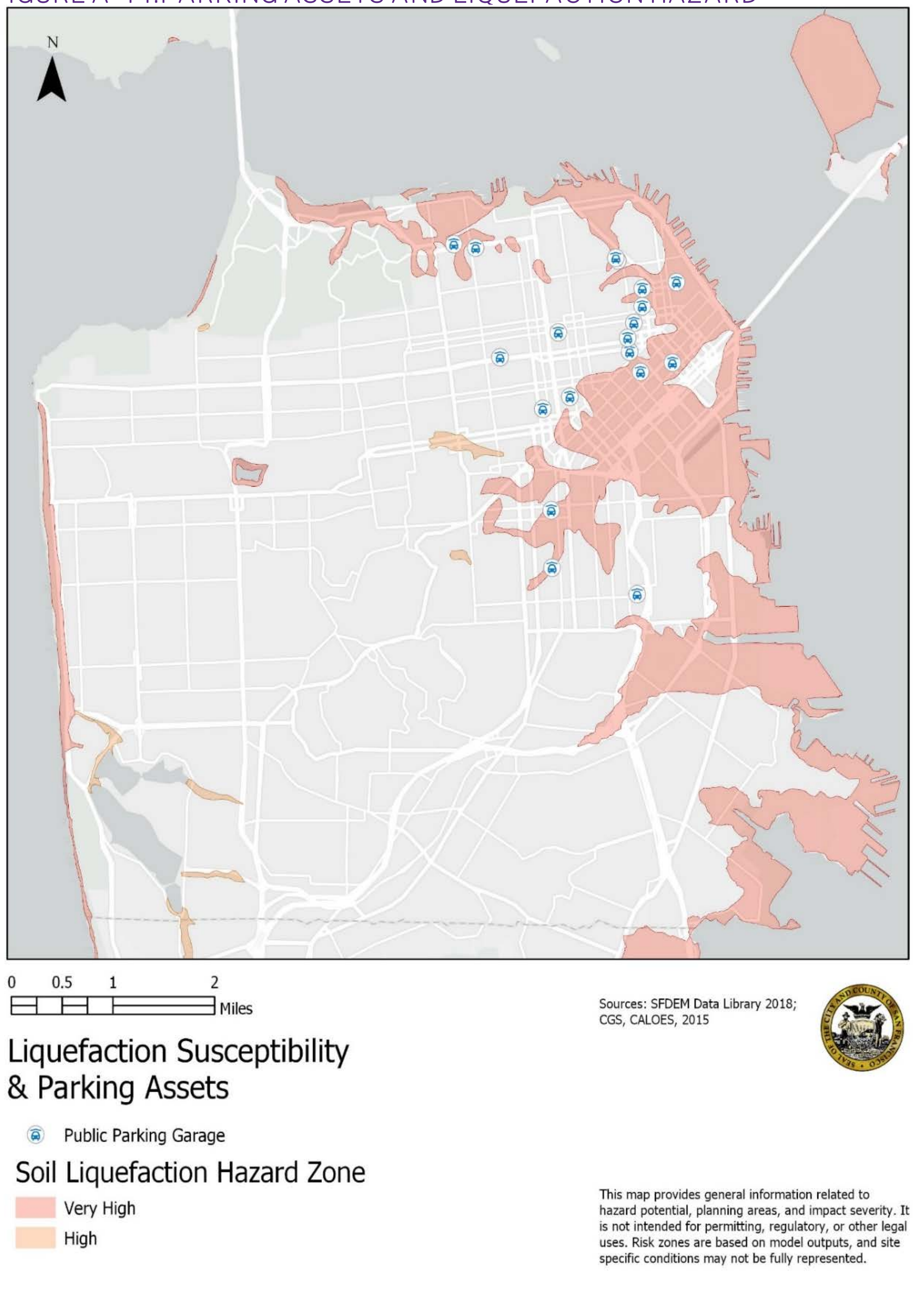
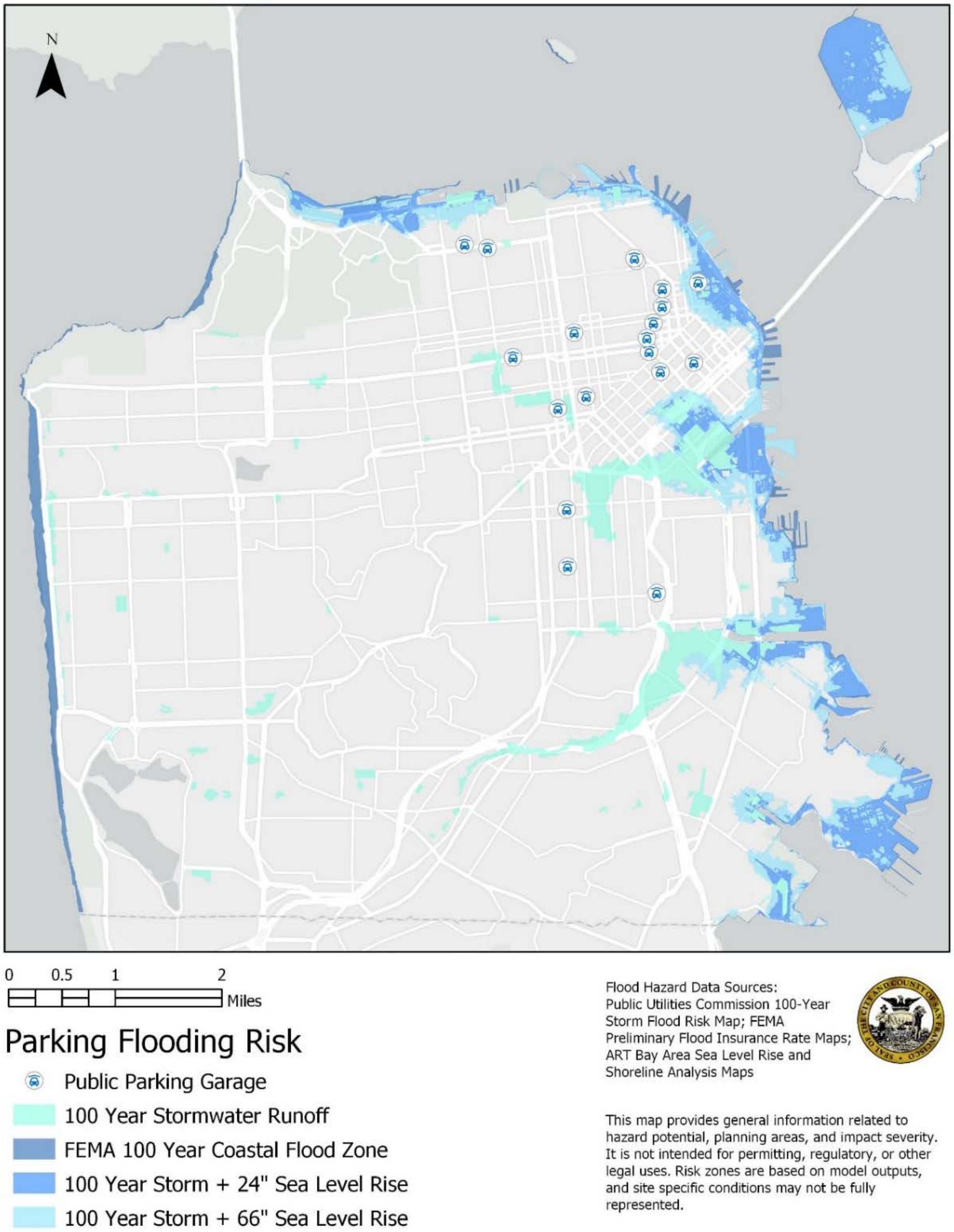


FIGURE A-45: PARKING ASSETS AND FLOOD HAZARDS



VULNERABILITIES

Category	Vulnerability
Physical	Geologic: Many structures were constructed prior to 1975 and many have not been seismically retrofit. However, some of the oldest, most heavily used structures have received some manner of retrofitting Flood: Some garages have sub-basements that can be subject to flooding, impacting access to some of these facilities. Extreme Heat: Most structures are naturally ventilated and are not confined spaces.
Functional	Networks: Garages often operate independently and do not provide services that would require their connection to networks. If one or more garages is damaged, that may result in increased demand at other nearby garages. External Services: Garage structures rely on external power and communications infrastructure in order to operate. There are no backup resources or contingency plans in place if these services were to be disrupted. Populations Served: All structures are built to be ADA compliant, publicly available to all, and offer parking services at market or below market rates. Unique or Critical Function: This asset offers public parking in congested areas, thus reducing the number of vehicles on the street and contributing to traffic calming.
Informational	All-hazards: Relevant asset information can be found in SF Public Works 2013 Condition Assessment Report.
Governance	All-hazards: Improvement and management of this asset is dictated by the SFMTA Parking Facilities Restoration and Compliance Program which is tasked with assessing and restoring all assets in order to make them code compliant.

CONSEQUENCES

Category	Consequence
Society/Equity	Geologic: Asset services may be disrupted for years as repair/replacement processes are carried out. Depending on the severity of the event, this could lead to a shortage of market or below market rate parking in congested areas. This could lead to more congestion as a greater number of cars are forced to park on the street. Flood: Asset services may be disrupted by days following a significant flooding event. Depending on the severity of the event, this could lead to a shortage of market or below market rate parking in congested areas. This could lead to more congestion as a greater number of cars are forced to park on the street.
Economy	Geologic: Costs of repair or replacement of the asset can lead to a loss of fiscal revenue. Prolonged disruption from events can have an impact on economic success of nearby businesses. Flood: Interruption of economic activity to nearby buildings can occur if flooding were to effect access to certain facilities. Generally, loss of fiscal revenue would occur if significant disruption of this asset were to occur. Operational costs for this asset would also be impacted from repair expenses over time.
Environment	All-hazards: Any disruption that led to more congestion or cars circling, looking for parking, would lead to greater emission of pollution from vehicle exhaust.

Public Transit

Introduction to Asset Class

The public transit system facilitates the movement of residents, workers, and visitors traveling within and through San Francisco, which supports economic activity and quality of life. The transit system links people with services, jobs, family and friends, recreation, and other destinations within the city and throughout the Bay Area region. Public transit is regional in nature and offered by over 20 service providers in San Francisco. The transit system includes SFMTA's Muni (buses, electric trolley buses, metro light rail, cable cars, and historic street cars), BART, Caltrain commuter rail, as well as regional bus services provided by transit operators such as AC Transit, SamTrans, and Golden Gate Transit. (For ferry service, please see the Water Transportation profile.) Given the lower adaptive capacity of fixed rail (e.g. more capital intensive and difficult to re-locate and re-route), this profile focuses on agencies managing fixed rail public transit assets in San Francisco: Muni, BART, and Caltrain. This profile provides greater detail on Muni assets and services because it is owned and managed by the City and County of San Francisco and more information was readily available for this assessment. These transit systems are each described below:

Muni

- Motor Coaches (Buses) are fuel efficient vehicles that operate on routes throughout the city that can be re-routed if needed. They carry about 45% of MTA's public transportation system riders. The motor coach fleet consists of roughly 610 vehicles and includes 32-foot, 40-foot and 60-foot buses.
- Metro light rail includes 71.5 miles of standard-gauge track, seven light rail lines, three tunnels, 12 subway stations, 25 surface stations, and 87 surface stops. The system has an average weekly ridership of 173,500 passengers. As of 2016, Muni Metro consisted of 149 light rail vehicles (LRVs)[44].
- Electric trolleys operate on a fixed overhead line network that provides electric power. These 202 zero-emission vehicles carry about 30% of the public transportation system's riders and operate on local streets.

[44] SFMTA (2017) *"2017-2030 Short Range Transit Plan"*. Retrieved from: https://www.sfmta.com/reports/short-range-transit-plan-fy-2017-fy-2030

- Cable cars operate on fixed routes and are hauled by a continuously moving cable located just below street level. 40 cable cars make up Muni's cable car fleet.
- Historic streetcars operate on tracks along the roadway, with some track sections separated from regular auto traffic. Muni has 43 operational vehicles. Streetcars carry roughly, 21,000 passengers daily.

Bay Area Rapid Transit (BART)

Operates four regional commuter rail lines within San Francisco which are served by eight below grade subway stations (four shared with Muni Metro above). These stations are located along the Market Street corridor, Mission Street and interstate 280. Embarcadero and Montgomery stations are the busiest in the BART system. In Fiscal Year 2017, over 180,000 trips were made to or from these stations each weekday. BART has an estimated 679 fleet vehicles.[45]

Caltrain

operates three regional heavy rail commuter transit stations within San Francisco, providing connectivity to Peninsula. These stations are typically at grade and are found along the southeastern portion of the city.

Given the limitations of conducting an assessment at a citywide scale, not all transit sub-assets that are required for a functioning system were included in this assessment, such as telecommunications, signaling equipment, etc. Instead, Transit stations and the fixed guide-way more broadly were assessed for exposure as representative assets and therefore used as a proxy for potential impacts to other critical sub-assets. These two asset types are described in greater detail below. The overhead catenary system used by Muni buses and street car fixed-guideways, and related infrastructure were included in the exposure assessment to the extent possible and their vulnerabilities and consequences of disruption are discussed in the qualitative sections below. Cable cars we not included in the exposure analysis but their vulnerabilities and consequences of disruption are discussed below as well. Additional infrastructure and facility

[45] BART 2018 factsheet (2018). https://www.bart.gov/sites/default/files/docs/2018_BART%20Factsheet.pdf

vulnerabilities that may affect transit service are discussed in the Roadways Profile and Municipal Yards Profile.

Stations

In general, two types of transit stations can be found in San Francisco: below grade subway stations and at grade surface stations. Subway stations consist of surface entrances and typically have two levels: a mezzanine concourse containing ticketing and passenger fare gates, and a lower level consisting of boarding platforms and transit system operation. In SFMTA/BART shared stations, BART operates on a third sublevel. At the surface, stations include elevated platforms, boarding islands, bus bulbs and curbside bus zones.

SFMTA Transit stations, street level boarding islands, and curbside bus zones may be shared among regional transit service providers with shared governance structure and maintenance jurisdictions. For stations shared with BART, SFMTA is responsible to SFMTA service level, and assets related to Muni service on the passenger mezzanine (i.e. Fare gates/ticketing) BART is responsible to remainder of the station. SFMTA, BART and Caltrain are all individually responsible for stations discreet to their services. Other regional transit services providers (e.g. Golden Gate Transit, SamTrans, AC Transit) also have boarding islands and curbside bus zones within San Francisco that are either stand-alone or jointly operated with SFMTA.

Muni Fixed Guideway

Trackways consist of several critical functioning sub-assets such as the train control system, traction power system and switches. Trackways also include the track itself which is the rail equipment the LRVs and street cars run on. Trackways span over 70 miles and support seven light rail lines. The trackway runs below ground in the subway along the Market Street corridor and other tunnels along the system. In many instances the trackway runs at or above grade as the metro lines extend towards outer service areas.

Issue Statement

The public transit system plays a unique and critical function in San Francisco. Muni alone moves over 700,000 individuals daily, providing access to jobs, shopping, recreation, and other services. Embarcadero Station (Muni and BART) is particularly vulnerable to future coastal flooding events as sea level rises because it is below grade and has sensitive equipment. The Ferry and Central Subway portals and Caltrain and Muni T-Third line through Mission Bay may also be vulnerable to future coastal flooding as sea level rises. Both the Embarcadero area and Mission Bay are also susceptible to liquefaction in an earthquake, which could damage transit-related assets and infrastructure. Transit systems rely on electric power and do not have backup redundancies. Impairment of transit systems from flooding, earthquake, power loss, or other hazard events would have severe economic and equity consequences, potentially at a regional scale.

Exposure

Hazard Data Assumptions

This analysis was conducted in 2018 and 2019 using publicly-available data sources. In the table on the following page, shaking intensity is represented for two Earthquake scenarios: San Andreas Fault 7.8M and Hayward Fault 7.0M events. Accounts of assets subjected to varying levels of shaking intensity are cumulative for each scenario.

Asset Data Assumptions

Data originates from DEM Data Library (2018) and the SFMTA (2018). As discussed above, the exposure assessment focuses on fixed guideway assets given their lower adaptive capacity. Stations and trackways were assessed as representative assets, but do not reflect all assets that are necessary to run a functioning transit system. Additionally, exposure assessment does not explicitly include potential impacts from damage to the Transbay tunnel from these hazards. Surface flooding of some stations (such as embarcadero) can lead to miles of underground flooding underground, a fact not captured in this analysis.

TABLE A-28: EXPOSURE

Hazard	Muni Stations: 9 Total		Muni LRV Fixed Guideway: 42 miles total		BART Stations: 8 total (4 shared with Muni)		BART Right of Way: 8 miles total		Caltrain Stations: 3 total		Caltrain Right of Way: 18 miles total		Overhead Catenary System: 332 miles total		Central Subway: 2 miles total		Central Subway Stations: 4 total		Cable Car Lines: 7 miles total	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Geologic																				
San Andreas 7.8 - Violent	0	0%	10	23%	0	0%	8	100%	0	0%	4	25%	32	10%	0.0	1%	0	0%	0	0%
San Andreas 7.8 - Very Strong	9	100%	32	76%	8	100%	1	13%	3	100%	11	60%	296	89%	1.6	79%	4	100%	7	100%
Hayward 7.0 - Very Strong	6	67%	7	16%	1	13%	4	50%	0	0%	2	11%	32	10%	0.2	11%	1	25%	1	7%
Hayward 7.0 - Strong	1	11%	18	44%	5	63%	2	25%	3	100%	13	74%	296	89%	1.4	68%	3	75%	6	86%
Liquefaction Zone	3	33%	10	24%	3	38%	4	50%	2	67%	9	50%	169	51%	0.9	47%	2	50%	1	17%
Flooding																				
100-Year Coastal Flood Zone	0	0%	0	0%	0	0%	2	25%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%

100-year storm + 24 inches SLR	1	11%	5	11%	1	13%	0	2%	1	33%	6	33%	7	2%	0.192	33%	0	33%	0.116	2%
100-year storm + 66 inches SLR	1	11%	7	17%	1	13%	0	5%	1	33%	7	39%	13	4%	0.432	39%	1	39%	0.306	4%
100-year Stormwater Flood	2	22%	1	2%	0	0%	1	7%	1	33%	8	44%	10	3%	0	44%	0	44%	0	0%

Note: For an exposure table with additional hazards, please see Chapter 5.

Exposure Summary

Geologic: A significant amount of transit assets are exposed to violent or very strong shaking in a 7.8M earthquake on the San Andreas Fault. BART trackway and stations, Embarcadero Station is exposed to very strong shaking in a 7.0M earthquake on the Hayward fault. Three Muni and Bart stations are in the liquefaction hazard zone and two Caltrain stations and a significant share of Caltrain trackway are in the liquefaction zone. Fixed-guideway for light rail, streetcar, cable car and trolley coaches are all exposed. Specifically, the Muni T-Third and Caltrain lines traverses liquefaction hazard zones in Mission Bay and Islais Creek areas in addition to half of the central subway stops being located in a liquefaction zone

Flood: Embarcadero Station and the Ferry Portal at Folsom are susceptible to coastal flooding. Future Central Subway Stations may also be vulnerable at 4th Street and Harrison. Surface stations along the Embarcadero may also be exposed future coastal flooding as sea level rises, impacting both surface and subterranean fixed-guideway services. The Caltrain San Francisco Station and Caltrain trackway in Mission Bay may also be exposed to coastal flooding as sea level rises. The Muni T-Third line traverses flood hazard zones around Mission Creek and Islais Creek.

Fire: The limited public transit assets included in this assessment are not exposed to wildfire risk.

FIGURE A-46: TRANSIT AND LIQUEFACTION HAZARD

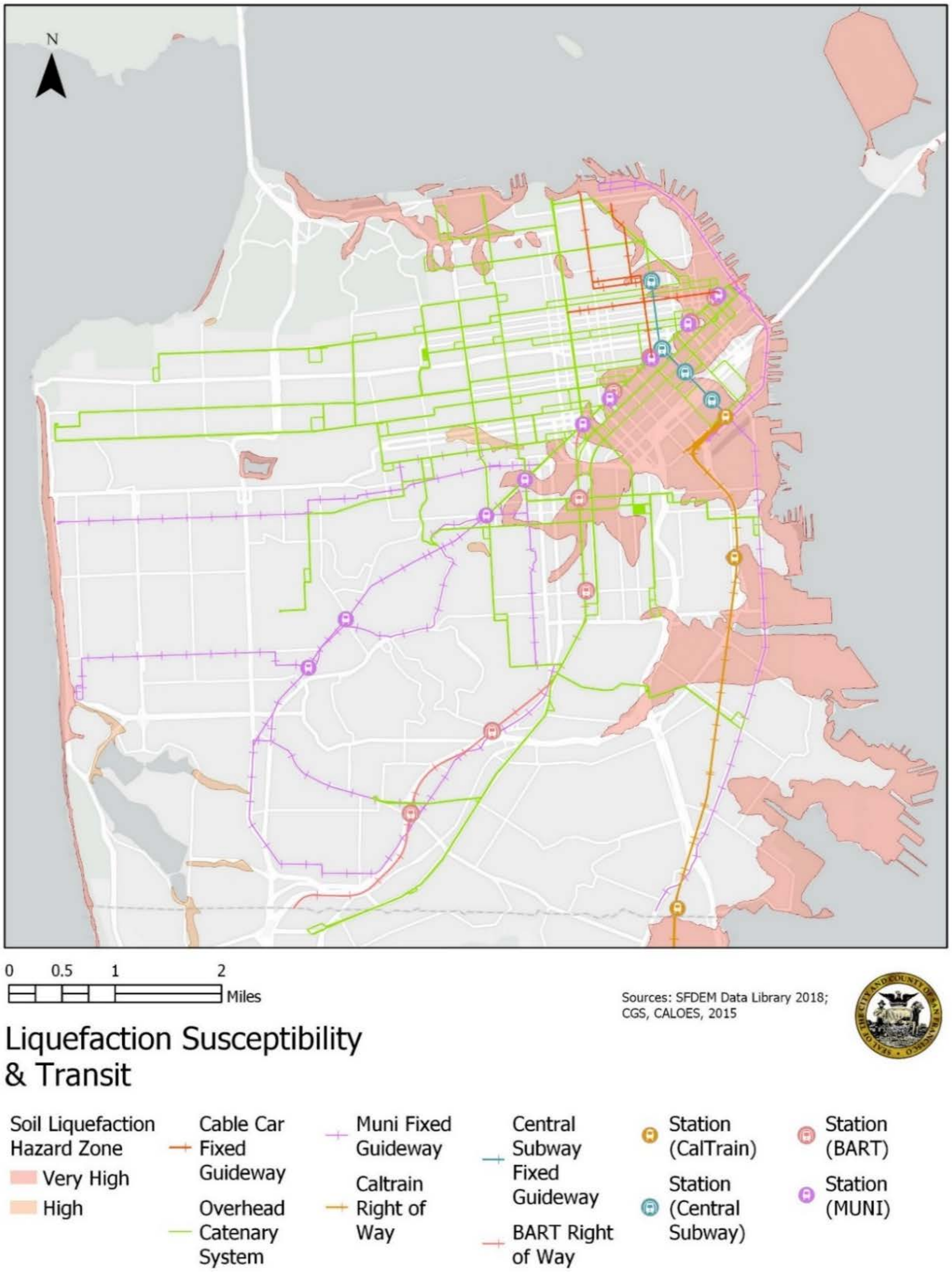
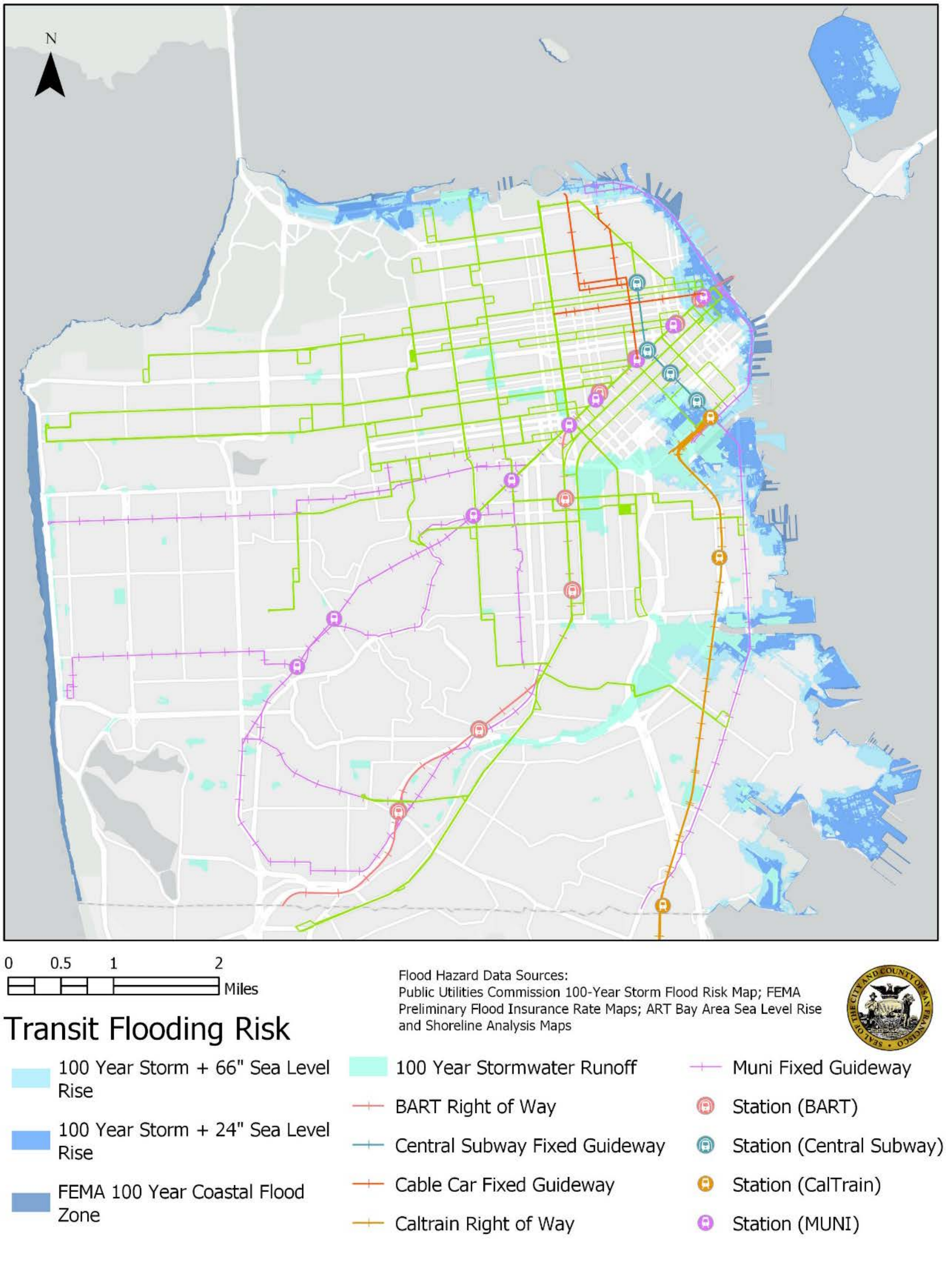


FIGURE A-47: TRANSIT AND FLOOD HAZARDS



VULNERABILITIES

Category	Vulnerability
Physical	Geologic: Transit fixed guideway infrastructure, such as the overhead catenary system and track, is vulnerable to groundshaking and liquefaction hazards but the scale of disruption or potential failure is relatively uncertain. For example, rail assets have a certain level of tolerance through shifting. However, if the seismic event appreciably disrupts any sub-assets, transit service in the metro will suspend until the issue is addressed. These sub assets include the signal system, switch system, and train control system among others.[114] Damage to roadways may impact transit service (see Roadways profile). Flood: Stations along the waterfront and market street see exposure to coastal flooding under projected sea level rise inundation scenarios and they are particularly vulnerable because these station systems are below grade, have electrical equipment that is sensitive to water, and metal components (e.g. track) that are particularly sensitive to the corrosive nature of saltwater. Stations are less vulnerable to stormwater flooding due to the relatively short term nature and shallow depth of water, however this is dependent the sewers' capacity to shed water. Pumps currently exist throughout the system, but have a limited capacity and are dependent upon a functioning sewer system. Light rail tracks are sensitive to inundation and service would be suspended if the flood depth exceeds operator ability to judge safe passage. The rail system would require inspection before placing the system back in service. Exposure to salt water would accelerate corrosion. Exposure of streetcar cable lines would also likely accelerate corrosion. The cable cars can continue to operate during minimal flooding (as long as operator can visibly assess safe passage); however, operation would likely cease until floodwaters recede for safety reasons. Cable cars are currently not used during severe weather.[115] Extreme Heat: High heat is likely to affect electrical components across sub-asset systems, including the vehicles themselves. There have been

[114] Rewers J, (October 2018). "*MUNI Lifelines Restoration Interview*". Interviewed by Mieler D.
[115] San Francisco Sea Level Rise Vulnerability & Consequences Assessment (forthcoming)

	instances of high heat affecting older light-rail vehicles (LRVs), however, there is uncertainty as to its effect on new LRVs. Pavement and track exposed to high temperatures over long periods of time may deform (such as pavement heave or track buckling),[116] affected rail lines and overhead catenary system poles. However, high temperatures can be considered in pavement design to avoid deterioration. Given the relatively short lifespan of pavement (20-25 years), the adaptive capacity is relatively high. The bus fleet may experience increased breakdowns and AC malfunction during extreme heat. BART's electrical and mechanical systems can potentially overheat during extreme heat events. This can impact delivery of power to the third rail used for the movement of vehicles as well as to BART stations. Additionally, essential air conditioning can fail from the strain of keeping other systems cool. Fire: All station and fixed guide-way sub-assets are vulnerable to fire. Even concrete assets (station platforms, tunnel walls, etc.) see reduced life expectancy if internal rebar is heated to (or near) the melting point. Failure in a single metro sub-asset halts or disrupts service until all sub-assets are functional. It is possible that service could continue at other points in the system if damage were isolated and the cause identified. Because cable cars are open air and without ventilation, they were removed from service during the severe air quality days in 2018 and replaced with bus service. Low visibility from wildland-urban interface fires may lead to service delays due to poor visibility of transit operators[117]
Functional	Networks: The transit systems are networked. The fixed guideway systems, including Muni metro, electric trolleys, cable cars, and historic street cars could experience widespread disruption even if a small portion of the network is damaged as it is difficult or impossible to re-route these services around impacted stretches. It is possible that subway stations along Market could be shut down with functional service remaining along the rest of the system unless system-wide electrical

[116] Caltrans, (2019). "*Caltrans Climate Change Vulnerability Assessment Summary Report District 4*"Retrieved From: http://www.dot.ca.gov/transplanning/ocp/docs/D4_Caltrans_Vulnerability_Assessment_v49.pdf

[117] SFMTA, (2018). *"San Francisco Commits to All-Electric Bus Fleet by 2035"* Retrieved from: https://www.sfmta.com/press-releases/san-francisco-commits-all-electric-bus-fleet-2035

	issues occur. In the case of BART stations affected by flooding, it is likely that all train connections to the East Bay would be disrupted until service could be restored. All MTA trolley coaches can run on batteries, which can help reroute the vehicle around a minor disruption. However, older vehicles have shorter battery range than newer models, especially in hilly conditions. Long-range plans to transition the electric trolley fleet to battery-powered busses that do not require overhead wires will increase the flexibility of the system.[118] If access or operations at a station is disrupted, redundancy and alternatives are very limited. It is possible that ground transit (motor coaches, electric trolley) could help to maintain continuity of services, but would still result in a net loss of services as vehicles would be diverted from other routes. Furthermore, ground transit reserve fleets are limited by federal law and available vehicles routinely replace broken down vehicles or vehicles scheduled for maintenance. This option is also dependent on the degree to which sub-assets associated with alternative service, such as the OCS, may also be impacted by hazard events. Motor coaches can be more easily be re-routed to avoid areas of flooding or other hazards. In addition, motor coaches can provide service along alternate routes during disruptions to electric trolley, cable car, and historic street car service if sufficient buses are readily available. However, there are limited buses available in the reserve fleet, therefore, serving alternative routes almost always necessarily reduces service on other existing bus routes. As BART is a regional service partner, disruptions from localized flooding can have an impact on other areas of the bay. <u>External Services:</u> Transit stations rely on electric power, communications systems, and the sewer system to operate. There are typically no redundancies in regards to external services, particularly electric power and networked communication systems. For example, If citywide power outages occur, the system will not be able to operate. If the power outage/interruption were isolated to a particular power supply/substation or transit station, it is possible that other elements/locations of the system could continue services. In regards to flooding, the ability to pump water is dependent on the sewer system.

[118] Ibid.

	As San Francisco transitions to an all-electric bus fleet by 2035, the system will be dependent upon electric power for battery charging. MTA motor coaches depend on fuel, which is stored in underground tanks and at all motor coach facilities. The transit system also relies heavily on water, for fire protection, and waste management services in order to maintain operations <u>Populations Served:</u> Muni service is critical to transit dependent residents including the elderly, very young, medically dependent or mobility challenged, low or very low income, housing or transportation cost burdened, renters, or those without a car. Service is critical to ethnically and culturally diverse populations with limited English-speaking capacity and non-English Speakers. SFMTA provides communications and critical information in languages prevalent in San Francisco. For people with disabilities who are unable to independently use public transit, SFMTA provides complementary Paratransit service via van and taxi services. <u>Unique or Critical Function:</u> Public transit is critical for movement of hundreds of thousands of commuter into and out of the city on a daily basis. Public transit provides access to San Francisco public parks and open spaces as well as state and regional recreational areas. Muni provides access to the local school system, cultural institutions such as museums and theaters and a critical in supporting access to neighborhood economic vitality.
Informational	<u>All-hazards:</u> Information related to vulnerabilities and consequences of this asset can be found through the San Francisco Vulnerability and Consequence Assessment, SFMTA Sea Level Rise Assessment, and the BART Local Hazard Mitigation Plan. Neither Samtrans or Caltrans have an Adaptation and Resilience plan formalized, Samtrans does have a plan underdevelopment. There is less information available on seismic and heat vulnerabilities.
Governance	<u>All-hazards:</u> Federal asset management and state of good repair reporting requirements assist in maintaining robust information on the status of our assets. This contributes to an understanding of asset useful life cycles and informs replacement/rehabilitation cycles based on maintenance and inspection activities. The diversity of funding sources (local, state and federal transportation funds) also informs governance of this asset class.

	Three different agencies own and operation transit station assets in San Francisco, including SFMTA, BART, and Caltrain.

CONSEQUENCES

Category	Consequence
Society/Equity	All-hazards: Equity impacts have the potential to happen at the neighborhood, citywide and regional scales. Depending on the scale of damage/disruption, loss of access to transit system or loss of mobility across communities could persist. Similarly, as travel shifted to other modes/routes, disruptions could impact the safety of pedestrians or cyclists causing additional traffic congestion. Additionally, impacts that disrupt multiple elements of the transportation network can potentially exacerbate existing access/mobility inequities and cause further geographic isolation.
Economy	All-hazards: Economic impacts would disproportionately impact communities who rely on transit for mobility. For the SFMTA, substantial funds would be lost from fares if the transit system is impacted and the costs of repairs would be dependent on severity of damage. Depending on the severity of the damages and scale of the disruptions and associated system failures, economic disruptions could occur at the neighborhood, citywide and regional scales. Past disruptions include stormwater flooding in December 2014 which required temporary shutdown of the subway. Geologic: According to BART119, direct capital losses to overhead and at-grade trackways, the Transbay Tube, the Berkeley Hills tunnel, stations, buildings, systems and equipment due to faulting, shaking, liquefaction, and landslides will be around $1.1 Billion for a 7.0M Hayward Fault event and as much as $860 Million for a San Andreas Fault event Flood: Exposure of station sub-assets to water, especially salt water, may increase maintenance costs and reduce the useful lifespan of assets, thereby increasing replacement costs. In the near term, flooding of BART assets can lead to more frequent delays of service, impacting fare revenues.

[119] BART, (2017). *"Local Hazard Mitigation Plan: San Francisco Bay Area Rapid Transit District"*.

	Extreme Heat: Exposure of station sub-assets to extreme heat may increase maintenance costs and reduce the useful lifespan of sub-assets.
Environment	All-hazards: In the event of a major disruption, existing air quality could change if congestion patterns shifted to remaining usable portions of the transportation network. Depending on the hazard/damage, release of hazardous materials could impact water quality with subsequent effects on various flora and fauna. Shifts in passenger loads at different transit locations can contribute to trash/debris accumulation.

Water Transportation

Introduction to Asset Class

Water transportation in San Francisco consists of ferries and water taxis, as well as facilities for private vessels and motorized and non-motorized boats. Ferry service was once the primary way people travelled over the Bay, but the California Legislature passed a law prohibiting other forms of transportation within 10 miles of the Bay Bridge upon its completion. It was not until the late 1960s and early 1970s that ferry service resumed on the Bay, albeit limited at the time. Only after several disasters, including a BART tube shutdown in 1979 and earthquake damage to the Bay Bridge in 1989, did ferry service substantively return as a regional transportation option. Since the early 2000s, ferry service and ridership has risen significantly and the region and San Francisco have been increasing the number of ferry landings to accommodate increased ridership and service. Approximately 5 million people travel between San Francisco and other locations by ferry each year, with the majority of those trips serving daily commuters travelling to and from work. San Francisco serves as the primary regional hub for ferry transportation and the major infrastructure for ferry service is located at the Ferry Building, as well as ferry and water taxi facilities that exist at AT&T Park, Pier 1 1/2, Hyde Street, Pier 43 /12, Pier 40 and a future ferry landing at 16th Street near Pier 54. Service is provided between San Francisco and Vallejo, Oakland, Alameda, Berkeley, Sausalito, Larkspur and with service planned between Richmond and San Francisco coming in 2019.

Physical characteristics unique to water transportation include the need to be at a waterside location, gates, gangways, floats and terminals and landside access by walking, biking, bus, scootering or car. In some cases, gangways and boats are designed in such a way as to make it impossible for certain boats to use particular ferry docks (this is true for Golden Gate and WETA ferries at the moment). Ferry terminals rely on several sub-assets to ensure that they can function to move passengers. These sub-assets include gangways, terminals, landside transportation, power and fuel supply, as well as sub assets that help run the system such as offices, maintenance, operations and repair facilities, fuel stations and the boats.

Ferry service is provided by several providers, including Water Emergency Transportation Authority (WETA), Golden Gate Ferry, Blue and Gold and smaller operators like SF Water Taxi and Tideline Marine Group. These providers either own or lease their ferry terminal, docks, gangways and staging areas. In San Francisco most of these facilities are leased from the Port of San Francisco. However, the new waterside infrastructure at the Downtown Ferry Terminal will be owned by WETA.

Issue Statement

Water transportation is a growing element of regional transportation and mostly serves commuters. Because water transportation assets are mostly found along the Embarcadero seawall, the landside facilities are vulnerable to damage in an earthquake. Ferry service is more sensitive to high winds than sea level rise or flooding, but landside access could be compromised in a flooding event. The most significant impact if water transportation was disrupted would be to emergency response as the system figures largely in the region's ability to transport people who are in San Francisco for work but who live in a different part of the region and as a means of getting emergency responders and supplies into San Francisco.

Exposure

Hazard Data Assumptions

This analysis was conducted in 2018 and 2019 using publicly-available data sources. In the table on the following page, shaking intensity is represented for two Earthquake scenarios: San Andreas Fault M7.8 and Hayward Fault M7.0 events. Accounts of assets subjected to varying levels of shaking intensity are cumulative for each scenario.

Asset Data Assumptions

Data on ferry landings and water taxi locations was provided by the SF Department of Emergency Management (DEM)

TABLE A-29: EXPOSURE

Hazard	Ferry Landing: 9 Total		Water Taxi Landings: 3 Total	
	#	%	#	%
Geologic				
San Andreas 7.8 - Violent	1	11%	3	100%
San Andreas 7.8 - Very Strong	7	78%	0	0%
Hayward 7.0 - Very Strong	6	67%	3	100%
Hayward 7.0 - Strong	3	33%	0	0%
Liquefaction Zone	9	100%	3	100%
Flooding				
100-Year Coastal Flood Zone	9	100%	3	100%
100-year storm + 24 inches SLR	9	100%	3	100%
100-year storm + 66 inches SLR	9	100%	3	100%
100-year Stormwater Flood	0	0%	0	0%
Wildfire				
High	0	0%	0	0%
Moderate	0	0%	0	0%

Note: For an exposure table with additional hazards, please see Appendix X.

Exposure Summary

Geologic: All water transportation assets are exposed to Violent or Very Strong shaking in a 7.8M earthquake on the San Andreas Fault. In addition, given the location on the east side of the city, they are nearly all exposed to violent or very strong shaking in a 7.0M on the Hayward fault.

Flood: Given the water-dependent nature of water transportation, all ferry and water taxi landings are exposed to current 100-year storm flooding and would continue to be as sea level rises. They are not exposed to 100-year stormwater flooding.

Fire: Water transportation assets are not exposed to wildfire risk.

FIGURE A-48: WATER TRANSPORTATION AND LIQUEFACTION HAZARD

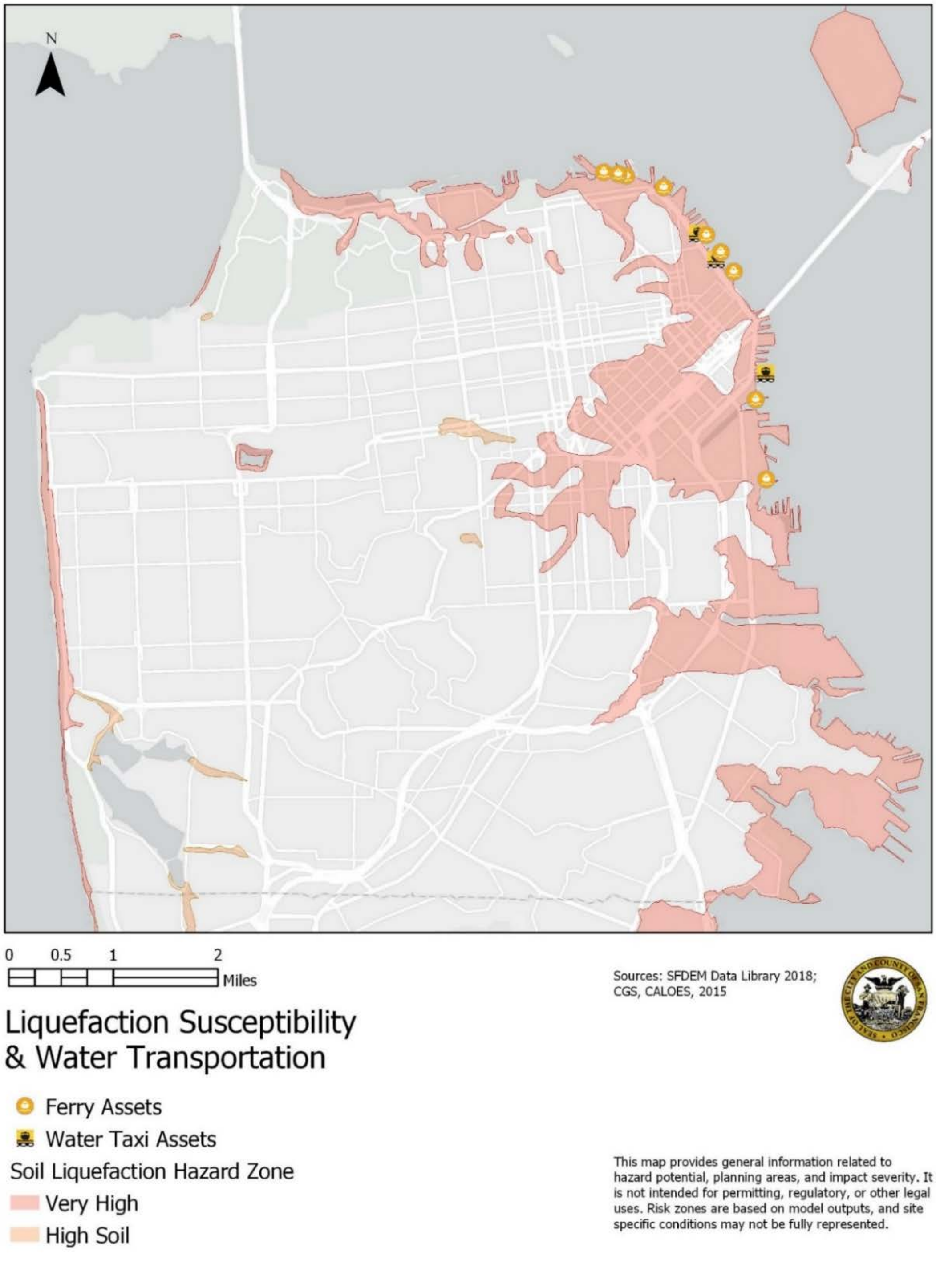
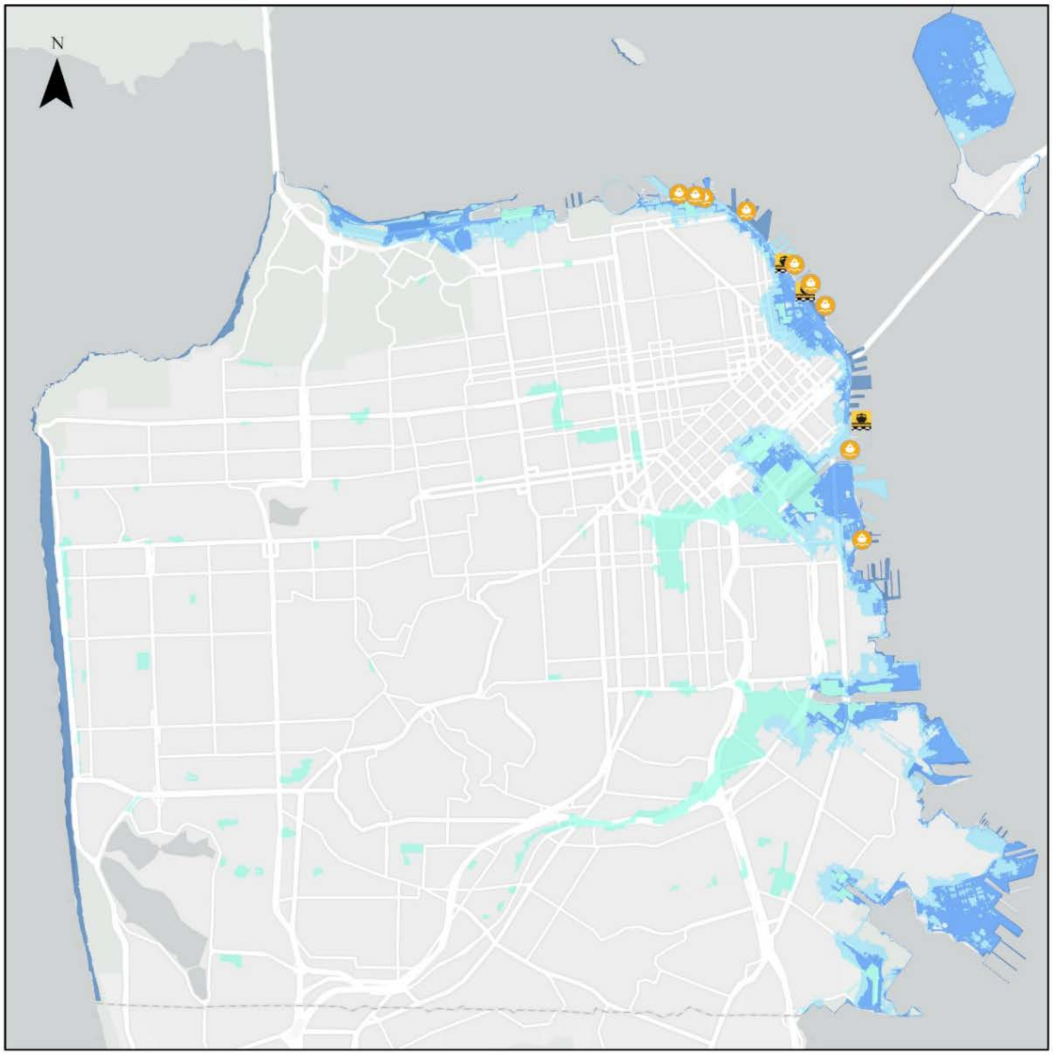


FIGURE A-49: WATER TRANSPORTATION AND FLOOD HAZARDS



0 0.5 1 2 Miles

Water Transportation Flooding Risk

- Ferry Assets
- Water Taxi Assets
- 100 Year Stormwater Runoff
- FEMA 100 Year Coastal Flood Zone
- 100 Year Storm + 24" Sea Level Rise
- 100 Year Storm + 66" Sea Level Rise

Flood Hazard Data Sources: Public Utilities Commission 100-Year Storm Flood Risk Map; FEMA Preliminary Flood Insurance Rate Maps; ART Bay Area Sea Level Rise and Shoreline Analysis Maps

This map provides general information related to hazard potential, planning areas, and impact severity. It is not intended for permitting, regulatory, or other legal uses. Risk zones are based on model outputs, and site specific conditions may not be fully represented.

VULNERABILITIES

Category	Vulnerability
Physical	Geologic: The water transportation assets in San Francisco are mostly found along the Embarcadero Seawall and on areas of fill. The landside facilities that the ferries rely on are at risk from a seismic event due to location on Bay fill, the age and construction of the Seawall and the age and construction of some of the buildings, such as the Ferry Building. The ferry assets themselves are less vulnerable to direct impact. A particular seismic related concern for WETA is potential failure of the Port of San Francisco seawall during a major earthquake. The seawall supports WETA's facilities at Pier 9 and the contract operator's facilities at Pier 41, the Ferry Building. The Downtown Ferry Terminal Expansion Project (FTX) upgrades water and landside terminal assets to Essential Facility Standards including design considerations of the seawall laterally shifting as much as 5 to 6 feet. Flood: When assessed as independent water side assets, floats, and gangways are not very sensitive to flooding and sea level rise because they are highly adaptable to the daily rise and fall of the tide. However, this is not necessarily true for the landside assets along the wharf. Additionally, many of the ferry piers appear not to be exposed directly to sea level rise because they are situated high enough above current Bay level and beyond the shoreline. Damage caused by storm events to the portions of the piers that are exposed to waves could be an issue for some of the ferry terminals. Ferry piers are sensitive to high winds because such events significantly affect the safe docking and operation of ferries. Even with today's sea level, ferry service has occasionally been suspended during storms. Landside access to the ferry terminals is also an important consideration and is vulnerable to flooding, making it difficult for people to travel to and from the terminals on whichever mode they use. Access roads are vulnerable to overtopping where they lie at lower elevations than the ferry docks and gangways. Their inundation would prohibit passengers from accessing the ferry piers. The Downtown Ferry Terminal Expansion Project (FTX) project is built to prevent exposure to 50-year sea-level rise is designed for adaptability to 100-year levels as well.

	Extreme Heat: Ferry service is open air and there is little ability to keep people cool while they wait in line for their ferries. There are some structures to shield people from the elements at the Ferry Building. Fire: There is no easy way to keep people who are queuing for a ferry out of smoke or poor air quality conditions.
Functional	Networks: Water transportation is part of the transportation network and disruption to these assets would result in affects to other modes in the system. If ferry service is disrupted, passengers may be able to use alternative transportation modes to cross the bay, such as BART, Transbay bus service, casual carpool, or personal auto. External Services: Water transportation relies on fuel supplies, landside transportation access, power and communications. Back up ferry service, back up docks and gangways, temporary facilities could be used in the event of failures due to earthquake or flooding. For high heat and poor air quality days, locations for queuing would need to be found to keep people safe while they wait for a ferry. The ferries are considered a critical component of the region's emergency response, particularly in the event of a large seismic event. WETA, MTC and the participating cities have emergency response plans and run drills to ensure a certain level of service. Populations Served: Water transportation may serve some people who are transit dependent. Additionally, ethnically diverse populations are served by this transit. Many riders live in isolated areas that are vulnerable to disruptions to the regional transportation system. Unique or Critical Function: Water transportation is a form of transit that keeps people out of their cars, provides a transportation alternative to driving alone and is increasingly switching to clean fuels. In addition, it provides relief capacity to other overburdened regional transit systems.

	Demand for water transportation options has been significantly increasing over the last decade and service is at capacity on most ferry lines. Water transportation will be critical during a significant hazard event, such as an earthquake or other disruption. It is an essential and critical back up service for moving people when other forms of travel are unavailable.
Informational	<u>All-hazards:</u> Currently, the most relevant publicly available information comes from the 2016 WETA Local Hazard Mitigation plan
Governance	<u>All-hazards:</u> WETA serves as a unique authority to alleviate transportation stress while securing emergency transportation. The WETA Emergency Response Plan (ERP) is designed to support the management of emergency water transportation after a catastrophic incident. When not serving in an emergency response capacity, WETA normally operates as a transportation agency with funding for operations derived from fares, bridge tolls, transportation sales taxes, local transportation funding, and state transit assistance. Federal, state and regional transportation funding has been used to assess the vulnerability of water transportation assets around the region.

CONSEQUENCES

Category	Consequence
Society/Equity	<u>All-hazards:</u> The most significant impact if water transportation was disrupted, damaged, or failed would be to emergency response. The water transportation system figures largely in the region's emergency response, particularly as a way to transport people who are in San Francisco for work but who live elsewhere in the region and as a way to get emergency responders and supplies into San Francisco. As a peninsula, water transportation is of particular importance to San Francisco during a hazard event. Additionally, any reduction in transit capacity could shift more people to drive their automobiles, increasing the impacts associated with that mode shift, such as congestion, longer commutes and air quality degradation associated with an increase in the number of automobiles idling on the region’s roadways.
Economy	<u>All-hazards:</u> In addition to the direct cost to agencies to repair or replace damaged facilities and infrastructure, potential congestion on other

	modes and longer commutes could impact businesses and employees. Geologic: Would have temporary impacts as people shifted to other modes or services while the facilities were reconstructed. The scale of impact would be citywide or regional. Flood: Temporary impacts and closures. Flooding would likely cause people to shift to other modes while flooding was present and while damage to facilities, if any, was being repaired. Extreme Heat: Temporary and minor impacts. Fire: Temporary impact on service, displacing travelers to other modes or other facilities.
Environment	All-hazards: There could be air quality consequences depending upon which modes replaced water transportation trips. Public access could be impacted near the terminals and access to and on the Bay would be reduced.

Airport

Introduction to Asset Class

The San Francisco International Airport (SFO) provides commercial air transportation for the Bay Area. It is the largest of the three commercial airports in the region and offers non-stop service to more than 50 international cities on 44 international carriers as well as domestic non-stop service to more than 85 cities on 12 domestic airlines. SFO is located 11 miles outside of the City and County of San Francisco between the east side of highway US-101 and the San Francisco Bay, in San Bruno. There is some airport property located to the west of US-101 that is mostly habitat and some utilities. A large part of SFO was built on landfill including the critical runway infrastructure. The airport property covers 5,207 acres in total with over 100 supporting buildings, Federal Aviation Administration (FAA) tower and four intersecting runways. SFO is wholly owned by the City and County of San Francisco.

SFO is a complex campus with many different components. For the purposes of the assessment, SFO consists of the following sub-assets:

- Airfield: The SFO airfield consists of runways, taxiways, and service vehicle roadways. The airfield also has a storm drain and power distribution system, as well as telecommunications copper and fiber optic infrastructure. However, these systems are not essential to the function of the airport operations area. In addition, the FAA also operate their own power and telecommunications infrastructure for independent navigational aids and lighting systems. There is a shoreline protection system around 6 of 8 miles of the airport's bay front perimeter that consists of various ages and construction types.
- Air Traffic Control Tower: SFO's 221-foot air traffic control tower is located in the connector building between Terminal building 1 & 2. Construction of the new tower was completed in 2016 to replace the seismically unsafe tower built in 1983. Deconstruction of the former tower and two floors of the base structure below are scheduled to be completed in 2019. The bottom two levels of the space are being rebuilt to include a new public café and an outdoor observation deck along with an airline lounge and office space, and an additional gate at Terminal 2.
- Terminal: The airport consists of three domestic terminals and one international terminal. The terminal complex consists of multiple structures with varying ages.

Terminal 1 and Boarding Area B are currently being reconstructed and will open in phases between 2019 and 2023. Terminal 2 was reconstructed and reopened 2011. The eastern portion of Terminal 3 and Boarding Area E was reconstructed and opened in 2014

- Parking facilities: SFO has several parking structures on its campus. The central garages and north and south international parking structures are located near the terminals. A surface lot is located near north field.
- Roadways: Elevated structures and roadways owned by SFO connect vehicles exiting US-101 to the airport, and an elevated viaduct provides service to the departure level of the domestic terminals.
- Utilities: Two utility tunnels, one at the north end of the airport campus and the other at the south end traverse below highway US-101 to deliver electrical power, water, data and telecom services to the airport. Electrical power is fed to the terminal complex and across the campus through an underground distribution network to a series of substations that feed all building and facilities on the airport campus. The potable water feed is connected to a distribution system which services the airport campus. The telecommunications service from outside the Airport are delivered to the North and South Minimum Point of Entry (MPOE). From there the Airport distributes telecommunication services to the terminals and Airport tenants. There is a third utility tunnel under highway 101 that provides a third potable water feed to the airport campus just north of the terminal complex. Sewage from SFO facilities is treated in the Mel Leong Treatment Plant (MLTP) in the North Field.
- Fuel: Fuel is provided to SFO via a Kinder Morgan fuel pipeline that provides fuel from refineries located in the North Bay. In 2017, San Francisco Airport reached a milestone of 28 million gallons annually.

Issue Statement

As the largest commercial airport in the region, SFO is a major economic driver. While some of the structures may experience damage in a major earthquake, the airfield is susceptible to major damage due to liquefaction in a major earthquake. In addition, the airport is currently subject to flooding during a 100-year storm. With sea level rise, flooding may become more frequent and/or severe. Disruption to the airport for an extended period would have severe regional economic consequences.

Almost all of the terminal buildings, the boarding areas, the outlying buildings across the campus, and all of the supporting infrastructure, from here on to be referred to as the Facilities, were constructed over the last sixty years. The Facilities were all constructed to the relevant codes at the time of construction. In the intervening years, some of the Facilities have been renovated or upgraded, in these instances those renovations/upgrades were also done in accordance to the relevant construction codes at the time. The Airport Facilities that are relatively new or have been recently renovated will be more resilient to the effects of an earthquake while others may be susceptible to damage. In the event of a major earthquake, the Airport can expect to have damage to the Facilities. Some buildings could be damaged and be temporarily or maybe even permanently unusable. Some of the Airport's elevated roadways could be damaged and be temporarily or permanently unusable. Given the Airport's soil condition and the age of its underground infrastructure, it is likely there would be damage to underground piping systems and damage to its underground electrical and data distribution systems. The effects of liquefaction may also damage the taxiway and runway systems.

Flooding from storms is another possible area for a severe or even catastrophic disruption to the Airport. Flooding would not necessarily damage buildings, the airfield, or landside roadways and structures to the point of being unusable, but key electrical power distribution equipment could be severely damaged or destroyed. Catastrophic damage to the electrical power distribution system would render facilities unusable until the electrical equipment was replaced or facilities were provided with temporary sources of power.

Exposure

TABLE A-30: EXPOSURE

Hazard	Power Station 10 Stations Total		Pump Station 54 Stations Total		Power Ducts 34 miles Total		Industrial Pump Station 26 Stations Total		Water Pipelines 35 Miles Total		Aviation Fuel Pipelines 30 Miles Total		Natural Gas Pipelines 16 Miles Total	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Geologic														
San Andreas 7.8 - Violent or Very Strong	10	100%	54	100%	34	100%	26	100%	35	100%	30	100%	16	100%
San Andreas 7.8 - Violent or Very Strong	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Hayward 7.0 - Violent or Very Strong	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Hayward 7.0 - Violent or Very Strong	10	100%	54	100%	34	100%	26	100%	35	100%	30	100%	16	100%
Liquefaction Zone	8	80%	54	100%	33	97%	26	100%	33	94%	19	63%	15	94%
Flooding														

100-year storm + 24 inches SLR	10	100%	52	96%	33	97%	25	96%	34	97%	19	63%	15	94%
100-year storm + 66 inches SLR	10	100%	53	98%	33	97%	26	100%	34	97%	19	63%	15	94%

Hazard	Industrial Water Pipelines 12 Miles Total		Sanitary Sewer (Forced) Pipelines 16 Miles Total		Sanitary Sewer (Gravity) Pipelines 14 Miles Total		Stormwater Pipelines 92 Miles Total		Telecom Ducts 31 Miles Total		SFO Structures 697 Total		SFO Runways 7 Total Miles		SFO Storage Tanks 131 Total	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Geologic																
San Andreas 7.8 - Violent	12	100%	16	100%	14	100%	92	100%	31	100%	697	100%	7	100%	131	100%
San Andreas 7.8 - Very Strong	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Hayward 7.0 - Very Strong	0	0%	0	0%	0	0%	0	0%	0	0%	5	1%	0.3	5%	0	0%
Hayward 7.0 - Strong	12	100%	16	100%	14	100%	92	100%	31	100%	692	99%	0	0%	0	0%
Liquefaction Zone	12	100%	14	88%	13	93%	91	99%	30	97%	683	98%	7	100%	127	97%
Flooding																
100-year storm + 24 inches SLR	12	100%	14	88%	13	93%	91	99%	30	97%	661	95%	7	100%	123	94%
100-year storm + 66 inches SLR	12	100%	14	88%	13	93%	91	99%	30	97%	666	96%	7	100%	125	95%

Exposure Summary

Geologic: All airport transit assets are exposed to violent or very strong shaking in a 7.8M earthquake on the San Andreas Fault. Virtually no airport assets are subjecting to violent or very strong shaking given a 7.0M earthquake on the Hayward fault. A significant majority of all airport assets are exposed to liquefaction hazard zones.

Flood: Assuming no action is taken, a significant majority of all airport assets would be exposed to inundation from mid-century projections of SLR with coastal storms. This increases further in the end of century scenarios as well. Every sub asset sees exposure above 88% percent except for aviation fuel due to portions of the infrastructure running offsite under the Bay. GIS data on FEMA FIRM coastal 100-year flooding or 100-year stormwater flooding hazards were available for the airport study area. However, static maps show almost the entire SFO campus being subject to some level of flooding from the 1% chance flood (a.k.a. the 100 year flood) as defined by FEMA under the National Flood Insurance Program.

Fire: Hazard data regarding the risk from Wildfires displayed negligible risk.

FIGURE A-50: AIRPORT AND LIQUEFACTION HAZARD

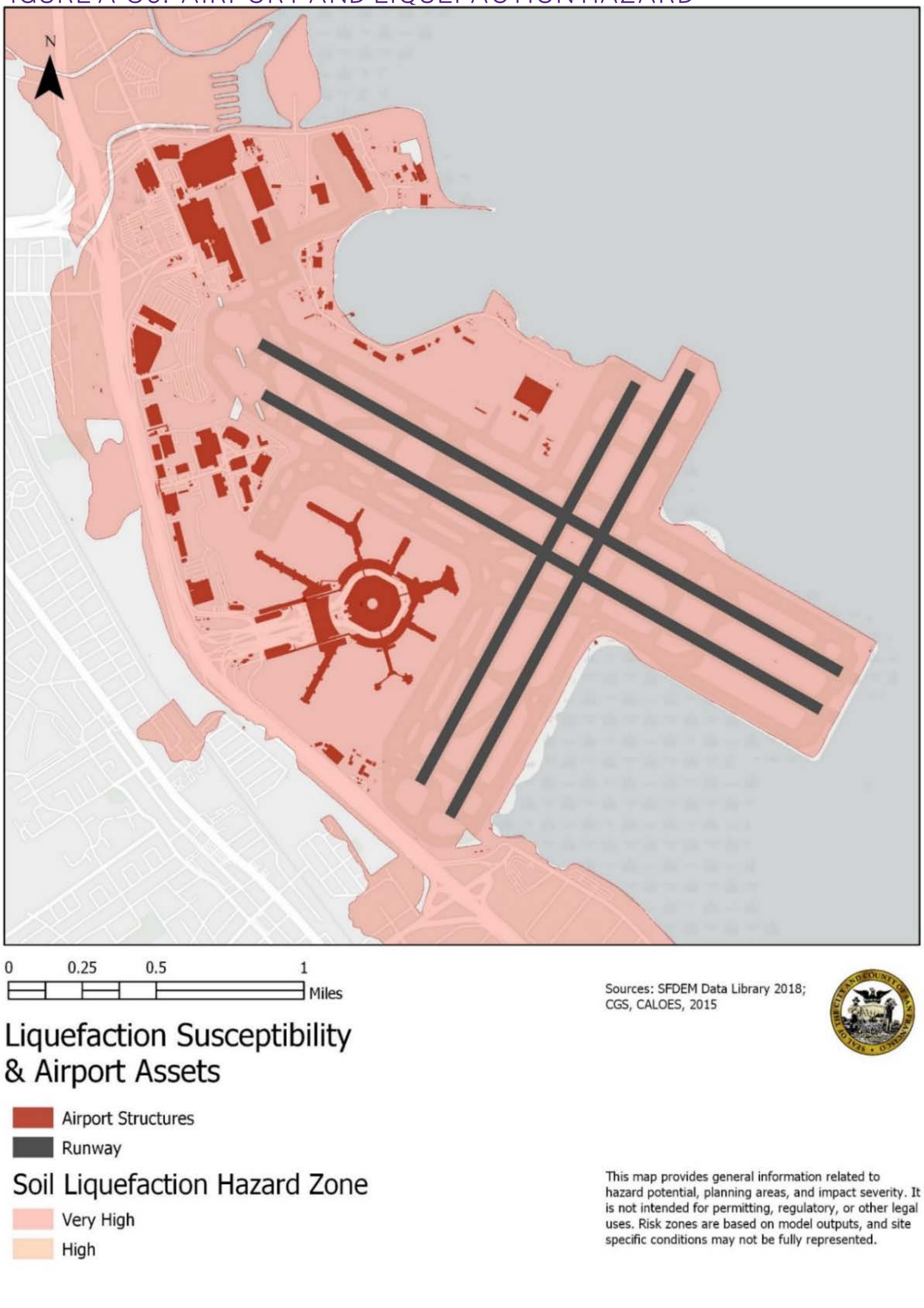
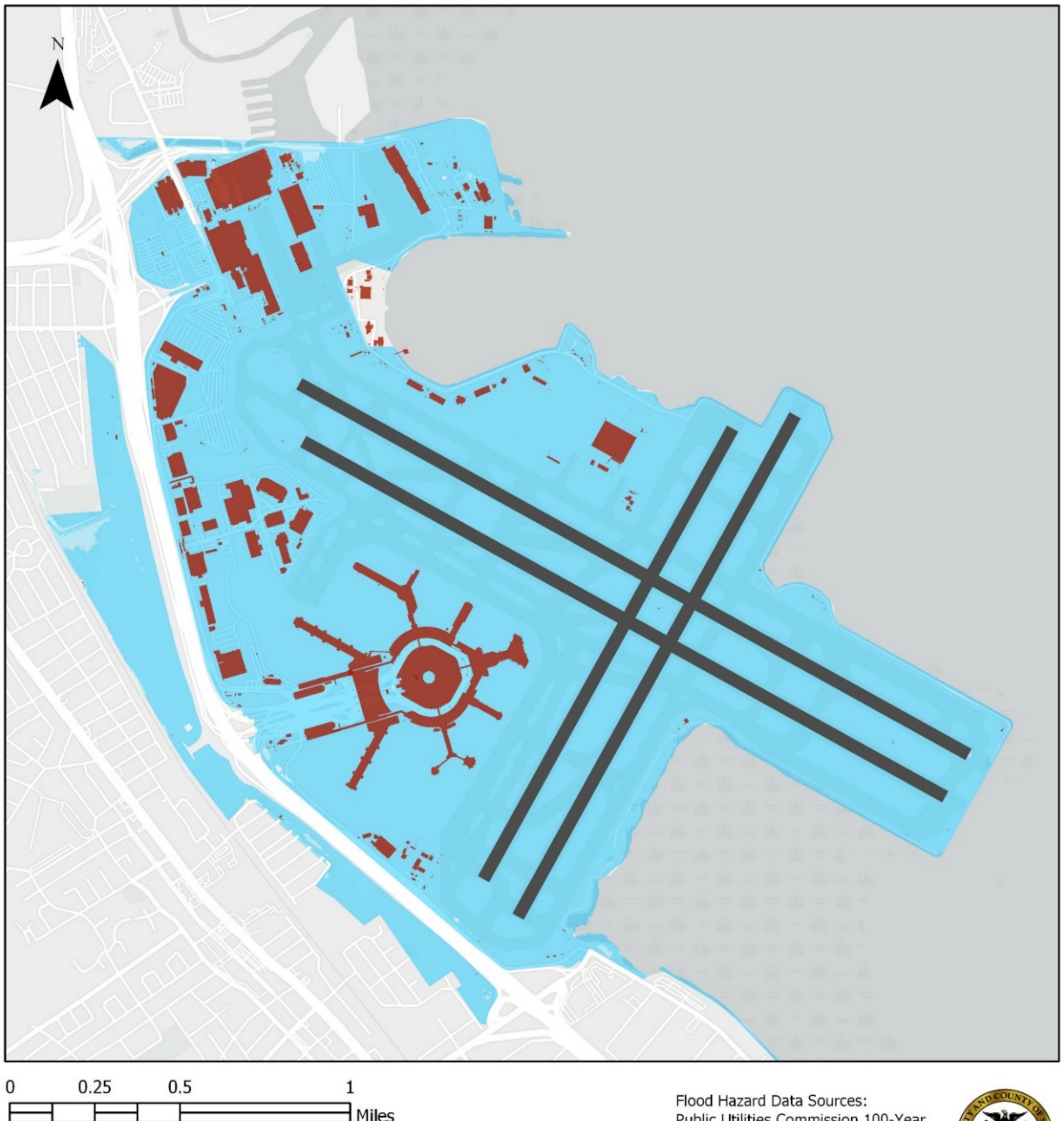


FIGURE A-51: AIRPORT AND FLOOD HAZARD

FIGURE A-52: AIRPORT AND FLOOD HAZARD WITH SEA LEVEL RISE



Airport Flooding Risk

- Airport Structures
- Runway
- 100 Year Storm + 24" Sea Level Rise
- 100 Year Storm + 66" Sea Level Rise

Flood Hazard Data Sources: Public Utilities Commission 100-Year Storm Flood Risk Map; FEMA Preliminary Flood Insurance Rate Maps; ART Bay Area Sea Level Rise and Shoreline Analysis Maps

This map provides general information related to hazard potential, planning areas, and impact severity. It is not intended for permitting, regulatory, or other legal uses. Risk zones are based on model outputs, and site specific conditions may not be fully represented.

VULNERABILITIES

Category	Vulnerability
Physical	Geologic: The terminal buildings consist of several different structures with varying ages that will perform differently in an earthquake. As structures are renovated or replaced, they are brought up to the current seismic standards of the time. The Air Traffic Control Tower and IT Building are expected to perform well. The airfield is vulnerable to severe damage from liquefaction. Underground utilities at the airport site are vulnerable to physical damage in an earthquake. External utilities such as power will also likely experience physical damage. The upper level viaduct which fronts the domestic terminals, T1, T2, and T3 has been seismically retrofit. The majority of the inbound outbound roadway structures from 101 were constructed in the late 1990's. These older ramps serving the Airport prior to the International Terminal Building development have been previously retrofitted The Central Garage consists of multiple buildings that employ two different design philosophies and construction methodologies. Each building type will perform differently in an earthquake, but neither one is up to current seismic requirements, and neither has been retrofit as of yet. The Central Garage also houses the airport's central heating and cooling plant and the main electrical substation which feeds all power to the terminal complex. The central plant's hot and chilled water distribution lines and as well as the electrical power distribution systems (PDS) are fed to the terminals via and underground utility tunnel and underground connectors to the individual terminal buildings. Flood: SFO was built in the late 1950's to early 1960's. The infrastructure has since been improved to meet the latest standards, but there are vulnerabilities. SFO has power substations located below sea level in the basement of the domestic garage which would be damaged by flooding. Depending on the scale of the damage, SFO could partially recover from a severe flood in as quickly as a week but full recovery could take months due to sensitive electrical field lighting and communications equipment distributed across the airfield. Almost the entire SFO campus is subject to some level of flooding from the 1% chance flood (a.k.a. the 100 year flood) as defined by FEMA under the National Flood Insurance Program. In the event of a 100 year flood, the airport campus would be flooded to various

	depths depending on local elevation. Critical infrastructure will be vulnerable to inundation and would be damaged in a 100 year flood. SFO has implemented a Shoreline Protection Program in order to address some of these flooding vulnerabilities this includes over $383 million dollars of funding to plan, permit, design and construct comprehensive shoreline protection systems and storm drainage improvements. Extreme Heat: Heat causes fluctuations in aviation fuel weight and volume. Max aircraft weight capacity is greatly reduced during an extreme heat day, which reduces the number of people and cargo an aircraft can carry. This has a large economic impact to the airline (lost revenue) and impacts commerce as passengers and as cargo is left behind to satisfy weight issues. Heat can also cause issues with the Air Train Service. SFO is currently upgrading the system to address this issue. Fire: SFO vulnerable to wildfire or wildfire given its location. However, SFO has a large underground fuel network that can be ignited under the wrong conditions. Natural gas distribution and transmission lines also pose a fire risk. However, the airport does not allow wood construction and requires all buildings to have fire suppression systems and fire alarms. Air Quality: Indirect smoke while a concern for employees who work outdoors does not have a major impact to SFO's ability to operate. Visibility issues from smoke might cause flight delays but the airport would continue to operate at some level.
Functional	Networks: While not part of a formal network, if SFO were disrupted, some air traffic could potentially be re-routed to other airports in the region, including Oakland International Airport (OAK) and San Jose International Airport (SJC). Nevertheless, these airport have constraints in terms of air traffic volume and aircraft size, such that they could not accommodate all of SFO's traffic. The Airport has the ability to isolate segments of the local fuel distribution network. However, transmission from East Bay refineries and Brisbane tank farm are not under airport control and fuel supply would be disrupted by damage to these transmission lines. The water and gas supply is also built on a closed loop design that can isolate damage and continue service, but if the damage is from the

input lines that service the airport (outside the closed loop) service would be disrupted.

The airport is designed with continuity in mind and could operate with limited capacity if parts of the critical infrastructure were undamaged. Following a major disaster, supporting emergency response will be the focus of restoration efforts, followed by a focus on business continuity.

<u>External Services:</u>
SFO relies on electric power, water, aviation, vehicle fuel, telecommunications services, and natural gas. Fixed and external generators can supply enough power for critical needs and emergency lighting. However, this would not be enough to maintain normal operations across the airports terminals. Passengers and staff also rely on the ground transportation network to access the airport.

SFO is dependent on fuel delivery to the Fuel Farm for its operations. If the fuel pipelines are damaged, fuel can be shipped to Brisbane or Port of San Francisco via barge, but there is currently no infrastructure to transport the fuel from the barges to SFO. Given the volume of fuel needing, fuel truck delivery is not a viable alternative. As SFO nears the capacity of the current pipeline, it is looking for alternative fuel delivery sources that will also increase the reliability of fuel delivery in an earthquake.

<u>Populations Served:</u>
The airport supports the needs of all of travelers (families, access and functional needs (AFN), business, low income). The buildings and offerings are compliant with all standards for AFN passengers and visitors. The airport supports low cost carriers and premier business carriers with a variety of options and offerings that meets the diverse needs of the community we serve.

Signage is compliant with International Air Transport Association standards for international airports. Additionally we have translation services if needed at all of our customer service centers. Airlines employee bilingual staff to assist their customers as well.

<u>Unique or Critical Function:</u>
SFO is a critical air transportation hub serving San Francisco and the Bay Area.

Wide body aircraft require long runways for takeoff and landing. This requirement makes SFO critical for air carriers in that OAK and SJC are limited and cannot support large aircraft appropriately.

	SFO maintains a season wetland across from U.S. Highway101. SFO also maintains a fully accredited on site museum.
Informational	All-hazards: SFO has conducted numerous studies that assess the many components of our infrastructure. These have included targeted structural assessments of key facilities, an airfield seismic stability study, contaminated soils studies, shoreline protection system assessments, and an ongoing master utility infrastructure assessment
Governance	All-hazards: Airports are highly regulated by several federal agencies including the FAA, CBP, TSA. The City and County Of San Francisco is the owner of SFO so all city standards apply, but SFO physically resides in the County of San Mateo which creates some political sensitivities and compromise. SFO primarily uses airport revenue bonds for funding projects to improve resilience. SFO also explore the use grants from CalOES and FEMA when appropriate.

CONSEQUENCES

Category	Consequence
Society/Equity	All-hazards: Disruption of SFO could result in separated families (if traveling members return trips are delayed). If SFO is damaged, SFO's workforce may experience fewer shifts and lost wages. SFO employs a diverse workforce with a range of skill types and levels. Geologic: In the event of a major earthquake, multiple airports in the region may be damaged. Medivac flights may need to be supported out of military airports and would be balanced with relief flights bringing in large amounts of life sustaining commodities (food, water, medical supplies, shelter, etc.). Flood: Should a flood event over take the airport grounds it would result in the immediately closure of SFO resulting in thousands of flight cancellations until the water recede. Fire:

	1-2 depending on where a fire breaks out the impacts to SFO and commercial aviation are not expected to be as dire. While flights my indeed be impacted the airport should still be able to operate at some level of managed capacity.
Economy	All-hazards: Depending on the level of damage, costs to repair airport infrastructure would be in the hundreds of millions to billions of dollars. Disruption to SFO would have a substantial economic impact both locally and regionally due to the significant economic footprint SFO has. The direct/indirect jobs it creates, and the multiplier effect this has on the regional economy, means that SFO generates as much as $62.5 billion dollars in business sales and supports 300,000 jobs across the Bay Area. Geologic: The ability for the greater Bay Area to recover from a major earthquake would be greatly hampered if SFO were damaged and not functioning for an extended period. Flood: Airlines and other airport tenants may lose revenue from a temporary loss in service due to flooding. Fire: Airlines and other airport tenants may lose revenue from a temporary loss in service.
Environment	Geologic: A ruptured fuel line would create a large pool of fuel that could contaminate the ground, estuary or bay. Flood: Flooding could release hazardous materials into the Bay. Air Quality: Smoke from a fire could temporarily impact local air quality.

Utilities and Infrastructure Sector

Power

Introduction to Asset Class

The electric power asset class generates, stores, manages, and delivers electricity to end-users, such as homes and businesses. For the purpose of this assessment we divided the asset class into four sub-asset types: Generation, Substations, Transmission and Distribution.

a) *Generation* refers to the process of electricity production from diverse sources of primary energy such as natural gas, hydropower, coal, wind, nuclear power, solar, geothermal, steam, agricultural waste products and more. CCSF electricity supply comes from both centralized and distributed generation.[121] All of the centralized generation assets (i.e. Hetch Hetchy Generation and industrial power plants) are located outside of the assessment area, therefore this sub-asset type is not assessed for vulnerability and consequences in this profile, but it is a critical piece of the overall resilience of the power system. Distributed generation assets include small, local, grid-connected devices (e.g. microgrids, combined heat and power systems, rooftop solar installations, backup power generators, and battery storage systems), referred to as distributed energy resources (DER).[122,123] Large DER providers are non-utility parties that own or operate onsite electric and thermal loads and participate in the wholesale market.[124]

b) *Substations* connect the electric power lines between the transmission and distribution systems. The main purpose of substations is to transform the energy to a lower voltage to safely deliver electricity to residences and businesses.[125] Substations have expensive and potentially dangerous equipment such as large

[121] SPUR. (2001) "*San Francisco's Utilities in 21st Century"*. Retrieved from: https://www.spur.org/publications/urbanist-article/2001-11-01/san-francisco-s-utilities-21st-century

[122] Virginia Tech. (2007) "*Introduction to Distributed Generation*. Retrieved from: http://www.dg.history.vt.edu/ch1/introduction.html

[123] C2ES. (2018). "*Resilience Strategies for Power Outages"*. Retrieved from: https://www.c2es.org/site/assets/uploads/2018/08/resilience-strategies-power-outages.pdf

[124] CAISO "*Distributed Energy Providers. Retrieved from: http://www.caiso.com/participate/Pages/DistributedEnergyResourceProvider/Default.aspx*

[125] ART. (2014). "*Chapter 16. Energy, Pipeline and Telecommunications Infrastructure*". Retrieved from: http://www.adaptingtorisingtides.org/wp-content/uploads/2014/12/Energy_Pipes_Telecom_VR.pdf

power transformers (LPT), which change the voltage of electrical current[126]; capacitors, which store energy in an electric field; voltage regulators, which maintain a constant voltage; and switchgears, which control, protect and isolate electrical equipment[127] - components critical to the substations operation. The service areas of substations are distributed and local, but substations function as a networked system, as they are connected through high-voltage transmission lines. Typically, substations are located aboveground in fenced enclosures or are in underground vaults within special-purpose buildings.

c) *Transmission* includes all electrical power lines that run underground and overhead and carry electricity from generators to substations. Transmission lines typically run through tall structures, usually steel lattice towers.[128] There are no aboveground high-voltage transmission towers within CCSF, as these have been previously undergrounded. The assessment area is served by an underground transmission lines network[129], as well as a 3.5-mile-long submarine transmission line under the San Francisco Bay.[130]

d) *Distribution* connects the transmission system with end customers. The system is comprised of main lines and lower voltage lines that supply power, and distribution transformers that lower voltage to usage levels.[131] We include the physical power poles, as well as street lights and supporting infrastructure in the vulnerability assessment, but do not include in the exposure assessment due to the ubiquitous locations of these assets across the city.

Pacific Gas and Electric (PG&E) and San Francisco Public Utilities Commission (SFPUC) are the two main electricity providers. PG&E predominantly services city residents and businesses. PG&E operates nine substations within CCSF.

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[126] CA Energy Commission. (2012). "*Large Power Transformers and the U.S. Electric Grid*". Retrieved from: https://www.energy.gov/sites/prod/files/Large%20Power%20Transformer%20Study%20-%20June%202012_0.pdf

[127] IEEE. (2001). "Standard Definitions for Power Switchgear". Retrieved from: https://ieeexplore.ieee.org/document/182886

[128,9] Ibid.

[129] CPUC. (1999). "*PG&E Divestiture of 4 Power Plants A.98-01-008, Chapter 4.12.1*". Retrieved from: http://www.cpuc.ca.gov/Environment/info/esa/divest-pge-two/eir/chapters/04-12utl.htm

[130] T&D World. (2015). "*System Upgrades Boost Disaster Resiliency*". Retrieved from: https://www.tdworld.com/features/system-upgrades-boost-disaster-resiliency

[131 5] ART (2017). "*Adapting to Rising Tides: Contra Costa County Assessment and Adaptation Project*" Retrieved from: http://www.adaptingtorisingtides.org/wp-content/uploads/2017/03/Contra-Costa-ART-Project-Report_Final.pdf#page=2

SFPUC operates its own municipal power network that supplies energy from several facilities in the Hetch Hetchy system to all municipal facilities, streetlights, customers in Hunters Point and Treasure Island, redevelopment areas and other critical facilities, such as the airport, San Francisco General Hospital, Muni, and the Police and Fire Departments. SFPUC transmits the power from Hetch Hetchy to a substation in Newark, where it is then distributed via PG&E's grid to end users. SFPUC is connected to a substation in the Port of Oakland, from which power is transmitted via a submarine cable under the Bay Bridge to Treasure Island and Yerba Buena Island. SFPUC is the exclusive power provider for TI/YBI and the redeveloped Hunters Point Shipyard. SFPUC owns intervening facilities (connections between SFPUC and PG&E) in the TransBay terminal, Laguna Honda, and Hunters Point. Three substations at SFO provide power to the airport, which is SFPUC's largest retail customer (please see Airport Profile for additional information). SFPUC is responsible for about 60% of the street lights in the city but is reliant on PG&E to actually supply the power to the lights (PG&E is responsible for the remaining 40% of street lights).

California's Investor-Owned Utilities (IOU), such as PG&E, are subject to regulation by the California Public Utilities Commission (CPUC) with respect to retail electricity distribution, and the Federal Energy Regulatory Commission (FERC) with respect to applicable wholesale electricity transmission.[132] The California Independent System Operator (CAISO) oversees the operation of California's bulk electric power system, transmission lines, and electricity market generated and transmitted by electricity providers. While PG&E still owns transmission assets, CAISO controls the power routing, maximizing transmission system efficiency and supervises the maintenance of the lines. CAISO is regulated by FERC.[133]

The vulnerability and consequences assessment focuses on in-county assets only, but recognizes our dependence on a broader system of generation and transmission located outside of the county.

[132] San Francisco Chronicle (2017). "*San Francisco Seeks Oversight for PG&E Transmission Spending*" Retrieved from: https://www.sfchronicle.com/business/article/California-SF-seek-oversight-for-PG-E-11095829.php

[133] CAISO (2018). *Understanding the ISO*. Retrieved from: http://www.caiso.com/about/Pages/OurBusiness/Default.aspx

Issue Statement

Electric power assets are vulnerable to seismic hazards. Electrical substations are the most vulnerable components of an electric power system.[134] Transmission lines are generally not impacted by earthquakes, except in areas of extreme ground failure.[135] Distribution power poles do not have robust foundation structure and are more vulnerable to ground shaking and liquefaction than transmission lines, while underground power lines may be damaged due to liquefaction induced lateral spreading.[136] Above ground distribution and transmissions lines are relatively easy to restore after an earthquake. However, underground distribution systems and substations can be difficult to replace in the event of a catastrophic failure and may require very expensive specialized parts making them more difficult to restore. Given data limitations, the extent of exposure of the electric power system in San Francisco to flooding is unknown. However, if exposed, flooding can damage electrical system components, potentially resulting in outages. Extreme heat may also strain the power system, as cooling demand increases, making the system more prone to brownouts and blackouts. Interruption to electric power would have severe and cascading economic, social and environmental consequences.

Assumptions and Limitations

Hazard Data Assumptions

This analysis was conducted in 2018 and 2019 using publicly-available data sources. In the table below, shaking intensity is represented for two Earthquake scenarios: San Andreas Fault M7.8 and Hayward Fault M7.0 events. Accounts of assets subjected to varying levels of shaking intensity are cumulative for each scenario.

[134] Cagnan, Z., Davidson, R., Guikema, S., (2006). Post-Earthquake Restoration Planning for Los Angeles Electric Power, *Earthquake Spectra* 22 (3), 589-608.
[135] ABAG (2014). "*Cascading Failures*" Retrieved from: http://resilience.abag.ca.gov/projects/transportation_utilities_2014/
[136] Kongar, I., Giovinazzi, S., Rossetto, T., (2017). Seismic performance of buried electrical cables: evidence-based repair rates and fragility functions. *Bulletin of Earthquake Engineering* 15 (7) 3151–3181.

Asset Data Assumptions

Asset data is sourced from the California Energy Commission open data portal, last updated in 2018. The sources used for the exposure analysis come from the California Energy Commission GIS Open Data Portal. It includes transmission line data, substation locations, and centralized electric generation within the city limits. While this does include some information on PG&E assets, it is not comprehensive. This is important to note, as without complete asset data, it is not possible to fully characterize the full extent of potential exposure of power assets to hazards in San Francisco.

Exposure Summary

Seismic: All power assets are exposed to violent or very strong shaking in a 7.8 earthquake on the San Andreas Fault. Based on the limited data available, two substations, four power generation sources, and six miles of transmission lines are subjected to violent or very strong shaking in a 7.0 earthquake on the Hayward fault. Seven substations, five generation sources, and 18 miles of transmission lines are in areas with high or very high liquefaction susceptibility.

Flood: Given the data limitations, the extent of power asset exposure to flooding hazards is unknown. Based on the limited data available, a single substation and three power generation sources are potentially exposed to coastal flooding by sixty-six inches of projected sea level rise. Additionally, underground distribution transformers inside vaults may be exposed.

Fire: Based on the limited data available, local power assets see no exposure to wildfire hazard within the City and County of San Francisco.

TABLE A-32: EXPOSURE

Hazard	Substations (9 Total)		Power Generation (11 Total)		Transmission Lines (47 Miles Total)	
	#	%	#	%	#	%
Seismic						
San Andreas 7.8 - Violent or Very Strong	9	100%	11	100%	47	100%
Hayward 7.0 - Violent or Very Strong	2	22%	4	36%	6	13%
Liquefaction Zone	3	33%	4	36%	18	38%
Flooding						
100-Year Coastal Flood Zone	0	0%	1	9%	0.13	0%
100-year storm + 24 inches SLR	0	0%	0	0%	1	2%
100-year storm + 66 inches SLR	1	11%	3	27%	5	11%
100-year Stormwater Flood	0	0%	0	0%	4	9%
Wildfire						
High	0	0%	0	0%	0	0%
Moderate	0	0%	0	0%	0	0%

Note: For an exposure table with additional hazards, please see Chapter 05.

FIGURE A-53: POWER AND LIQUEFACTION HAZARD

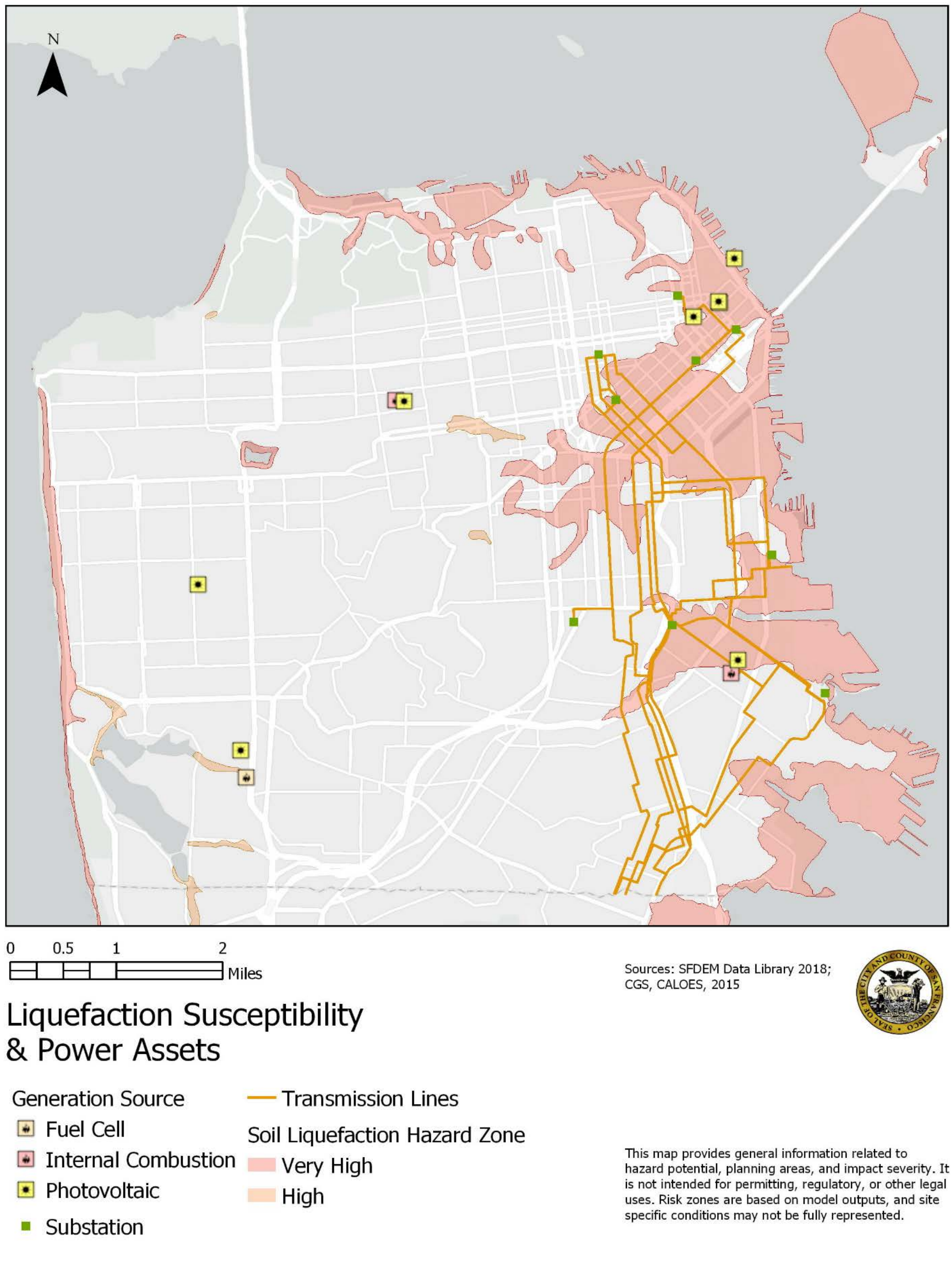
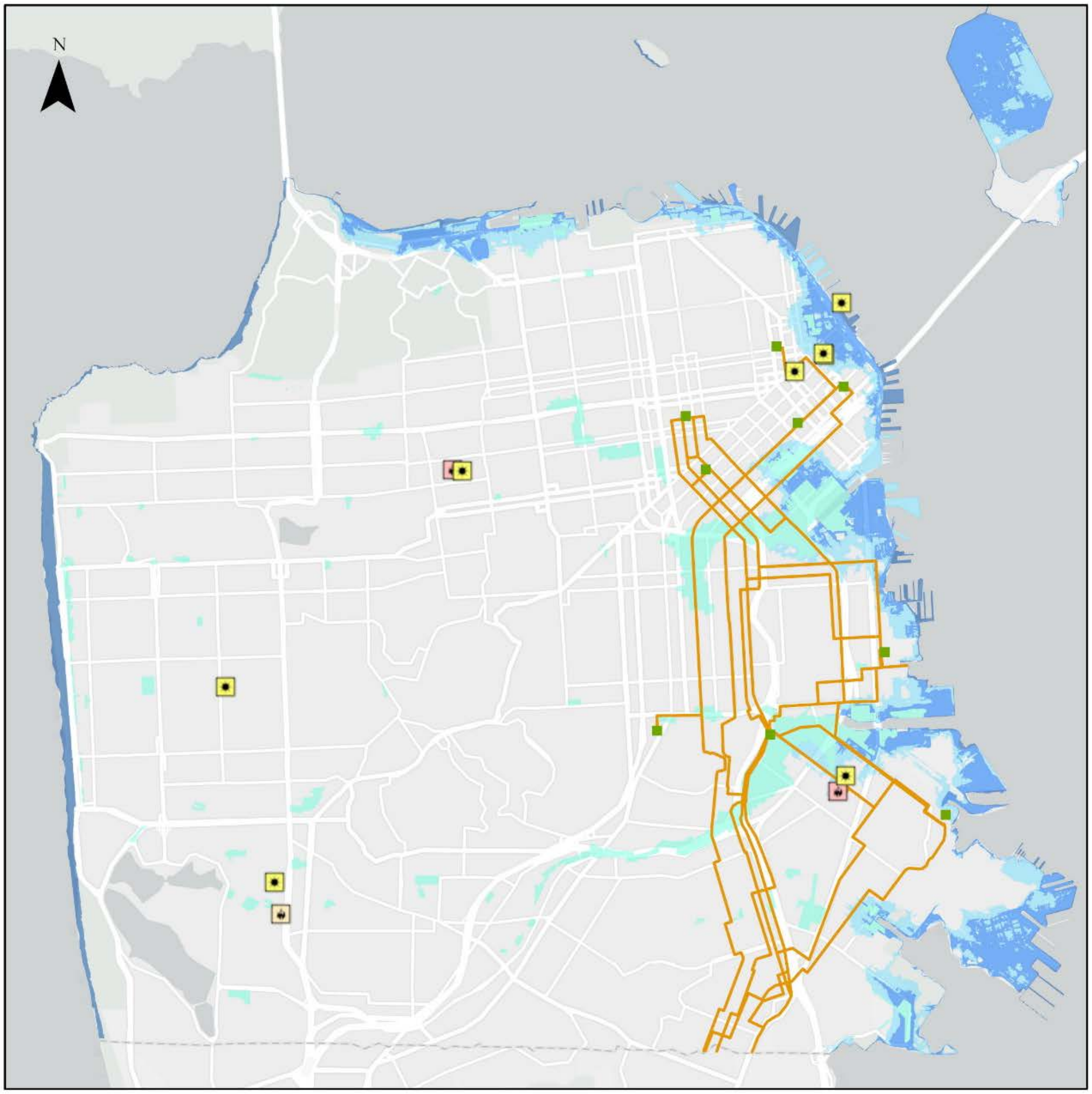


FIGURE A-54: POWER AND FLOOD HAZARDS



0 0.5 1 2 Miles

Power Flooding Risk

Generation Source
- Fuel Cell
- Internal Combustion
- Photovoltaic
- Substation

- Transmission Lines
- 100 Year Stormwater Runoff
- FEMA 100 Year Coastal Flood Zone
- 100 Year Storm + 24" Sea Level Rise
- 100 Year Storm + 66" Sea Level Rise

Flood Hazard Data Sources: Public Utilities Commission 100-Year Storm Flood Risk Map; FEMA Preliminary Flood Insurance Rate Maps; ART Bay Area Sea Level Rise and Shoreline Analysis Maps

This map provides general information related to hazard potential, planning areas, and impact severity. It is not intended for permitting, regulatory, or other legal uses. Risk zones are based on model outputs, and site specific conditions may not be fully represented.

VULNERABILITIES

Category	Vulnerability
Physical	Geologic: Transmission and distribution systems include generation sources, transmission lines, substations, transformers and distributions lines that could be damaged from earthquake shaking or liquefaction. Estimates of duration of power outages following a major seismic event range from few hours to 1-14 days in San Francisco.[137] Damage to this asset may be also exacerbated by the following vulnerabilities: • Transmission power lines are well engineered but are vulnerable to damage in areas of extreme ground failure. • Distribution power poles have no foundations and their stability is reliant upon soil conditions. • Above ground power lines are vulnerable to damage by falling debris. • Underground power lines are vulnerable to lateral spreading damage and may take longer to repair due to more difficult access. • Substation structures and supporting equipment are fragile and may be damaged during a seismic event, especially in areas of high ground shaking. However, there have been efforts to increase the resiliency of the system to date, including: • PG&E investing in advanced meters, automated switches technology[138] and testing commercial-grade earthquake early warning (EEW) system for substations.[139] • PG&E upgrading the power transmission system, especially in the high liquefaction susceptibility zone

[137] Range estimated based on past outages events. Sources include various news articles and PG&E press releases.
[138] San Francisco Chronicle (2017). "*Despite Recent Blackout, PG&E Upgrading Its Substations"*. Retrieved from: https://www.sfchronicle.com/opinion/openforum/article/Despite-recent-blackout-PG-E-upgrading-its-11109701.php
[139] PG&E (2016). "*Climate Change Vulnerability Assessment"*. Retrieved from: http://www.pgecurrents.com/wp-content/uploads/2016/02/PGE_climate_resilience.pdf

	• PG&E adding redundant transmission paths between its substations and adding redundancy within the substations. • PG&E increasing its power restoration capability through the Greater ay Restoration Project. • The submarine transmission line is located in trench designed to allow the cable to flex during ground shaking.[140] Flood: • Substations have electrical components that are both water and saltwater sensitive, if located at- or below grade. • Transformers and switches in Hunters Point and TransBay Center, located below ground in subsurface vaults, are somewhat flood resilient and can operate for extended periods of time under water.[141] • Underground transmission and distribution lines are unlikely to be affected by coastal flooding unless flooding results in erosion and scouring. • Switchgears are extremely vulnerable to flooding and need to be shutdown to avoid explosions. If switchgears are not operational, the downstream distribution system will fail. • Any electrical equipment at sidewalk grade is not water tight. Standing water within street light boxes can enter conduits that protect electrical wiring.[142] • High winds associated with storm events could down power lines and poles.[143] Extreme Heat: Heatwaves generally lead to higher energy demand for cooling, as air conditioning loads rise in the afternoon and remain high until late at night. There have been incidents where extreme heat has caused demand to exceed supply resulting in blackouts in San Francisco and other cities in the region and the risk is increasing as extreme heat

[140] 10 T&D World, Resiliency
[141] 10 SFPUC, Vulnerability Assessment
[142] Ibid.
[143] 3 C2ES, Resilience

	events are becoming more frequent and severe.[144] Prolonged and extreme heat can degrade the operational lifetime of large power transformers (LPTs) and increase the risk of their premature failure by reducing the structural integrity of insulation.[145] Fire: If exposed, assets are directly vulnerable to fire. Substations are generally located in open-air urban areas with no fire-resistant perimeter fences or enclosures. Overhead electric power assets can ignite if vegetation or other combustible objects come into contact during high winds events[146]. PG&E's Wildfire Safety Operations Center monitors extreme weather and fire threats in real time.[147] PG&E also has extensive vegetation management program to protect overhead electric lines and reduce the likelihood of an ignition associated with vegetation contact.[148]
Functional	Networks: All sub-assets are connected through the transmission and distribution system as part of the power grid, such that if an asset fails, it may result in operation failure in its service area. If damage is limited, it may be possible to contain the service disruption and reroute electricity around the damaged assets. However, if several critical assets, such as substations, are damaged, service interruption may be more widespread. Even if the substations themselves do not fail, its status can be off because of connectivity, power imbalance, or abnormal voltage level.[149] CAISO implemented emergency technology and energy conservation programs to mitigate the risk of outages and blackouts and reduce distribution bottlenecks by rotating blackouts among customers to reduce load demands, but this varies by neighborhood substation grid design.

[144] California National Resources Agency (2018). "*Safeguarding California Plan: 2018 Update – California's Climate Adaptation Plan*". Retrieved from: http://resources.ca.gov/docs/climate/safeguarding/update2018/safeguarding-california-plan-2018-update.pdf

[145] MIT (2017). "*Preventing the Next Blackout*" Retrieved from: https://phys.org/news/2017-12-blackout.html

[146] PG&E (2016). "Climate Change Vulnerability Assessment". Retrieved from: http://www.pgecurrents.com/wp-content/uploads/2016/02/PGE_climate_resilience.pdf

[147] San Francisco Chronicle (2018). "*Utility Plans 24/7 Prediction and Response Center in CA*" Retrieved from: http://www.govtech.com/public-safety/Facing-Blame-for-Fires-Utility-Plans-247-Prediction-and-Response-Center-in-California.html

[148] [19] PG&E, Climate

[149] Cagnan, Z., Davidson, R., Guikema, S., (2006). Post-Earthquake Restoration Planning for Los Angeles Electric Power, Earthquake Spectra 22 (3), 589-608.

	Certain City entities also own and operate their own on-site backup generators and/or have installed solar PV panels and storage, which decreases their vulnerability. There are backup generators on Treasure Island that are sufficient to meet the needs of both islands, if sufficient fuel is available. <u>External Services:</u> The power asset class relies on transportation access for vehicles and personnel in order to maintain and repair assets. Maintenance and repair vehicles also rely on fuel. Backup power generators also rely on fuel. <u>Populations Served:</u> Power serves all residents and businesses in the city. Electric power is especially critical for those dependent on 24/7 life supporting medical equipment, as well as to mobility-impaired and all elderly residents. Electric power is also critical for the continued operation of public services, such as public transport, sewage, water and waste management. <u>Unique or Critical Function:</u> Power is critical for a functioning city, from transportation to business to healthcare to households. Service providers of electric power are limited, and the city depends on their ability to manage and operate a secure and reliable electric power grid. Since energy storage technology solutions are not yet cost-effective and accessible to regular consumers it is vital that power supply is not interrupted.
Informational	<u>All-hazards:</u> Electrical single line drawings are available for the location of both SFPUC and PG&E owned substations and PG&E transmission lines.[150] However, information is not publicly available about the age, expected remaining service life and condition of substations, as well as their operational capacity and load sharing possibilities due to security concerns. The Lifelines Restoration Performance Project (report forthcoming) has assessed restoration timelines for the power sector in the event of a seismic event.

[150] CA Energy Commission (2017). "*California Transmission Lines and Substations Map*". Retrieved from: http://www.energy.ca.gov/maps/infrastructure/3P_Enlg.pdf

	In past events, there have been delays in utilities signaling substation fires to public service authorities.[151] Emergency response authorities and utilities are already collaborating to increase oversight and training.[152]
Governance	All-hazards: CPUC approval is needed for any resilience improvement projects and the CAISO determines whether or not new transmission lines and substations are needed to meet the grid's future demands. There is continued investment in renewable energy and community choice aggregation (CCA) programs, which would allow for redundancies and a more diversified and localized energy supply system,[153] but solutions remain reliant on the integrity of the transmission and distribution systems. There is a lack of clarity on exactly where PG&E service ends and SFPUC service begins, which results in some challenges regarding ownership and repair of some assets.[154]

[151] San Francisco Chronicle (2017). "Fires at PG&E's Substations a Recurring Problem". Retrieved from: https://www.sfchronicle.com/bayarea/article/Fires-at-PG-E-s-SF-substations-a-recurring-11119604.php
[152] [19] PG&E, Climate
[153] CPUC (2018). "California Customer Choice" Retrieved from: http://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/Utilities_and_Industries/Energy_-_Electricity_and_Natural_Gas/Cal%20Customer%20Choice%20Report%208-7-18%20rm.pdf
[154] Lifelines Restoration Performance Study (forthcoming)

CONSEQUENCES

Category	Consequence
Society/Equity	All-hazards: Power outages are generally short-term, but any prolonged widespread service interruption will pose health risk to people dependent on medical equipment if no backup or alternatives are available. Potable water systems are also affected by power outages, potentially leading to public health impacts. Mobility would be affected if transit and street lights are not operational. Communications networks could be affected posing risk to public safety. Low-income residents relaying on day paychecks and small businesses would be more affected due to halt of activities. Elderly and/or mobility-impaired residents in multi-story buildings may be unable to access critical daily needs if elevators are not functioning. Geologic: Health, public safety and mobility would be affected (see all hazards). Depending on the magnitude of the earthquake, disruption of the power grid could be regional in nature. Flood: Health, public safety and mobility would be affected (see all hazards) if there were localized power outages due to a flooding event. Substation equipment contain insulating oil that could contaminate if released into floodwaters. Extreme Heat: Health, public safety and mobility would be affected if there were widespread power outages due to a heat event. Fire: Health, public safety and mobility would be affected if there were localized power outages due to a fire.
Economy	All-hazards: A power outage may have severe economic consequences as it interrupts business operations across all industries. In the digital age, business operations are more dependent on reliable power than ever. The scale of the disruption will depend on the type and extent of the hazard event. Substations that are damaged or need to be shut down will not be able to provide power to the neighborhoods in their service area. Geologic: In the event of an earthquake, electric power would likely be affected at a regional scale. The economic consequences would include the cost to repair damaged infrastructure and the loss of

	economic activity during the power outage, including municipal operations. Flood: In the event of a flood the impacts would likely be localized. The impacts could become regional in nature if the outage affects regionally critical assets, such as BART or a wastewater treatment plant. The economic consequences would include the cost to repair damaged infrastructure, loss of economic activity and municipal revenue. Extreme Heat: In the event of a heatwave, the effects are most likely widespread power outages that could be regional in scale or at neighborhood level. The costs would include the loss of economic activity during the outage. Fire: In the event of a fire the impacts would likely be localized. The impacts could become regional in nature if transmission lines are affected or the outage affects regionally critical assets, such as BART or wastewater treatment. The economic consequences would include the cost to repair damaged infrastructure and the loss of economic activity.
Environment	All-hazards: Many facilities within the city maintain backup supply generators. However, if they are widely used for an extended period, air quality may be affected. If wastewater systems are unable to operate due to a power outage, then water quality may be impacted.

Natural Gas

Introduction to Asset Class

The natural gas asset class generates, stores, manages, and delivers natural gas to end-users, such as homes and businesses. For the purpose of this assessment we divided the asset class into five sub-asset types: production, interstate transmission, intrastate and local transmission, distribution and service lines.

a) *Production:* Most of the natural gas used in California comes from out-of-state natural gas basins. In 2012, California customers received 35% of their natural gas supply from basins located in the Southwest, 16% from Canada, 40% from the Rocky Mountains, and 9% from basins located within California.[155] The main source of natural gas for San Francisco is Canada and the Rockies.[156] Natural gas processing plants separate hydrocarbon gas liquids, nonhydrocarbon gases, and water from the natural gas to make it safe for delivery into the interstate transmission system. PG&E does not own any natural gas production facilities. Production facilities are not included in the exposure assessment given the focus on assets within the City and County of San Francisco.

b) Interstate Transmission: Transmission pipelines carry natural gas across long distances, usually to and from compressors or to a distribution center or storage facility. Transmission lines are large steel pipes (10" to 42" in diameter) that are federally-regulated. They carry unodorized gas at a pressure of approximately 60-900 psi. Natural gas is delivered into California from producing and processing areas via the interstate natural gas pipeline system to storage facilities and distribution centers where natural gas is delivered to local distribution companies, such as PG&E. The major interstate pipelines that deliver out-of-state natural gas to California are the Gas Transmission Northwest Pipeline, Kern River Pipeline, Transwestern Pipeline, El Paso Pipeline, the Ruby Pipeline, Questar Southern Trails and Mojave Pipelines.[157] Interstate transmission facilities are not included in the exposure assessment given the focus on assets within the City and County of San Francisco.

[155] http://www.cpuc.ca.gov/natural_gas/
[156] https://www.quora.com/Where-does-PG-E-source-their-gas-and-electricity-to-provide-consumers-homes-in-San-Francisco
[157] http://www.cpuc.ca.gov/natural_gas/

c) *Intrastate Transmission:* PG&E delivers natural gas across its service area through high pressure transmission lines, often called the backbone system. Natural gas on the backbone pipeline system is then delivered into the distribution pipeline systems, to natural gas storage fields and directly to some large customers, such as power plants. There are no gas storage facilities or power plants located in San Francisco. Three 19-30 inch diameter PG&E transmission lines deliver natural gas up the Peninsula into the City of San Francisco. A fourth transmission line delivers natural gas from Oakland to Treasure Island via submarine pipeline. Local transmission is included in the exposure assessment below.

d) Distribution: Smaller diameter, lower pressure pipelines are the middle step between high pressure transmission lines and low-pressure service lines. These small to medium sized pipelines (2-24 inches in diameter) are generally located beneath all surface streets in San Francisco and carry odorized gas at intermediate pressure levels. Distribution pipelines are not included in the exposure assessment below as the City and County of San Francisco does not have access to that data.

e) Service Lines: Service lines connect distribution lines to meters at homes and businesses and carry odorized gases at low pressures. Most natural gas customers are in residences and small commercial businesses that use natural gas for heating and cooking. Some fleet vehicle owners rely on compressed natural gas delivered by PG&E for their vehicles.

PG&E is regulated by the California Public Utilities Commission (CPUC) and the Federal Energy Regulatory Commission (FERC). CPUC regulates natural gas rates and services including in-state transportation of natural gas over transmission and distribution pipeline systems as well as the storage, procurement, metering and billing of natural gas.[158] FERC is an independent agency that regulates interstate natural gas transmission.

Issue Statement

Natural gas pipelines are vulnerable to seismic hazards, particularly liquefaction. Damage in two or three transmission lines could result in a pressure loss and gas service would be curtailed throughout the city.[159] Since 2014, all seismically vulnerable cast iron

[158] http://www.cpuc.ca.gov/natural_gas/
[159] 2014 SF Lifelines Council Interdependency Study

transmission pipe have been replaced in the City and PG&E plans to upgrade some of its seismically vulnerable distribution pipes. Any gas leaks on the transmission system would be controlled through 2,200 manual, remote, or automatic shut-off valves located throughout the system. Gas leaks on the distribution system are primarily controlled by manual shut-off valves that need to be located by field personnel below the street. Restoration of the gas system can take several weeks due to the time needed to inspect, repair, test, and re-pressurize the system. Relighting individual pilot lights at each service location would also require coordinating a large number of personnel to achieve. The consequences of impairment of natural gas service would have health impacts due to the lack of building heating, which would especially impact vulnerable populations during winter months. Damage to the natural gas system due to an earthquake or other hazard event also has the potential to result in an explosion and fire, potentially leading to deaths, injuries, and/or property damage.

Assumptions and Limitations

Hazard Data Assumptions

This analysis was conducted in 2018 and 2019 using publicly-available data sources. In the table below, shaking intensity is represented for two earthquake scenarios: San Andreas Fault 7.8 and Hayward Fault 7.0 events. Accounts of assets subjected to varying levels of shaking intensity are cumulative for each scenario.

Asset Data Assumptions

Asset data is sourced from the California Energy Commission open data portal, last updated in 2018.

TABLE A-33: EXPOSURE

Hazard	Natural Gas Transmission Pipelines 19 Miles Total		Natural Gas Stations 3 Total	
	#	%	#	%
Geologic				
San Andreas 7.8 - Violent	2	11%	0	0%
San Andreas 7.8 - Very Strong	17	91%	3	100%
Hayward 7.0 - Very Strong	2	13%	1	33%
Hayward 7.0 - Strong	13	68%	2	67%
Liquefaction Zone	5	26%	3	100%
Flooding				
100-Year Coastal Flood Zone	0	0%	0	0%
100-year storm + 24 inches SLR	1	5%	0	0%
100-year storm + 66 inches SLR	2	11%	2	67%
100-year Stormwater Flood	2	11%	0	0%
Wildfire				
High	0	0%	0	0%
Moderate	0	0%	0	0%

Note: For an exposure table with additional hazards, please see Chapter 05.

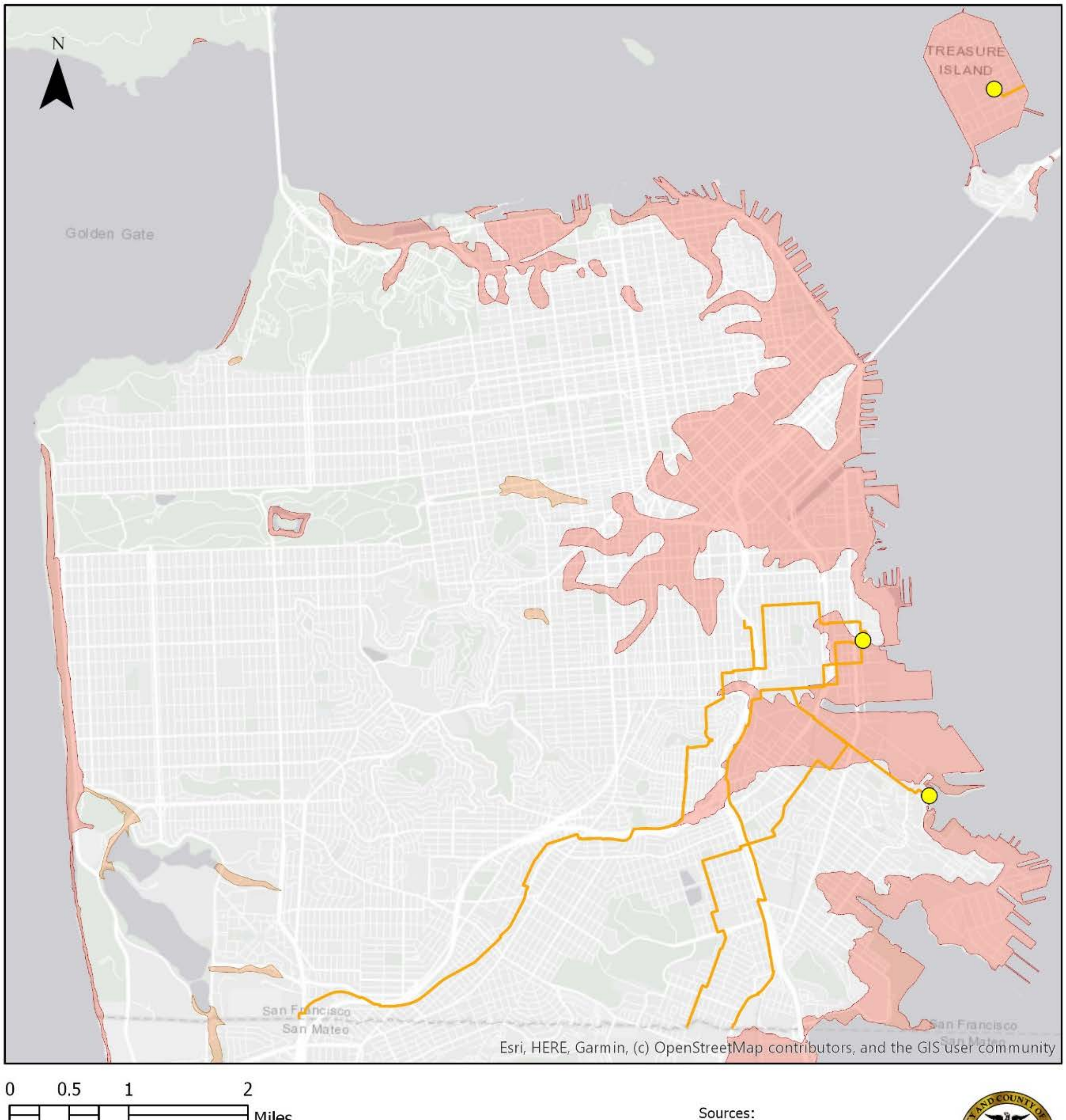
Exposure Summary

Geologic: All natural gas stations and one quarter of transmission pipelines are located in areas with liquefaction risk. 91% percent of natural gas transmission line assets are in very strong ground shaking risk areas assuming a M7.8 San Andreas earthquake. Every natural gas station is subjected to very strong shaking in this scenario as well. A significant proportion (greater than 60% percent) of all natural gas assets are subjected to strong shaking from a M7.0 Hayward earthquake.

Flood: One mile of transmission pipelines are in a 24" sea level rise risk area, and an additional mile of pipelines are in a 66" risk area. Two natural gas stations are in a 66" sea level rise risk area. Two miles of pipelines are in a 100-year stormwater flood area.

Fire: Natural gas transmission pipelines and stations are not in a wildland-urban interface risk zone. Natural gas valves are not included in the exposure analysis.

FIGURE A-55: NATURAL GAS AND LIQUEFACTION HAZARD



Liquefaction Susceptibility & Natural Gas

- Natural Gas Stations
- Natural Gas Pipelines

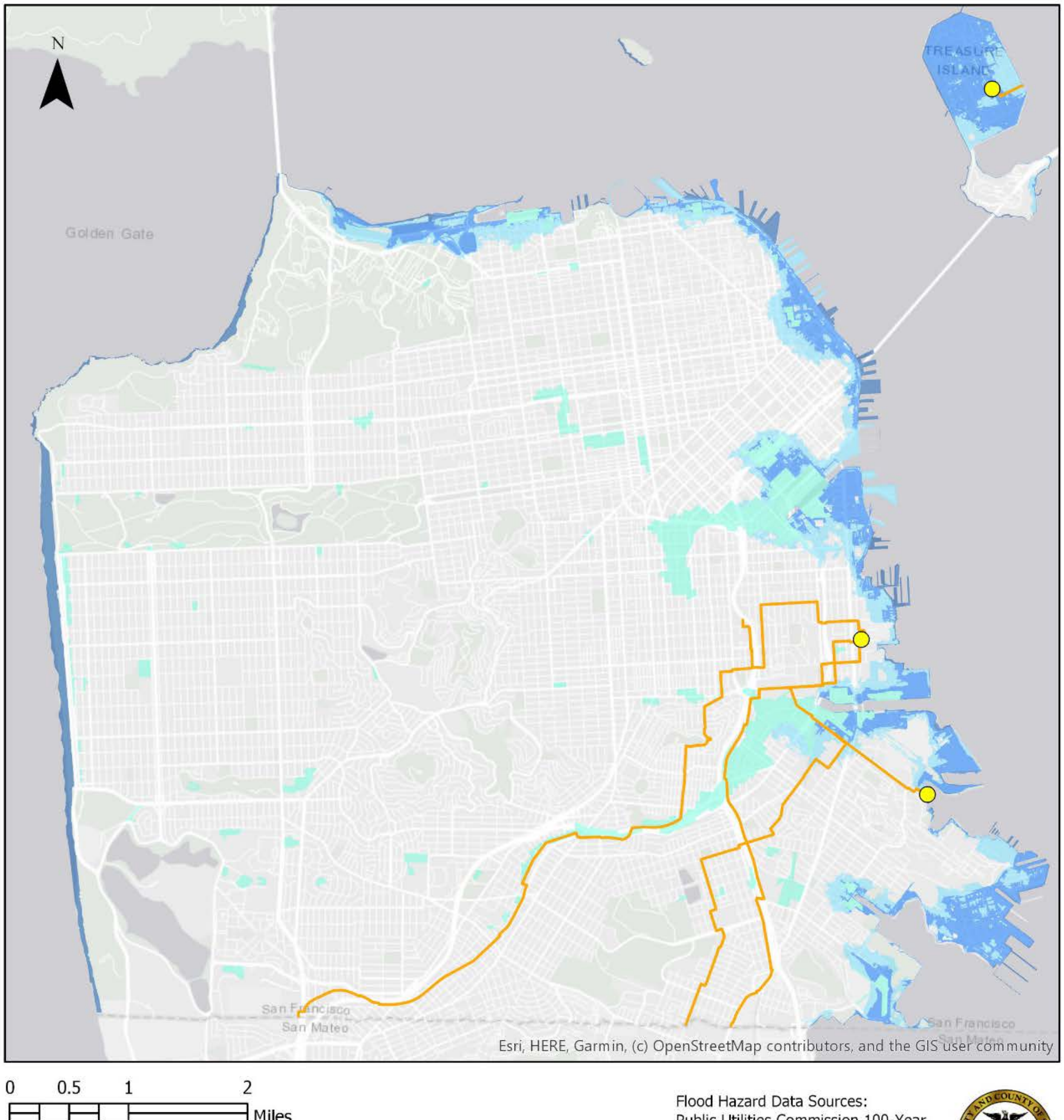
Soil Liquefaction Hazard Zone

- Very High
- High

Sources:
California Energy Commission - GIS Unit (2018); CGS, CALOES, 2015

This map provides general information related to hazard potential, planning areas, and impact severity. It is not intended for permitting, regulatory, or other legal uses. Risk zones are based on model outputs, and site specific conditions may not be fully represented.

FIGURE A-56: NATURAL GAS AND FLOOD HAZARDS



Natural Gas Flooding Risk

- Natural Gas Stations
- Natural Gas Pipelines
- 100 Year Stormwater Runoff
- FEMA 100 Year Coastal Flood Zone
- 100 Year Storm + 24" Sea Level Rise
- 100 Year Storm + 66" Sea Level Rise

Flood Hazard Data Sources:
Public Utilities Commission 100-Year Storm Flood Risk Map; FEMA Preliminary Flood Insurance Rate Maps; ART Bay Area Sea Level Rise and Shoreline Analysis Maps

Asset Data Sources: California Energy Commission - GIS Unit (2018)

This map provides general information related to hazard potential, planning areas, and impact severity. It is not intended for permitting, regulatory, or other legal uses. Risk zones are based on model outputs, and site specific conditions may not be fully represented.

VULNERABILITIES

Category	Vulnerability
Physical	Geologic: Since 2005, all seismically vulnerable cast iron transmission pipe have been replaced in the City. Any gas leaks on the transmission system would be controlled through 2,200 remote and automatic shut-off valves located throughout the city. Remote shut off valves can be controlled from the new Gas Control Center in San Ramon when significant drops in pressure are detected. Automatic gas shut off valves have been installed in densely populated areas and where transmission lines cross major faults. The shutoff valves have been designed to close automatically when local sensors at the valve site detect a possible pipe rupture. PG&E has plans to upgrade brittle cast iron distribution pipes. These pipes will likely be damaged in areas of high liquefaction. Shut off valves on the distribution system are manually and automatically operated. Natural gas valves are frequently collocated with streets, and damage to streets impedes operators' ability to access manual valves. Restoration of the gas system can take several weeks due to the time to inspect, repair, test, re-pressurize the system and relight pilot lights at each service location, requiring a large number of personnel. PG&E has a prioritization of customers for restoration with hospitals and other critical customer's first and residential customers later. Flood: While most pipelines are cathodically protected, those constructed with older seam types are susceptible to corrosion from saltwater intrusion.[160] The rates of unprotected pipes are low statewide (0.5%), but information on the specific conditions in San Francisco is not available. Depending on the intensity of storm energy, pipelines may be damaged due to increased hydrostatic pressures. Burial depth and covering material also affect vulnerability. Extreme Heat: Natural gas systems have low vulnerability to extreme heat. Natural gas production from hydraulic fracturing (fracking), however is very water intensive. Extreme heat and related drought conditions

[160] 2017 California Energy Commission Climate Change Center, Assessment of California's Natural Gas Pipeline Vulnerability to Climate Change

	projected to increase in California under climate change make this source of fuel less adaptive under climate change.[161] Fire: Aboveground components are vulnerable to fire. If meters are melted away during a fire, gas can ignite.[162]
Functional	Networks: San Francisco receives natural gas from three transmission lines running up the peninsula and into the city with a fourth submarine transmission line supplying gas to treasure island from Oakland. PG&E manages gas infrastructure for contingencies, but damage to two or three of these transmission lines could result in a pressure loss which would limit gas service to the city. PG&E estimates that following a 7.8M earthquake on the San Andreas Fault, it could take up to 6 months for full restoration of service if gas transmission is lost.[163] External Services: The collocation of natural gas infrastructure with San Francisco streets increases vulnerabilities for both assets. Following Loma Prieta, most street damage was due to sewer, water, gas breaks. Before street repair can begin, underground utility breakage will need to be repaired. Operators may need to manually control natural gas valves, an ability that may be hindered if streets are closed, damaged, or obstructed.[164] Populations Served: Natural gas is primarily used by residences and small businesses for cooking, space heating and water heating. Hospitals and some other large entities also rely on natural. Loss of natural gas service would have a significant impact on vulnerable populations, especially during winter months. Unique or Critical Function: Natural gas is important for a functioning city, especially for household cooking, water heating and space heating. There is only one provider of natural gas, and the city depends on their ability to manage and operate a secure and reliable pipe network. Disruption to

[161] Moran, M. D., N. T. Taylor, T. F. Mullins, S. S. Sardar, and M. R. McClung, 2017: Land-use and ecosystem services costs of unconventional US oil and gas development. Frontiers in Ecology and the Environment, 15 (5), 237–242. doi:10.1002/fee.1492
[162] Case Studies of Natural Gas Sector Resilience Following Four Climate-Related Disasters in 2017
[163] 2014 SF Lifelines Council Interdependency Study
[164] 2018 Interview for Lifeline Restoration Performance Project

	the gas system has the likelihood to ignite fires and pilot lights must be manually relighted at each individual residence or business, which is extremely time and labor intensive.
Informational	All-hazards: The locations of natural gas transmission pipelines and facilities are made publicly available by PG&E and the California Energy Commission, however distribution pipe locations are not known, though it is generally co-located with roads in residential areas.
Governance	All-hazards: Natural gas is privately managed by PG&E. Natural gas infrastructure is collocated with roads, and requires coordination among multiple managers, both public and private. The PUC's Fuel Switching Project is working to replace natural gas heating systems with electric systems for public schools and small commercial properties.[165] Department of Environment also identifies fuel switching as a prioritized action to reduced greenhouse gas emissions. A hazard event such as an earthquake that damages natural gas pipelines could provide an opportunity to switch other facilities from natural gas to electric cooking and heating systems.

CONSEQUENCES

Category	Consequence
Society/Equity	All-hazards: Gas leaks or explosions pose risks to public health and safety. Homes and businesses without natural gas can still be occupied, however they might not be able to cook or heat their homes or water if those appliances rely on natural gas. Most restaurants rely on natural gas for cooking and would be particularly affected by an outage. Loss of natural gas over an extended period of time can impact the ability of communities to shelter in place, impacting the long-term neighborhood stability and cohesion.
Economy	All-hazards: The economic consequences of disruption of the natural gas system include the cost to repair damaged infrastructure and the loss of business activity during the outage. Geologic: In the event of an earthquake, natural gas would likely be affected at a regional scale.

165 SFPUC 2017 Energy Benchmarking Report

Environment	<u>All-hazards:</u> Gas leaks or explosion pose risks to air quality and natural area habitats and sensitive species. Loss of natural gas supply could increase electricity use, especially in winter. This could have a positive or negative effect on emissions depending on the source of electricity.

Potable Water

Introduction to Asset Class

The potable water system delivers roughly 60 million gallons per day to meet the needs of San Francisco residents and businesses. The local water supply system is made up of over 1,250 miles of distribution pipelines (also known as distribution mains), 17 storage reservoirs and tanks, and 4 groundwater well sites. Recently, SFPUC has expanded the local supply to include groundwater sourced from the 45-square mile Westside Basin located under Golden Gate Park. This new source is explicitly developed to provide emergency water in the case of system disruptions. Currently, 17 pumping stations move water across the city, spanning a range of elevations and serving a wide range of users including users via the Treasure Island/Yerba Buena distribution system. In order to maintain this service, 24 pressure zones are created throughout the system based on user elevation, available pumping capacity, and water supply.

SFPUC's Water Enterprise is responsible for managing the transmission, treatment, storage and distribution of potable water to San Franciscans and 27 water agencies in three Bay Area counties – San Mateo, Santa Clara and Alameda.[166] While the majority of San Francisco's potable water resources come from outside the county, and we are committed to their resilience, this vulnerability and consequence assessment focuses on local water supply assets within the city and county boundaries. The system has seen extensive improvements over the last decade as a result of the Water System Improvement Program (WSIP) which has included local and regional improvements replacing outdated/worn infrastructure as well as the installation of seismic improvements to reservoirs, pumping stations, reservoirs and other critical facilities.

Issue Statement

The potable water system provides a vital lifeline service to the residents and businesses of San Francisco and there are limited alternatives should the system be impaired. Some distribution mains are old and made of less resilient materials such as cast iron, and pipelines traverse seismic hazard zones, which could result in damage in an earthquake. The system heavily relies on pumping stations with some containing

[166] SFPUC. "About US: Water". Retrieved from: https://www.sfwater.org/index.aspx?page=6

below grade electrical components. This may be an issue for the Bay Bridge Pumping Station which would be exposed to flooding from a 100-year storm with 66 inches of sea level rise and is the only connection for potable water into the Treasure Island/Yerba Buena distribution system. Water storage is centralized in reservoirs that may face contamination issues if damaged.

TABLE A-34: EXPOSURE

Hazard	Pump Stations: 17 Total		Water Transmission Lines: 24 Miles Total		Water Reservoirs 15 Total	
	#	%	#	%	#	%
Geologic						
San Andreas 7.8 - Violent	4	24%	11	46%	3	20%
San Andreas 7.8 - Very Strong	13	76%	13	54%	12	80%
Hayward 7.0 - Very Strong	1	6%	0.1	0%	0	0%
Hayward 7.0 - Strong	6	21%	0.1	0%	9	60%
Liquefaction Zone	0	0%	0.4	2%	0	0%
Flooding						
100-Year Coastal Flood Zone	0	0%	0	0%	0	0%
100-year storm + 24 inches SLR	0	0%	0	0%	0	0%
100-year storm + 66 inches SLR	1	3%	0	0%	0	0%
100-year Stormwater Flood	0	0%	0	0%	0	0%
Wildfire						
High	0	0%	0	0%	0	0%
Moderate	1	6%	2	8%	0	0%

Note: For an exposure table with additional hazards, please see Chapter 05.

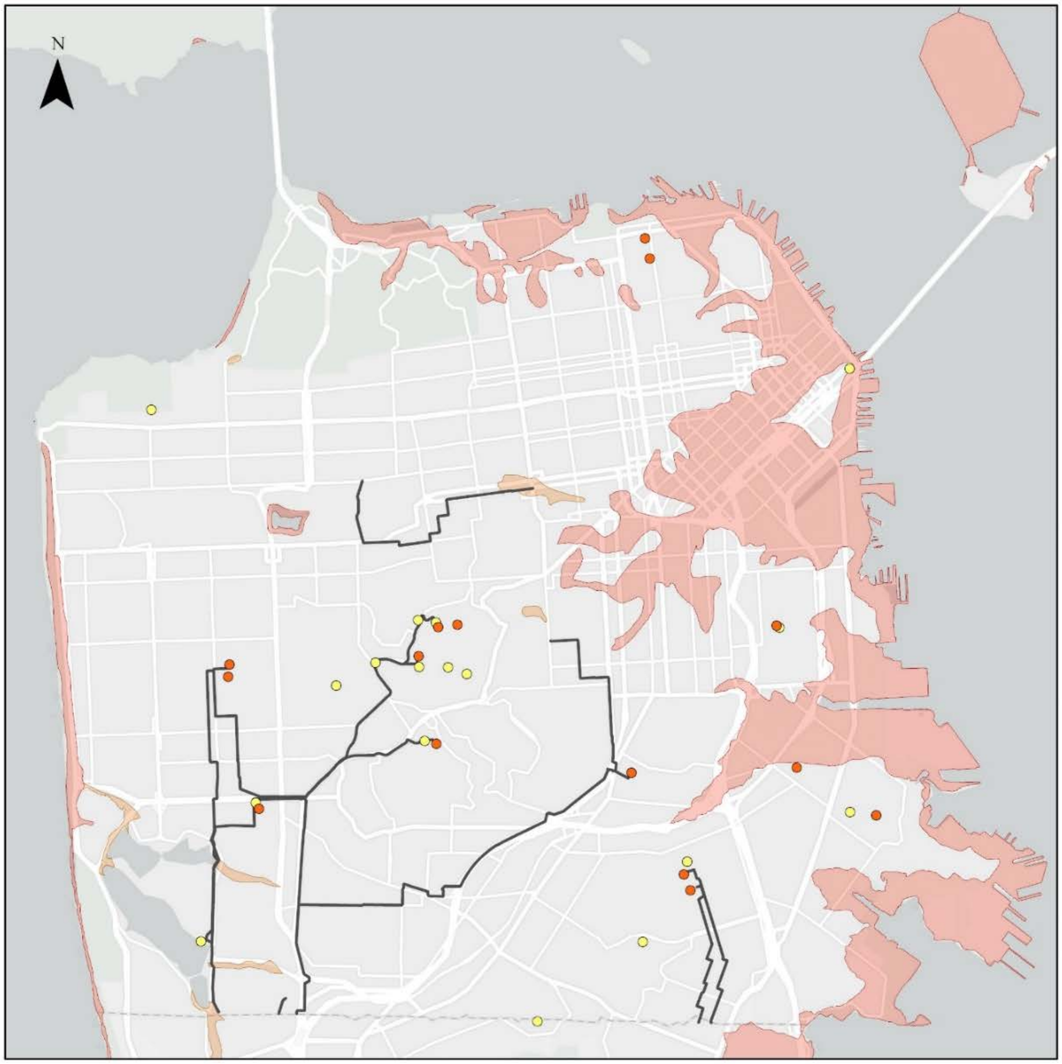
Exposure Summary

Geologic: All potable water assets are exposed to violent or very strong groundshaking in a 7.8 earthquake on the San Andreas Fault. Potable water assets have limited exposure to violent or very strong shaking in a 7.0 earthquake on the Hayward fault and the liquefaction hazard.

Flood: Only one pump station is exposed to flooding in a 100-year storm with 66 inches of sea level rise. This is the pump stations that provides potable water service to Yerba Buena Island.

Fire: four pump stations are exposed to moderate wildfire risk.

FIGURE A-57: POTABLE WATER ASSETS AND LIQUEFACTION HAZARD



0 0.5 1 2 Miles

Sources: SFDEM Data Library 2018; CGS, CALOES, 2015

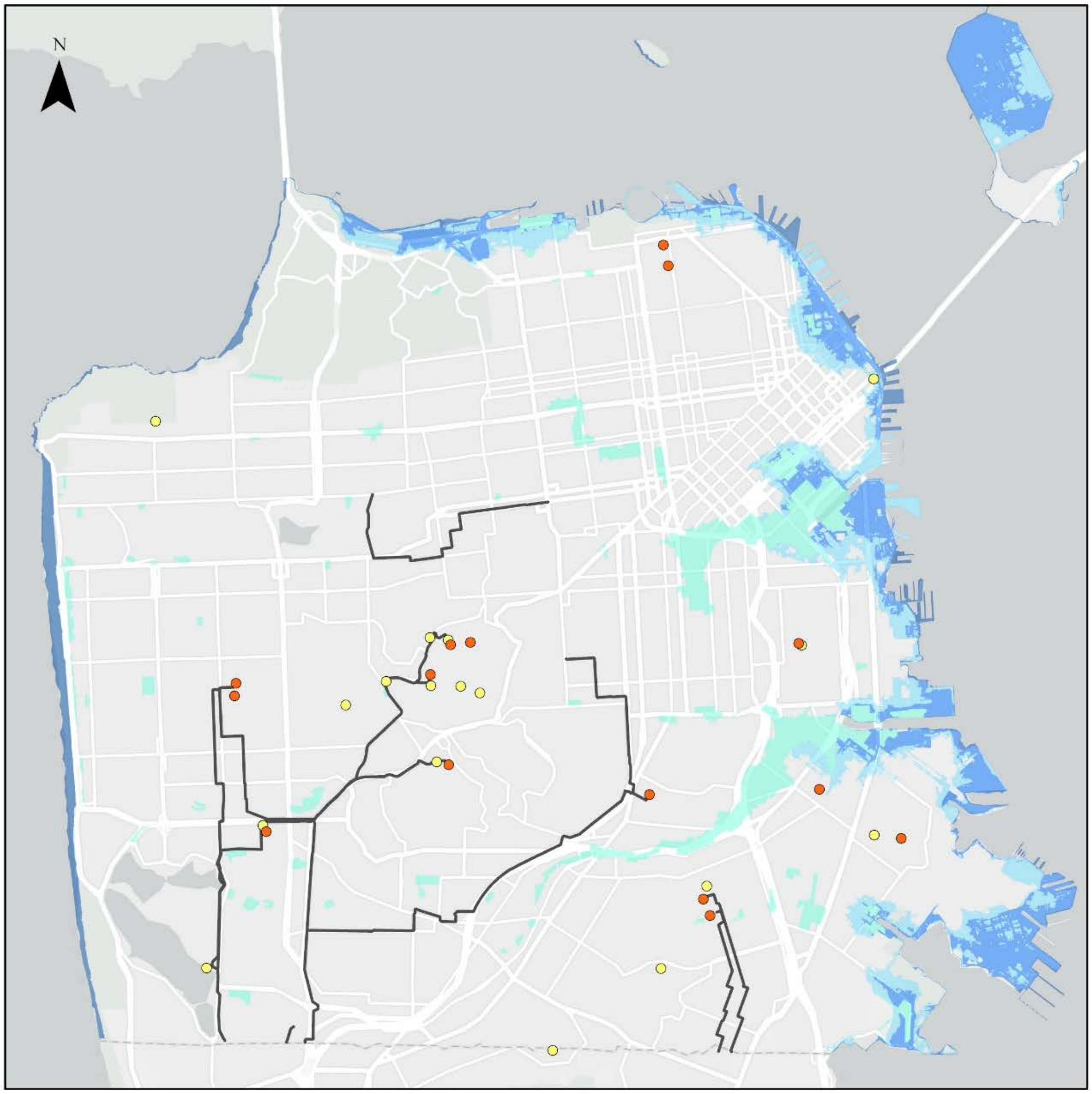
Liquefaction Susceptibility & Potable Water Assets

- Potable Reservoirs
- Potable Pumps
- Water Transmission Pipeline

Soil Liquefaction Hazard Zone
- Very High
- High

This map provides general information related to hazard potential, planning areas, and impact severity. It is not intended for permitting, regulatory, or other legal uses. Risk zones are based on model outputs, and site specific conditions may not be fully represented.

FIGURE A-58: POTABLE WATER ASSETS AND LIQUEFACTION HAZARD



0 0.5 1 2 Miles

Potable Water Flood Risk

- Potable Reservoirs
- Potable Pumps
- Water Transmission Pipeline

Flood Hazards

- 100 Year Stormwater Runoff
- FEMA 100 Year Coastal Flood Zone
- 100 Year Storm + 24" Sea Level Rise
- 100 Year Storm + 66" Sea Level Rise

Flood Hazard Data Sources: Public Utilities Commission 100-Year Storm Flood Risk Map; FEMA Preliminary Flood Insurance Rate Maps; ART Bay Area Sea Level Rise and Shoreline Analysis Maps

This map provides general information related to hazard potential, planning areas, and impact severity. It is not intended for permitting, regulatory, or other legal uses. Risk zones are based on model outputs, and site specific conditions may not be fully represented.

VULNERABILITIES

Category	Vulnerability[167][168]
Physical	Geologic: Previous experience has shown that transmission mains in liquefaction zones can experience some damage, particularly if they are cast iron construction. This damage can leave some users without access to water if they are located at higher elevations. Damage to reservoirs can lead to the contamination of potable water resources. However, most reservoirs have been seismically retrofitted and can be expected to perform well in the case of a major earthquake. Flood: Pumping stations have below grade electrical components that are sensitive to inundation. Additionally, some pumping stations have numerous flood vulnerable entryways and may lack comprehensive flood proofing. Most notable is the Bay Bridge Pumping Station that is in the sea level rise hazard zone and functions as the sole entry point for water into the Treasure Island/Yerba Buena Water Distribution System. Many local water control systems used to maintain reservoir levels and control water flows are dependent on below grade electrical components that face inundations risks. Repeated, increasingly frequent saltwater inundation of transmission mains can lead to corrosion damage to these sub-assets. The overall system relies on valves for isolation and distribution routing of water throughout the city. Under sea level rise scenarios carried out by the PUC, these valves will not be accessible or will be located under water, potentially impacting the function of the system in the inundation areas. Extreme Heat: None. Fire: None.
Functional	Networks:

[167] Miller K, Bechelli A, Young S, Teahan B, Gonzalez R, Conci B, Gabriel B, Lampe D. "SFPUC Water Lifelines Interview" Interview by Mieler D. 8/16/18
[168] SF Planning (2019) "*SLR Vulnerability and Consequences Assessment*"

	This system is networked and depends on the maintenance of pressure zones for transportation of water across the city to customers at different elevations. The networked nature of the system means that assessments can be made to identify breakages in the system and water can be rerouted around these breakages to maintain service. There is redundancy in the distribution network that can assist in rerouting water around areas that have been damaged. Lower pressure water hydrants may serve as water distribution points in the community, with support from trained volunteers with NERT. However, this is reliant on hydrants which may also be damaged in an earthquake event. Taken together, reservoirs can hold about 500 million gallons (4-5 day's supply) of potable water when full which can siphoned off and transported in water trucks if the distribution network were disrupted. <u>External Services:</u> The system has reliance on external power to operate pumping stations. While there are backup generators, these are reliant on diesel fuel availability. The system relies heavily on pumping capability to function and loss of power can impact the ability to move water or maintain operational pressure in the system. Telecommunications are vital to coordinate actions over the wide geographic extent of the system. These function to coordinate reservoir levels to maintain pressure as well as remotely operate pumping stations. Transportation access is essential to facilitating repair employees to access the city from their housing outside the county and is also essential for accessing broken pipe sections around the city as sections are repaired. <u>Populations Served:</u> This system is essential for providing potable water to all residents and businesses in the city and county of San Francisco. As the system spans the entire city, it serves numerous community members that are ethnically/culturally diverse and may have limited English proficiency and access or functional needs. <u>Unique or Critical Function:</u> This asset functions as the primary source of potable drinking water for everyday use by residents as well as businesses operating in the city.

	In addition, potable water is critical following a significant earthquake event for the general public, mass care facilities, and fire-fighting needs.
Informational	<u>All-hazards:</u> Generally, there is information available regarding the flood and seismic risks to the system but significantly less information regarding potential impacts to the system from extreme heat events or direct fire events. The primary fire risk to the system would most likely occur outside of the city/county boundary, and therefore outside the scope of this effort.
Governance	<u>All-hazards:</u> The WSIP program is the primary policy/funding initiative guiding the maintenance, repair, and improvement of the system. Additionally, this program strives to specifically identify seismic resilience improvements for implementation. SFPUC also plans the system based on its Level of Service (LOS) goals. In the case of a large disruptive event, such as an earthquake, repair work would have to compete with other priorities such as the EFWS system or the wastewater collection system, which could potentially delay restoration of any of these services without proper coordination.

CONSEQUENCES[169]

Category	Consequence
Society/Equity	<u>All-hazards:</u> Delays to water supply restoration following an event could impact restoration of wastewater, telecommunications equipment cooling, refueling services, and even the provision of basic services for the city's lifelines systems. This would be disruptive across numerous aspects of society.[170] In the case of major disruption over a protracted period, the mobility challenged may find it difficult to access locations with alternative

[169] Miller K, Bechelli A, Young S, Teahan B, Gonzalez R, Conci B, Gabriel B, Lampe D. "SFPUC Water Lifelines Interview" Interview by Mieler D. 8/16/18

[170] SF Lifelines Council (2014). "Lifelines Interdependency Study I Report" Retrieved from: https://sfgov.org/orr/sites/default/files/documents/Lifelines%20Council%20Interdependency%20Study.pdf

	water resources, be they water distribution points in the form of low pressure hydrants or community centers distributing water bottles. Geologic: Significant breakage of mains and distribution infrastructure could lead to an extended period without potable water, with detrimental health and safety implications for community residents
Economy	All-hazards: Disruption to this asset would have significant citywide consequences across numerous sectors Geologic: Damage to transmission mains and pipelines can lead to water leaks and damage to co-located assets. For example, burst water mains that haven't had their flow rerouted can create sinkholes or cause surface flooding, potentially damaging roadways and buildings. This can necessitate costly repairs by public and private entities. Damage to transmission mains can also lead businesses to lose potable water access and have to shut down temporarily, losing revenue. Flood: Saltwater corrosion could shorten the life expectancy of buried pipe infrastructure. This could lead to increased replacement costs for the system as the frequency of inundation increases over time. This would be most pronounced for assets in coastal inundation zones. Extreme Heat: Warmer temperatures can lead to increased demand by both water utility customers and competing users, with demand peaking when supplies are most restricted. This can lead to increases in water pricing, putting pressure on local businesses and low income individuals.[171]
Environment	All-hazards: If the potable water system were disrupted, alternative source of potable water could have environmental impacts such as waste management issues from disposable plastic water bottles or emissions from water distribution trucks.

[171] AWWA Research Foundation (2008) "Effects of Climate Change on Public Water Suppliers"

Emergency Firefighting Water System

Introduction to Asset Class

The Emergency Firefighting Water System (EFWS) is a high-pressure firefighting water system constructed shortly after the 1906 earthquake to safeguard lives and property in the case of future earthquakes. The system is routinely tapped to fight multi alarm fire events even in the absence of an earthquake and can be called on as much as 30 times in a single year.[172] The primary function of the system is to provide large volumes of high pressure water for firefighting purposes and numerous types of equipment are used to achieve this goal. Although the eastside is reliably and extensively covered by the system, the Westside has lower reliability due to its more recent development in the city's history. Currently, agencies are identifying extension alternatives in partnership with the public to increase Westside reliability.[173,174]

The primary water supply for the system comes from the Twin Peaks reservoir, with a storage capacity of 10.5 million gallons. This is bolstered by the Ashbury and Jones Tanks. In addition, the EFWS system has a secondary water source, the San Francisco Bay, which can be accessed via two pump stations, five manifolds connections, and drafting points that allow saltwater to be drawn into the system with the assistance of three fireboats and pumping engines. Approximately 210 underground cisterns located around the system can also provide water for the system. 131 miles of pipelines and motorized/manual valves facilitate transportation of this water across the city to the high pressure fire hydrants used by SFFD.

Originally, the EFWS was constructed by Public Works and managed by SFFD. However, ownership transferred to SFPUC in 2010 and a full assessment of all existing facilities commenced through a comprehensive planning study. The analysis showed that the 2010 EFWS would be about 47% reliable in terms of providing EFWS water citywide

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[172] METCALF AND EDDY/AECOM (2009) "*Auxiliary Water Supply System Study: Final Report*. Retrieved from: https://s3-us-west-2.amazonaws.com/ucldc-nuxeo-ref-media/b2754026-dded-4ee6-b24c-2cf837f3bc00

[173] AECOM/AGS (2014). "*CS-199 Planning Support Services for Auxiliary Water Supply System (AWSS): Project Report*". Retrieved from: https://sfwater.org/Modules/ShowDocument.aspx?documentid=5055

[174] San Francisco Public Utilities Commission. (2012) "*Assessment of Fire Suppression Options for Westside*". Public Presentation. Retrieved from: https://sf-fire.org/sites/default/files/COMMISSION/Fire%20Commission%20Support%20Documents%202015/AWSS%20Presentation%20for%20SFFD%20Commission.pdf

following a 7.8M earthquake. It also identified combined projects to be completed using the 2010 and 2014 Earthquake Safety and Emergency Response (ESER) bonds authorized by voters to increase average reliability from 47% to 87% with additional projects raising it to 96%.

Issue Statement

The EFWS provides a critical emergency response function, supporting firefighting efforts both in the event of a major earthquake and on a more regular basis. The ability of the EFWS system to provide high pressure water for firefighting may be disrupted by hazard events, particularly as it is a networked system that relies on interconnected system components. Using ESER bond funds, the SFPUC has increased average citywide reliability to 87% once the ESER 2010 and 2014 projects are completed and additional projects will bring it to 96% reliability following a 7.8 earthquake. With regarding to flooding impacts, below grade valve and pumping station components are vulnerable to damage from flooding. Access to hydrants, drafting points, or manifolds may also be compromised by flooding. If functionality of the EFWS is disrupted, firefighting capabilities may be compromised, increasing the risk of fire damage and potentially injury or loss of life.

Exposure

Hazard Data Assumptions

This analysis was conducted in 2018 and 2019 using publicly-available data sources. In the table below, shaking intensity is represented for two earthquake scenarios: San Andreas Fault 7.8 and Hayward Fault 7.0 events. Accounts of assets subjected to varying levels of shaking intensity are cumulative for each scenario.

Asset Data Assumptions

EFWS pipeline data contains proposed EFWS pipes, existing EFWS pipes, and existing potable water pipes that are used in the system. The dataset containing valves only contained information for 18 of the 30 valves used in the system. Additionally, a 32 foot buffer was applied to the pump stations due to a lack of redundancy and proximity to coastal flood zones.

Asset data is originates from datasets maintained by SFPUC, SF Planning, and SF DEM (2018).

Exposure Summary

Geologic: All of the EFWS system is exposed to violent or very strong shaking in a 7.8 earthquake on the San Andreas Fault. A much smaller share of the system is exposed to violent or very strong shaking in a 7.0 earthquake on the Hayward fault. Almost a third of the EFWS systems pipelines are in the liquefaction hazard zone.

Flood: The EFWS systems pipelines have very little exposure to the current 100-year flood zone. With sea level rise, more of the EFWS will be exposed. For example, with 66 inches of sea level rise 17% percent of valves and 14% percent of pipelines may be exposed to flooding during a 100-year storm.

Fire: Only a very limited amount of the system is exposed to moderate wildfire risk.

TABLE A-35: EXPOSURE

Hazard	Valves: 3326 Total		Cisterns: 210 Total		Pipelines: 131 Miles Total		High Pressure Hydrants: 1,644 Total		Pump Stations: 2 Total	
	#	%	#	%	#	%	#	%	#	%
Geologic										
San Andreas 7.8 - Violent	176	5%	30	14%	10	8%	102	6%	0	0%
San Andreas 7.8 - Very Strong	3148	95%	180	86%	120	92%	1542	94%	2	100%
Hayward 7.0 - Very Strong	483	15%	6	3%	16	12%	218	13%	2	100%
Hayward 7.0 - Strong	2584	78%	172	82%	101	77%	1257	76%	0	0%
Liquefaction Zone	1262	38%	45	21%	45	34%	602	37%	1	50%
Flooding										
100-Year Coastal Flood Zone	21	1%	0	0%	1	1%	12	1%	1	50%
100-year storm + 24 inches SLR	308	9%	3	1%	10	8%	138	8%	0	0%
100-year storm + 66 inches SLR	545	16%	11	5%	19	15%	253	15%	1	50%
100-year Stormwater Flood	154	5%	8	4%	7	5%	84	5%	0	0%
Wildfire										
High	0	0%	0	0%	0	0%	0	0%	0	0%
Moderate	10	1%	2	1%	0.7	0%	6	0%	1	50%

Note: For an exposure table with additional hazards, please see Chapter 05.

FIGURE A-59: EFWS ASSETS AND LIQUEFACTION HAZARD

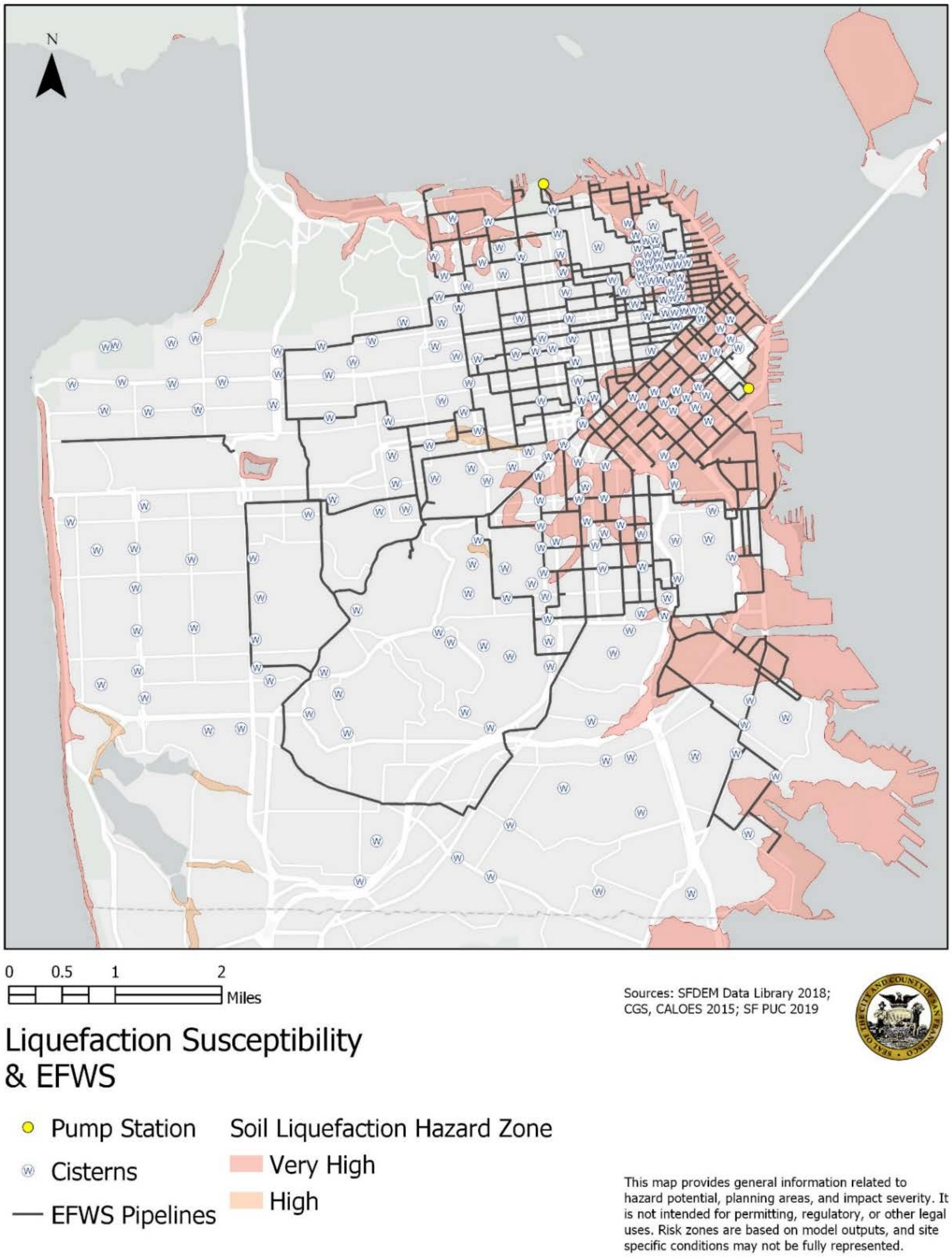
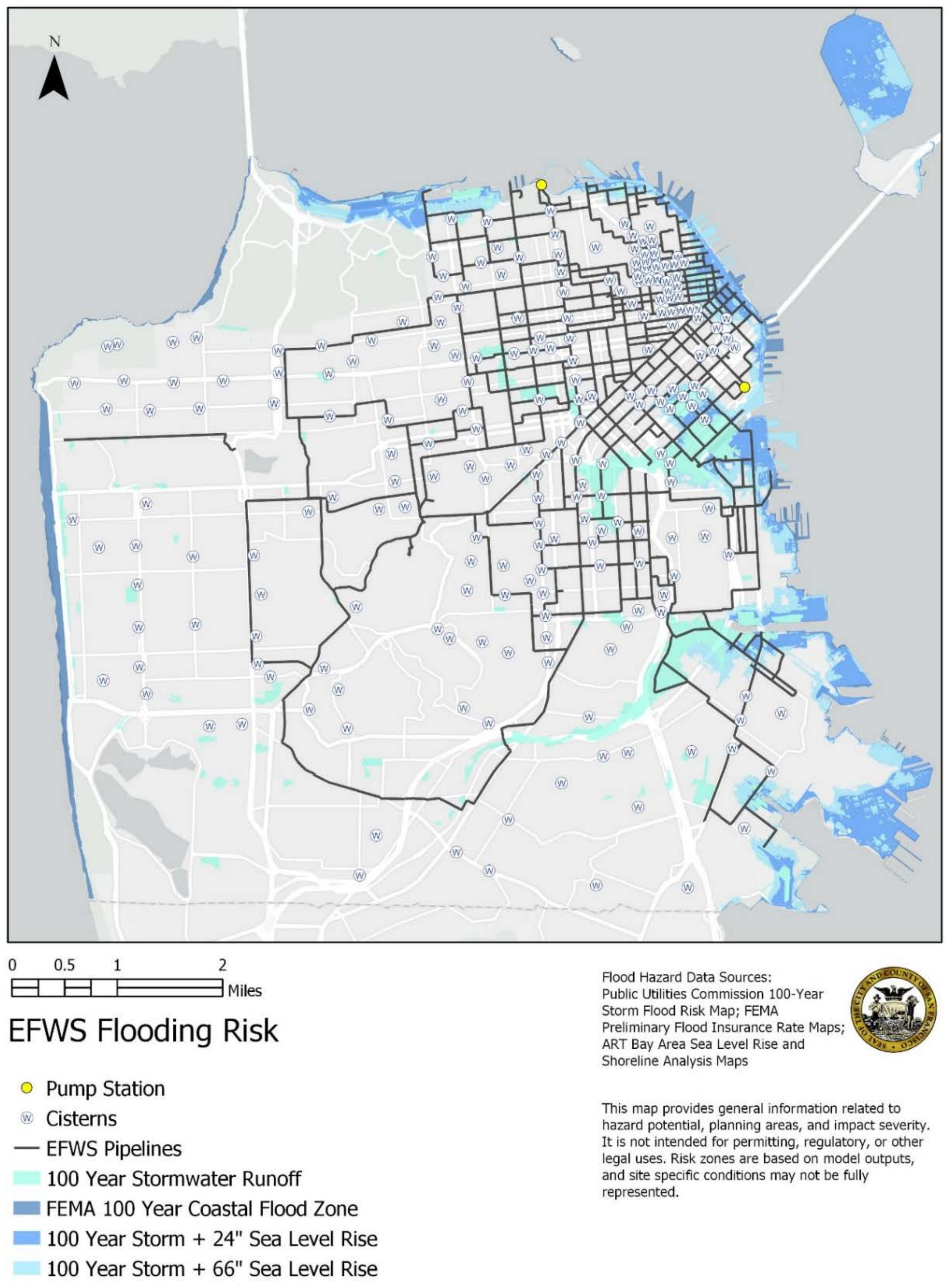


FIGURE A-60: EFWS ASSETS AND FLOOD HAZARDS



VULNERABILITIES

Category	Vulnerability
Physical	Geologic: EFWS pipelines are vulnerable to damage from bending or pipe joint extension/ compression, particularly where they pass through liquefaction zones. The SFPUC has performed pipe assessment analysis and EFWS pipelines will see some degree of breakage or failure, however, the system is expected to meet level of service goals in the case of a disaster. The SFPUC and SFFD utilize earthquake resistant pipe for new pipeline projects. The rigid pipes in the EFWS system are being replaced with Kaboda, flexible pipe systems that are substantially less prone to damage. Physical damage to valves or loss of power to areas that rely on motorized valves can compromise the ability to immediately isolate damaged sections of the system. However, all motorized valves have the ability to be closed manually. Damage to reservoir or storage tanks could reduce available water supply to fight large fires as well as disrupting operational pressure levels. Twin Peaks Reservoir, Jones Street Tank, and Ashbury Heights Tank have all completed seismic upgrades. Pumping stations may be subject to damage during a large seismic event because the age of the facility as well as the aged status of their mechanical/electrical systems. Pump Station No.1 was recently upgraded and Pump Station No. 2 is receiving seismic retrofits to be completed in 2020. High pressure hydrants have been designed to withstand large earthquake events. Flood: Contact with seawater from coastal flooding can increase hydrant corrosion damage. Increasingly frequent contact with seawater can lead to increased corrosion of distribution pipelines. Below grade battery vaults powering motorized valves can become inoperable if exposed to water. These would require repair and replacement in order to be operational again. Additionally, exposure to saltwater can increase valve corrosion damage. Both pumping stations have below ground electrical components that are sensitive to inundation. Additionally, Pump Station No. 2 only has 1 to 2 feet of freeboard in its seawater tunnel during king tides, which is expected to reduce even further as sea levels rise. Upgrades to the

	Pump Station No.2 tunnel is a potential project that SFPUC and SFFD are analyzing. Drafting connection points can become unusable if they are fully inundated by flood waters. Extreme Heat: None.
Functional	Networks: The system Is heavily networked and disruptions to one area can negatively impact the pressure and performance of the whole system, rendering some areas of the system completely inoperable. Valves can be used to isolate compromised or damaged sections of pipeline so that other areas can remain fully operational. Currently, seismically triggered valves will automatically isolate certain areas prone to liquefaction following any 6.8Mw earthquake or higher. This increases reliability of the whole system until pressure can be verified and valves re-opened. Recent efforts have focused on remotely motorizing valves to shorten response time to pipe breaks and reduce potential loss of stored water. However, their use is circumstantial and not always included as normal operational practice. External Services: The EFWS system relies on access to water to operate. The EFWS' primary source of water is the Hetch Hetchy Regional Water System, which feeds the reservoir and tanks that fill the system. A secondary source of water for the EFWS is the San Francisco Bay. Finally, there are approximately 210 cisterns throughout the city that hold water specifically for firefighting. EFWS pumping stations rely on electric power. Both pumping stations have backup diesel generators in the event of a power outage. The EFWS system relies on firefighting apparatus to utilize the water it supplies for firefighting purposes. A two-stage turbine pump can be used to fill Twin Peaks Reservoir from Ashbury tank and can run on an emergency diesel engine in the event of a power outage. Additionally, using ESER Bond funds, the SFPUC added a larger pipe to increase the speed of re-filling the Twin Peaks reservoir from the 11 Million gallon Summit Reservoir. Populations Served:

	Generally, the EFWS serves the whole city's population. This is a particularly essential service for individuals with access or functional needs. These individuals may not be able to quickly exit structures during urban conflagration events. <u>Unique or Critical Function:</u> The EFWS is one tool that the city can use to avoid urban conflagrations following a severe earthquake. Additionally, it provides year-round assistance fighting multi-alarm fires.
Informational	<u>All-hazards:</u> Information regarding seismic and flooding impacts to the EFWS are available from the following publications: Auxiliary Water Supply System [EFWS] (2009),[175] Earthquake Safety Implementation Program (2017), CS-199 Planning Support Services for Auxiliary Water Supply System [EFWS} Project Report (2014),[176] 2019 Sea Level Rise Vulnerability and Consequence (2019)[177]. As new developments and population growth occur in San Francisco, the water required for firefighting to address post-earthquake fires may change. SFPUC is modelling the effects of new developments on EFWS capacity requirements, both within the new developments and in the City as a whole. The SFPUC and SFFD are working together to specify new EFWS piping and hydrants required within the new developments. Additionally, developers are required to contribute financing towards, or construct, EFWS facilities such as pipelines or pump stations, for additional firefighting needs. These requirements are specified in the Development Agreements approved by the Board of Supervisors for new, large development projects.
Governance	<u>All-hazards:</u> Analysis showed that the 2010 EFWS was 47% reliable, and thus only able to provide about half of the water needed for city-wide firefighting following a 7.8 earthquake. Utilizing this information, the SFPUC, SFFD, and SFPW identified projects that would increase system reliability and could be funded by the 2010 and 2014 Earthquake Safety and Emergency Response (ESER) Bonds authorized by San Francisco voters. Decisions on which projects to implement utilizing bond funds are based on a given project's ability to improve the reliability score for the Fire Response Area that the

175 METCALF AND EDDY/AECOM (2009) "Auxiliary Water Supply System Study: Final Report. Retrieved from: https://s3-us-west-2.amazonaws.com/ucldc-nuxeo-ref-media/b2754026-dded-4ee6-b24c-2cf837f3bc00
176 AECOM/AGS (2014). "CS-199 Planning Support Services for Auxiliary Water Supply System (AWSS): Project Report". Retrieved from: https://sfwater.org/Modules/ShowDocument.aspx?documentid=5055
177 SF Planning (2019) "SLR Vulnerability and Consequences Assessment"

	given project serves and its ability to increase the likelihood of delivering water after an earthquake. Bond-funded projects make seismic upgrades to the system and repair, replace, and extend system components to increase the ability to provide adequate water for firefighting. Funding is allocated to repair, replace, and extend system components to improve the ability to provide adequate water for firefighting purposes following a major earthquake and during multiple-alarm fires from other causes. This includes repairs and upgrades to core facilities, pipelines, and tunnels, and construction of new cisterns. Once fully completed, the projects implemented with the ESER 2010 bond funds will increase the citywide reliability score from 47% to 67%. The full completion of the projects implemented with the ESER 2014 bond funds will increase the citywide reliability score from 67% to 87%. Construction of additional recommended future projects will increase the citywide reliability score to 96%. Overseeing the selection and implementation of EFWS projects is the Management Oversight Committee consisting of the SFPUC General Manager, SFFD Chief, SFPW Director, and SFPUC Assistant General Manager of the Water Enterprise. The San Francisco Capital Planning Committee, consisting of the City Administrator and including the President of the Board of Supervisors, the Mayor's Budget Director, the Controller, the City Planning Director, the Director of Public Works, the Airport Director, the Executive Director of the Municipal Transportation Agency, the General Manager of the Public Utilities System, the General Manager of the Recreation and Parks Department, and the Executive Director of the Port of San Francisco, reviews the progress and implementation of EFWS capital projects. Capital Planning Committee meetings are open to the public.

Consequences

Category	Consequence
Society/Equity	Geologic: If the EFWS were disrupted, firefighting abilities may be compromised, thereby increasing the likelihood of urban conflagrations that threaten life safety and property. Fires may cause health impacts, including death or injury as well as illness due to exposure to smoke and toxic substances. Community members with access and functional needs and the elderly are more likely to experience health impacts from fires due to potential reduced ability

	to evacuate a building. Increased fire damage would cause displacement and disrupt community and social networks. Damage to businesses may impact jobs and workers. Flood: Disruption of the EFWS may compromise firefighting capabilities during the flood event. However, it is possible that the portion of the EFWS network impacted by flooding would not have its performance affected by the flooding. If its performance was impacted, the impacted portion could be isolated from the rest of the system, limiting the level of disruption.
Economy	Geologic: If the system were to be significantly disrupted during a major earthquake event, the risk of building damage due to fires and resultant loss of economic activity could increase. Depending on the scale of fire damage, the consequences could be at the scale of the neighborhood, citywide, or regional. Additionally, there would be replacement costs for damaged pipes or other components. Flood: Shortened repair and replacement cycles from increased corrosion due to exposure to seawater can increase the costs of maintaining the distribution pipeline system. This is particularly notable in the bay shore area that is most prone to damage from liquefaction, which could become more likely in corrosion-weakened distribution pipelines. There may also be repair and replacement costs of below grade valve system/pump station components from flood damage. This could particularly effect critical electrical components as well as underground battery vaults.
Environment	All-hazards: Disruption of the system could lead to more severe fires, increasing contamination of air, soil, and water from toxic materials commonly found in urban areas, such as asbestos and household chemicals. Geologic: Decreased ability to fight urban conflagrations would have a temporary impact on the air quality following a seismically induced urban conflagration event. This would have implications at the citywide scale.

Combined Sewer System

Introduction to Asset Class

San Francisco's combined sewer system treats over 70 million gallons of combined wastewater during dry conditions and peaking to as much as 575 million gallons during wet weather conditions. The collection system is largely gravity driven, using an interconnected web of combined sewers, tunnels, and transport/storage boxes to intercept, store, and convey combined sewer flows throughout the City. Where gravity isn't sufficient to move this water around the system, or where weather conditions require the use of different facilities, force mains and pumping stations move wastewater to its eventual destination at one of three treatment facilities. Following treatment to nationally permitted standards, effluent is either discharged to the Pacific Ocean through one of eight combined sewer discharge outfalls on the Western/Pacific shoreline or discharged to the Bay through one of the twenty-nine outfalls located along the Bayshore.

For the purposes of this assessment, the combined sewer system is composed of seven sub-assets that are spread across the city with different patterns based on their function.

- Combined sewer pipes and tunnels convey sewage from buildings and runoff from streets and are spread widely throughout the City. This infrastructure has a wide inland extent as there are countless points of combined wastewater generation across the city.
- Pumping stations are predominantly located along the Pacific coast or Bayshore with a few exceptions, and connected to the force main infrastructure.
- Force mains are typically buried conduits used when gravity flow is not sufficient to move combined sewer flows through a sewer. They link pump stations to other part of the collections system or deliver combined wastewater to treatment facilities.
- Outfalls and transport/storage boxes ring the City's coastal area and transport flows from the collection system to the treatment facilities, and storage of combined sewer in wet weather events.
- Treatment facilities receive combined sewer flows from the system for treatment before being discharged into the San Francisco Bay or Pacific Ocean. Two of the three treatment facilities that make up the system are considered

aged and the City has been investing heavily in improvements in recent years. The North Point Wet Weather facility (Constructed in 1951) only operates in wet weather conditions and is found close to the Bayshore near Fisherman's Wharf. The Southeast Treatment Plant (Constructed in 1952) is located in Bayview/Hunters Point, is San Francisco's largest wastewater facility, and serves the eastside of the City. The Oceanside facility is the youngest in the system (Constructed in 1993), is located near the Pacific Ocean and the San Francisco Zoo, and serves the westside of the City. The Southeast Treatment Plant and the Oceanside Treatment Plant operate 24 hours a day, every day of the year with the North Point Treatment Facility brought online during large rain events.[178]

Every resident, worker, public/private organization, or tourist relies on the combined sewer system to manage wastewater generated in the city. SFPUC's Wastewater Enterprise is responsible for operation, maintenance, and capital improvement of all the combined sewer system assets and facilities.

Issue Statement

The combined sewer system provides a vital service by treating wastewater and stormwater before it is discharged into the Bay or ocean. While the combined sewer system has a high exposure to seismic hazards, significant investment has been made to improve the seismic performance of the system, mainly at the treatment facilities. Coastal flooding will become increasingly become an issue as sea level rises, particularly for sensitive assets in low-lying coastal areas, including outfalls, pump stations, and force mains. While specific consequences of disruption in San Francisco have not been studied, generally negative impacts to environmental health can be expected from the discharge of untreated wastewater into ecosystems. Impacts to economic activity and human health can also potentially occur from the inability to remove waste from homes and business. This document is intended to conceptually describe the various assets and potential effects of service disruption.

[178] SF PUC, San Francisco's Wastewater Treatment Facilities (2014). Retrieved from: https://sfwater.org/modules/showdocument.aspx?documentid=5801

Exposure

Hazard Data Assumptions

This analysis was conducted in 2018 and 2019 using publicly-available data sources. In the table below, shaking intensity is represented for two Earthquake scenarios: San Andreas Fault 7.8M and Hayward Fault 7.0M events. Accounts of assets subjected to varying levels of shaking intensity are cumulative for each scenario.

Asset Data Assumptions

Asset data originates from datasets maintained by SFPUC, SF Planning, and SF DEM (2019).

Exposure Summary

Geologic: All combined sewer assets would be exposed to violent or very strong shaking in a 7.8 earthquake on the San Andreas Fault. A smaller share of infrastructure would be exposed to violent or very strong shaking in a 7.0 on the Hayward fault, but this does include almost half of pump stations and Southeast Treatment Plant. A large share of pump stations, force mains, and transport/storage boxes, and outfalls are located in the liquefaction hazard zone.

Flood: Pump stations and outfalls have greater exposure to coastal flooding than other asset types. With 66 inches of sea level rise and a 100-year coastal storm event, nearly half of all outfalls and 75% of pumps may be exposed to flooding.

Fire: Only a small amount of combined sewer system assets are exposed to moderate wildfire risk.

TABLE A-36: EXPOSURE

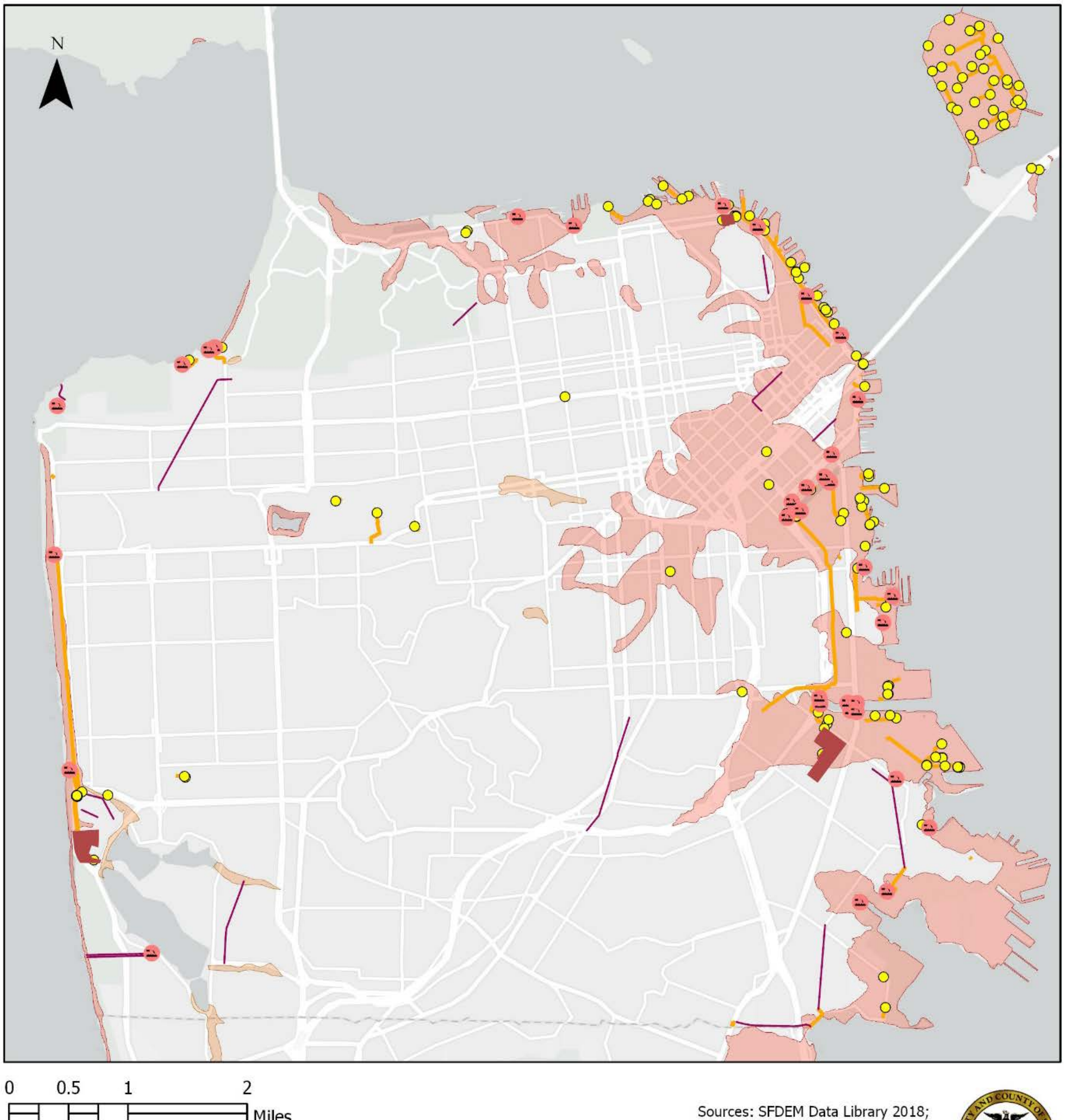
Hazard	Combined Sewers 1,058 Miles Total		Tunnels 8 Miles Total		Pump Stations 181 Pumps in 32 Pump Stations Total [(a)]		Force Mains 23 Miles Total		Transport and Storage Boxes 16 Miles Total		Outfalls 34 of 37 Total [(b)]		Treatment Plants 3 Total	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Geologic														
San Andreas 7.8 - Violent	303	29%	4	47%	74	41%	8	100%	9	57%	17	50%	1	33%
San Andreas 7.8 - Very Strong	755	71%	5	57%	107	59%	15	66%	7	46%	17	50%	2	67%
Hayward 7.0 - Very Strong	88	8%	1	13%	93	51%	11	48%	5	32%	12	35%	2	67%
Hayward 7.0 - Strong	681	64%	5	57%	87	48%	12	52%	5	31%	21	62%	1	33%
Liquefaction Zone	200	19%	1	13%	160	88%	20	87%	11	69%	24	71%	2	67%
Flooding														

100-Year Coastal Flood Zone	15	1%	0	0%	61	34%	3	13%	1	6%	7	21%	1	33%
100-Year Storm + 24 inches SLR	63	6%	0	0%	78	43%	9	39%	4	25%	8	24%	2	67%
100-Year Storm + 66 inches SLR	107	10%	0	0%	135	75%	14	61%	7	44%	16	47%	2	67%
100-Year Stormwater Flood Risk	39	4%	0	1%	21	12%	1	4%	3	19%	10	29%	1	33%
Wildfire														
High	1	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Moderate	21	2%	1	13%	5	3%	0.4	2%	2	13%	2	6%	0	0%

(a) Data was available for 181 individual pumps, some of which are redundant. Numerous pumps are located at 32 pump stations around the city.

(b) Data was only available for 34 out of 37 outfall locations. Eight outfalls are located on the Westside and 29 on the Bayside

FIGURE A-61: COMBINED SEWER ASSETS AND LIQUEFACTION HAZARD



Sources: SFDEM Data Library 2018; CGS, CALOES, 2015

Liquefaction Susceptibility & Shoreline Protection Assets

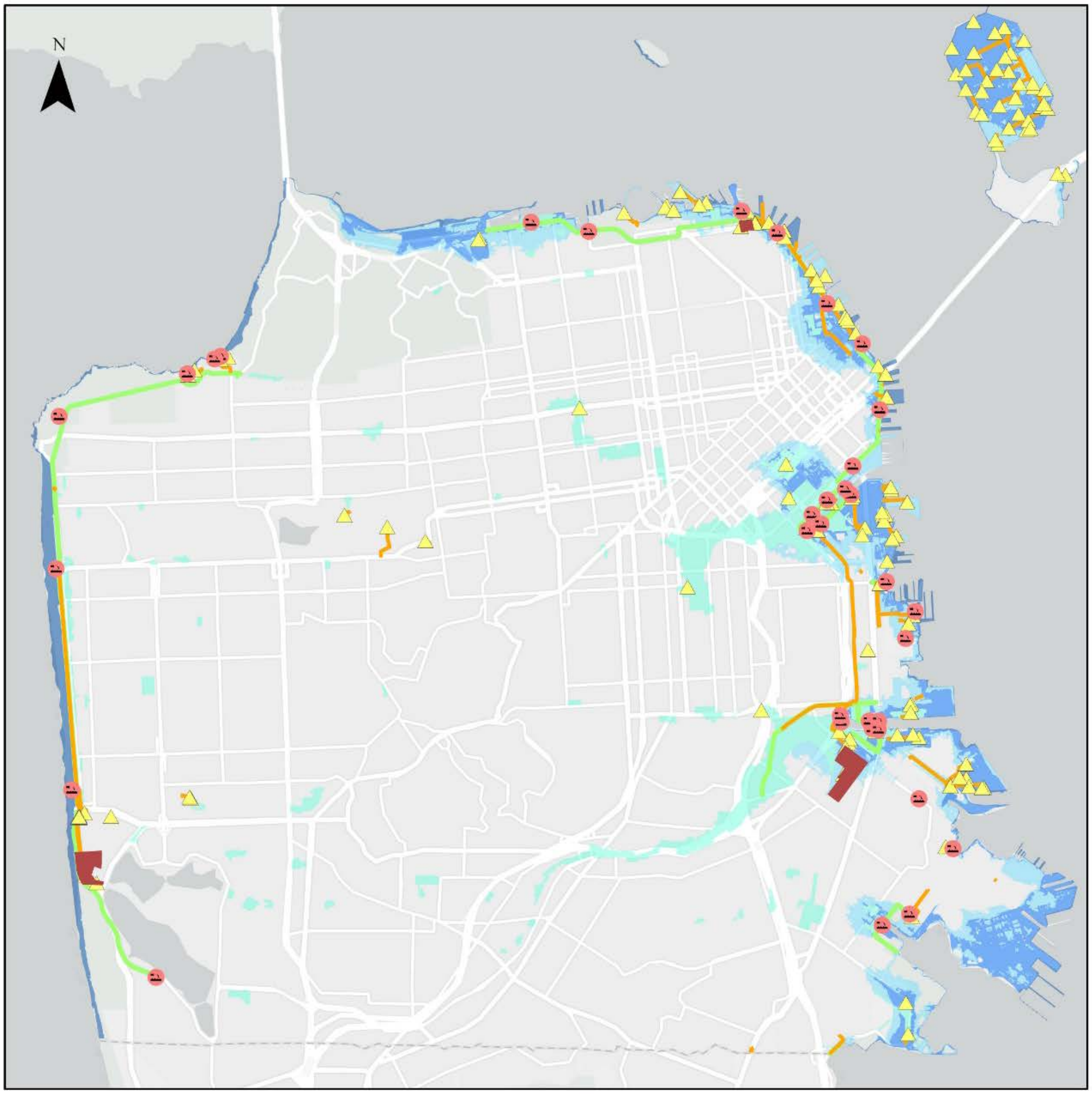
- Outfalls
- Pumps
- Force Mains
- Treatment Facilities
- Tunnels

Soil Liquefaction Hazard Zone

- Very High
- High

This map provides general information related to hazard potential, planning areas, and impact severity. It is not intended for permitting, regulatory, or other legal uses. Risk zones are based on model outputs, and site specific conditions may not be fully represented.

FIGURE A-62: COMBINED SEWER ASSETS AND FLOOD HAZARDS



0 0.5 1 2
Miles

Stormwater/Wastewater Flooding Risk

- Outfalls
- Pumps
- Force Mains
- Transport and Storage Boxes
- Treatment Facilities
- 100 Year Stormwater Runoff
- FEMA 100 Year Coastal Flood Zone
- 100 Year Storm + 24" Sea Level Rise
- 100 Year Storm + 66" Sea Level Rise

Flood Hazard Data Sources:
Public Utilities Commission 100-Year Storm Flood Risk Map; FEMA Preliminary Flood Insurance Rate Maps; ART Bay Area Sea Level Rise and Shoreline Analysis Maps

This map provides general information related to hazard potential, planning areas, and impact severity. It is not intended for permitting, regulatory, or other legal uses. Risk zones are based on model outputs, and site specific conditions may not be fully represented.

VULNERABILITIES

Category	Vulnerability[179 180]
Physical	Geologic: Pump stations are vulnerable to damage during significant ground shaking events due to land movement and liquefaction. Areas of all three treatment plants are seismic hazard zones based on their development on Bay fill material or in areas vulnerable to landslides Aspects of the older treatment plants were not constructed to modern seismic building codes, although improvements are underway to retrofit them. For example, all three plants have undergone seismic reliability and condition assessments and seismic retrofits are underway. Underground infrastructure (force mains, tunnels, combined sewers, and transport/storage boxes) may be susceptible to damage due to their linear nature and their potential placement in liquefaction prone soils. Some of the larger infrastructure, such as tunnels and T/S boxes, are constructed on piles or are in bedrock. An asset-specific analysis of the underground infrastructure is beyond the scope of this document. Flood: Pump stations are vulnerable to structural damage from direct wave action, coastal erosion, and potential storm surge/stormwater inundation from numerous non-flood proofed entryways in their structures. Many pump station control components are located below grade, making them particularly vulnerable. The Southeast Treatment Plant and North Point Wet Weather Facility are vulnerable to future storm surge events based on projected SLR. Many treatment plant components, such as electrical components, may be salt-sensitive so exposure to coastal flooding can render a facility inoperable for an extended time. Combined sewer discharges during wet weather may be interrupted when outfalls are exposed to flooding for an extended period of time and this disrupts the ability of the system to discharge combined sewer flows if the treatment and storage capacity of the entire system is maximized. Presently, many outfalls are below current 100-year storm surge elevations and may see saltwater intrusion during this severity of storm today. Sensitivity to flooding is largely dependent on whether an outfall as backflow prevention. SFPUC has

[179] San Francisco Public Utilities Commission (2019) "*Climate Vulnerability and Adaptation Assessment, Sewer System Improvement Program*"
[180] SF Planning (2019) "*SLR Vulnerability and Consequences Assessment*"

	a plan to install backflow prevention at the outfall structures over time as part of the capital improvement plan. Underground infrastructure is vulnerable to the corrosive effects of saltwater which can occur from permanent inundation or from compounded temporary events. SLR induced saltwater intrusion can also potentially physically damage these components or result in a loss of storage capacity. Interdependent vulnerabilities are also a concern. For example, storm surge can impact the function of outfall infrastructure and because the sub-assets are connected, water can backflow through outfalls all the way to the treatment plant, impacting the effectiveness of treatment plant processes. Extreme Heat: Generally, warmer temperatures correlate with drought and heatwaves which can cause odor management or conveyance issues in the collection system. Biological treatment processes are temperature sensitive. In the long term, by the end of the century, elevated summer temperatures and prolonged heat waves may begin to impact biological wastewater treatment processes, leading to increased difficulty meeting effluent discharge standards. The potential effects of warmer temperatures on San Francisco's biological treatment plant processes have not been studied.
Functional	Networks: The system is heavily networked to introduce flexibility in moving sewage from one part of the system to another as available capacity or treatment volume demands change. The system is also networked to route combined stormwater from numerous collection points around the city to just three centralized treatment plants. While the network provides flexibility, it also poses some risks. For example, outfalls have been identified as a network vulnerability because they are directly connected to transport/storage boxes, often without backflow preventers, and some may be prone to flooding during a 100-year storm event. Additionally, disruption of particular sub-assets can impact a large portion of the network. Due to the location of treatment plants at the terminus of the collection system, their disruption would have significantly more wide felt impacts than sub-assets further upstream. There are no viable alternatives if the entire networked system was severely disrupted. If certain elements were to fail, there is spare capacity in the system that can be utilized to collect wastewater and wait out the disruption. However, this is dependent on dry weather conditions as wet weather conditions would quickly exceed the

	storage capacity that transport/storage boxes normally have when they convey wastewater to treatment plants. <u>External Services</u>: The combined sewer system is dependent on electric power. Some pump stations have backup power to continue flowing sewage to treatment plants, however, the electrical capacity needed to power the treatment process exceeds the energy that can be provided by backup power systems.[181] If power supply were disrupted, pumping and aeration would be impacted. Prolonged disruption can interrupt biological treatment process, which can take days/weeks to recover. The system depends on the transportation network for delivery of necessary chemicals via truck from Southern California and Richmond. In addition, effective operation of the system requires coordinated efforts of numerous staff who rely on a secure transportation network to reach system infrastructure.[182] Coordinating efforts between system components also requires external telecommunication services. <u>Populations Served</u>: Combined sewer systems serve all community members and businesses. <u>Unique/Critical function:</u> Wastewater treatment is critical to maintaining a healthy Bay ecosystem, a function that is nearly impossible to replace. SFPUC integrates green infrastructure in their urban water management approach and focus on increasing on-site stormwater retention. This provides a variety of co-benefits for city residents as well as replenishing groundwater beneficial to urban habitats.
Informational	<u>All-hazards:</u> General information on impacts of coastal/stormwater flooding and extreme heat hazards are available through the following SFPUC publications: Draft Climate Vulnerability and Adaptation Assessment (forthcoming, 2019), Urban Watershed Assessment, Collection System Capital Needs Report, and the Flood Resilience Study. However, site specific characteristics of sub-asset vulnerability are not readily available for analysis (i.e., where flood vulnerable

[181] Andrew C, Henderson B, Harris M, Harrison L, McDaniels C, Prather J, Norby G, Koehler-Downie "SFPUC Sewer Lifelines Interview" Interview by Mieler D. 8/14/18
[182] Andrew C, Henderson B, Harris M, Harrison L, McDaniels C, Prather J, Norby G, Koehler-Downie "SFPUC Sewer Lifelines Interview" Interview by Mieler D. 8/14/18

	components are located on site, where non-flood proofed entryways are in relation to flood prone areas). Another notable information source is the Lifelines Restoration Timelines Project currently being pursued by ORCP which identifies interconnected points between wastewater and other lifeline systems in order to propose potential interventions to improve resiliency.
Governance	<u>All-hazards:</u> Notable policies governing system maintenance, repair, or improvement of assets in this class are the SSIP Program and Level of Service Goals which are based on M7.8 San Andreas Fault and M7.1 Hayward Fault events. This policy works to ensure that the system can treat flows within 72 hours of a major earthquake or catastrophic event. Additionally, the Capital Planning Committee SLR guidance ensures that any new facilities are planned and designed to consider SLR projections in their development. Repair policies include contractual obligations with private contractors that perform roughly 75% of repairs as well as contractual obligations with DPW for the remaining 25% of repairs. The duties of these parties in times of disaster remains unclear.[183] Currently, the most appropriate funding source for improvements to these assets comes from the $2.9 Billion dollars allocated for Phase One of the SSIP Program. Additional funding will likely be available during subsequent phases, pending approval from the SFPUC Commission. A variety of state and federal grants have been identified for projects improving, protecting, or enhancing water quality. Many improvements to the combined sewer system would also satisfy this criteria.

CONSEQUENCES

Category	Consequence
Society/Equity	<u>All-hazards:</u> There are potentially significant impacts to health and human safety in the event of a disruption to the combined sewer systems. Collapse of combined sewer pipes can allow sewage to back up into streets or in home systems that aren't outfitted with a backflow preventer, increasing the risk of community member contact with human waste and related pathogens. In the case of disruption during wet weather conditions, stormwater flooding on streets can also put

[183] Ibid.

	the community in contact with pathogens found in combined sewage water. Flooding can also presents challenges for vulnerable populations with mobility impairments. Geologic: Loss of the ability to dispose of waste from homes can increase community members contact with human waste and attendant pathogens unless proper procedure is followed. Flood: Disruption of the system during wet weather conditions can increase stormwater flooding, particularly in low-lying areas, which can disrupt the ability of community members to safely access their own neighborhoods, jobs, or participate in their regular community social events. If disruption of the system leads to the temporary closing of businesses, the lost income could impact the ability of community members to pay their bills. This impact would be more pronounced for low-income families, which may even extend to their ability to purchase essential goods.
Economy	All-hazards: If businesses lose the ability to flush their toilets or dispose of waste, they may have to temporarily shut down, losing revenue. Disruptions that lead to more untreated sewage reaching the Bay and Pacific Ocean can have impacts on tourism due to increased prevalence of litter or odor management issues. If effluent from required hazard induced discharges into The Bay or Pacific Ocean exceed water based effluent limits for any given pollutant, it is expected that operational costs would increase due to the structure of the permit based National Pollutant Discharge Elimination System (NPDES)[184]. Geologic: In the case of severe shaking, such as a 7.8M San Andreas Fault or 7.0M Hayward Fault seismic event, the treatment system will be automatically shut down in order for an immediate condition assessment on broken pipelines and other infrastructure. At a minimum the system would be down for at least 24 hours before primary treatment could begin. However, the duration of system disruption would be comparatively short if system components are not severely damaged. However, damage from seismic events to treatment plant assets can damage expensive, unique equipment that can compromise secondary treatment that is costly to replace.

[184] WERF (2009) "*Implications for Climate Change for Adaptation by Wastewater and Stormwater Agencies*" Retrieved from: http://www.climatestrategies.us/library/library/download/960

	Flood: If collection is disrupted leading to backups and flooding, businesses may temporarily close. Extreme Heat: If increased heatwave events reduce the efficiency of the treatment process, it can become more costly to treat combined wastewater up to effluent standards or result in more permit violations and subsequent payments.[185]
Environment	All-hazards: Disruption of the system may result in water quality permit violations and impact the ecosystems and habitats of San Francisco Bay and the Pacific Ocean from the release of minimally treated sewage. Coastal waters may see microbiological contamination, oxygen depletion from high concentrations of fecal matter, or potentially, eutrophication from excess nutrients. These impacts would depend heavily on the volume of combined sewage released and the duration of the disruption. Without the treatment of sewage before release, many industrial pollutants can make their way to surrounding ecosystems in The Bay and Pacific Ocean as well. This would have a strong impact on regional environmental conditions.

[185] Ibid.

Shoreline Protection

Introduction to Asset Class

Shoreline infrastructure provides a critical function to much of the city, including flood protection during storms and extreme tide events, habitat, recreation opportunities, and public access. It also supports key utility and transportation infrastructure, including BART, Muni, the Port maritime facilities and ferry transportation. During an emergency it supports emergency response and recovery operations. Shoreline protection around San Francisco is made up of a variety of shoreline types and conditions, including beaches and bluffs along the western and northern shoreline of San Francisco, which fronts the Pacific Ocean and structural protection in many forms along the eastern and southern shorelines of the city along the San Francisco Bay.[186] The elevation of the shoreline also varies, with some of the lowest areas between the Bay Bridge and Pier 9 and in the southern waterfront. Some of the highest shoreline elevations can be found near Fort Mason and along the northern edge. The risks to shoreline protection infrastructure are related to several factors, including age, maintenance schedule, construction materials and methods, soil/substructure composition, elevation and near-shore conditions. Shoreline infrastructure in San Francisco is not able to provide the level of service that it has in the past, given its current elevation, age and condition.

The majority of San Francisco's shoreline protection infrastructure is owned by public agencies, including the Port of San Francisco and the Department of Parks and Recreation; and the National Park Service. Although the majority of the owners and managers of the city's shoreline protection are public entities, none of these agencies have flood management as a primary role or have dedicated funding or mandates to focus significant resources on flood management. However, the City is prioritizing action to improve the Embarcadero Seawall to reduce risks to the City from earthquakes and flooding, with the Port leading the effort.

[186] Regional resource and research agencies and organizations have been working together to classify the types of shorelines that make up the region's current Bayfront. These eight shoreline types are identified as engineered levee, berm, shoreline protection structure, embankment, transportation structure- major road, transportation structure-railroad, natural shoreline and wetlands. Further information about this analysis can be found here: https://www.sfei.org/content/flood-infrastructure-mapping-and-communication-project#sthash.Kj0plZxL.dpbs.

Issue Statement

Shoreline infrastructure provides a critical function to much of the City, including during an emergency. In most locations, failure of the infrastructure due to flooding, erosion, settlement or seismic event would cause significant impacts to community, economic and environmental resources. Areas of shoreline protection infrastructure serve as essential transportation, maritime and utility connection points while being seismically vulnerable. Future sea level rise and storm events can be expected to contribute to overtopping and flooding impacts across a wide geographic range of this asset and this flooding will potentially span multiple neighborhoods.

Exposure

Hazard Data Assumptions

This analysis was conducted in 2018 and 2019 using publicly-available data sources. In the table below, shaking intensity is represented for two Earthquake scenarios: San Andreas Fault 7.8M and Hayward Fault 7.0M events. Accounts of assets subjected to varying levels of shaking intensity are cumulative for each scenario.

Asset Data Assumptions

Asset data is sourced from the SF Bay Shore inventory GIS data created by the San Francisco Shoreline Estuary Institute in 2016. To convey overtopping for 100-year storm events with different sea level rise scenarios, each map displays color where overtopping would likely occur. The color displayed shows the type of shoreline found at the site of likely overtopping as well.

Exposure Summary

Geologic: All shoreline protection infrastructure is exposed to violent or very violent shaking in a 7.8 earthquake on the San Andreas Fault. Notable amounts of shoreline protection infrastructure are subjected to violent or very strong shaking in a 7.0 earthquake on the Hayward fault. As much as 70% of shoreline protection structures and 80% of embankments are subjected to liquefaction hazard zones.

Flood: Flooding exposure is described as the amount of overtopping seen by each shoreline type based on the two sea level rise scenarios. With 24 inches of SLR, significant overtopping can be expected in the north, in down town, and to the south but many pier structures remain protected. However, with 66 inches of SLR, virtually all shoreline protection assets can expect to see some degree of overtopping without intervention.

TABLE A-37: EXPOSURE

Hazard	Berm 1 Miles Total		Embankment 6 Miles Total		Natural Shoreline 5 Miles Total		Shoreline Protection Structure 37 Miles Total		Transportation Structure .11 Miles Total		Wetland .32 Miles Total	
	#	%	#	%	#	%	#	%	#	%	#	%
Geologic												
San Andreas 7.8 - Violent	0.41	100%	3	44%	4	100%	16	42%	0	0%	0	0%
San Andreas 7.8 - Very Strong	0.57	57%	3	54%	1	19%	19	52%	0.1	100%	0.32	100%
Hayward 7.0 - Very Strong	0.28	28%	4	67%	0.6	12%	24	65%	0.05	53%	0	0%
Hayward 7.0 - Strong	0.70	70%	0.5	8%	4	86%	11	29%	0.05	54%	0.32	100%
Liquefaction Zone	0.9	90%	5	83%	3	60%	26	70%	0.1	100%	0.32	100%
Flooding												
100-year storm + 24 inches SLR	0.8	80%	5	83%	2	40%	19	51%	0.06	55%	0.32	100%
100-year storm + 66 inches SLR	0.9	90%	6	100%	3	60%	34	92%	0.07	64%	0.32	100%

Note: For an exposure table with additional hazards, please see Chapter 05.

FIGURE A-63: SHORELINE PROTECTION AND LIQUEFACTION HAZARD

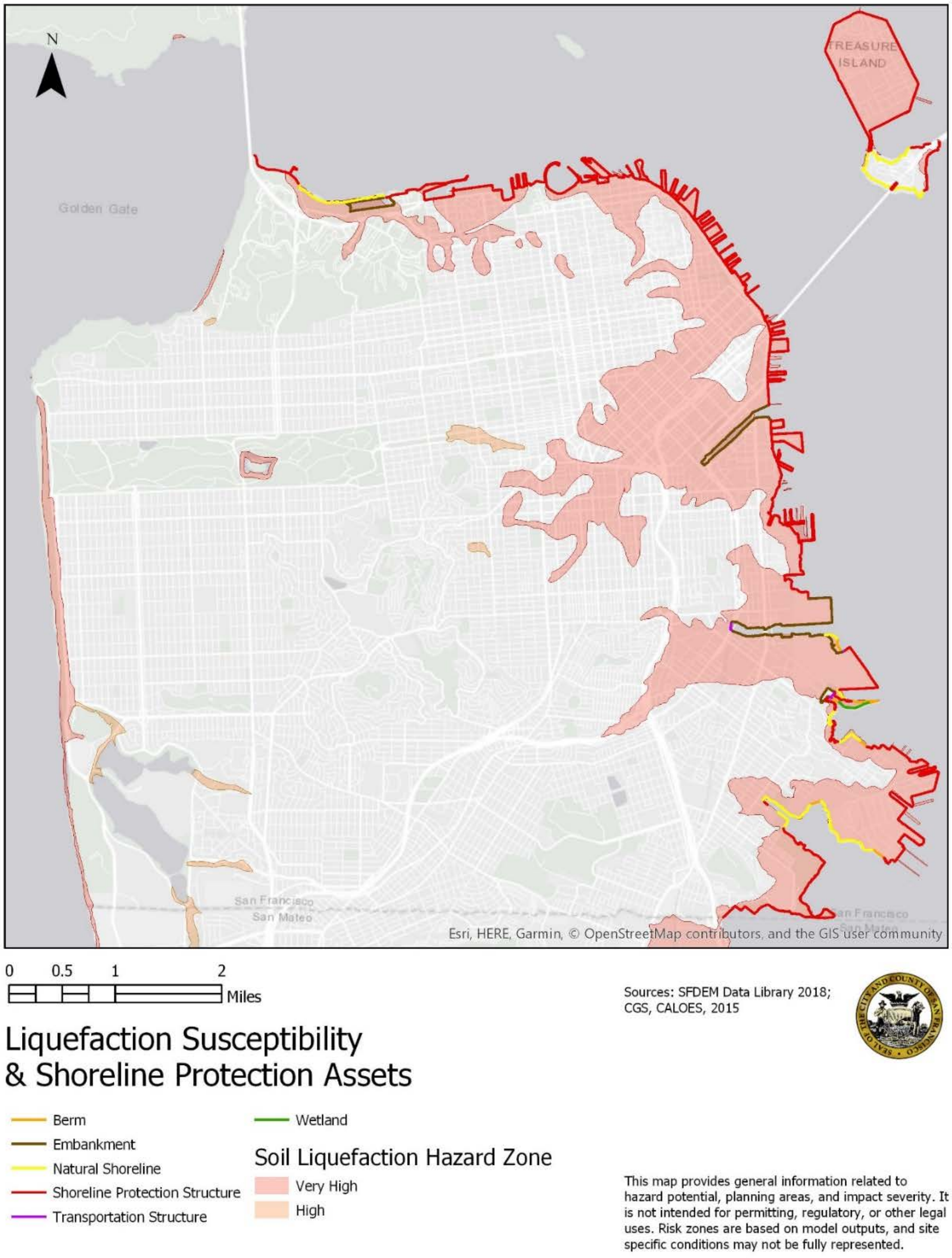


FIGURE A-64: SHORELINE PROTECTION AND FLOOD HAZARD (100 YEAR STORM + 24" SEA LEVEL RISE

Shoreline Protection Flooding Risk

- Berm
- Embankment
- Natural Shoreline
- Shoreline Protection Structure
- Transportation Structure
- Wetland
- Low Lying Disconnected Areas Subject to Flooding
- 100 Year Storm + 24" Sea Level Rise

Flood Hazard Data Sources:
Public Utilities Commission 100-Year Storm Flood Risk Map; FEMA Preliminary Flood Insurance Rate Maps; ART Bay Area Sea Level Rise and Shoreline Analysis Maps

This map provides general information related to hazard potential, planning areas, and impact severity. It is not intended for permitting, regulatory, or other legal uses. Risk zones are based on model outputs, and site specific conditions may not be fully represented.

FIGURE A-65: SHORELINE PROTECTION AND FLOOD HAZARD (100 YEAR STORM + 66" SEA LEVEL RISE)

0 0.5 1 2 Miles

Shoreline Protection Flooding Risk

Shoreline Protection Type
- Berm
- Embankment
- Natural Shoreline
- Shoreline Protection Structure
- Transportation Structure
- Wetland
- Low Lying Disconnected Areas Subject to Flooding
- 100 Year Storm + 66" Sea Level Rise

Flood Hazard Data Sources:
Public Utilities Commission 100-Year Storm Flood Risk Map; FEMA Preliminary Flood Insurance Rate Maps; ART Bay Area Sea Level Rise and Shoreline Analysis Maps

This map provides general information related to hazard potential, planning areas, and impact severity. It is not intended for permitting, regulatory, or other legal uses. Risk zones are based on model outputs, and site specific conditions may not be fully represented.

VULNERABILITIES

Category	Vulnerability
Physical	Geologic: The shoreline is made up of fill along most of the Bay shoreline along the eastern and southern parts of the shoreline, making settlement and liquefaction risks more significant for these areas. Many of the shoreline structures, including the Embarcadero Seawall, were constructed prior to current seismic standards and have not been retrofit. Flood: Shoreline infrastructure has characteristics that make it vulnerable to flooding, including the elevation of the infrastructure, the age of the infrastructure, the soils and foundation that supports the infrastructure, the nearshore environment, the maintenance schedule and the materials used to construct the infrastructure. San Francisco's shoreline infrastructure was designed for lower water levels and without consideration of sea level rise. Much of the shoreline currently consists of ad hoc flood protection and was not intended to protect against higher water levels. Much of the shoreline infrastructure is beyond its expected project life and has not been significantly maintained or rehabilitated. Extreme Heat: Not vulnerable to extreme heat. Fire: Not vulnerable to fire.
Functional	Networks: If one segment of the shoreline infrastructure along the City's shoreline were to be overtopped by a flood event or damaged in an earthquake, the damage would extend beyond the segment and cause water to inundate the areas around the damaged segment. If parts of the shoreline are damaged, temporary flood management (such as deployables, pumps, etc.) could be used to keep water out of as many areas as possible. However, it is uncertain whether there is sufficient equipment available to deal with a shoreline failure. External Services:

	Power and fuel are important if pumps are used as a back-up in the case of shoreline infrastructure failure. <u>Populations Served:</u> Shoreline infrastructure that protects the neighborhoods, services, and jobs of those with access or functional needs includes areas where there is a large population of people, such as the Embarcadero Seawall segment and Mission Bay and areas with shoreline protection that serve significant geographic area, including those locations as well as Ocean Beach and Islais Creek. <u>Unique or Critical Function:</u> Much of San Francisco's shoreline infrastructure serves as, or is directly adjacent to, recreational and habitat areas, as well as interpretive and educational sites. Examples include Heron's Head Park and the Ecocenter in the Southern Waterfront: the Embarcadero Seawall which includes Rincon Park, the Embarcadero Promenade, Piers 7 and 14, Brannan Street Wharf and the Exploratorium along the Northeastern Waterfront and a significant amount of open space along the Northern and Western shorelines including Marina Green, Crissy Field and other open spaces and natural areas. Emergency responders rely on the stability of the shoreline infrastructure, particularly along the eastern portion San Francisco's shoreline. After a significant event, the shoreline will be used to move people who work in the City but live elsewhere out of the City and move supplies and emergency responders into the City. Additionally, after a significant event, emergency responders will need to deal with the direct impacts of the event and limiting secondary events, such as flooding caused by the failure of shoreline infrastructure or damage to utilities and transportation due to the failure of shoreline infrastructure, will make it much more challenging to respond to an event. The Port's maritime industries and historic resources also serve unique and critical functions in the city's economy. Maritime industries include cargo, cruise, fishing, ship repair, ferries, and recreation. All of these industries rely heavily on the Port waterfront, and associated shoreline protections, to operate effectively. Shoreline protections assets are also responsible for preserving the three National Register historic districts along our waterfront: Central Embarcadero Piers Historic District, Embarcadero Historic District, Union Irons Works Historic District
Informational	<u>All-hazards:</u> There have been a number of recent studies for some segments of the City's shoreline infrastructure. The Citywide SLR work has

	included mapping of the entire City shoreline. The regional shoreline typology work provides some understanding of the shoreline type and elevation. The Ocean Beach Master Plan provides information on the western shoreline. The earthquake and flood studies for the Embarcadero Seawall provide an overview of the risks in that segment. The Seawall Program's Multi-Hazard Risk Assessment will provide a more refined understand of the vulnerabilities and consequences of seismic and flooding along those three miles. There is a lack of analysis related to the seismic risks to other parts of the shoreline infrastructure outside of the Embarcadero Seawall. Additionally, the risks of combined coastal and riverine flooding in the areas where creeks enter the Bay is also a gap in knowledge. There is some information available on shoreline conditions from the agencies, such as the Port of San Francisco, Parks and Recreation and Public Works, that manage the shoreline, but it is not in one dataset.
Governance	<u>All-hazards:</u> There are planning and analysis efforts in place, such as the Lifelines and Hazard Mitigation Planning where City priorities are identified in order to take action. For example, the Embarcadero Seawall was identified as a priority in the Lifelines Interdependency Study of 2014. Capital Planning funding, SB1 Funding, Port capital funding. It is important to note that the funding available for assessment and taking action is significantly less than what is needed.

CONSEQUENCES

Category	Consequence
Society/Equity	Geologic: If a significant earthquake were to damage the shoreline infrastructure along the San Francisco shoreline it could have significant impacts on society and equity- disrupting the ability of those who are transit dependent to travel; the ability to get to work, school, other critical trips; small businesses; may result in difficulties to respond to an earthquake and to recover from it which would impact the neighborhoods closest to the failed infrastructure and those who lack redundant networks and assets. Damage to utilities would have widespread impacts on a large number of neighborhoods. Existing issues such as housing and transportation costs, transportation access, access to jobs, income and health disparities could be exacerbated by a significant earthquake that damages shoreline infrastructure and results in disruption or temporary displacement of homes, businesses or other services. Damage to the shoreline infrastructure due to an earthquake would also have significant impacts on historic, cultural and recreation resources along the shoreline, including the Embarcadero Historic District, the Ferry Building, the Embarcadero Promenade and many shoreline open spaces. Flood: If a significant flood event were to temporarily overtop the shoreline protection along the San Francisco waterfront it could disrupt transportation and utility services, affect people's ability to travel to work or make other trips, disrupt small and local businesses and damage homes and neighborhoods, as well as damage the cultural, historic and recreational resources along the shoreline. Additional issues related to flood damage including mold and the possible mobilization of contaminants which could result in larger impacts to community members with underlying health conditions such as asthma.
Economy	Geologic: Significant damage to Port facilities, the Embarcadero, the transportation and utilities in the Embarcadero, recreation and natural areas, historic and cultural resources, jobs, maritime uses, and other roadways and utilities adjacent to the shoreline. The scale of impact could range from the neighborhood to the region and state. Flood:

	Currently there are portions of the San Francisco shoreline that are within the 100 year flood zone. As sea level rises, the area that is at risk from flood events will increase. These areas include significant sections of downtown San Francisco, regional and Citywide transportation infrastructure including BART, MUNI and ferry service; Citywide utilities are also at risk from coastal flood events, some of the City's last maritime and industrial land. Even temporary disruption of some of these sections of the city could have significant economic impacts. The scale of impact could range from the neighborhood to the region and state.
Environment	Geologic: If a significant earthquake were to damage the shoreline infrastructure there would also likely be damage to water and soil quality from the debris that would result from such a failure, habitat and species could be affected by the mobilization of debris and contaminants, a significant amount of public access and open space could be disrupted and damaged and flood risk would increase as the shoreline infrastructure failed and water overtopped the damaged, lower shoreline. The liquefaction risk at the shoreline significantly increases the risk to shoreline infrastructure. It is possible that a significant seismic event could cause soils to liquefy at the shoreline, the infrastructure to fail and slide into the Bay. This would mobilize debris and contaminants into the water and sediment, have impacts to habitat and species and result in a shoreline that loses elevation and provides flooding pathways suddenly inundating public access and open spaces along the shoreline. Flood: Flooding that overtopped the current shoreline infrastructure could result in damage to water and soil quality by mobilizing contaminants and toxics and increasing stormwater runoff, such flooding could drown habitats and impact the species that rely on the transition zone for habitat, toxics and contaminants mobilized by the flooding could also damage habitats and species. Flooding would disrupt and damage public access and open spaces.

Communications

Introduction to Asset Class

The City's communications asset class transmits voice, video and data communications by fiber infrastructure, cellular and radio communications, and inside wired infrastructure. San Francisco Department of Technology manages a wide array of communications systems including radio, TV, internet, City internal data network, public warning sirens, emergency call boxes, communication path for traffic signals and the Mayor's Emergency Telephone Systems (METS). In some instances, these communication channels leverage, private communications operators fiber networks and internet service

Key City owned systems assessed for this assessment, include the municipal fiber optics network, data centers, and an 800Mhz radio system.

a) Fiber optics network: Hundreds of miles of fiber optic cable connects every municipal building in San Francisco. This fiber network provides internet access, email and VoIP communications.

b) Data centers: The primary data centers store, manage, and transmits the information for the City's communications systems. A back up data center out of the area, is used as a disaster recovery site for City information systems.. Between the primary and DR data center there are two separate and redundant network paths.. In addition to the City owned data centers, the City manages and uses a distributed number of cloud service providers for compute and storage infrastructure.

c) 800 MHz radio: The City is transitioning to a new 800MHz radio system for emergency communications. The system relies on 11 antennas placed on buildings or high locations throughout the city, with two antennas located outside of San Francisco in Daly City and on San Bruno jail. Most antennas are located on shared radio tower sites on buildings or high ground. The towers are not owned by the City of San Francisco. They are built to the highest seismic standards, but the performance of the buildings on which they are placed is generally not known. Loss of one or more antennas in the network will degrade communications, but the system is designed so it can remain operational despite loss of several antennas.

The antennas are connected to each other by fiber cables and microwave paths. Radio towers have back up power.

Private communications systems are owned by a wide range of operators, including Verizon, AT&T, T-Mobile, also Comcast and these are used for redundant access to the Internet. Primarily these private fiber networks are used when City fiber is unavailable.

Issue Statement

City owned communications assets are vulnerable to damage in earthquakes, especially where there is ground failure or buildings that support antennas are damaged. The communication system is highly redundant, so loss of a few antennas, data centers or a portion of the fiber cables, may not result in outage of the system. Long term inundation and exposure to heat can also damage the communication system.

Exposure

Hazard Data Assumptions

This analysis was conducted in 2018 and 2019 using publicly-available data sources. In the table below, shaking intensity is represented for two Earthquake scenarios: San Andreas Fault 7.8 and Hayward Fault 7.0 events. Accounts of assets subjected to varying levels of shaking intensity are cumulative for each scenario.

Asset Data Assumptions

Some of the assessed fiber assets are located within buildings, underground, or overhead. Distinctions between these location options were not assessed, as that relates to the infrastructures adaptive capacity rather than the exposure. Data was sourced from the SF Department of Technology (SF DT, 2019).

Exposure Summary

Geologic: All communications assets are exposed to very strong or violent shaking in the 7.8 earthquake on the San Andreas Fault. In the 7.0 scenario earthquake on the Hayward Fault, 30 miles of fiber, one data center and one radio antenna are exposed to very strong or violent shaking. Seventy miles of fiber, one data center and 3 radio antennas are located in areas with high or very high liquefaction susceptibility.

Flood: Fiber is not significantly exposed to flooding. With 66 inches of sea level rise and a 100-year coastal storm event, 33 miles of fiber will be exposed to flooding. In this scenario, one data center and two radio antenna are within the flood zone, however the radio antenna may not get wet depending on if they are on top of buildings. Ten miles of fiber, two data centers and two radio antennas may be exposed to stormwater flooding, depending on their elevation above ground.

Fire: Less than one percent of the fiber network, radio antenna and data centers are exposed to wildland-urban interface fire risk.

TABLE A-38: EXPOSURE

Hazard	Fiber Network: 203 Miles Total		Data Centers: 3 In County Total		Radio Antenna: 12 Total	
	#	%	#	%	#	%
Geologic						
San Andreas 7.8 - Violent	33	16%	0	0%	6	50%
San Andreas 7.8 - Very Strong	167	82%	3	100%	6	50%
Hayward 7.0 - Very Strong	30	15%	1	33%	1	8%
Hayward 7.0 - Strong	138	68%	2	67%	7	58%
Liquefaction Zone	70	34%	1	33%	3	25%
Flooding						
100-Year Coastal Flood Zone	4	2%	0	0%	0	0%
100-year storm + 24 inches SLR	18	9%	1	33%	1	8%
100-year storm + 66 inches SLR	33	16%	1	33%	2	17%
100-year Stormwater Flood	10	5%	2	33%	2	17%
Wildfire						
High	0	0%	0	0%	0	0%
Moderate	1	0%	0	0%	1	8%

Note: For an exposure table with additional hazards, please see Chapter 05.

VULNERABILITIES

Category	Vulnerability
Physical	Geologic: Fiber cables are contained in below ground conduit, primarily made of flexible PVC. Shaking will likely not damage the conduit, but significant ground movement, such as in liquefaction or landslide could cause the conduit to break. Some fiber is located on above ground lines that would break if the poles fail, most likely in liquefaction areas. Data centers are built to a high seismic standard with seismic bracing for components and are not likely to experience significant earthquake damage, however data centers contain significant sensitive components which are sensitive to shaking and if fire sprinklers are activated the electronic equipment will be damaged. Radio antennas are also built to high seismic standards, but may be located on buildings that are not. Radio antennas have back up power with redundant microwave and fiber connections. Flood: Fiber conduit is not sensitive to short-term flooding, but permanent inundation would damage the conduit over time. Antennas are located on high ground or on top of buildings and will not likely be damaged by flooding. Flood inundation will damage data centers. Extreme Heat: Telecommunications systems are extremely sensitive to heat. Data centers rely on cooling technology to keep the equipment cool and high temperatures can stress those systems. Extended exposure to high temperatures will result in failure of electronics. Increased temperatures can also decrease the life span of telecommunications infrastructure as well[187]. When fiber cables get hot, they lengthen and soften and can result in weaker connectivity. Buried cables are less affected by high air temperatures. Fire: Recent wildfires have damaged buried and above ground fiber optic cables.[188] Buildings that house datacenters or support antennas can be damaged in fires.
Functional	Networks:

[187] GSA (2014). "Climate Risks Study for Telecommunications and Data Center Services". Retrieved from: https://sftool.gov/Content/attachments/GSA%20Climate%20Risks%20Study%20for%20Telecommunications%20and%20Data%20Center%20Services%20-%20FINAL%20October%202014.pdf

[188] https://www.geo-tel.com/california-camp-fire-threatens-fiber-optics/

	Communications systems have significant redundancy. Redundant fiber paths means that loss of some fiber cables may not result in loss of system functionality. Similarly, the loss of a few radio antennas will not impact communications functionality. Most networks have back up communication paths to provide redundancy if one is lost. San Francisco has an out of city back up data center to provide this redundancy. It is noted that not all City business and information systems are located and tested for disaster recovery at the Disaster Recovery data center. <u>External Services:</u> Communications systems are primarily reliant on power to operate. Some components have battery backup that will provide continued service for up to 8 hours. Fuel will then become critical for continued operations of backup generators. <u>Populations Served:</u> All San Francisco residents, business, as well as City Government rely on communications services. The City owned communications systems analyzed in this assessment provide service for the 911 system, MUNI signals and trains, emergency radio services, City email, phone and internet, City payroll, and SCADA systems. <u>Unique or Critical Function:</u> Communication systems are critical for emergency responders to communicate with one another through the 800mHz radio and for the citywide 911 system to function.
Informational	<u>All-hazards:</u> Because of the critical services provided by City owned communications infrastructure, the location of these assets cannot be shared with the public.
Governance	<u>All-hazards:</u> The City not the only provider of communications in San Francisco. Multiple private owners also operate internet, and cell networks throughout the City. The City, as well as the public, relies on these networks for many forms of communication.

CONSEQUENCES

Category	Consequence
Society/Equity	<u>All-hazards:</u> Loss of the City owned communication system has significant consequences on public health and safety due to the loss of 911 system, emergency radio system for fire and police, traffic signals

	and operations of the SCADA system to run water and wastewater. Loss of citywide communication in a disaster will hamper emergency response and recovery efforts.
Economy	<u>All-hazards:</u> The economic costs of disruption to the City owned communication system in a natural disaster include the cost to repair the system and the cost of business interruption during the outage.
Environment	<u>All-hazards:</u> Disruption to the City owned communication system will not have environmental consequences.

Open Space Sector

Parks and Open Space

Introduction to Asset Class

Recreation and open space are critical components of any community's quality of life; for San Franciscans they are defining elements of the City itself. The City's open space system provides places for recreation, activity and engagement, for peace and enjoyment, and for freedom and relief from the built world. Many of these open spaces also include natural areas, native species and habitat spaces, as well as serving the social and environmental health of the City, providing additional ecosystem services like reducing the urban heat island effect and filtering stormwater. Open space includes recreation centers, playgrounds, playing fields, un-programmed open areas, trails and natural areas, cultural arts and recreation centers, and sports facilities.

San Francisco has around 3,400 acres of recreation and open space owned and managed by the Recreation and Park Department (SFRPD[189]). San Francisco has over 800 acres of open space owned and managed by the State of California, and another 2100 acres of federally owned open space in the Golden Gate National Recreation Area including Ocean Beach, the Presidio, Lands End, Sutro Heights, and Fort Mason.[1] The Port of San Francisco manages additional 88 acres of public open space along the City's Bay shoreline, as well as heavily used pedestrian bicycle networks along the waterfront, such as the Embarcadero Promenade. The federal, state and Port open space includes more natural areas and fewer recreation facilities compared to the City Parks. These publicly owned open spaces make up almost 20% of the City's total land area.

Issue Statement

Parks and open space contribute to San Franciscan's quality of life by providing access to nature, recreation, and respite. Parks and open space can also help mitigate urban heat island effects and provide refuge for residents during heat events. While open space has low to moderate vulnerability to most natural hazards, the buildings that support open space use and recreation can be damaged by seismic, flooding, or other hazards. Shoreline habitat will be lost to erosion and sea level rise if sufficient space is not provided for it to move inland. Recreation Centers that serve as shelters are doubly

[189]San Francisco Planning Department. SF Open Space Dataset, 12/13/18

important after disaster events and they may not be resilient to seismic or flood events depending on their age and construction type.

Exposure

Hazard Data Assumptions

This analysis was conducted in 2018 and 2019 using publicly-available data sources. In the table below, shaking intensity is represented for two Earthquake scenarios: San Andreas Fault M7.8 and Hayward Fault M7.0 events. Accounts of assets subjected to varying levels of shaking intensity are cumulative for each scenario.

Asset Data Assumptions

Asset data was collected from contacts within the SF Planning Department, which keeps an updated database of park assets in order to assist their planning processes.

Exposure Summary

Geologic: All open space assets experience Violent or Very Strong shaking conditions in a 7.8M earthquake on the San Andreas Fault. Given the Port's location on the eastern shoreline, under the Hayward 7.0M scenario, the Port has the highest share of open space assets exposed to Violent or Very Strong shaking even though they represent less in total acreage compared to the assets managed by SFRPD, State, or Federal entities. 904 acres of open space are located in the liquefaction zone, comprising 15% of open space citywide.

Flood: 45 acres of SFRPD parks are currently exposed coastal flooding in a 100-year storm. However, with 66 inches of sea level rise, up to 128 acres could be exposed. 59 acres of SFRPD parks are exposed to the 100-year stormwater flood. While the Port open space will see similar exposure in acres, that exposure represents a greater share of the Port's open space. With 66 inches of SLR, up to 77 acres or 88% of Port parks could be exposed to coastal flooding. Federal open spaces located on the north and west side of the city are also exposed to coastal flooding with 246 acres of Federal open space exposed to coastal flooding with 66 inches of sea level rise, which comprises 10% of total state/federal acreage in the city.

Fire: Exposure of open space to wildland-urban-interface fire risk within the city is limited to moderate risk. Exposure to wildland-urban interface fire is pronounced for a significant share of State/Federal open space in the city (1,549 acres, 65%), particularly in Presidio Park and Mount Sutro open space. Exposure of SFRPD open space is 565 acres (17%) and concentrates in the Glen Canyon and Mount Davidson Parks.

TABLE A-39: EXPOSURE

Hazard	SFRPD Parks 3,398 Acres Total		Port Open Space 88 Acres Total		State/Federal Open Space 2,388 Acres Total	
	#	%	#	%	#	%
Geologic						
San Andreas 7.8 - Violent	2,004	59%	9	11%	1,333	56%
San Andreas 7.8 - Very Strong	1,394	41%	79	90%	1,055	44%
Hayward 7.0 - Very Strong	137	4%	59	67%	116	5%
Hayward 7.0 - Strong	2,123	36%	29	33%	2,023	85%
Liquefaction Zone	347	10%	83	93%	474	14%
Flood						
100-Year Coastal Flood Zone	45	1%	43	49%	310	13%
100-Year Storm + 24 Inches SLR	87	3%	45	51%	123	5%
100-Year Storm + 66 Inches SLR	128	4%	77	88%	246	10%
100-Year Stormwater Flood	59	2%	5	5%	11	0.4%
Wildfire						
High	0	0%	0	0%	0	0%
Moderate	565	17%	0	0%	1,549	65%

Note: For an exposure table with additional hazards, please see Chapter 05.

FIGURE A-66: OPEN SPACE AND LIQUEFACTION HAZARD

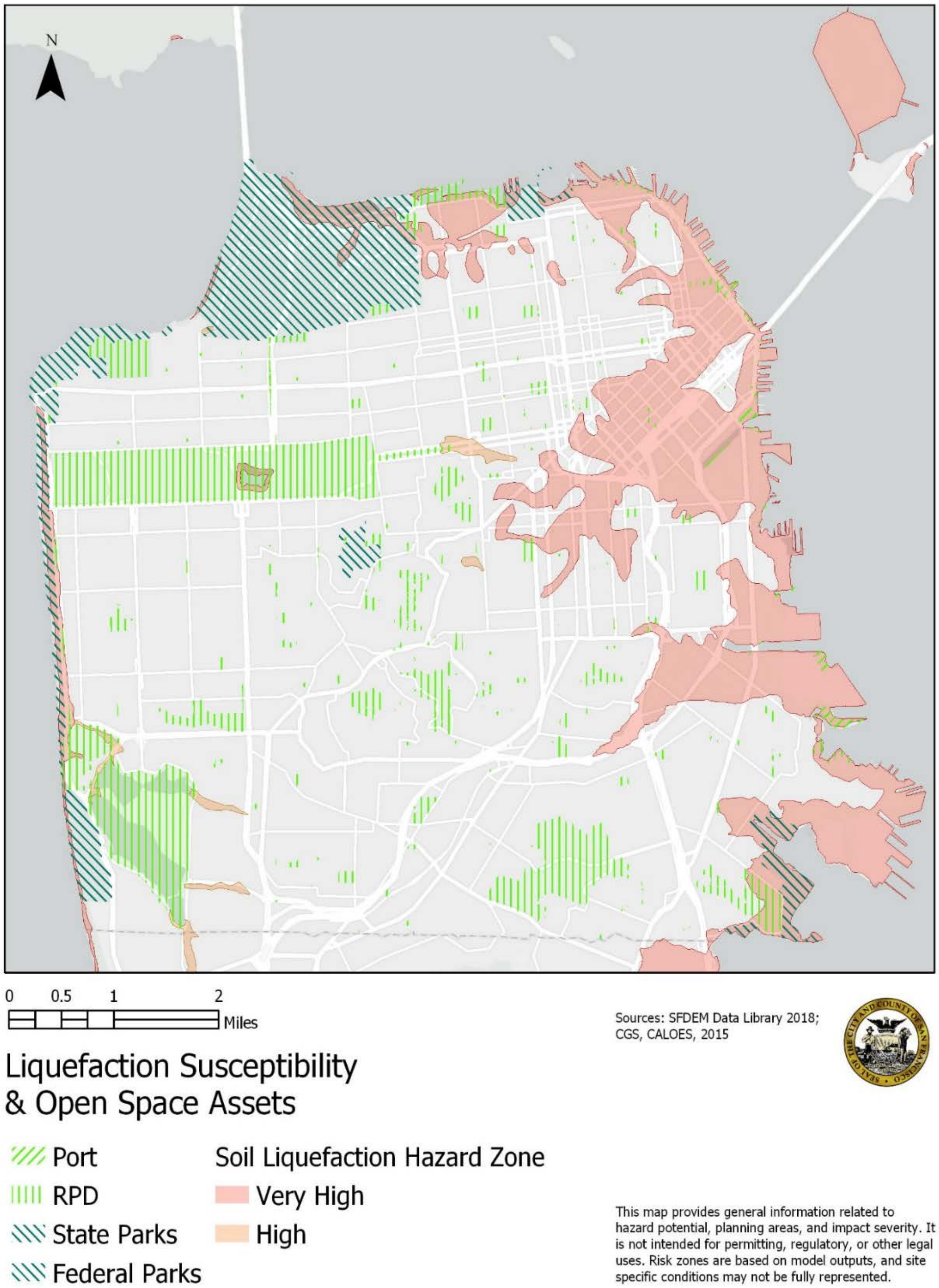


FIGURE A-67: OPEN SPACE AND FLOOD HAZARDS

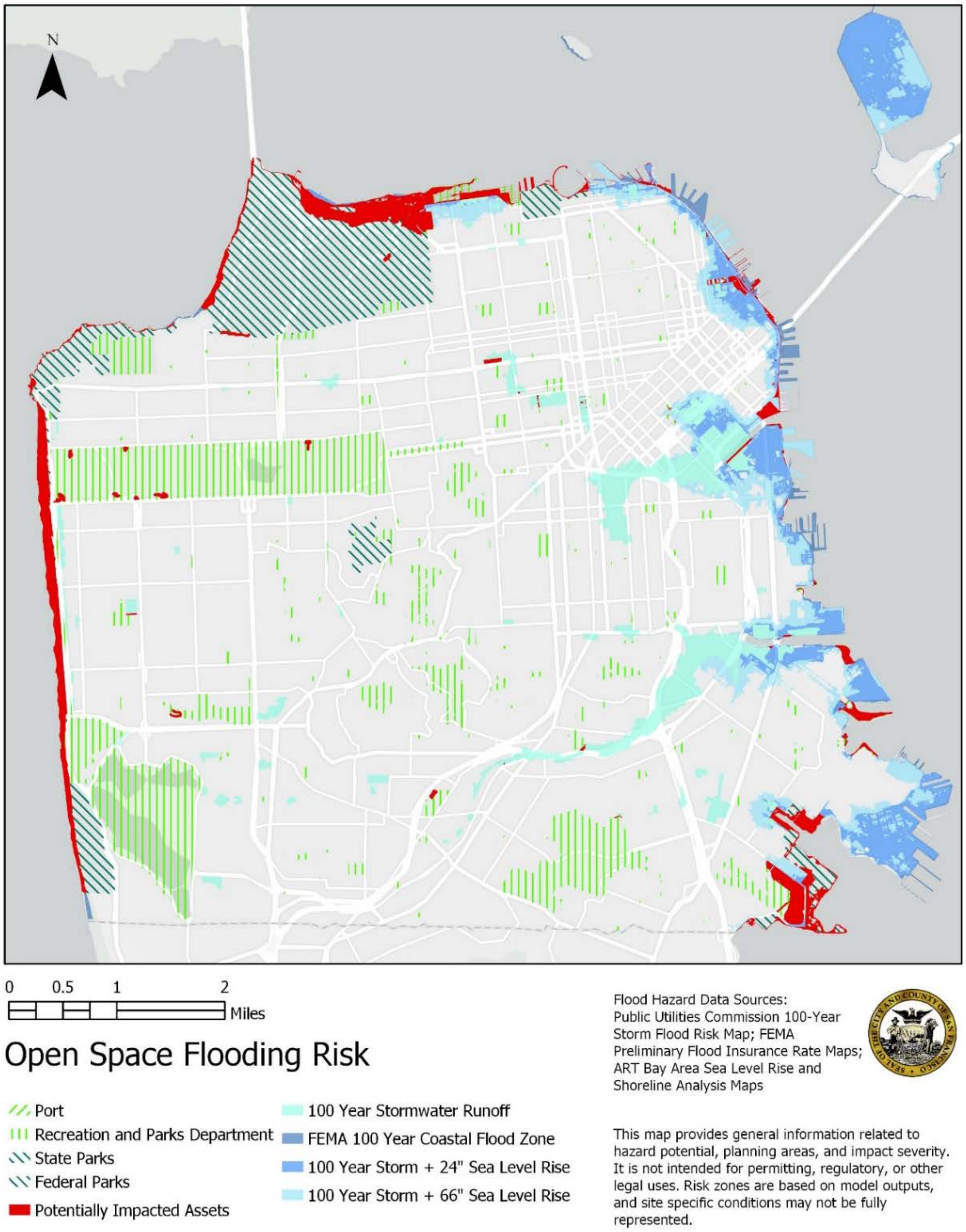
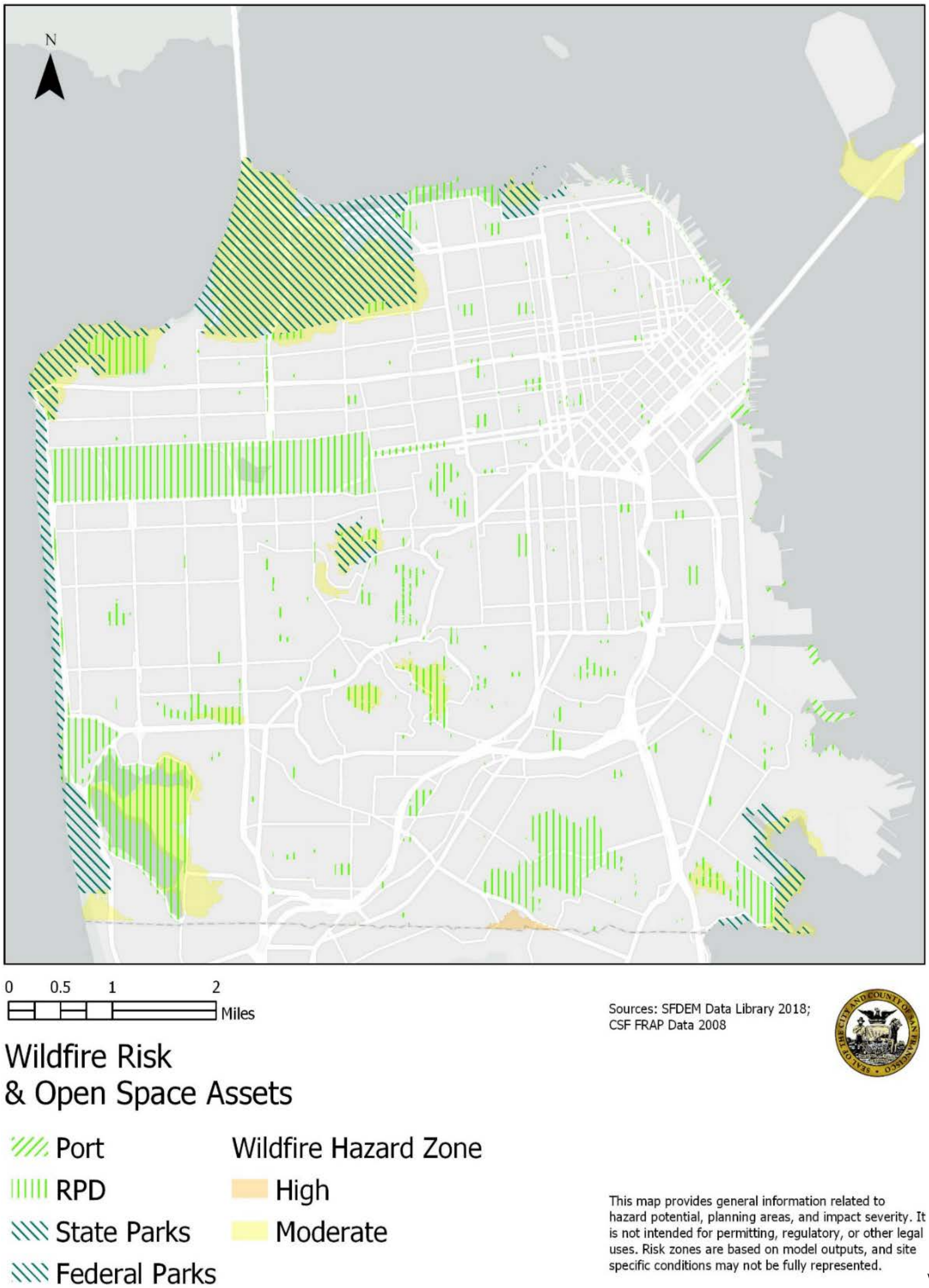


FIGURE A-68: OPEN SPACE AND WILDFIRE HAZARD



VULNERABILITIES

Category	Vulnerability
Physical	Geologic: Park buildings may be damaged by seismic hazards depending on their construction type. Park buildings are generally low rise and have various construction methods. Flood: Park buildings like offices, maintenance facilities, and restrooms may be sensitive to flooding. Planted areas and sports fields are sensitive to flooding and extremely sensitive to saltwater flooding. Damage due to flooding will increase operations and maintenance costs. Extreme Heat: Park buildings without sufficient AC may be impacted during high heat days. This is even more important if they provide community shelter during heat days like rec centers and community centers. Although there can be concerns regarding air quality during high heat days, dependent on geographic and health disparity considerations, parks and open space can provide refuge from extreme heat to residents and visitors. Fire: Recreation centers, especially older facilities that have not been remodeled, may not have sufficient HVAC for fire events in the region. This may be even more critical if these facilities provide shelter during events. Wildland open space, particularly Glen Canyon, Presidio, and other grassland open space, are vulnerable to direct fire
Functional	Networks: SF has many parks and open space facilities although some neighborhoods have more access than others. For inland parks, if one park is closed due to a hazard, other parks may be used as an alternative. SFRPD has identified Equity Zones where parks are less available and residents may be unable to access alternative parks. Closure of a park may also put additional use strain on nearby parks. Additionally, redundancy does not apply to our waterfront parks,

	which often have no viable alternative nearby when disrupted by hazards. <u>External Services:</u> Park buildings rely on power, water, wastewater, and often staff access. Open space itself is not reliant on any of these systems in the short term. In the long term, parks may not be able to provide high quality recreation without irrigation and transit access. <u>Populations Served:</u> Parks and open space serve all community members but access may be limited in underserved areas, especially for specific types of open space and recreation like water access, rec centers, athletic fields or others. SFRPD has identified equity zones where improving access and open space quality is a priority. Open space is especially important for people who live in multifamily housing without private outdoor space and those without air conditioning. During heat events, open space and air-conditioned recreation centers provide respite for residents. <u>Unique or Critical Function:</u> 1. Recreation and habitat are core goals of SFRPD open space. Although CCSF has many parks, they are heavily used and could not be easily replaced. This is particularly true for shoreline habitat, waterfront parks and open spaces, water access, and athletic fields.
Informational	Information on the location and condition of open space is available through SFRPD and SF Planning efforts. Little information is available on the number of visitors or who uses various open space facilities citywide. Crissy Field and Ocean Beach have assessed their sea level rise vulnerability and identified some resilience strategies through the Rise Up[190] and Ocean Beach Master Plan projects[191].
Governance	Regional and state funds (SB 68) are available for park and habitat improvement related to climate change impacts.

[190] "Crissy Field Rise Up" Golden Gate National Parks Conservancy, October 2016, https://issuu.com/parks-conservancy/docs/crissy_field_sea_level_rise_analysi

[191] "Ocean Beach Master Plan" SPUR, June 26th, 2012, https://www.spur.org/featured-project/ocean-beach-master-plan

	Open space, particularly shoreline habitat, is subject to extensive regional, state and federal regulations that may make adaptation difficult to implement. This includes coastal management regulations from the Coastal Commission and the Bay Conservation and Development Commission, the Regional Water Quality Control Board, the Endangered Species Act, and others.

CONSEQUENCES

Category	Consequence
Society/Equity	All-hazards: Open space is used by all residents and many visitors to SF. This would be particularly important in SFPRD's identified equity zones where park access is limited. Parks and open space are especially critical for residents without private outdoor space and those without air-conditioning. The distribution of, and access to, parks and open spaces is not equal in the City and damage and/or disruption to any of these facilities could have significant consequences for communities with fewer park spaces and/or lack the ability to access other parks.
Economy	All-hazards: Depending on the scope of the hazard, impacts could range from the loss of SFRPD revenue to major citywide capital costs for habitat restoration and building reconstruction. Damage and disruption to parks and open spaces will increase the operations and maintenance costs for these facilities and functions. Some parks and open space in San Francisco are significant tourist attractions. Even temporary closures at these sites could lead to reduced tourism and spending, which would affect San Francisco's economy.
Environment	All-hazards: None. Geologic: None. Flood: Coastal flooding due to sea level rise could eventually drown shoreline habitats resulting in the loss of critical ecosystem services

	and biodiversity. Flooding can negatively impact planted areas and trees and saltwater flooding is especially damaging to both planted areas and electrical and mechanical equipment in parks like irrigation systems and lights. Extreme Heat: Extreme heat can damage vegetation over extended periods, impacting the function of ecosystems found within them and thereby reducing the efficacy of the ecosystem services that they provide. Fire: Fires can damage natural areas and require long term recovery.

Appendix B

Out-of-County Major Assets

The following section highlights the major out-of-county major assets that are owned, managed, or relied on by the City and County of San Francisco. These facilities include the San Francisco International Airport[1]; County Jail #5-San Bruno Complex; facilities managed by the Parks and Recreation Department; a mental health facility owned by the Department of Public Health; wastewater treatment plants owned by San Francisco Public Utilities Commission; and the numerous infrastructure components that facilitate the operation of the Hetch Hetchy Regional Water System.

A complete vulnerability analysis for the out-of-county areas where these facilities and infrastructure are located was beyond the time and resources of the Planning Team for this year's assessment. However, the team is committed to completing the integration of vulnerability-related information for the out-of-county major assets during the implementation process for this plan as well as in subsequent plan updates.

[1] Analyzed at length in the Vulnerability and Consequences Profile found in Appendix A.

TABLE B-1
OUT-OF-COUNTY MAJOR ASSETS

Dept.	Facility Type	Facility Name	City	County
DPH	Mental Health Center	Redwood Center	Redwood City	San Mateo
MTA	Service, Repair, And Storage	Towed Cars And Signal Shop	Daly City	San Mateo
RPD	Other Recreational Building	Camp Mather	Groveland	Tuolomne
RPD	Other Recreational Building	Polo Fields	Daly City	San Mateo
RPD	Other Recreational Building	Sharp Park Clubhouse	Pacifica	San Mateo
SFO	Aircraft Operator Support	American Airlines Cargo	Unincorporated Area	San Mateo
SFO	Department Operations Center	Airport-San Francisco (SFO)	Unincorporated Area	San Mateo
SFO	Aircraft Operator Support	Japan Airlines Cargo	Unincorporated Area	San Mateo
SFO	Aircraft Operator Support	Japan Airlines Cargo Shop Building	Unincorporated Area	San Mateo
SFO	Aircraft Operator Support	N. Cargo Joint Use Freight	Unincorporated Area	San Mateo
SFO	Aircraft Operator Support	NW Airlines Cargo	Unincorporated Area	San Mateo
SFO	Aircraft Operator Support	Signature Flight E. Maintenance	Unincorporated Area	San Mateo
SFO	Aircraft Operator Support	Signature Flight Executive Air	Unincorporated Area	San Mateo
SFO	Aircraft Operator Support	Signature Flight Support Fuel	Unincorporated Area	San Mateo
SFO	Aircraft Operator Support	Skywest Commissary	Unincorporated Area	San Mateo
SFO	Aircraft Operator Support	Superbay	Unincorporated Area	San Mateo

Dept.	Facility Type	Facility Name	City	County
SFO	Aircraft Operator Support	Swissport	Unincorporated Area	San Mateo
SFO	Aircraft Operator Support	TAG Aviation Flight	Unincorporated Area	San Mateo
SFO	Aircraft Operator Support	TWA Cargo Building	Unincorporated Area	San Mateo
SFO	Aircraft Operator Support	UAL Cargo Building	Unincorporated Area	San Mateo
SFO	Aircraft Operator Support	UAL Service Center	Unincorporated Area	San Mateo
SFO	Aircraft Operator Support	W. Cargo Joint Freight Building (Old Building 7)	Unincorporated Area	San Mateo
SFO	Aircraft Operator Support	West Field Cargo No. 1	Unincorporated Area	San Mateo
SFO	Airfield Lighting	Field Lighting Building No. 1	Unincorporated Area	San Mateo
SFO	Airfield Lighting	Field Lighting Building No. 2	Unincorporated Area	San Mateo
SFO	Airfield Lighting	Field Lighting Generator Building	Unincorporated Area	San Mateo
SFO	Communications	SFO MPOE No. 1	Unincorporated Area	San Mateo
SFO	Communications	SFO MPOE No. 2	Unincorporated Area	San Mateo
SFO	Education	City College Aeronautic Shop	Unincorporated Area	San Mateo
SFO	Education	City College Aeronautics	Unincorporated Area	San Mateo
SFO	Fire Station	Apparatus Storage	Unincorporated Area	San Mateo
SFO	Fire Station	Fire Station No. 1	Unincorporated Area	San Mateo
SFO	Fire Station	Fire Station No. 2	Unincorporated Area	San Mateo
SFO	Fire Station	Fire Station No. 3	Unincorporated Area	San Mateo
SFO	Fire Station	Old Fire House No. 2	Unincorporated Area	San Mateo

Dept.	Facility Type	Facility Name	City	County
SFO	Law Enforcement	Police Main Training Facility	Unincorporated Area	San Mateo
SFO	Terminal	East Terminal No. 2	Unincorporated Area	San Mateo
SFO	Terminal	International Terminal	Unincorporated Area	San Mateo
SFO	Terminal	New Terminal No. 2	Unincorporated Area	San Mateo
SFO	Terminal	North Terminal No. 3	Unincorporated Area	San Mateo
SFO	Terminal	South Terminal No. 1	Unincorporated Area	San Mateo
SFO	Transportation Systems & Facilities	Airtrain Maintenance	Unincorporated Area	San Mateo
SFO	Transportation Systems & Facilities	Airtrain Station B	Unincorporated Area	San Mateo
SFO	Transportation Systems & Facilities	Airtrain Station D	Unincorporated Area	San Mateo
SFO	Transportation Systems & Facilities	Airtrain Station F	Unincorporated Area	San Mateo
SFO	Transportation Systems & Facilities	Airtrain Station Garage A	Unincorporated Area	San Mateo
SFO	Transportation Systems & Facilities	Airtrain Station N. International Terminal	Unincorporated Area	San Mateo
SFO	Transportation Systems & Facilities	Airtrain Station S. International Terminal	Unincorporated Area	San Mateo
SFO	Transportation Systems & Facilities	Airtrain System & Trains	Unincorporated Area	San Mateo
SFO	Transportation Systems & Facilities	Central Parking Garage	Unincorporated Area	San Mateo
SFO	Transportation Systems & Facilities	Garage G Office Building	Unincorporated Area	San Mateo
SFO	Transportation Systems & Facilities	Lot D Exit Shelter/Ticket Booths	Unincorporated Area	San Mateo

Dept.	Facility Type	Facility Name	City	County
SFO	Transportation Systems & Facilities	Lot D Long Term Parking	Unincorporated Area	San Mateo
SFO	Transportation Systems & Facilities	Lot DD Parking Garage	Unincorporated Area	San Mateo
SFO	Transportation Systems & Facilities	N. International Terminal Parking Garage G	Unincorporated Area	San Mateo
SFO	Transportation Systems & Facilities	Parking Garage A	Unincorporated Area	San Mateo
SFO	Transportation Systems & Facilities	RAC Mechanical Equip Buildings	Unincorporated Area	San Mateo
SFO	Transportation Systems & Facilities	Rental Car Center	Unincorporated Area	San Mateo
SFO	Transportation Systems & Facilities	Rental Car Quick Turn-Around	Unincorporated Area	San Mateo
SFO	Transportation Systems & Facilities	Road Signs / Street Lighting	Unincorporated Area	San Mateo
SFO	Transportation Systems & Facilities	Shuttle Bus Vehicle Maintenance Facility	Unincorporated Area	San Mateo
SFO	Transportation Systems & Facilities	Airtrain Station Rental Car Center	Unincorporated Area	San Mateo
SFO	Transportation Systems & Facilities	Airtrain Station W. Field Rd	Unincorporated Area	San Mateo
SFO	Transportation Systems & Facilities	Former Dollar Rent-A-Car	Unincorporated Area	San Mateo
SFO	Transportation Systems & Facilities	W. Field Parking Garage	Unincorporated Area	San Mateo
SFO	Transportation Systems & Facilities	Concourse H Facility	Unincorporated Area	San Mateo
SFO	Water Quality Control	Generator Building	Unincorporated Area	San Mateo
SFO	Water Quality Control	Headworks	Unincorporated Area	San Mateo
SFO	Water Quality Control Operations	14 Sludge Drying Beds	Unincorporated Area	San Mateo

Dept.	Facility Type	Facility Name	City	County
SFO	Water Quality Control Operations	2 Clarification Tanks	Unincorporated Area	San Mateo
SFO	Water Quality Control Operations	2 Concrete Digesters	Unincorporated Area	San Mateo
SFO	Water Quality Control Operations	Chemical Contact Basin	Unincorporated Area	San Mateo
SFO	Water Quality Control Operations	Effluent Pump Station	Unincorporated Area	San Mateo
SFO	Water Quality Control Operations	Equalization Tank	Unincorporated Area	San Mateo
SFO	Water Quality Control Operations	Generator Building No. 2	Unincorporated Area	San Mateo
SFO	Water Quality Control Operations	Recirculating Tanks and Pumps	Unincorporated Area	San Mateo
SFO	Water Quality Control Operations	Trickling Filter	Unincorporated Area	San Mateo
SFO	Water Quality Control Operations	Water Quality Control Building	Unincorporated Area	San Mateo
SFO	Water Quality Control Operations	Water Quality Control DeLong Building	Unincorporated Area	San Mateo
SFO	Water Quality Control Reclaim	Water Quality Control Reclaim	Unincorporated Area	San Mateo
SFPUC	Bypass Tunnel	Crystal Springs Bypass Tunnel	Unincorporated Area	San Mateo
SFPUC	Chlorine Station	Pulgas Dechlorination Facility	Unincorporated Area	San Mateo
SFPUC	Corporation Yard/Vehicle Repair	South Forks Maintenance Yard	Groveland	Tuolomne
SFPUC	Corporation Yard/Vehicle Repair	Millbrae Yard	Millbrae	San Mateo
SFPUC	Crossover	Pelican Crossover	Patterson	Stanislaus
SFPUC	Dam	Alameda Creek Diversion Dam	Unincorporated Area	Alameda

Dept.	Facility Type	Facility Name	City	County
SFPUC	Dam	O'Shaughnessy Dam	Yosemite National Park	Tuolomne
SFPUC	Filter Plant	San Andreas Filter Plant	San Bruno	San Mateo
SFPUC	General	Sunol Yard	Sunol	Alameda
SFPUC	Labs, Shops, Yards	Millbrae	Millbrae	San Mateo
SFPUC	Lime Treatment Plant	Rock River Lime Treatment Plant	Unincorporated Area	Tuolomne
SFPUC	Powerhouse	Holm Powerhouse	Groveland	Tuolomne
SFPUC	Powerhouse	Kirkwood Powerhouse	Unincorporated Area	Tuolomne
SFPUC	Powerhouse	Moccasin Powerhouse	Unincorporated Area	Tuolomne
SFPUC	Pump Station	Cherry Lake Pump Station	Groveland	Tuolomne
SFPUC	Pump Station	San Antonio Sub Station	Sunol	Alameda
SFPUC	Pump Station	Irvington Portal Pump Station	Unincorporated Area	Alameda
SFPUC	Pump Station	San Antonio Pump Station	Unincorporated Area	Alameda
SFPUC	Pump Station	Sunnydale Pump Station	Brisbane	San Mateo
SFPUC	Pump Station	Crystal Springs Pump Station	Unincorporated Area	San Mateo
SFPUC	Reservoir	Calaveras Reservoir	Calaveras	Alameda
SFPUC	Reservoir	Crystal Springs Reservoir	San Bruno	San Mateo
SFPUC	Reservoir	Pulgas Balancing Reservoir	Unincorporated Area	San Mateo
SFPUC	Surge Shaft	Alameda East Portal	Sunol	Alameda
SFPUC	Switchyard	Warnerville	Oakdale	Stanislaus

Dept.	Facility Type	Facility Name	City	County
SFPUC	Valve House	Early Intake Valve House	Groveland	Tuolomne
SFPUC	Valve House	Roselle Crossover	Modesto	Stanislaus
SFPUC	Valve House	San Joaquin Valve House	Modesto	Stanislaus
SFPUC	Valve House	Cashman Creek	Oakdale	Stanislaus
SFPUC	Valve House	Tesla Valve House	Tracy	San Joaquin
SFPUC	Valve House	Oakdale Portal / Valve House	Unincorporated Area	Tuolomne
SFPUC	Valve House	Albers Road Crossover	Oakdale	Stanislaus
SFPUC	Valve Lot	San Pedro Valve Lot	Daly City	San Mateo
SFPUC	Valve Lot	Baden Valve Lot	South San Francisco	San Mateo
SFPUC	Warehouse	Oakdale Office / Warehouse	Oakdale	Stanislaus
SFPUC	Water Delivery Facility	Thomas Shaft Water Delivery	Unincorporated Area	Alameda
SFPUC	Water Temple	Pulgas Water Temple	Unincorporated Area	San Mateo
SFPUC	Water Treatment Plant	Ravenswood Valve House	East Palo Alto	San Mateo
SFPUC	Water Treatment Plant	Harry Tracy Water Treatment Plant	San Bruno	San Mateo
SFPUC	Water Treatment Plant	Sunol Valley Water Treatment Plant	Sunol	Alameda
SFPUC	Water Treatment Plant	Tesla Water Treatment Facility / Portal	Vernalis	San Joaquin
SFSD	Jail / Correctional	San Francisco County Jail, San Bruno Facility	San Bruno	San Mateo

FIGURE B-2:
OUT OF COUNTY ASSETS

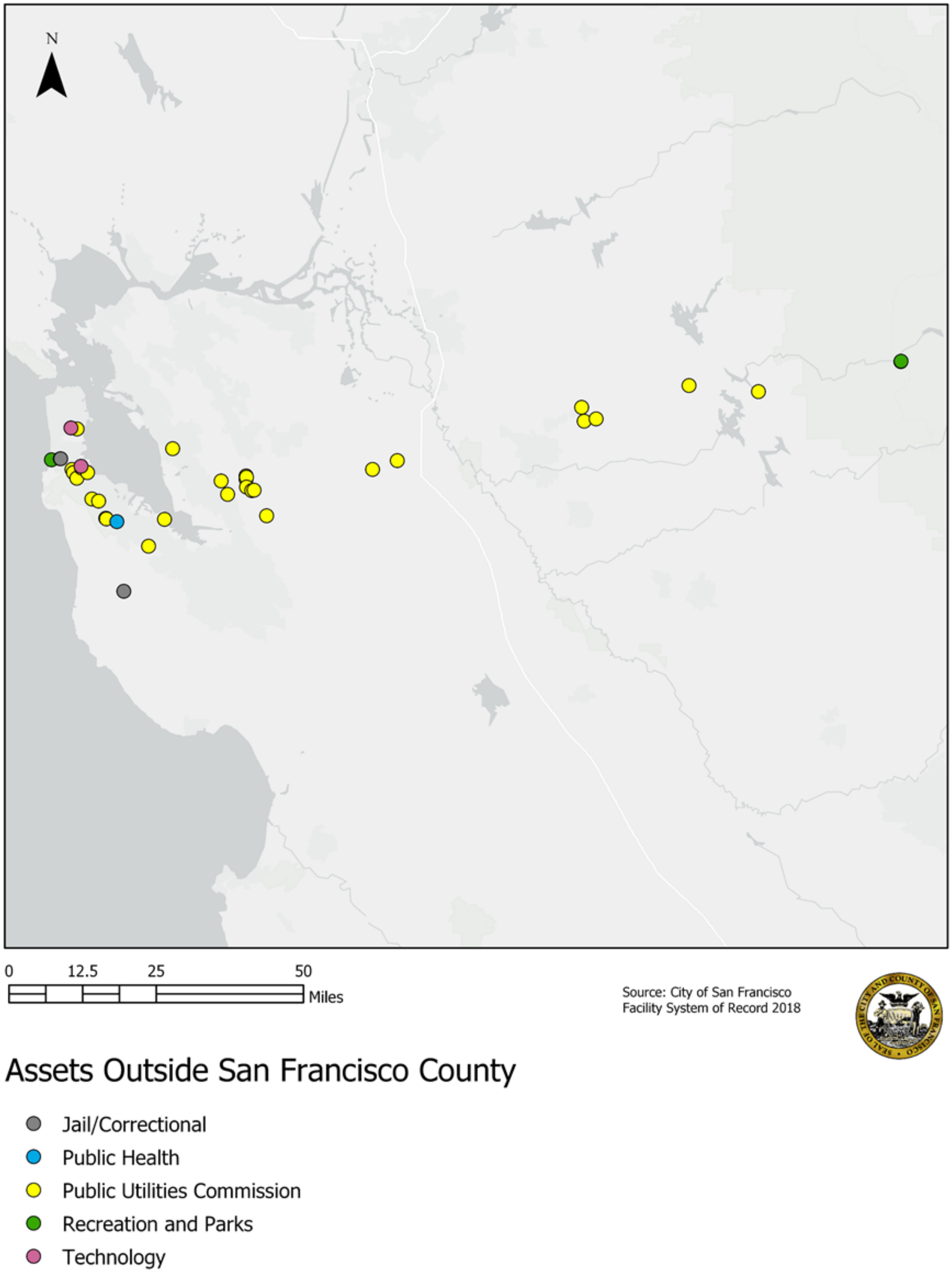


FIGURE B-3:
SAN MATEO COUNTY SAN ANDREAS M7.8 SHAKING INTENSITY AREAS

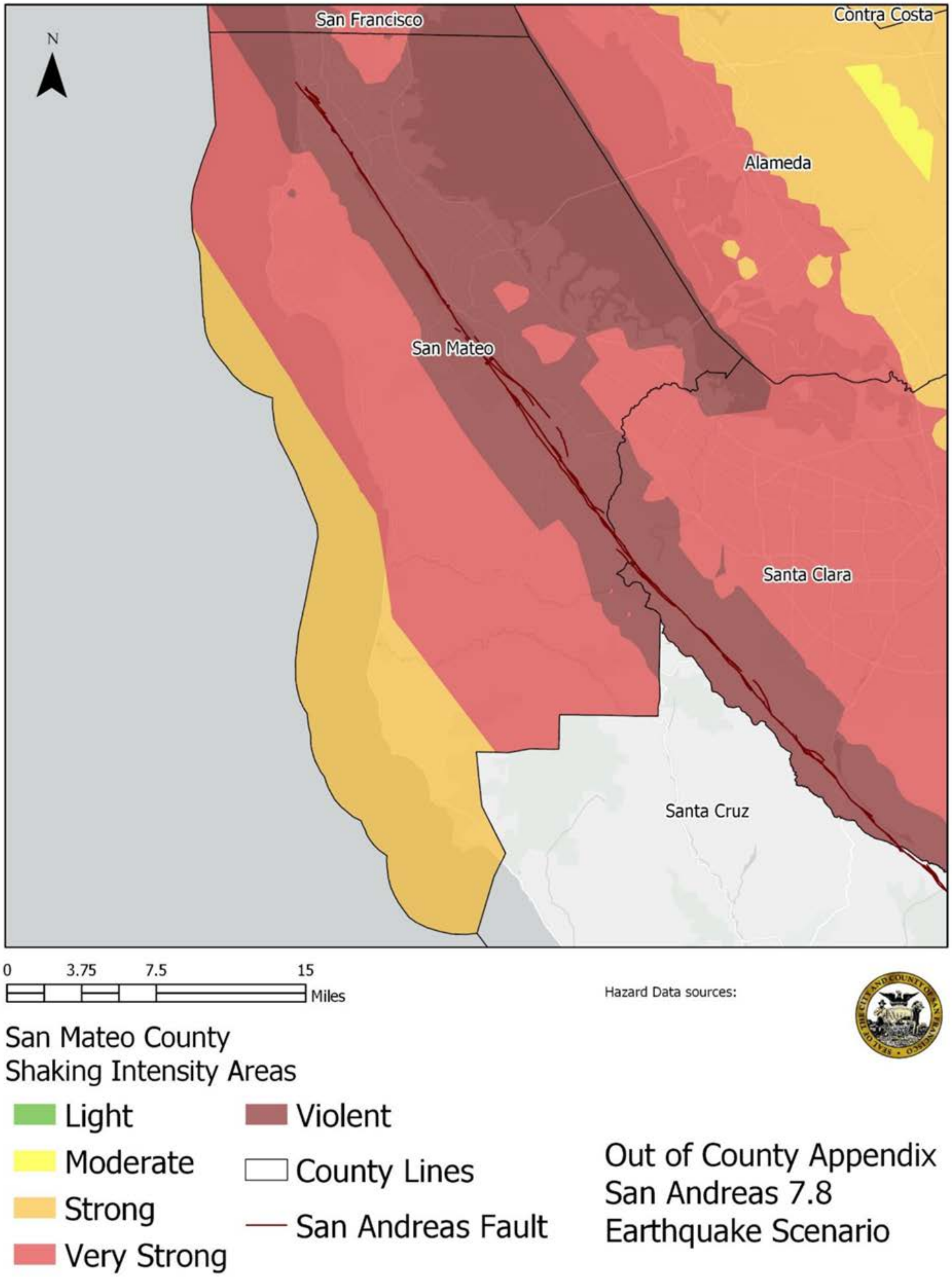


FIGURE B-4:
SAN MATEO COUNTY HAYWARD M7.0 SHAKING INTENSITY AREAS

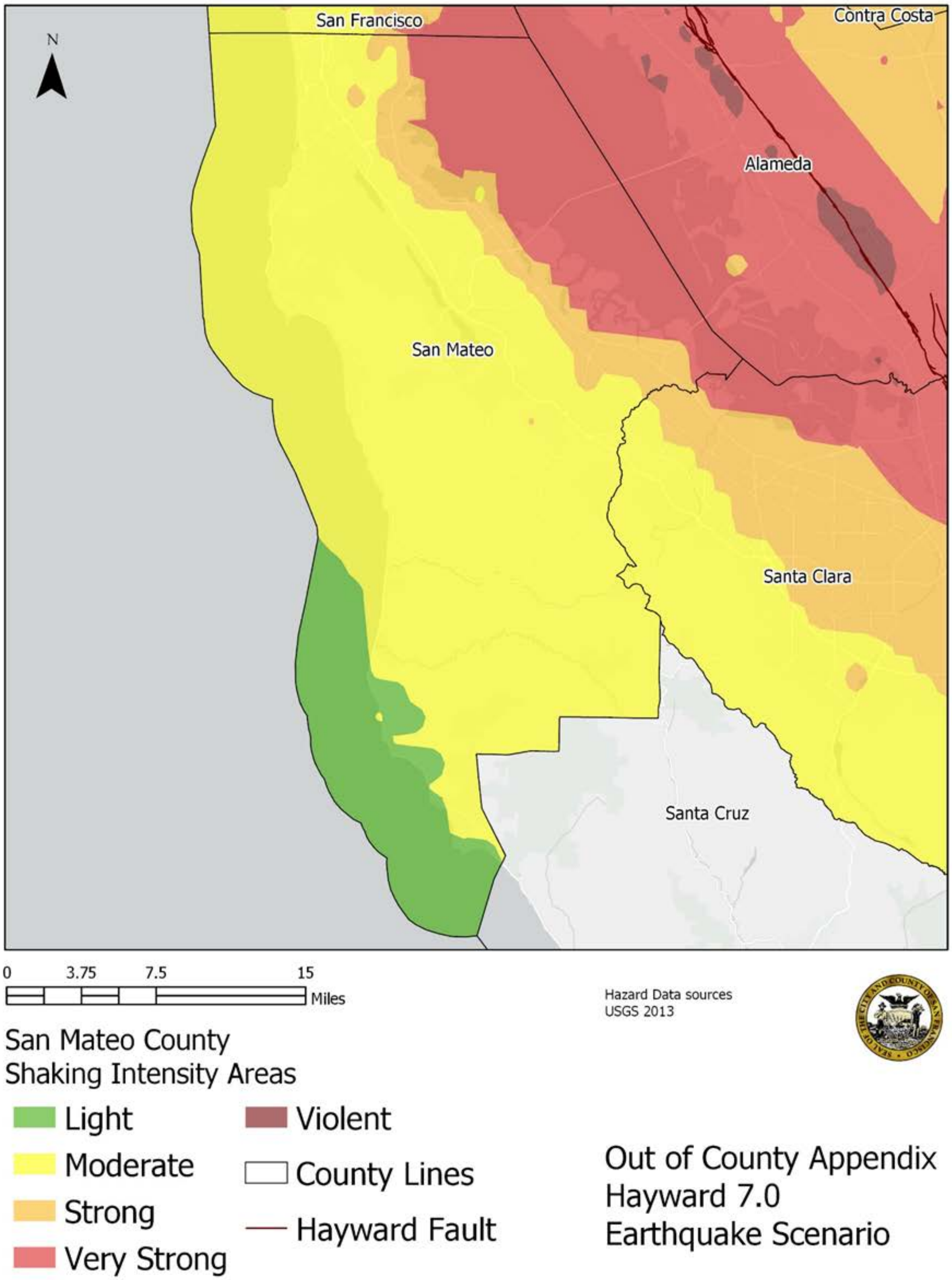


FIGURE B-5:
SAN MATEO COUNTY WILDFIRE HAZARD ZONES

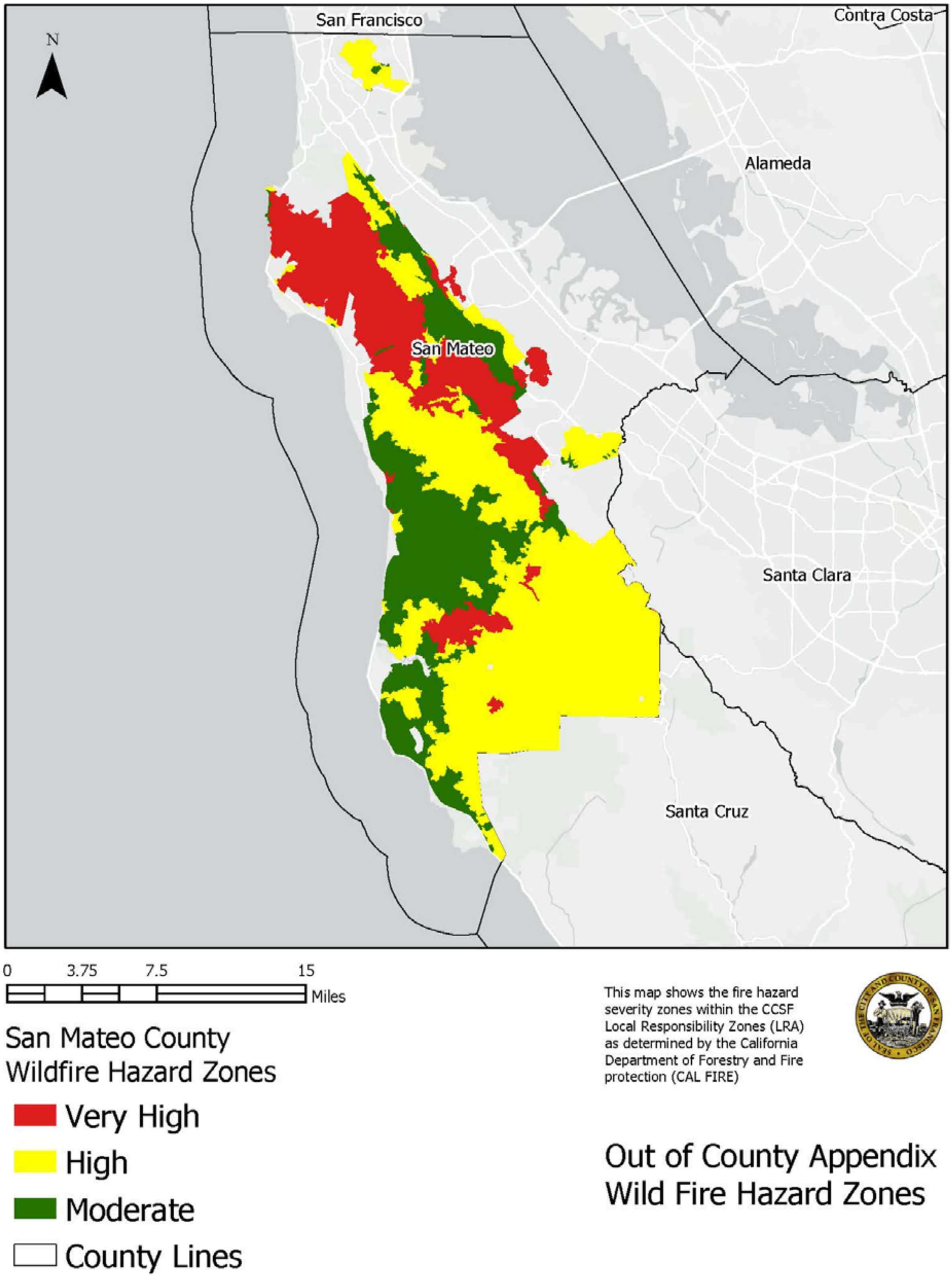


FIGURE B-6:
ALAMEDA COUNTY SAN ANDREAS M7.8 SHAKING INTENSITY AREAS

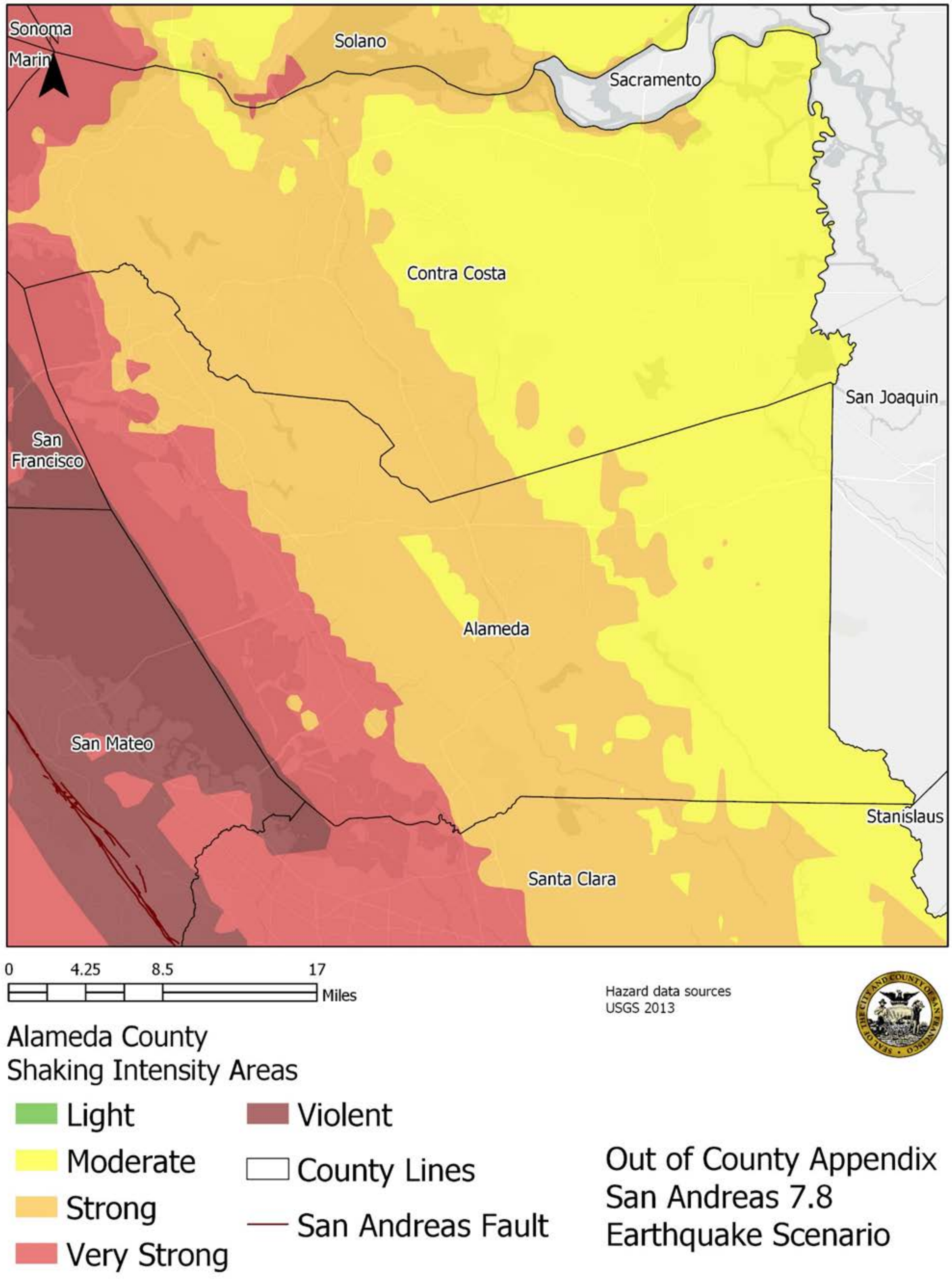


FIGURE B-7:
ALAMEDA COUNTY HAYWARD M7.0 SHAKING INTENSITY AREAS

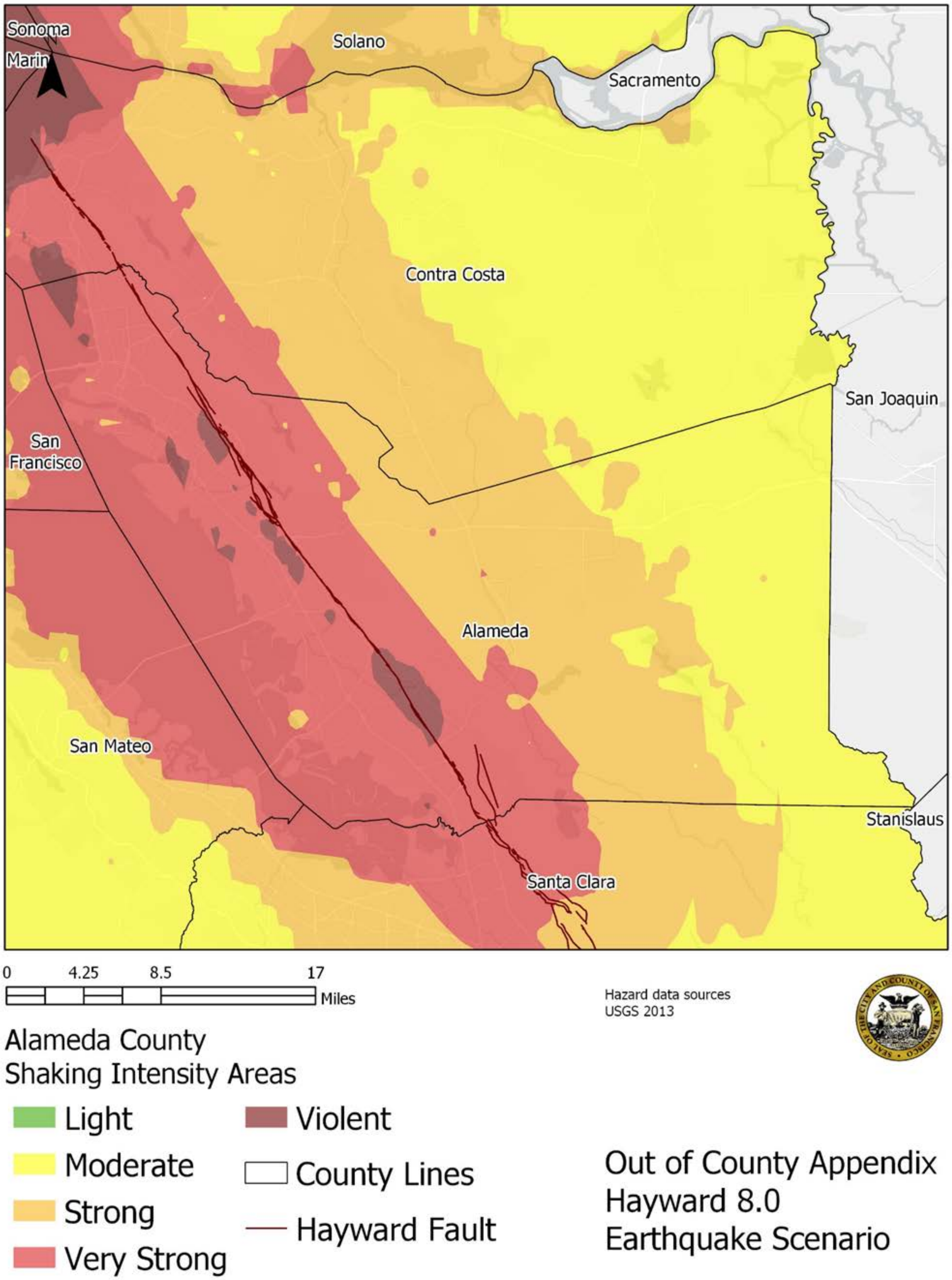


FIGURE B-8:
ALAMEDA COUNTY WILDFIRE HAZARD ZONES

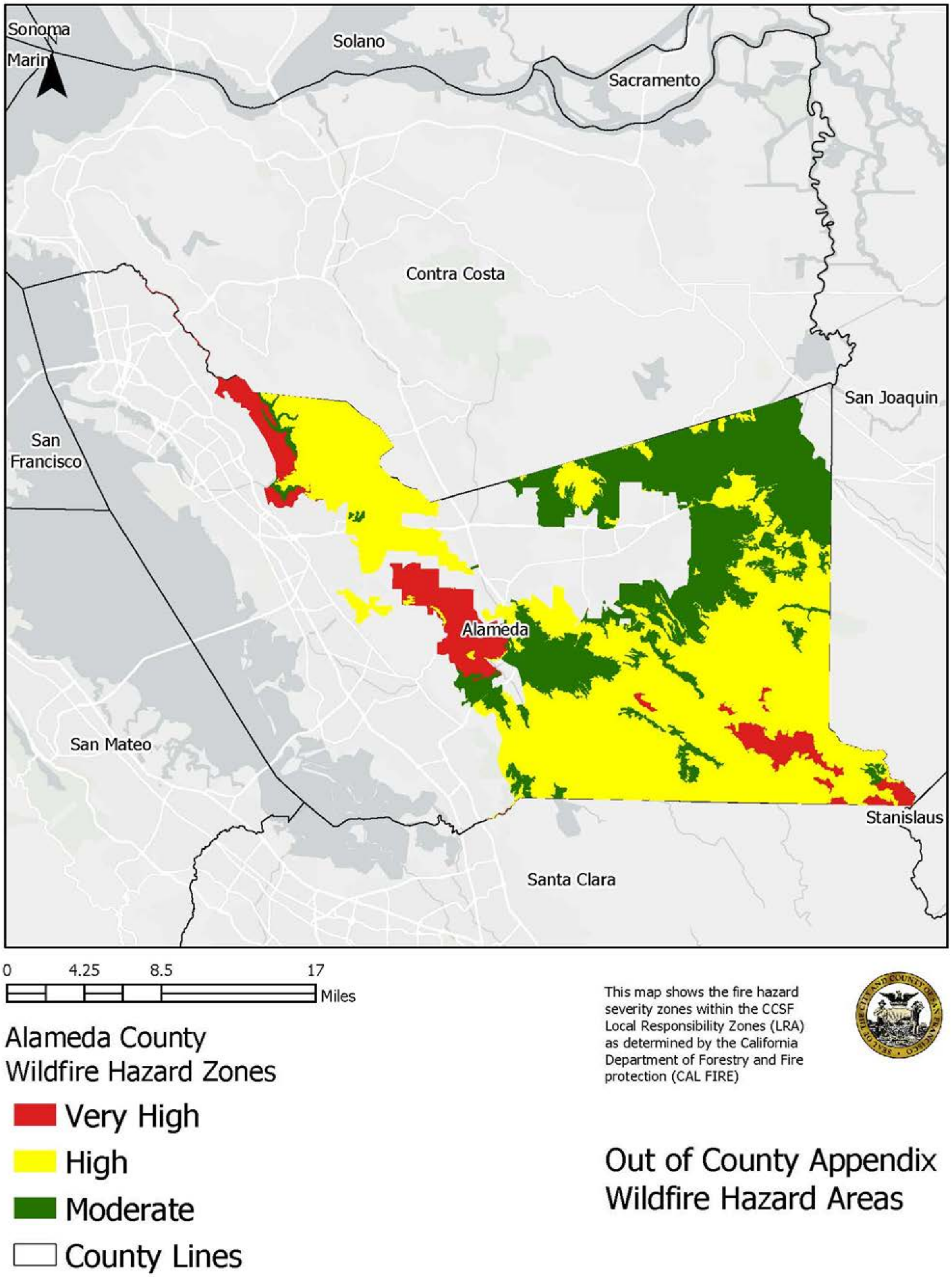


FIGURE B-9:
ALAMEDA COUNTY LIQUEFACTION HAZARD ZONES

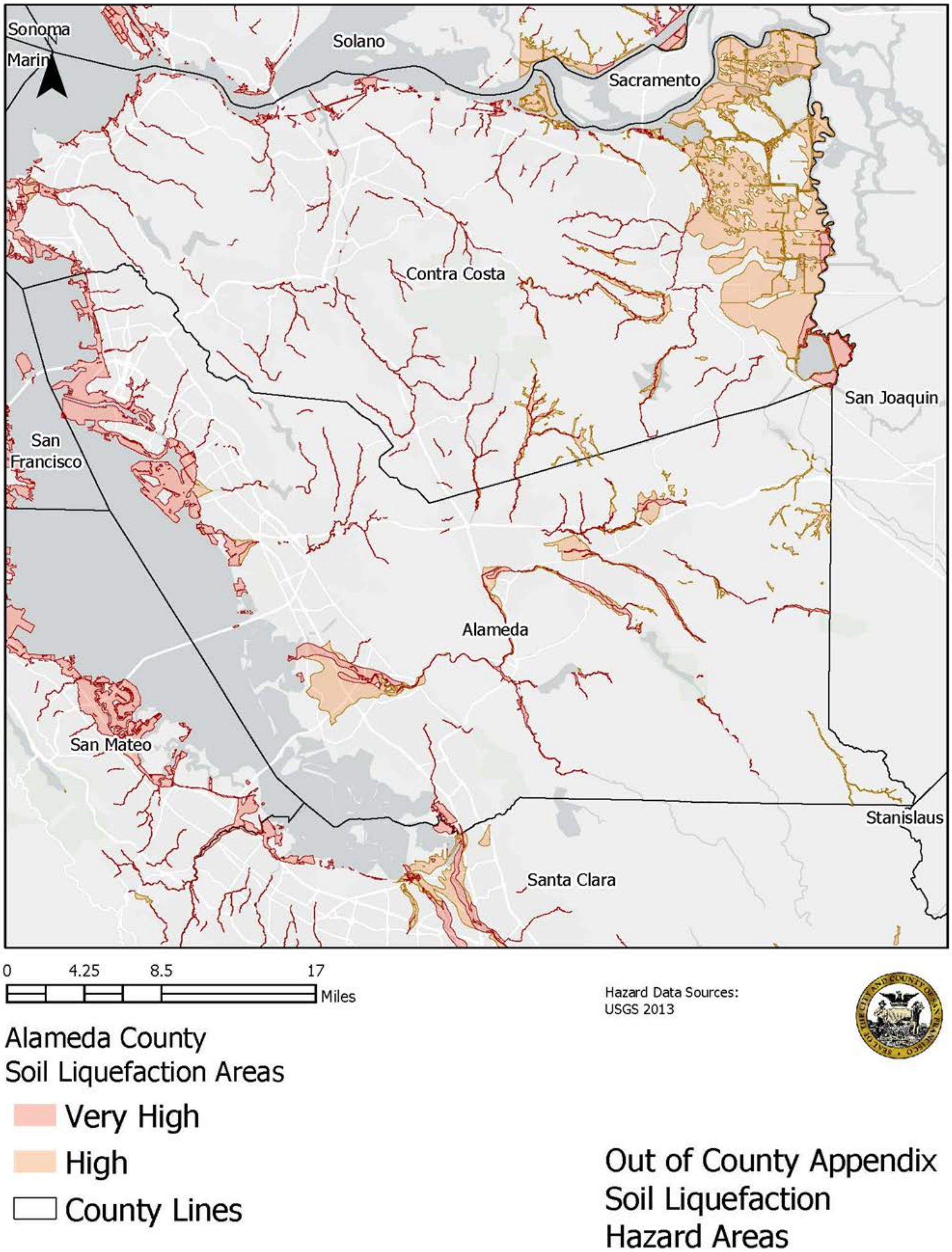
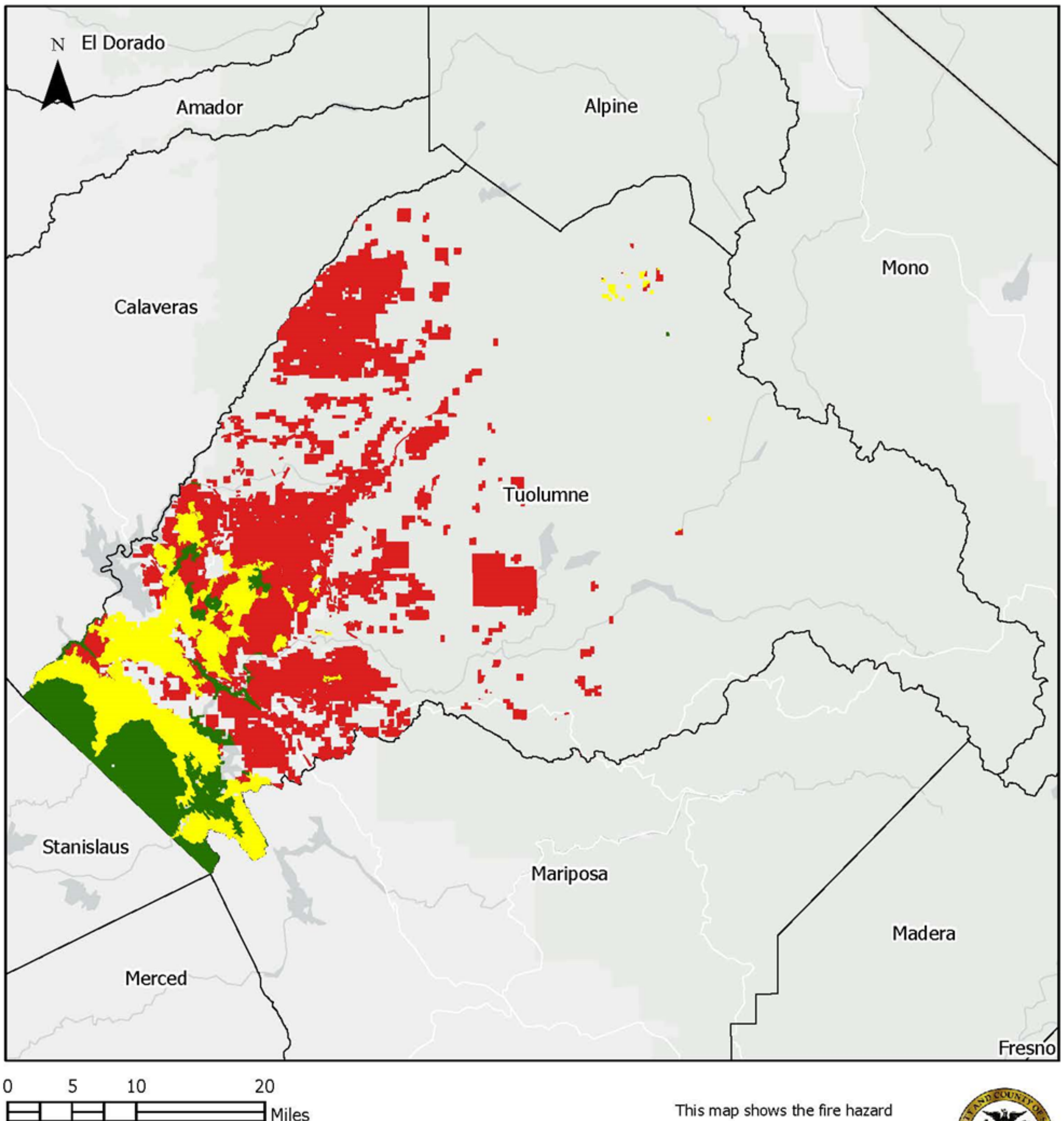


FIGURE B-10:
TUOLUMNE COUNTY WILDFIRE HAZARD ZONES



Tuolumne County
Wildfire Hazard Zones

- Very High
- High
- Moderate
- County Lines

This map shows the fire hazard severity zones within the CCSF Local Responsibility Zones (LRA) as determined by the California Department of Forestry and Fire protection (CAL FIRE)

Out of County Appendix
Wildfire Hazard Areas

Appendix C

Capabilities Assessment Details

The following tables provide additional details on the capabilities described in Chapter 06. They are organized by San Francisco Government Activities:

- Funding and Financing
- Public Asset Owner
- Planning, Research, and Guidance
- Adopt and Enforce Regulations
- Deliver Community Services

TABLE C-1:
FUNDING AND FINANCING CAPABILITIES

Resource	Department / Agency	Ability to Support Resilience
10-Year Capital Plan	ORCP	In compliance with Administrative Code Section 3.20, the 10-Year Capital Plan is the guiding document for the City's capital needs, identifies the level of investment to meet those needs, and provides a constrained plan of finance for the next 10 years. The FY 2024-2033 Capital Plan projects $41.4 billion in city investments that will improve San Francisco's resilience through critical seismic repairs, transportation and utility system improvements, a stronger seawall, modern public health and safety facilities, and safer streets for all.
Capital Appreciation Bonds	City and County of San Francisco	Bonds in which the principle and accumulated interest are repaid in a single balloon payment once the bond reaches maturity. These have not seen widespread use in adaptation funding in California
Catastrophe (CAT) Bonds	City and County of San Francisco	The City may serve as a sponsor of Cat Bonds to insure against damages and fund recovery efforts in the case.
Certificates of Participation (COPs)	City and County of San Francisco	Used for acquisition of existing facilities or construction of new facilities that result, on a present value basis, in immediate or future savings in payments currently made or to be made by the City's general fund. For example, COPs may be used to provide funds to execute a lease purchase option for a facility through which future savings accrue, on a net present value basis, to the general fund during the period for which the COPs and the obviated lease would be outstanding.
Departmental General Revenue Bonds	SFO, SFPUC, SFMTA, Port	Revenue bonds are a type of debt that is repaid from department or other revenue streams. Revenue bonds are typically used by the City's enterprise departments (SFMTA, Port, SFPUC, and SFO), which generate their

Resource	Department / Agency	Ability to Support Resilience
		own revenues from fees paid by users of services provided by those agencies. This type of debt is repaid solely by users of those projects and therefore does not require payments from the General Fund.
Finance Staff	Department-specific Office of Public Finance	Manages grants and utilizes three principal types of municipal debt obligations to finance long-term capital projects and the acquisition of select equipment. Other departments with financial or grant personnel include DEM, Port, Planning, SFMTA, SFPUC, SFE, and RPD.
Financing District: Business Improvement Districts	City and County of San Francisco	The City can levy an assessment against businesses or property to fund services or improvements that benefit the assessed value of businesses or property within a given overlay area
Financing District: Infrastructure Finance District	City and County of San Francisco	Uses Property tax increment revenues to finance infrastructure projects
Financing Districts: Special Assessment Districts	City and County of San Francisco	The City can form assessment districts that fund a portion of public facilities and service costs to provide a "Special" benefit to parcels paying the assessment. This cost has to be separate from the general costs to properties inside and outside of the district for those facilities and services. Therefore, mutual benefits must be disaggregated through the use of formulas to determine different benefit shares. Examples include Geological Hazard Abatement Districts (GHADs), Integrated Financing Districts, and can have numerous forms of special purposes based on the needs of the jurisdiction.

Resource	Department / Agency	Ability to Support Resilience
Financing Districts: Special Tax Districts	City and County of San Francisco	Special taxes are imposed through Community Facilities Districts (CFDs). CFD special taxes are levied on parcels within a district, without the need to distinguish between special and general benefit. The City and County can create the special tax formula in order to garner the broadest landowner support and maximize revenue. For example, a CFD could fund resilient infrastructure by levying special taxes on the basis of exposure to rising sea levels and amount of property protected (e.g. building square footage).
General Obligation (GO) Bonds	City and County of San Francisco	GO Bonds are appropriately used for the construction or acquisition of improvements to real property broadly available to San Francisco residents and visitors. Such improvements include, but are not limited to, libraries, hospitals, parks, public safety facilities, educational facilities, and housing.
General Taxes	City and County of San Francisco	General tax revenues can be used to fund adaptation projects as a portion of general fund budgets.
Green Bonds	City and County of San Francisco	Green bonds are issued to fund projects with environmental or climate adaptation benefits. Standards for these bonds are set by the International Capital Market Association and the Climate Bonds Initiative. SFPUC has experience issuing these bonds in the past.
Impact Fees	City and County of San Francisco	A development impact fee is an exaction that is imposed as a precondition for the privilege of developing land. Such fees are commonly imposed on developers in order to lessen the impacts of increased population or demand on services generated by that development.
Lease Revenue Bonds	City and County of San Francisco	Lease revenue bonds are appropriately used to finance capital projects that (1) have an identified budgetary stream for repayment (e.g., specified fees, tax receipts, etc.); (2)

Resource	Department / Agency	Ability to Support Resilience
		generate project revenue but rely on a broader pledge of general fund revenues to reduce borrowing costs; or (3) finance the acquisition and installation of equipment for the City's general governmental purposes.
Long-Range Financial Management	Mayor's Office Board of Supervisor's Controller's Office	Forecasts the impact of existing service levels and policies on revenue and expenditures, considering departmental operations, facilities, debt management, capital, and technology. Institutionalizes financial policies that increase resilience. These measures include budget stabilization reserves, economic resiliency and recovery planning, interfund borrowing provisions, GO Bond authorization, and state/federal assistance programs.
Pooled Financing	City and County of San Francisco	These can come in numerous forms but generally the main goal is to have multiple agencies pool their resources and issuing joint public bonds in order to pay for capital improvements that may cross jurisdictional lines. Numerous types: Joint-use facility pool, dedicated pools, blind pools, and composite issues.
Property Assessed Clean Energy (PACE)	Various regional Joint Powers Authorities (JPA's) with PACE Program Administrators)	100% upfront, long-term financing for energy efficiency and renewable energy projects om privately owned property, paid back as a non-ad valorem assessment added to property taxes. Recent state bill added fire protection measures as a PACE-eligible measure.
Public-Private Partnerships	Various Departments, City Administrator	Includes the use of professionals and professional associations for research and development of plans, guidance, recommendations, etc.
Resilience Bonds	City and County of San Francisco	Similar to CAT bonds but may also provide financing for adaptation and resilience projects. Financing comes from rebates to sponsor government action where rebates are used to reduce exposure and risk. Thereby,

Resource	Department / Agency	Ability to Support Resilience
		investor risk is reduced and premiums go down for the sponsoring entity.
Seismic Retrofit Financing	City and County of San Francisco	The City is offering a public financing option through AllianceNRG/ Counterpointe Sustainable Real Estate (CounterpointeSRE) to help property owners make soft story retrofit improvements to their properties more affordable. PACE Financing is offered for thousands of risk mitigation, energy efficiency, and water conservation improvements. Property owners can enhance the property's value while also promoting a more sustainable and safer environment.
Stormwater Floodproofing Grant Program	SFPUC	Provides grants for property owners who experience flooding from the sewer system or adjacent public right-of-way caused by heavy rains. The program was recently enhanced to include improved funding, technical assistance.
Green Infrastructure Grant Program	SFPUC	The Green Infrastructure Grant Program funds the design and construction of green stormwater infrastructure on large public and private properties, with the goal of reducing stormwater runoff while delivering public benefits. Project types can include permeable pavement, bioretention, rainwater harvesting, rain gardens, and vegetated roofs.

TABLE C-2: PUBLIC ASSET OWNER CAPABILITIES

Resource	Department / Agency	Ability to Support Resilience
Ambulance Deployment Facility	SFFD	The current SFFD houses the entire SFFD ambulance fleet, medical equipment inventory, pharmaceuticals, and logistics and is located in a structure that is extremely susceptible to seismic

Resource	Department / Agency	Ability to Support Resilience
		damage. Currently, there is a new Ambulance Deployment Facility being constructed as it's replacement.
Asset management and repair assessment	Public Works SFMTA	Asset management tool for roads and street structures that helps prioritize repair work and establish fiscal year projects. Projects are submitted through the capital plan process for funding. This process could be adapted to include hazard vulnerability in DPW annual inspection process. The SFMTA is committed to maintaining its transportation infrastructure in a State of Good Repair. State of Good Repair is defined as the condition in which a capital asset is able to operate at a full level of performance. This is done by monitoring the assets its condition, and age, and establishing performance metrics. Additionally, the SFMTA's Asset Management Program has established a Transportation Asset Management Policy and set forth goals consistent with the Federal Transit Administration's requirements for Transit Asset Management.
Building Occupancy Resumption Program	DBI	The Building Occupancy Resumption Program consists of three basic phases geared towards reducing the potential disruptions from earthquake hazards by streamlining the inspection and safe reoccupation of buildings through the creation of inspections plans before an event. The first is the assessment of the building and preparation of a BORP program, including a building-specific post-earthquake inspection plan. The second phase includes annual update and renewal activities, the maintenance portion of the work. The third phase is the post-disaster implementation of the program.

Resource	Department / Agency	Ability to Support Resilience
Emergency Firefighting Water System (EFWS)	SFPUC	The purpose of the EFWS is to provide the San Francisco Fire Department (SFFD) with a high-pressure fire suppression water system that can be utilized during large fires. The system is vital for protection against the loss of life, homes, and businesses from fire following an earthquake and non-earthquake multiple-alarm fires. Following a 2014 planning study, projects were identified to increase the systems citywide reliability following seismic events from 47% to 94%.
Engineers or professionals trained in construction practices related to buildings or infrastructure	DBI/Public Works/ADM/ SFPUC SFMTA/SFO/SFE/Port	DBI oversees enforcement of the San Francisco Building, Housing, Plumbing, Electrical, Mechanical, and Disability Access Codes. Public Works maintains city roads and street structures; promotes the undergrounding of overhead utilities; and provides architectural, civil, structural, electrical, hydraulic, and mechanical engineering services, including project and construction management. Public Works also is the regulator of the Subdivision Code. The Office of the City Administrator (ADM) oversees the maintenance, operations, and management of City-owned buildings and infrastructure, technology and telephony services, and design and construction of department's capital improvements. SFPUC, under the Infrastructure Division, has engineers (Civil, Mechanical, Electrical, Structural, and Corrosion disciplines) in the Engineering Management Bureau (EMB) and construction inspectors in the Construction Management Bureau (CMB).

Resource	Department / Agency	Ability to Support Resilience
		SFMTA's Capital Program and Construction oversees capital improvement programs for city's transportation initiatives and employs Civil, Mechanical and Electrical engineering. Additionally, SFMTA has subdivisions that oversee transportation engineering and bus, rail and transit right of way maintenance. SFO oversees maintenance, operations, and management of city-owned airport buildings and infrastructure, technology, and telephony services, design and construction of the SFO's capital improvements, and airport risk management. The Environment Department (SFE) works with other city departments to update and maintain the SF Green Building Code and the Municipal Green Building Code. SFE also leads green building programs and policy initiatives to advance state-of-the art practices toward sustainability in design, construction, and operation.
Executive Directive 18-04: Air Quality Emergency Response	DEM, ADM, DPH	This executive directive mandates DPH, DEM, and ADM to update existing emergency response plans for poor air quality, create a task force to establish public respite facilities, set up a structure of mutual aid around these events, and organize culturally competent regional coordination.
Neighborhood Fire Stations	SFFD	Driven by a comprehensive SFFD Capital Improvement Plan, the Neighborhood Fire Stations program addresses the most urgently needed repairs and improvement to critical firefighting facilities and infrastructure. Projects can

Resource	Department / Agency	Ability to Support Resilience
		be comprehensive, focused, or seismic in scope.
Risk Management	ADM SFO	ADM maintains the Risk Management Program for the city, which provides services to City departments by assisting them in managing their risk of injury to people and property, involving employees, City property, and the public at large. This program purchases insurance for City departments and acts in an advisory capacity with respect to workers compensation, public liability, City property, and City contracts. Risk Management is also active in bond and insurance matters to facilitate small-business contracting with the city. SFO risk management staff evaluates risk at the Airport and ensures proper mitigation for the impact of SFO-related hazards.
San Francisco International Airport Shoreline Protection Program	SFO	This program integrates the results of the Airport Shoreline Protection Feasibility Study to plan, permit, design, and construct comprehensive shoreline protections systems and storm drainage improvements to protect SFO from the impacts of sea level rise.
San Francisco Unified School District (SFUSD) Capital Improvements	SFUSD	Substantial capital improvements to 59 school sites, including addressing safety and modernization needs.
Seawall Safety Improvement Program	Port	Improvements to the Embarcadero Seawall will reduce the significant life safety seismic risk, improve current flood protection and provide a stable foundation for future adaptation to sea level rise. Full infrastructure improvements will cost up to $5 billion

ONESF
Building Our Future

Resource	Department / Agency	Ability to Support Resilience
		dollars. Phase 1 funding has been developed to address immediate life safety improvements.
Sewer System Improvement Program (SSIP)	SFPUC	The Sewer System Improvement Program (SSIP) is a 20-year citywide investment to upgrade our aging sewer infrastructure to ensure a reliable, sustainable and seismically safe sewer system now and for generations to come.
SFMTA Building Progress Program	MTA	Building Progress is a modernization program for SFMTA facilities in order to meet the needs of everyone who travels in San Francisco. The program will improve our transportation system's resiliency to climate change and seismic events. Furthermore, the program will allow us to be a better neighbor in the parts of the city that currently host our facilities. Benefits that could accompany modernizing our facilities could potentially include beautification, noise reduction and joint uses like housing or other uses that support community goals.
SFPUC Local Water Program	SFPUC	This program develops the City's local groundwater supply portfolio and ensures that we have a local source for water should a drought, earthquake or other disaster interrupt our Regional Water System supply. This includes specific projects such as the San Francisco Groundwater Supply Project, Westside Enhanced Water Recycling Project, and the Eastside Recycled Water Project
StreetTreeSF	Public Works	StreetTreeSF is a voter-approved initiative managed by San Francisco Public Works to professionally maintain and care for the 124,000-plus street trees growing throughout all neighborhoods in the City. These trees

Resource	Department / Agency	Ability to Support Resilience
		provide a variety of benefits to communities and help mitigate extreme heat and flooding hazards.
Water System Improvement Program (WSIP)	SFPUC	The Water System Improvement Program (WSIP) is a $4.8 billion dollar, multi-year capital program to upgrade the SFPUC's regional and local water systems.
Wildfire Mitigation	SFPUC	SFPUC staff and contractors continuously maintain vegetation in all watersheds to mitigate wildfire hazards as much as possible. Special attention is paid to this in summer months, when the potential for fire is increased.

TABLE C-3: PLANNING, RESEARCH, AND GUIDANCE CAPABILITIES

Resource	Department / Agency	Ability to Support Resilience
AB 617 Implementation	Multiple with Bayview Community Advocates and Marie Harrison Community Foundation	Establishes a new structure of community focused enforcement on air quality reduction goals, centered on communities impacted most heavily. Limited funding earmarked for the implementation of identified actions.
Airport Shoreline Protection Feasibility Study	SFO	Recognizing the flood risks, SFO completed an Airport Shoreline Protection Feasibility Study to better understand the deficiencies in its existing shoreline protection system. The study also provides recommendations on improvements needed to protect the Airport from 100-year flood events and sea level rise.

Resource	Department / Agency	Ability to Support Resilience
Annual Urban Forest Report	SF Urban Forestry Council	This resource establish a long-term urban forestry vision among multiple City departments and tracks metrics towards achieving these shared goals
Community Action Plan for Seismic Safety (CAPPSS)	ORCP	25-year action plan for seismic improvements targeted at private buildings.
Central SoMa Plan, Ch.6: Environmental Sustainability & Resilience	Planning	The Central SoMa plan focuses on redeveloping this section of the city to be as sustainable and resilient community as possible. To achieve this, provisions have been added to create an eco-district in the neighborhood that will include local energy generation, increased flood resiliency, and increased biodiversity among other interventions.
City and County of San Francisco, General Plan Updates.	Planning	San Francisco's General Plan is designed as a guide to coordinate the development of the city in a way that attains common goals and preserves the values of the community. These goals and values are achieved through implementation of the zoning code that undergirds the plan, this determines the land use across the city through a variety of mechanisms. Currently, the general plan is being updated in order to increase the climate resilience of the city as a whole.
City and County of San Francisco Climate Action Strategy update (2021)	SFE	The San Francisco Climate Action Plan (the Plan) charts a pathway to achieve net-zero greenhouse gas (GHG) emissions and works toward addressing racial and social equity, public health, economic recovery, resilience, and providing safe and affordable housing to all. This plan spans 7 sectors including Buildings, Zero Waste, Clean Energy, Transportation, Carbon Sequestration, housing, and Water.

Resource	Department / Agency	Ability to Support Resilience
Climate and Health Profile	DPH	Describes health impacts of climate change, maps vulnerable populations across the city, and indicators contributing to community resilience. Identifies flooding as a high priority and high health vulnerability in specific geographies such as Chinatown and Downtown; Bayview Hunters Point; and SOMA and Mission Bay.
Climate and Health Program	DPH	An initiative created in 2010 by the San Department of Public Health in recognition of the health impacts of climate change. This program develops research backed solutions to support healthy and climate-ready communities across San Francisco.
Concrete Building Safety Program	ORCP	The City of San Francisco is developing a new earthquake retrofit program to identify and strengthen vulnerable concrete buildings. The City brought together a working group of people and organizations potentially impacted to co-design aspects of the program. This has included the development of a database for concrete buildings across the City.
Crissy Field Sea Level Rise Analysis Report (2016)	Golden Gate National Parks Conservency	This report describes impacts to Crissy Field from sea level rise and identifies potential adaptation measures that protect and enhance cultural and natural assets at the park.
Disaster recovery and vulnerability assessment of information technology (IT)	DT	Currently conducting a disaster recovery and vulnerability assessment of IT infrastructure. Results of the assessment will help identify hazard mitigation projects.
Emergency managers and analysts	DEM Other Departments	DEM maintains the Emergency Response Plan and other emergency plans for San Francisco. Provides support to local response and relief activities within the Emergency Operation Center, and works closely with regional, state,

Resource	Department / Agency	Ability to Support Resilience
		and federal partners to provide information and coordinate resources and other assistance. Helps coordinate regional emergency response planning in partnership with the nine Bay Area counties and the cities of Oakland and San Jose. Highlights the importance of disaster preparedness through public education efforts; including its preparedness website, www.sf72.org, which helps San Franciscans plan for emergencies such as earthquakes, fires, severe storms, and power outages. Facilitates meetings of the San Francisco Disaster Council. Other departments with emergency management staff include San Francisco Public Works (SFPW), General Services Agency (GSA), the Port, San Francisco International Airport (SFO), the San Francisco Municipal Transportation Agency (SFMTA), and SFPUC. Public Works plans for emergency route clearance, post emergency inspection services, and debris removal.
Emergency Response Plan (ERP) (2017-Updated 2024)	DEM	Provides a high-level overview of how the City will respond to an emergency. The ERP also describes the role of the Emergency Operation Center (EOC), and the coordination that occurs between the EOC and City's departments and other response agencies. Additionally, the ERP describes how the EOC serves as the focal point among local, state, and federal governments in times of disaster. Annexes to this plan describe in more detail the actions required of the City departments, agencies, and personnel in addressing particular hazards or carrying out specific emergency functions.
ESIP (Earthquake Safety Implementation Program)	ORCP	An adjusted 30-year implementation program formally adopting the recommendations and goals of the CAPPSS to create an earthquake resilient San Francisco

Resource	Department / Agency	Ability to Support Resilience
Extreme Precipitation Study	SFPUC	This project focuses on using climate simulations of past notable storms, and two climate future scenarios, to develop a practical stakeholder guidebook for use by various San Francisco agencies when determining design standards (i.e., Level of Service Goals, Design Storms, Intensity-Duration-Frequency Curves)
General Plan Update: Environmental Justice (EJ) Framework	Planning	This framework identifies communities facing highest environmental burdens. Additionally, this community-led effort developed strategies to address environmental justice issues across multiple sectors, including Healthy and Resilient Environments.
General Plan Update: Housing Element	Planning	Per State policy, directs housing growth towards "Well Resourced Areas" which have better access to resources (adaptive capacity) and generally less exposed to hazards such as flooding and liquefaction.
General Plan Update: Safety and Resilience Element	Planning	All-hazard focused update to the general plan. Provides policies to integrate racial and social equity, environmental justice and climate resilience into the city's preparation for, response to, and recovery from disasters.
Geographic Information System (GIS)- or HAZUS-MH-skilled personnel	DT GSA, Public Works, DEM, Port, RPD, SFPUC Planning	Department of Technology's San Francisco Enterprise Geographic Information System (SFGIS) provides high-quality spatial data to City departments and to the public and offers essential mapping services to citizens through SFgov.org. These departments contain professionals trained in GIS. Used for a variety of purposes ranging from standard record keeping to detailed spatial analysis.
Guidance for Incorporating Sea Level Rise into Capital	ORCP	This guidance provides a framework for City departments to consider sea level rise within the capital planning process. This document is not made to provide specific adaptation

Resource	Department / Agency	Ability to Support Resilience
Planning in San Francisco		strategies but rather, sets a step by step process for departments to consider SLR while pursuing the assessment of their capital planning needs. It includes a guidance and a checklist for assessing the vulnerability and risk of capital projects to sea level rise.
Heat and Air Quality Resilience Project (HAQR)	DPH, ORCP, DEM	The Heat and Air Quality Resilience Project (HAQR) is San Francisco's first comprehensive approach to identify and address the public health and infrastructure impacts of extreme heat and wildfire smoke in San Francisco. It supports existing and new projects on heat and air quality through coordination between City departments, academic organizations, and community partners.
Islais Creek Adaptation Strategy	Planning	The Southeast Mobility Adaptation Strategy (SMAS) is a two-year community planning process in the Islais Creek area that will develop actionable strategies that address sea level rise and coastal flood risk through a robust public engagement process. Building on the Resilient by Design proposal and other city and regional efforts, the SMAS will develop a long-range vision for the Islais Creek shoreline, asset-specific solutions for public infrastructure, and a prioritized funding and implementation strategy that increases the resilience of the community and provides improved transportation networks and new open space. This will include robust public engagement over the lifetime of the planning period.
Lifelines Restoration Timelines Project	ORCP	The goal of the project is to help the City and County of San Francisco and its people more quickly recover from a major earthquake by assessing ways to reduce damage to critical systems, and therefore, improve the restoration performances of lifelines (transportation, communication, water and wastewater, electricity, natural gas, and fuel). By identifying the gap between current recovery performance and recovery performance goals, targeted

Resource	Department / Agency	Ability to Support Resilience
		improvements can be developed and implemented.
Long-term Vulnerability Assessment and Adaptation Plan for the SFPUC Water Enterprise	SFPUC	The SFPUC Water Enterprise has conducted a long-term vulnerability assessment to its levels of service for the Regional Water System (RWS). This vulnerability-based planning approach will explore a range of future conditions to identify vulnerabilities, assess the risks associated with these vulnerabilities and later develop an adaptation plan that is flexible and robust to a wide range of future outcomes. This plan will guide water supply decisions to reduce the risk of particular vulnerabilities of the Hetch Hetchy Regional Water System (RWS) over the next 50 years or longer.
Ocean Beach Master Plan	SFPUC, RPD, MTA, Planning	The Ocean Beach Master Plan, completed in 2012, lays out a vision for adapting to a changing coastline at Ocean Beach. It is the result of a two-year process that brought together community members and numerous public agencies to consider the area's future as erosion continues.
Planners or engineers with knowledge of land development, land management practices, and human-caused and natural hazards	Planning Department SFPUC Public Works Port Recreation and Parks Other Departments	Planning develops and maintains the General Plan, including the Community Safety Element. Develops area plans based on the General Plan to provide more specific guidance for the development of the various neighborhood areas. Reviews of private development projects and proposed capital improvements projects and other physical projects involving property for consistency and conformity with the General Plan. Design Guidelines and Design Review for vertical development in the City. Anticipates and acts on the need for new plans, policies, and Planning Code changes. Applies approved General Plan Elements, Area plans, policies, Planning Code, and other regulations to proposed land use decisions. Planning capacity may also be applied to the Other city departments with planning personnel including the Port of San Francisco (Port), the

Resource	Department / Agency	Ability to Support Resilience
		Recreation and Parks Department (RPD), Department of the Environment (SFE), San Francisco Municipal Transportation Agency (SFMTA), Public Works, and the San Francisco Public Utilities Commission (SFPUC).
Planning for Sea Level Rise: Treasure Island Development Project	Treasure Island Community Development	Identifies specific adaptation needed to support current and future development of Treasure Island. This includes stipulations for building pad heights, infrastructure provision for shoreline protection and laying an adaptive management strategy to adjust to future water levels.
Port of San Francisco Stormwater Management Plan (2003)	Port	Describes measures the Port will take on Port property to minimize stormwater ponding and pollution.
Resilience Framework	SFO	This high-level road map detailing changes needed to Airport critical facilities to ensure continuity of service in case of major disasters. Implementation of this framework ensures airport can fulfill its local and regional support function in future disaster events.
Resilient By Design: Islais Creek	Planning	In May 2018, the Resilient by Design Bay Area Challenge launched design concepts for nine sites including one in the Islais Creek area in San Francisco. The design developed by the BIG+Sherwood team includes a restored creek with public spaces offering recreational amenities, as well as industrial zones clustered in a jobs and logistics hub.
Resilient San Francisco	ORCP	This plan sets a bold strategy for the city to deal with the most pressing interconnected challenges of the 21st century. This plan sets out actionable goals to address challenges ranging from sea level rise and climate change to social inequity and unaffordability.

Resource	Department / Agency	Ability to Support Resilience
San Francisco Climate and Health Adaptation Framework	San Francisco Climate and Health Adaptation Framework	San Francisco Climate and Health Adaptation Framework
San Francisco Transportation Sector Climate Action Strategy (2017)	MTA	The strategy contains seven climate mitigation program areas with actions to reduce greenhouse gas emissions and five climate adaptation program areas that provide the framework for building a more resilient transportation system.
Sea Level Rise Action Plan	Planning	The SLR Action Plan defines an overarching vision and set of objectives for future sea level rise and coastal flooding planning and mitigation in San Francisco.
Sea Level Rise Vulnerability and Consequences Assessment	Planning	This study shows the vulnerability of city-owned assets to a wide range of future bay water levels and the consequences for society, economy, and the environment. The assessment analyzes numerous sea level rise scenarios to identify impact tipping points to inform citywide planning and capital improvement efforts
SFPUC Climate Adaptation Plan	SFPUC	The SFPUC Climate Adaptation Plan lays the foundation to safeguard San Francisco's wastewater enterprise by identifying the stressors and vulnerabilities due to climate change impacts. This facilitates SFPUC's mission to provide quality service and environmental stewardship to the residents of San Francisco
SFPUC Climate Stressors and Impacts: Bayside Sea Level Rise Mapping	SFPUC	This technical memorandum provides context for the ongoing assessment of SSIP projects for their vulnerability and risk from climate change impacts, particularly focused on Bayside assets.

Resource	Department / Agency	Ability to Support Resilience
Solar+Storage for Resilience Assessment	SFE	San Francisco's Solar+Storage for Resiliency project is a national model for integrating solar and energy storage into City emergency response plans. With the grant funding, SFE examined the possibility of solar plus storage in both individual and groups of buildings in the event of the next large-scale disaster in San Francisco, and developed resources and tools, such as Best Practice Guide and SolarResilient.org, a sizing tool for solar PV and battery storage systems. (SF Environment)
Sustainable Chinatown Plan Implementation	RPD, Planning, SFPUC	Sustainable Chinatown aims to protect those most vulnerable to climate change and gentrification by improving the neighborhood's environmental performance, ensuring long-term cultural resilience and maintaining affordability of housing and commercial properties threatened by a speculative market. (SF Planning and SF Environment)Current implementation projects include the improvement of all existing park features in Portsmouth Square including buildings, pedestrian bridges, landscaping, adjacent streetscapes, and associated site work to include more greenspace and the development of a community/cooling center. Another project includes the installation of a parklet/living alleyway spearheaded by PUC.
Tall Buildings Safety Strategy	ORCP	This strategy stems from the 2012-2042 work plan developed through the ESIP program and presents key recommendations to begin understanding and addressing the unique seismic challenges facing the City's tall buildings.
U.S. Army Corps of Engineers General Investigation Feasibility Study	Port	Congress and the White House awarded the Port New Start for a General Investigation that will analyze the entire Port jurisdiction and can bring substantial amounts of federal money for projects that protect not only the Port, but the City broadly. As a result, a new General Investigation Feasibility Study is beginning. The

Resource	Department / Agency	Ability to Support Resilience
		study is targeted to be complete in 3 years and will hopefully culminate in one or more flood risk reduction projects to protect stretches of the City's Bayfront, from Fisherman's Wharf to Heron's Head Park at Cargo Way, including Mission Creek and Islais Creek.
Understanding the Risk: An Assessment of San Francisco's Vulnerability to Flooding & Extreme Storms	DPH	This risk assessment provided relevant information to develop adaptive measures that protect public health in the face of climate change related extreme weather events. Specifically, this assessment is designed to prepare the San Francisco Department of Public Health and the City for both the direct and indirect health impacts of flooding.
Understanding the Risk: An Assessment of San Francisco's Vulnerability to Extreme Heat Events	DPH	This report provides an overview of the health department's study of neighborhoods that are especially vulnerable to extreme heat in San Francisco, California. The assessment will inform climate change adaptation planning efforts including a heat wave disaster response plan.
Urban Water Management Plan: 2015 Update	SFPUC	As water supplies become more vulnerable due to drought and the effects of climate change, it is critical that we diversify our water supplies to add more local sources into our water portfolio. Urban Water Management Plan (2015) presents the latest information on the San Francisco Public Utility Commission's service areas, Hetch Hetchy Regional Water System and other water systems operated by the SFPUC, system supplies and demands, water supply reliability, Water Conservation Act of 2009 compliance, water shortage contingency planning, and demand management.
Waterfront Resilience Program/Army Corps Flood Study	Port/USACE	The Draft Plan was released in February 2024 and includes selected seismic and flooding adaptation strategies along the Port's 7.5 miles of waterfront, including costs and benefits, potential federal investment, and local cost share.

TABLE C-4:
ADOPT AND ENFORCE REGULATIONS CAPABILITIES

Resource	Department / Agency	Ability to Support Resilience
100-Year Storm Flood Risk Map and Ordinance	SFPUC	This ordinance requires information be provided to existing and future property owners and those leasing properties about flood risks on the properties within the 100-year storm flood risk map area.
Administrative Code	n/a	Specific chapters of the code that address hazards include: Chapter 66 – Seismic Safety Retrofit Program Chapter 66A – Seismic Safety Loan Program--Implements a program to lend taxable general obligation bond proceeds to building owners to finance the seismic retrofit of unreinforced masonry buildings. Administrative Code updates for Urban Flood risk
Building Code (2022), including California Residential Code (2022) and California Green Building Standards Code (2022)	n/a	Establishes minimum requirements to safeguard the public health, safety, and general welfare through structural strength, means of egress facilities, stability, access to persons with disabilities, sanitation, adequate lighting and ventilation, energy conservation, and safety to life and property from fire and other hazards attributed to the built environment; to regulate and control demolition of all buildings and structures, and the quarrying, grading, excavation, and filling of land; and to provide safety to fire fighters and emergency responders during emergency operations
San Francisco Biodiversity Guidelines	SFE	The Biodiversity Guidelines translate various Local, State, National and International biodiversity plans and policies, into concrete actions that support the City's biodiversity goals and the conservation and restoration of San

Resource	Department / Agency	Ability to Support Resilience
		Francisco's natural heritage. These guidelines are a tool for integrating biodiversity into the built environment.
Construction and Demolition Program	SFE	In partnership with DBI, Public Works, DPH, SF Planning, and many private sector actors, this program aims at reducing the number of materials needlessly discarded to existing landfills by increasing the amount of materials reused/recycled from demolition or construction activities within the city. This reduces the possibility that the city exceeds landfill capacity in the case of an emergency/disaster.
Façade Maintenance Ordinance	ORCP	The program was established by Ordinance 67-16 which amended 2016 San Francisco Existing Building Code to require that San Francisco building facades be regularly inspected by a California licensed architect or engineer and maintained. The inspections are meant to ensure public safety and reduce the risk of death or injury resulting from deteriorated building façade elements falling onto streets and sidewalks below.
Fire Code	n/a	Regulates and governs the safeguarding of life and property from fire and explosion hazards arising from the storage, handling, and use of hazardous substances, materials, and devices, and from conditions hazardous to life or property in the occupancy of buildings and premises; provides for the issuance of permits, inspections, and other Fire Department services, and the assessment and collection of fees for those permits, inspections, and services.
Health Code	n/a	Specific chapters that address hazards include: •Article 2 – Communicable Diseases •Article 21 – Hazardous Materials: Provides information on the location, type, and health risks of hazardous materials used, stored, or disposed of in the City to firefighters, health

Resource	Department / Agency	Ability to Support Resilience
		officials, planners, elected officials, and residents. •Article 21A – Risk Management: Implements a program for prevention of accidental releases. •Article 22 – Hazardous Waste Management: Regulates local facilities that generate or treat hazardous waste. •Article 30 – Regulation of Diesel Backup Generators: Regulates the use of diesel backup generators •Article 38 – Enhanced Ventilation Required for Urban Infill Sensitive Use Developments
Housing Code	n/a	Provides for the maintenance of minimum requirements for the protection of life, limb, health, property, safety, and welfare of the general public and the owners and occupants of residential buildings in San Francisco.
Local Coastal Program Amendment (Ocean Beach)	Planning	The Local Coastal Program is a policy and regulatory document required by the California Coastal Act that establishes land use, development, natural resource protection, coastal access, and public recreation policies for San Francisco's Coastal Zone. Amendments to this document are essential to implementing the aspects of the Ocean Beach Master Plan.
Municipal Green Building Code	n/a	In addition to the requirements of the San Francisco Green Building Code, city-owned facilities and leaseholds are subject to the requirements set by Chapter 7 of the Environment Code, which requires LEED certification from the US Green Building Council for all new construction projects and major alterations for projects >10,000 SF, and additional measures such as Solar+Storage feasibility analysis for certain public facilities; and for projects less than or equal to three stories above grade, design teams shall determine the feasibility of designing and constructing such project to have zero net annual site energy consumption, including all building end uses.

Resource	Department / Agency	Ability to Support Resilience
Planning Code	n/a	Establishes procedures rules and regulations governing the composition and form of urban development within the city. This can include provisions for Living Roofs, Special Use Districts that include sea-level rise adaptation, increased bike parking, and more flood resilient street designs.
Port Building Code	n/a	•Specific chapters that address hazards include: Chapter 7 – Fire Resistance Rated Construction Chapter 7A – Materials and Construction Methods For Exterior Wildfire Exposure Chapter 9 – Fire Protection Systems Chapter 10A – Security Systems Chapter 13 – Resource Conservation Chapter 13A – Commercial Water Conservation Chapter 16 – Structural Design Chapter 31F – Marine Oil Terminals
Private School Earthquake Program	DBI	Per the Private School Earthquake Program, existing private elementary and secondary schools in San Francisco are now required to obtain an earthquake evaluation of their campus. The goal of this program is to ensure that all private school structures are safe for the students who attend them and the staff who teach there. The associated ordinance, number 202-14, amends the building code to make the assessment mandatory for applicable buildings.
Public Works Code	n/a	Specific chapters that address hazards include: •Article 4 – Sewers: Article 4.2, Sewer System Management, protects and enhances sewer system water quality and stormwater collection by minimizing increases in pollution from stormwater runoff; by controlling discharges to the sewer and drainage systems from spills, dumping, or disposal of pollutants; and by reducing stormwater run-off rates, volume, and nonpoint source pollution through stormwater management controls. •Article 16 – Urban Forestry Ordinance: Promotes the planting and maintenance of trees and green spaces in public places to

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Resource	Department / Agency	Ability to Support Resilience
		favorably modify microclimates, abate air and noise pollution, and reduce soil erosion and runoff. •Article 18 – Utility Facilities: Regulates activities such as undergrounding utilities in designated areas of the jurisdiction, which can contribute to their resiliency to certain hazards •Article 22: Reclaimed Water: Regulates effective management of limited water resources by creating provisions allowing for the use of reclaimed water in certain development situations
San Francisco Floodplain Management Program: National Flood Insurance Program (NFIP)	ADM	San Francisco is a member of the National Flood Insurance Program (NFIP). Finalized maps were released for the program in March 2021. The Floodplain Manager is responsible for working with stakeholders to ensure the Floodplain Damage Prevention Ordinance is followed. Under this program, which is managed by FEMA, the Federal government makes flood insurance available at affordable rates in the city. Homeowners, renters, and businesses in areas of the City that are subject to flooding during severe storms are eligible to purchase Federally subsidized flood insurance to financially protect their properties. San Francisco will continue to adhere to all NFIP requirements.
San Francisco Stormwater Ordinance and Design Guidance	SFPUC, Port	The guidelines require new development and redevelopment disturbing 5,000 square feet or more of ground surface to manage stormwater on-site using low impact design (LID) strategies such as vegetated roofs, wales, rainwater harvesting, and rain gardens. The Guidelines protect THE CITY by reducing the wet weather burden on its combined sewer and by reducing pollution in stormwater runoff in areas of new development and re development.
SFPUC Non-Potable Water Program	SFPUC	The Non-potable Water Program details the steps that must be taken to collect, treat, and use non-potable water in commercial, mixed-use, and multi-family residential developments. The program also outlines the oversight of the

Resource	Department / Agency	Ability to Support Resilience
		SFPUC and the City's Departments of Public Health (SFDPH) and Building Inspection (DBI) during the review process. This amendment added Article 12C to the San Francisco Health Code, allowing for the collection, treatment, and use of alternate water sources for non-potable applications in individual buildings and at the district-scale.
Soft Story Retrofit Ordinance and Program	DBI	This program administers mandatory retrofits to wood-frame buildings of three or more stories, or two stories over a basement, or underfloor area that have any portion extending above grade containing five or more residential dwelling units where the permit to construct was applied for prior to January 1, 1978, and where the building has not yet been seismically strengthened. This targets buildings that are most vulnerable to significant damage or potential collapse in a significant earthquake event. The program has a tiered implementation structure, where buildings have different deadlines for the submission of building permits as well as the completion of applicable retrofits. The program is 98% complete with DBI engaged in enforcement actions for the outstanding units.
Subdivision Code	n/a	Establishes procedures and requirements for control and approval of subdivision development within the city in accordance with California Subdivision Map Act (SMA); ensures the development of subdivisions consistent with the objectives of the San Francisco Master Plan.
Unreinforced Masonry Building Retrofit Program	DBI	Provided $350M in bonds to retrofit privately owned UMBs to minimize potential injury or damage from earthquake hazards.

TABLE F-5:

COMMUNITY SERVICES

Resource	Department / Agency	Ability to Support Resilience
NEN: Empowered Communities Program	ADM	The Empowered Communities Program helps neighbors connect and collaborate to create stronger, healthier, safer and more resilient communities. This is done through the HUB program which activates community serving organizations to support each other and NeighborFest, an initiative that builds social cohesion and awareness through block parties and the production of other materials
National Weather Service (NWS) TsunamiReady and StormReady Status	DEM, SFO	To achieve TsunamiReady and StormReady status, San Francisco County incorporated severe weather threats into the HMP and the Emergency Response Plan; maintains a 24-hour warning point and an emergency operations center; established multiple ways to receive severe weather warnings and forecasts and to alert the public; created a system to monitor weather conditions locally; and promoted public readiness through community seminars, severe weather spotter training, and by conducting emergency exercises. In addition, San Francisco International Airport became a NWS StormReady Commercial Site in 2009, and a TsunamiReady Commercial Site in 2013.
Public Information Officers (PIO)	Department-specific	Provide public and media information regarding disaster preparedness, response, mitigation, and recovery efforts. Gather and integrate community input into resilience and hazard mitigation planning processes. The city departments with PIOs include DEM, SF Planning, SFFD, SFPD, the Port, SFO, and SFPUC.
Community Training on Emergency Preparedness	DPH	The Department of Public Health has developed and offers community trainings and multilingual informational sheets on a variety of emergency preparedness topics: e.g. Psychological First Aid, storm and flood

Resource	Department / Agency	Ability to Support Resilience
		impacts, extreme heat impacts, and proper shelter-in-place practices. The presentations and tip-sheets are provided by DPH staff and are also available for trainers in other organizations to provide to their staff and/or the public.
Public Preparedness Education	San Francisco Fire Department (SFFD) Neighborhood Emergency Response Team (NERT) San Francisco Animal Care and Control (ACC) Disaster Animal Response Team (DART) SFPD Auxiliary Law Enforcement Response Team (ALERT) SF Planning	NERT offers free disaster preparedness training to thousands of San Francisco residents and to those who work in the city. Provides an organizing framework and support to neighborhood NERT teams, which self-deploy in the event of a serious earthquake or other major disaster. DART offers free training in caring for and sheltering animals in a disaster. Volunteers assist ACC in staffing animal shelters in disasters. Participants must complete basic NERT training in order to volunteer. ALERT offers free training to those who live, work, or attend school in the city in how to assist law enforcement during disasters, including performing traffic control, reporting criminal activity, assisting at an SFPD incident Command Post, providing well-being checks, securing resource locations, and delivering logistical supplies. Participants must complete basic NERT training in order to volunteer. SF Planning educates the public on resilience issues and gathers/ incorporates community input into the planning process
Zero Waste Outreach	SFE	Through maximization of the use of the three primary residential and commercial zero waste programs, the city can reduce the amount of unnecessary materials headed to landfill sites, thus saving their capacity for use when disasters or other major hazard events strike. Current programs will be expanded in the future to increase promotion and community education. These efforts also assist the city in meeting state regulatory requirements.

Appendix D

Response to Public Comments

The following section details the e-mail submissions received during the Draft 2025 Hazards and Climate Resilience Plan public comment period, from July 29 to September 30, 2024. The table includes a summary of the comment, as well as the associated action and explanation. For a summary of overall public feedback received during the plan update process, please see Chapter 02: Planning Process.

Summarized Comment	Topic	**Action Key** A – Revision made B – No revision recommended C – Applicable to future implementation or other resource	Response / New Draft Text	Commenter
• Notes that the city has no plans or reports in reference to dead, dying and dangerous trees.	Biodiversity/Open space	A	The San Francisco Environment Department produces the Annual Urban Forest Report that includes detailed information on budgets, staffing, maintenance activities, and concerns. While it does report trees removed, we do not account for dying and dangerous trees, as this would require citywide surveys of tree health and none of the reporting agencies have the staff or funding to do this. The Annual Urban Forest Reports will be added to the HCR's Capabilities Section (Chapter 6 and Appendix C) to increase their visibility to readers.	Denise Louie
•Highlights the importance of focusing on reducing existing pattern of biodiversity loss.	Biodiversity/Open space	B	Agree, many nature-based solutions that support hazard mitigation and biodiversity are reflected under Objective IN 1-4: Promote, design, and use nature-based solutions to mitigate current and future hazards. "Biodiversity and Connection to Nature" is also one of the guiding principles of the HCR, described in Chapter 1: Introduction.	Susan Karasoff (Russian Hill Neighbors Parks)
•RPD Natural Resources Division is underfunded to protect San Francisco's existing remaining biological heritage.	Biodiversity/Open space	B	The HCR does not have authority over department budgets.	Susan Karasoff (Russian Hill Neighbors Parks)
•To meet San Francisco's Climate Action Plan Healthy Ecosystem targets, city agencies should plant only local native plants and introduced plants that people can eat as part of urban agriculture.	Biodiversity/Open space	A	San Francisco's Biodiversity Guidelines will be added to the Capabilities Section (Chapter 06). Growing food for communities in public open spaces will be added to Table 7.7 Additional Strategies for Consideration.	Susan Karasoff (Russian Hill Neighbors Parks)
•In Infrastructure Table 7-5, in IN-4.2, Maximize native species in plantings in parks and landscaping, remove references to "drought tolerant plants".	Biodiversity/Open space	A	Will revise the action to: "Maximize drought tolerant, native species in plantings for parks and landscaping whenever feasible." Will reference Biodiversity Guidelines and Updated Street Tree List in the description of the action.	Susan Karasoff (Russian Hill Neighbors Parks)

•Strategy IN-4.2, Green infrastructure not only applies to RPD and DPW but also every city agency that installs plants, including but not limited to the Port, SFPUC, SFPL, OCII, CCSF, SFSU, UCSF, SFUSD, SF Housing Authority, Laguna Honda Hospital, SF General Hospital, SFMTA, SFFD, SFO, OEWD, SF Children and Nature, TIDA, City contractors, non-profits who plant on city land and/or with city, state, or federal funds, state agencies, including Caltrans and the California State Parks, federal agencies including Presidio Trust and GGNRA, and private agencies like PG&E.	Biodiversity/Open space	A	The HCR designates 1-2 lead agencies maximum for accountability purposes, it is not meant to be an exhaustive list of entities with a stake in a strategy. Additional partners will be added, to the extent that the template's space allows. Agencies not listed as partners may still be involved.	Susan Karasoff (Russian Hill Neighbors Parks)
•In Infrastructure Table 7-5, IN 4.5, Adapt shoreline parks to sea level rise and saltwater intrusion using marshes and [NATIVE] plant diversity. add specification of native plant diversity here.	Biodiversity/Open space	A	Will revise IN 4.5 to: Adapt shoreline parks to sea level rise and saltwater intrusion using marshes and maximizing native plant diversity.	Susan Karasoff (Russian Hill Neighbors Parks)
•In Infrastructure Table 7-5, IN 5.3,Islais Creek: Add SFPRD to partner agencies	Biodiversity/Open space	B	No lands with RPD jurisdiction were included in the Islais Creek Mobility Adaptation Strategy. RPD will be involved in action 6.1 Develop shoreline resiliency plan by 2034 per SB 272.	Susan Karasoff (Russian Hill Neighbors Parks)

•In Communities-Related Objectives and Actions Table 7-4, in subsection C-2, Support the growth of community resilience networks to empower all people, add "Grow Food for Communities action" with the lead of every agency with public green space.	Biodiversity/Open space	A	Growing food for communities in public green spaces will be added to Table 7.7 Additional Strategies for Consideration. The City will continue to explore how it can best support community organizations that are involved in food systems resilience. Additionally, the City's General Plan / Environmental Justice Framework contains a section on Healthy Food Access (https://generalplan.sfplanning.org/Environmental_Justice_Framework.htm). It contains a vision and set of policy priorities that touch upon empowering food system workers and community members; leveraging the food system as a means of strengthening communities; and fostering climate resilience in the food system. The Planning Code also defines multiple Agriculture Use Categories which are often allowed in P-Public Use Districts (https://codelibrary.amlegal.com/codes/san_francisco/latest/sf_planning/0-0-0-48980). In addition, the HCR needs to be able to designate 1-2 lead agencies maximum for a given action for accountability and monitoring purposes.	Susan Karasoff (Russian Hill Neighbors Parks)
•Communities-Related Objectives and Actions 7-4, C-1.1, Facilitate the development of priority areas for green infrastructure investment using health-equity data, please specify using local native plants as green infrastructure with the lead of every agency with public green space.	Biodiversity/Open space	A	The City's Biodiversity Guidelines will be referenced in the HCR's Capabilities Section (Chapter 06). Will reference the City's updated Street Tree list in the description of the action. The HCR designates 1-2 lead agencies maximum for accountability purposes, it is not meant to be an exhaustive list of entities with a stake in a strategy. Additional partners will be added, to the extent that space allows. Agencies not listed as partners may still be involved.	Susan Karasoff (Russian Hill Neighbors Parks)

•In Communities-Related Objectives and Actions 7-4, C-1.2, Develop public education initiatives to connect benefits of green infrastructure to public health, specify "using native local plants", with the lead being every agency with public green space.	Biodiversity/Open space	A	The City's Biodiversity Guidelines will be referenced in the HCR's Capabilities Section (Chapter 06). The HCR designates 1-2 lead agencies maximum for accountability purposes, it is not meant to be an exhaustive list of entities with a stake in a strategy. Additional partners will be added, to the extent that space allows. Agencies not listed as partners due to space constraints may still be involved.	Susan Karasoff (Russian Hill Neighbors Parks)
•Request that the city report every year on the status of every endangered and threatened species in San Francisco, including health, quality (reduced invasive species) and quantity of surrounding ecosystem that provide food and habitat for each endangered and threatened species in San Francisco. Federal, California Department of Fish and Wildlife (CDFW) and/or IUCN Red List provide endangered and threatened species lists. List of endangered, rare, and threatened species provided.	Biodiversity/Open space	B	This comment is outside of the scope of the HCR.	Susan Karasoff (Russian Hill Neighbors Parks)
•City, State, and Federal tree planting funds should be used to plant local native trees in all tree planting situations. City should avoid planting medium water use trees that don't require	Biodiversity/Open space	B	The City's updated Street Tree list will be referenced in Action C-1.1 and IN-4.2.	Susan Karasoff (Russian Hill Neighbors Parks)
•Request for planting local native trees to mitigate landslides. Commenter noted the number of trees that have been impacted by landslides in 2022-2023 and 2023-2024 wet season.	Biodiversity/Open space	A	The City's Biodiversity Guidelines will be referenced in the Capabilities Section (Chapter 06).	Susan Karasoff (Russian Hill Neighbors Parks)

• Requests reports on underground aquifers for environmental quality issues.	Biodiversity/Open space	C	Currently, SFPUC performs annual and triennial reporting on water quality for the San Francisco Regional Water system. This reporting included groundwater quality and can be found online through SFPUC water quality webpage.	Susan Karasoff (Russian Hill Neighbors Parks)
•To pay for San Francisco Resilience projects, write grants to fund resilience initiatives as soon as possible. It can take years for native species to integrate into the ecosystem and start to provide benefits, therefore we should move as fast as possible.	Biodiversity/Open space	B	Grants are a funding source identified in numerous actions relating to green infrastructure and biodiversity. Departments will pursue grants to the extent feasible.	Susan Karasoff (Russian Hill Neighbors Parks)
•The plan fails to acknowledge and address the role of corporate and agency malfeasance in exacerbating potential hazards, especially in the Bayview and on Treasure Island. Specifically, related to Tetra Tech and other cleanup contractors.	Contaminated Sites	C	As a Citywide resilience plan with a focus on natural hazards, it is not feasible for the HCR to provide a detailed account of specific contaminated sites and the activities of regulatory agencies and remediation contractors. The HCR provides high level information about resilience-related actions at Hunters Point Shipyard and Treasure Island so that community members may get involved in on-going community processes for those sites, if interested.	Eric Brooks (San Francisco Bay Shoreline Contamination Cleanup Coalition)
•The Plan must specifically identify capped or contained contamination as a hazard. The plan must ensure that no remediation plans include leaving waste left in place in order to protect current and future generations. The plan should define a cleanup standard that does not allow waste to be capped or contaminated at sites that are or could be vulnerable to sea level rise and groundwater rise.	Contaminated Sites	C	Section 4.13 specifically identifies contaminated lands as representing a hazard, and that sea level rise threatens to alter and mobilize pollutants thought to be sufficiently abated by site-scale remediation efforts. The HCR is not a regulatory document, and it has no authority over remediation standards. However; regulatory agencies for contaminated sites in San Francisco, including the San Francisco Department of Public Health, California Department of Toxic Substances Control, San Francisco Bay Regional Water Quality Control Board, and the United States Environmental Protection Agency, all follow the latest science, policy, and guidance, to determine how best to address sea level and groundwater rise impacts on existing and new remediation efforts, for the protection of public health, safety, and the environment.	Skylar Sacoolas (Greenaction for health and environmental justice)

The Plan outlines some specific details about the Hunters Point Naval Shipyard but fails to mention critical hazards related to waste left in place and planned development. Additional actions must be included that provide standards for the cleanup of the historical radioactive and toxic waste that remains at the shipyard. The Navy's latest Five-Year Review report for the Hunters Point Naval Shipyard continues to falsely claim the current and proposed asphalt and vegetative covers/caps will remain protective of human health and the environment, even in conjunction with sea level rise, groundwater rise, and storm surges.	Contaminated Sites	C	Hazards related to contaminated lands are described in the Hazardous Materials Release Hazard Profile (Section 4.13 and Appendix A: Vulnerability and Consequences Assessment: Contaminated Lands) As described in Action C-1.6, The Hunters Point Shipyard is a federal Navy site and the Navy selected the remedy with regulatory agencies, including EPA, DTSC, and RWQCB. The Navy is required to consider climate change impacts in their 5-Year Review, including the Appendix A Climate Resilience Assessment. Future findings from this Assessment may require reconsideration of the planned remedies.	Skylar Sacoolas (Greenaction for health and environmental justice)
•In Table Communities-Related Objectives and Actions 7-4, C-1.5, Conduct studies to better understand how sea level rise may interact with contaminated lands and potential health risks, please add a requirement to report this data to the public.	Contaminated Sites	B	The HCR does not have the authority to make data reporting requirements, but the intention of this action is to produce data and other information resources for the public.	Susan Karasoff (Russian Hill Neighbors Parks)
•In Table Communities-Related Objectives and Actions 7-4, C-1.6, Protect human health and the environmental through close involvement in the framework of property controls and mitigations at the Hunters Point Shipyard, please add a requirement to report this data to the public.	Contaminated Sites	B	The HCR cannot make data reporting requirements. However, information pertaining to the action is already publicly accessible and will continue to be. https://www.sf.gov/hunters-point-naval-shipyard	Susan Karasoff (Russian Hill Neighbors Parks)
•To speed feedback process, free Wi-Fi should continue to be provided at all SFPL locations and free Wi-Fi should be expanded to all	Extreme heat and poor air quality	C	Currently, free Wi-Fi is available at over 40 recreation and park facilities across the city and there is currently a fiber to housing program that is expanding access to affordable housing around the city. Regarding air conditioning, adding	Susan Karasoff (Russian Hill Neighbors Parks)

city buildings, including schools. Air conditioning should also be provided at all city buildings to provide a variety of places for people to shelter in response to heat and air quality issues.			air conditioning to every city building as a response to heat and air quality issues would be prohibitively expensive and every city building is not poised to serve a respite and shelter role in the face of those kinds of emergencies. In the plan strategy B-2.2 relates to working to identify which city facilities can best provide a public respite function and working to implement programs to move them into that function. The city continues to make efforts to analyze its building stock to determine where it is feasible to improve air conditioning potential.	
•Make it faster for PG&E to add electrical upgrades to buildings to add energy efficient, low carbon building management appliances. Currently can take up to a year to upgrade building electrical systems for these upgrades.	Extreme heat and poor air quality	C	The City does not have direct control over PG&E and the speed at which it approves electrical upgrades and also experiences long waits. We agree that speeding this up is critical and the City is trying to work with PG&E to accelerate the transition to all electric buildings. You can find out more about the various efforts toward that end in the Climate Action Plan.	Susan Karasoff (Russian Hill Neighbors Parks)
•In Table Communities-Related Objectives and Actions 7-4, C-3.3, Develop and improve systems for hazard and climate resilience data, please add a requirement to report this data to the public.	Hazard data	B	The HCR cannot make data reporting requirements, but the intention of this action is to produce data and other information resources for the public.	Susan Karasoff (Russian Hill Neighbors Parks)
•Specific ask regarding where/how wind speed is measured	High Wind	A	Wind speed determination is referenced on pg.143 of the High Wind hazard profile.	Pam Helphill
•Requests clarification on discrepancy between Mission Bay being denoted as having no data in figure 4-24, and it being listed as an area with greatest risk of large urban fires on page 165	Large Urban Fire	A	The figures in the Large Urban Fire hazard profile were produced prior to the redevelopment of the Mission Bay neighborhood. As a result, the area is characterized as none/no data categorization. Mission Bay was likely included in the list due to historical factors, such as large amounts of construction. However, in its current state, the Fire Department believes the risk to be low.	Joy Glasier
The plan underestimates the risk of a large urban fire and could have more proactive measures for that hazard. Numerous factors	Large Urban Fire / Wildland-Urban Interface Fire	B	The HCR uses the best available science from federal, state, and local agencies. The Large Urban Fire risk assessment was completed by Charles Scawthorn for the City's Earthquake Safety Implementation Program.	Pam Helphill

contribute to this including eucalyptus trees, densely wooded areas, as well as high winds.			In relation to vegetated areas of the city, according to state (CalFire) and federal (FEMA) sources, the risk of wildfire in San Francisco is relatively low compared to other counties in the region and compared to other hazards in San Francisco. The HCR includes 6 actions for mitigating Large Urban Fires and Wildfires. The HCR prioritizes actions that have high feasibility and high benefits for risk reduction and co-benefits.	
The plan must adopt stronger standards than the Ocean Protection Council (OPC) 2024 State Sea Level Rise Guidance, by following worst case scenario "High" SLR projections which the current Intergovernmental Panel on climate Chante (IPCC) Sixth Assessment Report (AR6) describes as less likely. Recommend the plan adopt a standard of 5 meters within the next 100 years.	Waterfront/Sea level Rise	C	The City relies on the best available science provided through federal, state, and regional agency guidance when considering how to plan for sea level rise. This scientific basis helps the City to allocate public funds most efficiently and effectively and maintain alignment with funding agencies. While the HCR does not set City policy or guidance regarding sea level rise standards, there are two related actions: 1. The Capital Planning Committee adopts the City's Sea Level Rise Guidance for Capital Planning (Action B-3.1) within the Sea Level Rise Vulnerability Zone. An effort is currently underway to align San Francisco's Guidance with the latest state and regional guidance. The update is expected to be considered at the Capital Planning Committee in Spring 2025. 2. The City will also be creating a Shoreline Resiliency Plan that is compliant with SB 272 (action IN-6.1). This plan must also comply with sea level rise planning guidance from the Bay Conservation Development Commission (BCDC). https://www.bayadapt.org/regional-shoreline-adaptation-plan/	Eric Brooks (San Francisco Bay Shoreline Contamination Cleanup Coalition)

•The Plan lacks a comprehensive wetlands restoration strategy. The plans need to assess the entire City and County as a watershed bioregion and develop comprehensive restoration within this watershed.	Waterfront/ Sea Level Rise	C	As part of the Waterfront Resilience Program through the Port/USACE San Francisco Waterfront Coastal Flood Study (Flood Study), the Port performed analysis on the feasibility of nature-based solutions including wetlands across the 7.5 miles of Port jurisdiction. This included identifying shoreline typologies and appropriate nature-based features, including wetlands, for each typology. As an urbanized area, many areas of the San Francisco shoreline are space constrained. For these areas, the Flood Study Draft Report (Draft Report) recommends space-limited nature-based features such as living seawalls and vegetated berms. In areas with more space, the Draft Report recommends nature-based features such as wetlands expansion. These measures are described as "independent measures" in the Draft Report. The use of nature-based solutions, such as wetlands, will continue to be analyzed and integrated as feasible in shoreline adaptation planning efforts, included in the HCR such as IN-6.1: Develop subregional shoreline resiliency plan by 2034 per SB 272 and IN-6.3: Develop the Yosemite Slough Neighborhood Adaptation Plan. Wetland construction for shoreline adaptation is a key component of Action IN-6.5: "Advance the Adaptive Management Strategy from the Treasure Island Infrastructure Plan to ensure continual protection to changing conditions" and stormwater treatment wetlands are a part of IN-7.3 "Complete construction of the Treasure Island Water Resource Recovery Facility..."	Eric Brooks (San Francisco Bay Shoreline Contamination Cleanup Coalition)

•Impacted communities, especially Frontline communities facing the most serious environmental justice harms posed by SLR and climate disruption, must be included in decision making, and the Plan must establish actual methods and tools for this inclusion, and for environmental, social, and economic action to address impacts. The Plan should describe what mechanisms (including changes in law) can be accessed and used to enable residents and workers impacted by SLR to have direct legal representation and input in the decision-making process for impacted communities, sites and/or projects.	Waterfront/Sea level Rise	A	The HCR strives to increase transparency and awareness of the wide range of resilience actions around the City so that community members may be informed and get involved in those actions, if interested. We acknowledge that it can be difficult to understand how to most effectively engage in decision-making relating to sea level rise. The City is working on improving engagement and communications related to these opportunities, which is reflected in Action C-3.1. "Coordinate resilience engagement across department and projects through ClimateSF." Information about opportunities for engagement in sea level rise planning and decision-making will be added to Section 8.3 "Continued Public Participation in Plan Maintenance". This will include information about the City's future work on a Shoreline Resiliency Plan (Action IN-6.1) which will include opportunities for EJ communities to engage in and support decision-making. We will also add the City's Environment Justice Communities Map to this section, which demonstrates the overlap between sea level rise vulnerability and EJ communities in, primarily in: Treasure Island and Yerba Buena Island, North Beach, and Bayview Hunters Point. Lastly, we will encourage readers to sign up for the ClimateSF newsletter where specific opportunities to be involved in sea level rise planning and decision-making will be announced in the future so that community members have opportunities to be informed and get more involved in the decision-making process."	Eric Brooks (San Francisco Bay Shoreline Contamination Cleanup Coalition)

•Impacted communities, especially Frontline communities facing the most serious environmental justice harms posed by SLR, climate change, industrial pollution, and displacement must be meaningfully included in decision making, including in development decisions. Too often communities are involved in early stages of a project or report, only to find their input was merely to ‘check a box’ for engagement. This Plan can outline the importance of meaningful engagement and advocate for public participation that has real influence on the outcome, especially when it comes to developing housing.	Waterfront/Sea level Rise	A	Please see response above.	Skylar Sacoolas (Greenaction for health and environmental justice)
•In Infrastructure Table 7-5, IN 5.5, Ocean Beach Climate Adaptation Project: Add SFRPD, SFMTA, state agencies including the California State Parks and federal agencies including Presidio Trust and GGNRA. Additionally, ensure there aren't plans to build on Ocean Beach to avoid future payments to protect buildings in flood zones.	Waterfront/Sea level Rise	A	The HCR designates 1-2 lead agencies for monitoring purposes. SFMTA and Rec Park are already included as partners. Additional partners will be added, to the extent that space allows. Agencies not listed may also be involved. As part of the Golden Gate National Recreation Area, Ocean Beach is a highly protected and regulated by the California Coastal Commission and Local Coastal Program. There are no plans to build on Ocean Beach.	Susan Karasoff (Russian Hill Neighbors Parks)
•In Infrastructure Table 7-5, IN 6.2, Advance the Waterfront Resilience Program: Add SFRPD, SFPUC, SFMTA, state agencies including the California State Parks, federal agencies including Presidio Trust and GGNRA as partners.	Waterfront/Sea level Rise	A	The HCR designates 1-2 lead agencies for monitoring purposes. The Waterfront Resilience Program is related to the Port jurisdiction of the shoreline, so some of the agencies listed are not as relevant. SFPUC and SFMTA are already listed as partners. Additional partners will be added, to the extent that space allows, but it is not intended to be an exhaustive list of all entities that may be involved. CA State Parks, GGNRA, and Presidio is outside of the Study Area of the Waterfront Resilience Program. The City coordinates with these agencies on other relevant shoreline adaptation plans where they overlap with their jurisdiction.	Susan Karasoff (Russian Hill Neighbors Parks)

•In Infrastructure Table 7-5, IN 6.4, Advance plans and projects for Ocean Beach: Add SFMTA, SFPUC and state agencies including the California State Parks as partners.	Waterfront/Sea level Rise	A	SFMTA is already listed as a partner. SFPUC, and state and federal agencies will be added as partners.	Susan Karasoff (Russian Hill Neighbors Parks)
•Update flood maps and prohibit building any new transportation projects in and near future flooding zones identified in San Francisco waterfront flood study.	Waterfront/Sea level Rise	C	The SF General Plan calls for examining sea level rise risk, adapting shorelines to flood risks, and prioritizing nature-based solutions in coastal flooding zones (Safety and Resilience Element, Objectives 2.2 and 2.3). The SF Planning Code regulates future growth and development in accordance with the General Plan of the City and County of San Francisco; future land use considerations will be studied in coordination with the Waterfront Resilience Program and other shoreline adaptation planning efforts.	Susan Karasoff (Russian Hill Neighbors Parks)
•Verify statement in Appendix A, page 49 that none of San Francisco's hospitals are in the stormwater flood risk zone. On maps on page 48 and 49 it looks like UCSF Mission Bay Hospital is in these zones or maybe just outside.	Waterfront / Sea Level Rise	A	While the Mission Bay Hospital is not in the stormwater flood risk zone, it is in the 100-year storm + 66 inches SLR zone. This will be corrected in the flooding summary table and summary statement.	Joy Glasier
Particularly concerned about fires that may occur in areas that have Eucalyptus. Expressed concern regarding Tasmanian Blue Gum, Eucalyptus Globulus trees in SF park lands	Wildland-Urban Interface Fire	B	According to state (CalFire) and federal (FEMA) sources, the risk of wildfire in San Francisco is relatively low compared to other counties in the region and compared to other hazards in San Francisco. Through the monitoring and update process, the HCR will continue to monitor for any changes in published wildfire risk assessments and share that information with affected departments and the public. Recreation and Park Department (RPD) prioritizes assessment of tree health based on resources available and related capital projects. Historically, trees falling pose a greater life safety hazard in San Francisco than wildfires. As such, RPD focuses limited resources on addressing hazard trees near paths and roads to protect life safety and RPD accordingly allocates more resources to abating this more pressing public safety hazard.	Jake Sigg

			Each year, RPD also conducts fire abatement in coordination with the San Francisco Fire Department. This work includes cutting dry grass, removing downed limbs, and pruning flammable (i.e., typically dead and dry) vegetation. This does not include removing green vegetation, live plants and trees, and low-fuel material. RPD performs its abatement procedure by clearing flammable vegetation that is on our property within a 30’ feet buffer zone adjacent to habitable structures.	
• Requests that SFFD or a third party perform an assessment of the condition of city-owned trees in open spaces and their related fire risks, preferably before the draft HCR is finalized.	Wildland-Urban Interface Fire	C	According to state (CalFire) and federal (FEMA) sources, the risk of wildfire in San Francisco is relatively low compared to other counties in the region and compared to other hazards in San Francisco. Through the monitoring and update process, the HCR will continue to monitor for any changes in published wildfire risk assessments and share that information with affected departments and the public. Departments with responsibility over City-owned trees also conduct periodic assessments of their condition and conduct fire abatement work in coordination with the San Francisco Fire Department. This work includes cutting dry grass, removing downed limbs, and pruning flammable (i.e., typically dead and dry) vegetation. This does not include removing green vegetation, live plants and trees, and low-fuel material. RPD performs its abatement procedure by clearing flammable vegetation that is on its property within a 30’ feet buffer zone adjacent to habitable structures.	Denise Louie
• Request that the following change to definition of Wildland-urban interface fires: "The WUI is an area where houses meet or are interspersed with undeveloped wildland vegetation. WUI fires typically occur in forests or other areas with ample vegetation."	Wildland-Urban Interface Fire	B	Current definitions for Wildland Urban Interface Fires are obtained from cited, peer reviewed sources.	Denise Louie

• There does not appear to be any basis for the statement that our WUI fire probability is low	Wildland-Urban Interface Fire	B	The Wildfire Hazard profile states that the expected severity wildfires or wildland-urban interface fires within San Francisco is low to moderate. This statement is borne out by the data in the Hazard Profile.	Denise Louie
•To reduce the chance of fire contagion, the plan should include a strategy to remove all eucalyptus trees and plants from all city properties, starting with the eucalyptus plantation in SFRPD Glen Canyon Park. This should extend to requiring all city, state, and private property owners to remove all eucalyptus trees and plants from their properties.	Wildland-Urban Interface Fire	B	The HCR examines feasibility and risk reduction benefit when evaluating actions to include. The suggested action has low feasibility due to high cost and legal authority over private, state, and federal property owners to remove trees and limited evidence of a high level of benefit from a risk reduction perspective. The risk of wildfire in San Francisco has been assessed by state and Federal sources to be relatively low compared to other counties in the region and compared to other hazards in San Francisco. Through the monitoring and update process, the HCR will continue to monitor for any changes in published wildfire risk assessments and share that information with affected departments.	Susan Karasoff (Russian Hill Neighbors Parks)
•In Infrastructure Table 7-5, IN 7.4, Complete studies and capital projects to improve and expand the Emergency Firefighting Water System (EFWS): add SFFD, DPW and SFRPD as partners due to potential impacts to tree plantations.	Wildland-Urban Interface Fire	B	SFFD and Public Works are already included as partners. Rec Park is a beneficiary of the EFWS but is not a partner involved in the studies and capital projects.	Susan Karasoff (Russian Hill Neighbors Parks)
•In Infrastructure Table 7-5, IN 8.2, Mitigate wildfire hazards in SFPUC owned watersheds: add SFFD, DPW and SFRPD as partners.	Wildland-Urban Interface Fire	B	This is an action specific to out-of-county watersheds.	Susan Karasoff (Russian Hill Neighbors Parks)
• In response to high winds and wind stress, PG&E and SFMTA should be required to upgrade or bury overhead wires. This should occur in partnership with improvements to the grid and development of microgrids to avoid outages.	Wildland-Urban Interface Fire	B	It is not feasible for all overhead wires to be upgraded or undergrounded. This is due to the high cost required to underground overhead utilities in a dense urban context, in addition to the necessity of overhead catenary system for the operation of MUNI	Susan Karasoff (Russian Hill Neighbors Parks)

•Verify footnote accuracy for statement: "Given that San Francisco is a highly urbanized area, CAL FIRE has also characterized the city as a low vegetative fuels hazard area"	Wildland-Urban Interface Fire	A	New footnote has been added to the Fire Resource Assessment Program (FRAP) page where you can find explanation of data for each county, including the designation of San Francisco as a low vegetative fuels hazard area.	Denise Louie
• Notes Figure 4-29 has been miss-referenced	Wildland-Urban Interface Fire	A	Figure has been appropriately re-numbered.	Denise Louie

Appendix E

Local Plan Adoption

Based on requirements as set forth in the Stafford Act, as amended by the Disaster Mitigation Act of 2000, and its implementing regulations, the local hazard mitigation plan shall include documentation that the plan has been formally adopted by the governing body of the jurisdiction.

The Board of Supervisors of the City and County of San Francisco adopted the Hazards and Climate Resilience Plan as the 2025 Hazard Mitigation Plan by resolution on [placeholder]. A scanned copy of the resolution follows. [placeholder].