PORT OF SAN FRANCISCO'S

# WATERFRONT RESILIENCE PROGRAM

**Get to Know Key Terms**

### 100-year flood (1-percent-annual-chance flood)
A flood event with a one percent chance of being equaled or exceeded in any given year.

### 1906 Earthquake
Centered about 60 miles from the Embarcadero Seawall and based on activity along the San Andreas Fault, the 1906 earthquake caused strong shaking in San Francisco that lasted about 45 to 60 seconds. The earthquake was felt from Oregon to Los Angeles and inland as far as central Nevada. Its magnitude is estimated to be approximately 7.9. The earthquake caused extensive damage in San Francisco and fires broke out throughout the city that burned for days. As the city rebuilt itself, buildings were constructed to better withstand earthquakes and additional measures for fire protection were also installed.

### 1989 Loma Prieta Earthquake
Centered about 60 miles from the Embarcadero Seawall along the San Andreas Fault to the south near Santa Cruz. The magnitude of the earthquake is estimated to be approximately 6.9, which is significantly smaller than the 1906 earthquake. The effects of liquefaction were also seen in the East Bay with the collapse of a section of the Nimitz Freeway in Oakland, and in the nearshore areas of Monterey Bay.

### Asset
An individual place or piece of the Port's infrastructure, such as an individual building, wharf, or pier, as well as those belonging to the City or private entities, such as wastewater infrastructure, historic resources, public parks, utilities, etc.

### Base Flood Elevation
The water elevation of a flood event with a one percent chance of being equaled or exceeded in any given year. It is also known as the 100-year flood and is the national standard for the National Flood Insurance Program (NFIP).

### Bulkhead
A retaining structure along a waterfront that provides a vertical face for mooring vessels.

### Case Studies
A location or project where a **measure** has been successfully implemented is listed where possible within the profiles of the **Measures Explorer**. Case studies will be used to identify best practices and lessons learned from previous projects to support adaptation planning and design.

### City's Sea Level Rise Vulnerability Zone
Covers the area within San Francisco that will likely face future flooding and inundation in a **100-year coastal flood** combined with 66 inches of sea level rise.

### Climate Adaptation
Steps to adjust existing or prepare new systems, including natural, constructed, and social systems, in ways to meet new or changing climate conditions or climate variability. Climate adaptation focuses on solutions that will reduce harm and/or create beneficial opportunities, including public use and ecology, etc.

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

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

### Coastal Flooding
Flooding that occurs on land when a combination of extreme tides and sea level rise causes overtopping - which is what happens when water levels reach over the shoreline. Floodwaters generally recede as water levels return to normal, but some areas may retain floodwaters for longer periods in areas where inland drainage is insufficient. With rising sea levels, some of these areas would be flooded daily due to normal high tides. Flood hazards are associated with inundation due to coastal flooding from waves, storm surge, and sea level rise that could potentially cause harm to people, buildings, and natural environments.

### Consequences
The extent to which people or assets can be affected by a hazard exposure. Consequences can describe qualitative and quantitative impacts to exposed and vulnerable people and assets, such as buildings or infrastructure; some impacts can be communicated in terms of economic losses. Sometimes impacts create "cascading consequences": a chain of events due to an impact on an asset or system (i.e., combination of assets). These can include system-level consequences that go beyond the scale of an asset, such as social consequences to the community, and/or consequences to the environment.

### Considerations
High-level considerations relevant to the selection, design, and construction of measures. These considerations will be used when developing adaptation strategies that are responsive to the needs and priorities of the Port, waterfront communities, and key stakeholders along the Port's 7.5-mile jurisdiction.

### Critical Facilities
As per City and County of San Francisco, facilities or programs that are essential to the health and safety of the public and recovery after a natural disaster, such as hospitals, medical centers, shelters, schools, fire stations, and police stations.

### Design Life
Period of time during which an **asset** is expected by its designers to operate or function within specified parameters.

### Design Opportunities
Possible **co-benefits** (above and beyond the direct intention of a proposed strategy without or with minimal additional costs) that **measures** can design for the environment, people, and the city.

### Earthquake
A sudden shaking of the ground as a result of movement along a fault line between two tectonic plates or volcanic activity. Seismic activity is another way of talking about earthquakes or related movement of the Earth's crust.

### Ecological Infrastructure Measures
Describes **flood risk measures** that use natural systems, forms, and patterns to provide flood protection. These ecological infrastructures can also combine with physical infrastructures to provide both robust flood protection and ecological benefits.

### Embarcadero Roadway
The roadway along the northern portion of San Francisco's waterfront.

### Embarcadero Seawall
The Embarcadero Seawall was built over a hundred years ago in earthquake country without today's seismic standards atop "weak young bay mud," a soft, weak mud that can amplify earthquake shaking. With over $100 billion in assets and annual economic activity along the waterfront supported by the Seawall, it truly is the City's economic backbone. The Seawall is part of the Embarcadero Historic District and underpins the Embarcadero Promenade, supporting many of the city's iconic destinations, parks, and local businesses, which attract more than 24 million people each year. The Seawall also supports key utility and transportation infrastructure including BART, Muni, and ferry networks, and serves as a critical emergency response and recovery area. Over 50 key emergency assets depend on the Seawall.

### Emergency Firefighting Water System
San Francisco's Emergency Fire Water System can be quickly accessed to draw water directly from the bay that can be pumped into the fire water distribution system and used at high-pressure at fire hydrants throughout the city.

### Erosion
The wearing away of the waterfront due to wave impacts.

### Exposure
The extent to which an **asset** is situated in a place or setting that could be adversely affected by hazards, such as coastal flooding or seismic shaking. For the Embarcadero Seawall Program, exposure analysis to flood and seismic hazards is limited to buildings, infrastructure systems, and assets associated with, and in the vicinity of, the Seawall. Exposure factors into an asset's vulnerability.

### Fault
A fault is a fracture in the earth's crust where a block of crust on one side moves relative to the other. Earthquakes occur on faults. How strongly we feel an earthquake at any specific location within San Francisco is based on which fault in the Bay Area causes the earthquake, where the movement occurs along the fault,

and how large the movement is. The two most hazardous (and most well-known) faults in the Bay Area are the Hayward Fault and the San Andreas Fault.

### Fireboat
A boat operated by the San Francisco Fire Department that is used to primarily respond to fires on land, water, or waterfront. Fireboats can draw bay water and use it directly to fight fires along the waterfront.

### Ground Motion / Shaking
The movement of the earth's surface from earthquakes. Ground motion is produced by waves of energy that are generated by a sudden slip on a fault (fractures in the earth's crust where rocks on either side of the crack have slid past each other) or by sudden pressure at the source and travel through the earth and along its surface. Ground motion is a type of seismic **hazard** that could potentially cause harm to people, buildings or natural environments.

### Groundwater
A type of coastal flood hazard that can occur from two different causes. One is flooding that occurs on the landside due to the land absorbing an excess amount of rainfall. Another cause could be from excess water on the bayside due to rising sea levels.

### Hazard
A source of potential danger or an adverse condition that could harm people, socioeconomic systems, or built and natural environments. This project is focused on the natural hazards associated with seismic and flood scenarios.

- Seismic hazards include effects such as ground motion / ground shaking, liquefaction, and lateral spreading.
- Flood hazards are associated with inundation due to coastal flooding from waves, storm surge, and sea level rise.

### High-end
A **scenario** that could occur if global greenhouse gas emissions are not successfully reduced and sea level rise follows the higher end of climate projections.

### Initial Southern Waterfront Seismic Study
A preliminary assessment of the southern waterfront that will:

- Examine potential earthquake hazards and vulnerabilities along the waterfront between Mission Creek and Heron's Head Park.
- Recommend areas for further analysis and produce a conceptual list of potential seismic mitigation measures.

### Islais Creek
Once a broad creek and marsh area that was filled for agricultural and industrial uses in the late 1800s. Filled areas, like Mission Creek and Islais Creek, are subject to **liquefaction** in the event of an earthquake.

### Islais Creek Southeast Mobility Adaptation Strategy (ICSMAS)

A two-year community planning process in the Islais Creek area led by SF Planning, in collaboration with the Port and SFMTA, that focused on developing 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 Islais Creek Southeast Mobility Adaptation Strategy developed 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.

### King Tides

The year's highest tides. King Tides occur when the sun and moon align along the same gravitational pull and both are at their closest point to the Earth.

### Lateral Spreading

A seismic hazard that causes large areas of land to move, typically toward a body of water. This results in potentially large cracks and settlement at the ground surface, resembling a landslide but on relatively flat ground. Lateral spreading is a type of seismic **hazard** that could potentially cause harm to people, buildings, or natural environments.

### Liquefaction

Occurs when water-saturated sediment (like sand) temporarily loses strength and acts as a fluid. Imagine jumping on wet sand near the water at the beach until it turns soft and your feet sink in.

Liquefaction is caused by strong ground shaking during an earthquake and is greater in areas with sandy soils. As a result of liquefaction, buildings, roads and utility lines may lose their foundational support and the likelihood of significant damage increases. Liquefaction of the soil behind the Seawall will also increase the risk of lateral spreading along the shoreline.

Liquefaction can also increase the risk of **lateral spreading**.

### Liquefaction Risk

An area's susceptibility to liquefaction is rated on a scale of Very High, High, Moderate, Low, and Very Low by the United States Geological Survey, the federal agency that also monitors seismic activity.

### Measures

Strategies for adapting and responding to impacts from earthquakes, flooding, and sea level rise that can be combined to form a comprehensive approach for protecting the waterfront now and in the future. The Port's goal is to identify the measures that are most appropriate to protect the many different conditions along the waterfront in ways that reflect city and community priorities, combining seismic and flood risk improvements wherever feasible and cost-effective. Learn more by visiting the Measure Explorer: sfport.com/wrp/measures-explorer.

### Measures Compatibility

Measures that can be combined with others for enhanced protection, including instances where a single construction can implement both flood and seismic measures.

### Multi-Hazard Risk Assessment (MHRA)
A study led by the Port that provides new information and insight into how earthquake damage and impacts from different flood events might impact people, the environment, and the economy. The MHRA focuses on the area supported by the **Embarcadero Seawall** and includes insight into which assets and services are most at risk along the Embarcadero waterfront.

### Overtopping
When water, usually in the form of **storm surge** or a wave, reaches over the shoreline and causes inland flooding. In general, overtopping of natural shorelines, such as wetlands and beaches occurs at a lower flood level than overtopping of engineered shorelines, such as seawalls, bulkheads, and wharves.

### Physical Infrastructure Measures
**Flood risk measures** that are constructed of hardened materials and built structures that are typical of the urban environment.

### Policy & Emergency Preparedness Measures
An approach to reduce both seismic and flood hazards. These **measures** use laws, policies, regulations, and systems to manage risk. This can come in the form of permit requirements, zoning, and plans to influence land use and the built environment. It also includes systems that help communities prepare for and avoid hazards.

### Precipitation or Land-based Flooding in San Francisco
As San Francisco has developed over time, its hilly topography has been largely paved over. During extreme storms, storm runoff flows by still following the naturally formed historical waterways. The resulting flooding can cause property damage.

### Resilience
The ability to react to and recover from a hazardous event (such as a flood or earthquake) in ways that help restore, maintain, and even improve essential functions, structures, and city identity. Resilience also retains the capacity for growth and change.

### Risk
A threat posed by an impact or hazard (i.e., flooding or earthquake).

Flood risk due to sea level rise examines to what degree flooding is likely to occur at a particular future water level. Flood risk also takes factors, such as storm events, precipitation, and groundwater levels, into consideration.

- In an ever-changing climate, these factors are becoming increasingly interconnected.
- For example, a sudden downpour during a larger-than-normal rainstorm, such as recent atmospheric rivers, causes intermittent flooding on city streets now and in the future could cause more severe and lasting flooding with a rising San Francisco Bay.

Seismic risk refers to the probable building damage and potential harm to people in the event of a likely earthquake on a particular fault.

Seismic risk and seismic hazard are occasionally, and incorrectly, used interchangeably. Hazards include specific effects such as ground motion / shaking, liquefaction, and lateral spreading that can happen during an earthquake.

### Risk Assessment
A quantitative or qualitative assessment of the potential consequences of the damage that could be the result of a hazardous event, such as flooding or an **earthquake**.

### Scenario
A plausible description of a possible future state used for planning. A climate change scenario describes the difference between a future climate scenario and the current climate.

### Sea Level Rise
Occurs when polar and glacial ice melts, causing global sea levels to rise in response to additional water. Polar ice melt has been occurring at an exponential rate due to increased carbon dioxide levels in the Earth's atmosphere, making sea level rise a symptom of global climate change.

### Seawall
A waterfront coastal protection structure built along a portion of a shoreline to prevent erosion and other damage by wave action. In San Francisco the Port and City partners use this term to refer to the **Embarcadero Seawall**.

### Shed
A structure built on top of a pier or **wharf**.

### Shoreline Stabilization
Describes **seismic risk measures** that will create strengthened conditions around the shoreline that will help resist its movement due to seismic events.

### Southern Waterfront Seismic Vulnerability Assessment
From Mission Creek to Heron's Head, this assessment will be used as part of the Port's work to better understand the waterfront risks of the entire 7.5 miles in its jurisdiction. This assessment will not be at the same level as the recently completed **Multi-Hazard Risk Assessment** (MHRA) under the Embarcadero Seawall Program.

### Storm Surge
Flooding during a storm event that creates higher water levels and waves for a period of time.

### Subarea
A subsection of the waterfront delineated by the **U.S. Army Corps of Engineers San Francisco Waterfront Costal Flood Study**.

### Targeted Measures
Describes **seismic risk measures** that target specific seismic risks and vulnerabilities of assets and features of the waterfront. In general, these measures need to be combined with Shoreline Stabilization measures to provide comprehensive seismic risk reduction.

### Tipping Point
A tipping point is reached when the impacts of a flood go beyond a certain area, creating cascading consequences that can have citywide or regional ramifications. Damage is more than can be immediately addressed and affects critical assets and the community. The Port and the City use the concept of a tipping point to understand when planning for large-scale shoreline adaptation projects is necessary and which site-specific approaches to flood risk reduction may be overwhelmed. Understanding tipping points and how they vary along the waterfront can also help compare and prioritize projects along the waterfront.

### U.S. Army Corps of Engineers San Francisco Waterfront Coastal Flood Study
The U.S. Army Corps of Engineers (USACE) and the Port have partnered to study flood risk along San Francisco's bayside shoreline. The USACE San Francisco Waterfront Coastal Flood Study is one of several coordinated waterfront resilience activities being undertaken in partnership with federal, state, and local agencies to plan for anticipated seismic activity, flooding, and sea level rise.

The study will identify vulnerabilities and recommend strategies to reduce current and future flood risks for consideration by the Assistant Secretary of the Army and the U.S. Congress for federal investment and implementation.

### Useful Life
The period of time during which an **asset** is expected to operate or function.

### Vulnerability
The degree to which someone or something is susceptible to, or unable to cope with, a **hazard**. Vulnerability is a function of exposure, sensitivity, and adaptive capacity. Types include:

- **Economic vulnerability** - Economic variables that may be affected by climate impacts, such as infrastructure damage, repair or replacement costs, and lost revenues during periods of recovery.
- **Environmental vulnerability** - Environmental variables that may be affected by climate impacts such as species biodiversity, water quality, and ecosystem functions.
- **Social vulnerability** - Characteristics of individuals and households that affect their ability to prepare for, respond to, and recover from a disaster.

### Waterfront
A section of a city or town fronting a body of water, such as the San Francisco Bay.

### Wharf
A structure that extends over the water and is parallel to the shoreline. A wharf is different from a pier, which extends perpendicularly from the shore into the water.

### Young Bay Mud
A soft, weak mud that can amplify earthquake shaking.