

Ferry Building



SHORELINE TYPE:	SEISMIC RISK ¹ :		FLOOD RISK ² :	
<p>Engineered: Filled land retained by concrete gravity wall or rock dike with pile supported bulkhead wall and wharf. Second generation wharves where still in existence.</p>	<p>Shoreline Instability: High to Very High</p>	<p>Tipping Point Elevation: 47" above high tide</p>		
	<p>Liquefaction Risk: High in Fill and Marine Sand Layers</p>	<p>Coastal Flood Events Timing</p>		
	<p>Shoreline Structure Vulnerability: High</p>			
<p>Subsurface Profile: Non-engineered fill, deep bay mud, very deep rock, historically Yerba Buena Cove made up of mudflats and open Bay</p>	<p>Unique Conditions: Agricultural Building highly vulnerable to flood and earthquakes, unique seawall type at the Ferry Building consisting of tall concrete wall constructed on top of liquefiable sand bed, Ferry Building foundation is made up of 100s of redwood piles, very deep mud due to area being located on top of historic Yerba Buena Cove</p>		<p>100-yr Flood + 7" SLR</p>	<p>Today</p>
		<p>High tide + 48" SLR</p>	<p>2070 - 2107</p>	

¹ Shoreline Instability ratings within Embarcadero Seawall Program area based on advanced shoreline stability analysis and averaged over each subarea. Shoreline Structure Vulnerability based on Mean Damage Ratio calculated for the 225 year seismic event averaged across subarea.

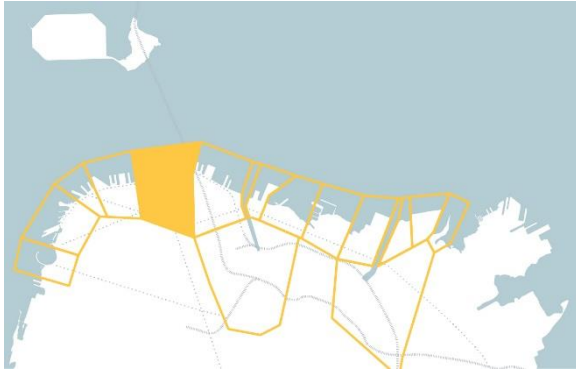
² The timing of coastal flood events that will cause significant flooding in this subarea is provided as a range of dates based on the sea level rise projection scenarios provided by the California Ocean Protection Council (OPC) per the Likely and 1-in-200 chance of occurrence projections.

Ferry Building

Subarea 2-2



SUBAREA DESCRIPTION



The Ferry Building subarea is characterized by the iconic Ferry Building, first opened in 1898 and now a bustling regional ferry terminal, farmer’s market, and home to small and local businesses as well as many restaurants and food and culinary spots. The Ferry Building area also includes popular open public spaces, such as Rincon Park, that serve local neighborhoods, regional visitors, and tourists alike.

Still a gateway to the city, it opens into the Financial District and connects to key city and regional transportation systems and networks through BART, Muni, historic street cars, cable cars, and the Transbay Transit Center. The many transportation hubs, historic waterfront, vibrant businesses of the Financial District, and large number of jobs

make this subarea critical to the San Francisco, regional, state, and federal economies. The combination of historic and cultural resources, along with open space and modern-day jobs and services, make preserving, enhancing, and adapting this subarea essential for creating a resilient and sustainable waterfront for generations to come. The shoreline of this neighborhood is one mile long and entirely engineered, including a series of aging seawalls referred to as the Embarcadero Seawall and historic piers. At the southern end of the Financial District, Pier 14 serves as a breakwater that extends over 600 feet into the Bay, protecting the Downtown Ferry Terminal from wave and tidal forces.

The primary flooding pathway is overtopping along the shoreline. Flooding first occurs near Pier 14, where nuisance flooding and wave overtopping occurs under existing conditions, impacting a small area of the Embarcadero Promenade and roadway. Higher Bay water levels would result in overtopping along most of the shoreline, allowing floodwaters to extend almost a quarter of a mile inland.

COMMUNITY IDENTIFIED PRIORITIES:	
<p>Places</p> <ul style="list-style-type: none"> • Ferry Building • Ferry Service • Rincon Park • Embarcadero Plaza • Farmer's Market • BART • Muni • SFFD Fire Boats • Financial District • Large and small businesses • Residential neighborhoods • Embarcadero Promenade 	<p>Since 2017, the Port has connected with tens of thousands of community members through the Waterfront Resilience Program. Public feedback collected about the Ferry Building subarea underscores the importance of transportation for both commuters and residents, protecting historic buildings, particularly the iconic Ferry Building, reducing damage and disruption to the all of the large and small businesses that are located in the subarea and/or rely on the assets and services within it, preserving and enhancing the very popular Embarcadero Promenade and open spaces, including views and access to the Bay and ensuring disaster response functions that are so critical in this subarea are available, including staging areas, transportation services and access to the water for service workers, evacuation and supplies. Further feedback highlights additional community priorities, including opportunities to improve bicycle and pedestrian mobility and safety and enhance and expand green space.</p>

Ferry Building

Subarea 2-2



FIRST FLOODING OF ASSETS

The chart below describes the vulnerability of specific assets within the Ferry Building and Financial District subarea to flooding. These assets will be exposed to coastal flooding when the water level in the Bay reaches a certain height above the current high tide. The heights at which each asset is exposed to flooding is indicated with the shaded cells in the table. Over time and due to sea level rise these water levels can occur due to large storm events such as a 100 year flood of daily high tides. For example, the Ferry Building is exposed to flooding when the water rises 66 inches above current high tide, which could occur due to a 100 year flood with 3 ft. of sea level rise or as during daily high tide with 5.5 ft. of sea level rise.

● High Tide ○ 100 Year Flood ■ Shaded cells indicate the water levels at which assets are exposed to flood

SEA LEVEL RISE		WATER LEVEL ABOVE CURRENT HIGH TIDE										
		0"	12"	24"	36"	48"	52"	66"	77"	84"	96"	108"
Today		●				○						
1 ft. SLR			●				○					
3 ft. SLR					●				○			
5.5 ft. SLR									●			○
Historic and Cultural												
	Ferry Building							■	■	■	■	■
	Agricultural Building							■	■	■	■	■
Disaster Response												
	Assembly Areas						■	■	■	■	■	■
	Rincon Park Assembly Area					■	■	■	■	■	■	■
	Fire Station 13									■	■	
	Fireboat HQ, Fire Station 35						■	■	■	■	■	■
	Primary Port Dept. Operations Center					■	■	■	■	■	■	■
Open Space and Ecology												
	Bay Trail					■	■	■	■	■	■	■
	Bay Water Trail Sites	N/A (Flooding not quantified for floating overwater or in-water assets)										
	Embarcadero Plaza						■	■	■	■	■	■
	Ferry Park						■	■	■	■	■	■
	Ferry Plaza					■	■	■	■	■	■	■
	Pier 7							■	■	■	■	■

Ferry Building



	Pier 14												
	Promenade												
	Rincon Park												
	Sue Biermann Park												
Maritime													
	Ferry Building Terminals												
	Pier 1.5 Water Taxi												
	Pier 22.5												
	Pier 24 Annex												
	Port of SF HQ												
Transportation													
	Embarcadero Roadway												
	California Street Cable Car												
	Embarcadero BART Station												
	Montgomery BART Station												>
	Muni Light Rail (E, F, T)												
Utilities													
	Embarcadero PG&E Substation												>
	Embarcadero Transport / Storage Box	N/A (Buried assets are not directly impacted by flooding)											
	Jackson Transport / Storage Box												
	North Channel Transport / Storage Box												
	North Point Force Main												
Critical Facilities													
	Chinese Education Center Elementary												>
	-	-											



EARTHQUAKE AND FLOODING RISKS: MULTI-HAZARD RISK ASSESSMENT KEY FINDINGS

As detailed in the Seawall Earthquake Safety General Obligation Bond Report prepared when Proposition A was considered for the November 2018 ballot, the Port has spent the past two years assessing what is at risk on the Embarcadero waterfront when considering an earthquake or flood event to establish a basis for the development of Proposition A projects. This study is called the Multi-Hazard Risk Assessment, or MHRA.

We knew the Port’s aging Embarcadero Seawall was at grave risk from earthquakes. MHRA findings tell us there are areas more at risk of earthquake damage due to different soil conditions - and some less so.

Specifically, The Ferry Building subarea is one of the highest risk areas on the waterfront vulnerable to both earthquakes and flooding. The subarea has some of the lowest elevations along the Embarcadero Seawall and includes areas of the shoreline that are currently overtopped by Bay waters during storm events and extreme tidal events. Additionally, the subarea’s location within historic Yerba Buena Cove results in significant risk from earthquakes due to the very deep Bay mud in this area. Further seismic analysis is required to better understand the impacts to the Ferry Building itself in various types of earthquakes.

We also learned:

- The Ferry Building Subarea is one of the highest seismic risk areas on the waterfront. A large earthquake will cause significant settlement and lateral spreading in this area, threatening life safety and disaster response efforts as well as many of the day-to-day functions along the waterfront.
- The Ferry Building itself requires further seismic analysis to understand its likely earthquake performance.
- The Agriculture Building is one of the buildings with the highest seismic and flood risks within the program area due to its location and construction type.
- The Port’s public outreach confirmed that stakeholders love the Ferry Building area and recognize the importance of the concentration of transportation modes, visitor-serving assets and services and the area’s historic significance.
- There is significant flood risk to the waterfront in this subarea, which includes the Financial District, inland residential neighborhoods, a large concentration of large and small businesses and jobs and other critical transportation and utility services. The flood risk is limited to localized flooding now and increases to significant and widespread flooding as sea levels rise. This subarea is the lowest point along the Embarcadero, making it the first section to be impacted by coastal flooding, with king tides already causing some flooding that results in temporary and partial closures of the Embarcadero Roadway.
- The Embarcadero Roadway has significant seismic risk which could impact disaster response and local and regional transportation. Due to the presence of weak soils, the Embarcadero transportation and utility corridor is at significant seismic risk. In a 1906 size earthquake, damage to the Seawall and Embarcadero may be severe enough to significantly hamper disaster response efforts along the waterfront. A more likely earthquake like the 1989 Loma Prieta earthquake – but centered closer to San Francisco – is expected to lead to loss of the Embarcadero as a transportation route for up to a year. The Embarcadero Roadway is also one of the lowest elevations along the shoreline in many locations and creates a pathway for flooding to adjacent areas.



Utilities and Mobility

- Both seismic and flood hazards pose a risk to utilities and mobility within this subarea.
- At 2.2 feet of sea-level rise, expected to occur between 2050 and 2075, the Embarcadero roadway and promenade reach a tipping point, where the 100-year flood causes widespread overtopping of the shoreline, resulting in complete elimination of function for multimodal movement with far reaching impacts to mobility patterns for both the city and region.
- Disruption to the utility and mobility systems will impact evacuations and emergency response for the 100-year earthquake level and beyond.
- There is a significant flood and seismic risk to the waterfront and Financial District. Between 2065 and 2100, a 100-year tidal event will expose the entire Embarcadero and historic district and 3 blocks of the Financial District to flooding, including the BART and Muni tunnels, with depths of floodwater up to 4 feet at the bottom of Market Street. Flooding to the BART and Muni will impact more than 1.1 million trips per day in San Francisco and repairs could take up to a year.
- Disruption of low pressure water service to residents and business is anticipated in the 100-year earthquake event and greater.
- Rising sea levels will reduce the hydraulic effectiveness of combined sewer discharges, which rely on gravity to drain into the Bay when they become overfilled.

Life Safety and Emergency Response

- Northeast Waterfront Subarea includes key locations like the Ferry Building and Plaza, the Exploratorium, and the cruise terminal, which are highly populated. These occupancy hotspots sit alongside numerous smaller venues and offices, which contribute to the relatively high occupant estimate throughout the Port's property in this subarea.
- Wharves and buildings adjacent to the seawall are high risk due to seawall-related earthquake damage and consequences for promenade and pier access. These facilities are much more likely to be damaged and have a higher potential for collapse and ignitions in very large earthquakes. In addition to the wharves and buildings, the adjacent promenade is highly occupied and damage to the seawall and wharves will limit landside access to the piers, complicating evacuation for thousands of people. The potential for damaging aftershocks can also cause life safety issues as people move to the waterfront for the purposes of evacuation and onto these structures before inspections and closures take place.
- Pier 1 will function as the central coordination location for both landside and waterside damage assessment efforts. The adjacent Pier 1 ½ will act as a rendezvous point for skilled tradespeople in skiffs from Pier 50 and engineers from Pier 1 to meet and begin conducting waterside damage assessments. Predicted damages at both locations in the 225-year and 975-year earthquake scenarios imperil the ability of the Port team to use those facilities as intended.
- Ferry Building Gates E, F, and G are expected to be operational throughout all earthquake scenarios for evacuation. With a passenger throughput capability of nearly 10,000 passengers per hour, safeguarding its operability from debris is vital. All other primary, supplemental, and alternate embarkation facilities are either impaired or closed by the 225-year earthquake scenario.

Transportation Assets

- Major repairs to the Embarcadero could take 6 months to 1 year following a 100-year earthquake, and severe damage following a 225-year earthquake would likely require complete reconstruction of some sections resulting in 1 to 2 years of construction and disruption.
- Local transit will likely be out of service for at least a few weeks and could be out for over 1 year. For a 43-year earthquake, the light rail trackway will likely be offline for 2 to 3 weeks, as checking and testing will be required even if damage is limited. This disrupts a total of 110,000 trips daily. After a 100-year earthquake, surface light rail will



likely resume in 6 to 8 months once local trackwork is complete, while the historic streetcars that depend on the special trackwork near Don Chee Way will likely be closed for up to 1 year. It is unlikely alternate bus service could be provided as roadways are also significantly damaged. These repair times will likely extend from 1 to 2 years for the 225- and 975-year earthquakes as full reconstruction of the Embarcadero becomes more likely.

- Underground transit systems, like BART and much of the SFMTA Muni light rail, are highly vulnerable to flooding. Under 1.1 feet of sea-level rise and a 100-year flood, as water enters the system, flood damage and disruption could extend well past the program area. Disruption of these underground transit systems can displace approximately 460,000 trips per day and indirectly impact over 1.1 million trips per day in San Francisco.
- Coastal flood risk to the Embarcadero roadway and promenade as well as streets in the Financial District will present a significant disruption to pedestrian, bicycle, and personal vehicle transit routes during and immediately after flood events in the short term, and complete disruption in the long term.
- The groundwater table will rise in unison with sea-level rise. By 2.2 feet of sea-level rise, the bedding underneath the Embarcadero roadway and SFMTA Muni light rail surface tracks will start to become continuously saturated, leading to a surge in operation and maintenance costs for the critical Embarcadero transportation corridor.

Maritime Assets

- Regional tourism is supported by cruise, excursion, and ferry services that are not replicated elsewhere in the region.
- Regional enjoyment of the Bay is facilitated by water recreation, excursion, ferry, cruise, and ceremonial berth functions that are not replicated, or are scarce, within the region.
- Critical disaster response and recovery services are provided by all maritime infrastructure assets and functions, including for embarkation and debarkation; assembly and staging; berthing for deep-draft vessels; and centers for emergency response and operations.
- The performance of most maritime functions depends upon a northern waterfront location for proximity to ocean fisheries, the Golden Gate arrival point, or centers of tourism and employment.
- Most maritime functions perform time-sensitive operations, such as commercial fishing, transportation and on Bay and shore services that need to be provided daily and would be severely impacted by (or may not recover from) downtime for repairs to damages.

Historic Resources

- This subarea has a significant number of historic assets that contribute to the Embarcadero Historic District and that are individually listed, such as the Ferry Building.
- As a group, the bulkhead wharves and bulkhead buildings, which includes Piers 1, 3 and 5 within this subarea, represent the greatest risk. Damage to or loss of the bulkheads would greatly affect the feeling of the district from the city side and could impact the district's integrity with regard to architecture, planning, engineering, and government.
- The Agriculture Building and Ferry Building area of the bulkhead wharf are the most at risk historic assets. The Agriculture Building is individually listed in the National Register of Historic Places (in addition to being a contributor to the district) so damage to or loss of this building could somewhat lessen the district's integrity.
- While in the near term, only a few historic buildings are at an increased risk from intermittent flooding, these already vulnerable buildings are some of the most recognized and highly trafficked along the waterfront, including the Ferry Building, Agriculture Building, and Piers 1 through 5.



Buildings and Structures

- At the Ferry Building, the risk analysis supports the generally good performance observed in the 1906 and 1989 earthquakes but indicates that larger earthquakes, such as the 975-year earthquake, may cause significant damage to the foundation.
- The first Port buildings anticipated to experience physical damage include the Agriculture Building, Pier 5, Pier 1 ½, and Pier 3, and this damage would be expected with a 100-year extreme tide under current sea level conditions. Prolonged restoration that causes economic or social disruption is not expected with one temporary flood event at this level, and repairs may not impede use of the building or require relocation of occupants.

Open Space and Public Realm

- The 43-year earthquake is predicted to cause minor damage and result in minimal disruption to the use of the promenade. There will be some inconvenience due to higher damage near the Ferry Building and near Oracle Park.
- The 100-year earthquake is predicted to severely reduce the promenade function. It may be generally accessible, but many waterside destinations would be disrupted for a few months. In particular, areas near the Ferry Building, Fisherman’s Wharf, and Oracle Park are likely to be significantly impacted, with the potential to affect access and use for approximately 570,000 users per month for a duration of 3 to 9 months.
- Under 1.1 feet of sea-level rise, a 100-year flood will disrupt travel in several areas along the waterfront including the Ferry Building area extending from Rincon Park to Pier 7, Pier 39, and Fisherman’s Wharf. These are some of the most heavily transited and visited spaces along the waterfront and are critical to commuters, workers, tourists, community members, and others for daily trips and recreational use. This will disrupt the overall function of the public realm because many people enter or travel through those areas.

Economic Risks

- The Northeast Waterfront presents the greatest combined earthquake and coastal flood economic risk in the near term due to the concentration of critical vulnerable transportation and economic assets (that is, the Embarcadero roadway, Embarcadero Station, and Financial District), the deep bay mud ground conditions, and the lower elevation of the seawall.
- The Northeast Waterfront is the first subarea where coastal flood losses will exceed seismic losses.

Environmental

- The open Bay provides habitat to native species, including the herring that use the San Francisco Waterfront to spawn and marine mammals who can often be spotted in the Bay and the aquatic birds and species that move in and out of the Bay within this subarea.
- The staircase south of the Ferry Building is an area that is currently used by native species and provides ecological enhancement opportunities.

WHAT IS AT STAKE?

Given the potential impacts of earthquakes, flooding, and future sea level rise, what is at stake in the Ferry Building subarea?

Community indicators, such as income level, mobility access, race, age, education level, and language access, all play a part in how communities are impacted and able to prepare and respond to hazards like earthquakes and sea level rise. In the Ferry Building subarea, elderly residents and residents without homes close to the Ferry Building would be disproportionately impacted by a seismic or flood event. Loss of homes, small businesses, jobs, critical transportation assets such as BART, MUNI and ferries, beloved visitor serving facilities such as the Ferry Building, the Farmer’s Market and the Embarcadero

Ferry Building



Promenade, the recreational resources and long-term economic impacts due to earthquakes and sea level rise would impact this subarea's vitality and likely have cascading effects in the region and beyond.



FUTURE POTENTIAL MEASURES UNDER CONSIDERATION IN THIS SUBAREA:

FLOOD MEASURES:			
Physical Infrastructure		Ecological Infrastructure	
 Floodwalls	 Levees	 Ecological Marine Structures	 Ecological Features
 Seawalls	 Breakwaters	 Aquatic Habitat	 Ecological Shorelines
 Raised Marine Structures	 Building Adaptations		
 Tide-Gates	 Deployables		
SEISMIC MEASURES:			
Shoreline Stabilization			
 Nearshore Buttress	 Landside Buttress	 Drilled Shafts	 Super Bulkhead Wharf
Targeted Measures			
 Bulkhead Wharf Retrofit	 Liquefaction Mitigation		
POLICY AND EMERGENCY PREPAREDNESS:			
 Policies and Zoning	 Emergency Preparedness		