BOUNDLESS SAN FRANCISCO

APPENDIX AND SUPPLEMENTAL INFORMATION

Letters of support, regional plans and technical studies referenced in this proposal


Doppelmayr

Letter of Testimony

Salt Lake City, October 2026

Bay Area Aerial Transit System (BAAT) – Boundless San Francisco

To Whom It May Concern,

On behalf of the Doppelmayr Group, we are pleased to provide this letter of testimony to acknowledge our preliminary discussions with the BAAT Project Group regarding the proposed Bay Area Aerial Transit System, and the group's submission to the Boundless San Francisco competition.

With a history of more than 130 years, the Doppelmayr Group has been dedicated to the development, installation, and operation of state-of-the-art ropeway solutions worldwide. During this time, we have successfully completed close to 16,000 ropeway installations across 100 countries, serving a wide variety of applications – from iconic mountain regions, impressive tourist attractions and cultural landmarks to natural wonders and leisure destinations as well as urban settings. This long-standing experience forms the foundation of our technological leadership and our deep understanding of how ropeways can provide reliable mobility solutions in urban areas.

Based on the information shared with us by the BAAT project Group, and our experience with urban ropeway systems worldwide, the proposed application of aerial ropeway technology represents a technically credible planning concept that merits further evaluation. BAAT offers a promising basis for exploring how proven ropeway technology could complement San Francisco's existing transportation network by creating additional connections across geographic and infrastructure barriers.

Doppelmayr supports the proposal's advancement for further development within the Boundless San Francisco award framework. Should BAAT be selected to proceed to the next stage, we would welcome the opportunity to continue working with the BAAT Project Group through high-level technical discussions, validation of preliminary planning assumptions, and identification of appropriate next steps. This cooperation could help inform a viable, cost-effective, and community-responsive approach to planning, designing, funding, and ultimately implementing BAAT in San Francisco.

This letter is a nonbinding expression of support for BAAT's proposal and of Doppelmayr's interest in continuing to evaluate and develop the concept with the BAAT Project Group. It does not constitute a final determination of the feasibility of any particular route, alignment, design, cost, schedule, or operating plan, nor does it commit Doppelmayr to provide engineering, pricing, equipment, services, financing, or project participation.

Any future involvement would remain subject to site-specific study, further review, internal approval, mutually acceptable terms, and appropriate definitive agreements.

We wish the BAAT Project Group every success with its Boundless San Francisco submission and look forward to the opportunity to continue our discussions should the proposal advance.

Sincerely,

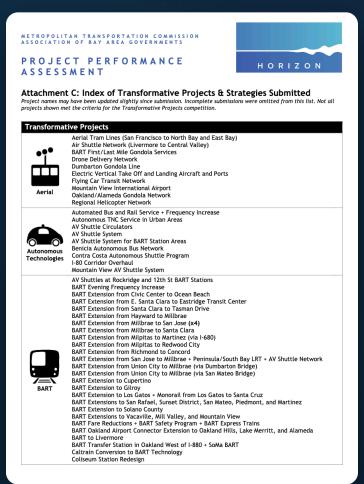
Shawn Marquardt
Sr Director of Sales
Doppelmayr USA, Inc

On behalf of the Doppelmayr Group Worldwide

A

DOPPELMAYR LETTER OF TESTIMONY

Doppelmayr USA, Inc.
October 2026


METROPOLITAN TRANSPORTATION COMMISSION
ASSOCIATION OF BAY AREA GOVERNMENTS

PROJECT PERFORMANCE ASSESSMENT

HORIZON

Attachment C: Index of Transformative Projects & Strategies Submitted

Project names may have been updated slightly since submission. Incomplete submissions were omitted from this list. Not all projects shown met the criteria for the Transformative Projects competition.

Transformative Projects

Aerial
- Aerial Tram Lines (San Francisco to North Bay and East Bay)
- Air Shuttle Network (Livermore to Central Valley)
- BART First/Last Mile Gondola Services
- Drone Delivery Network
- Dumbarton Gondola Line
- Electric Vertical Take Off and Landing Aircraft and Ports
- Flying Car Transit Network
- Mountain View International Airport
- Oakland/Alameda Gondola Network
- Regional Helicopter Network

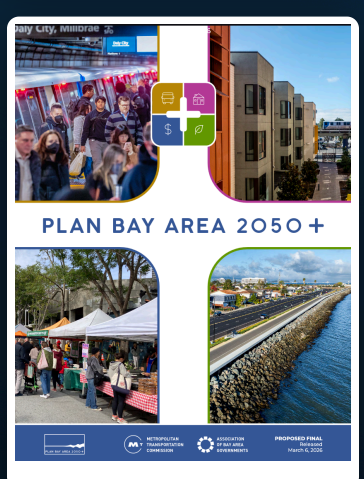
Autonomous Technologies
- Automated Bus and Rail Service + Frequency Increase
- Autonomous TNC Service in Urban Areas
- AV Shuttle Circulators
- AV Shuttle System
- AV Shuttle System for BART Station Areas
- Benicia Autonomous Bus Network
- Contra Costa Autonomous Shuttle Program
- I-80 Corridor Overhaul
- Mountain View AV Shuttle System

BART
- AV Shuttles at Rockridge and 12th St BART Stations
- BART Evening Frequency Increase
- BART Extension from Civic Center to Ocean Beach
- BART Extension from E. Santa Clara to Eastridge Transit Center
- BART Extension from Santa Clara to Tasman Drive
- BART Extension from Hayward to Millbrae
- BART Extension from Millbrae to San Jose (x4)
- BART Extension from Millbrae to Santa Clara
- BART Extension from Milpitas to Martinez (via I-680)
- BART Extension from Milpitas to Redwood City
- BART Extension from Richmond to Concord
- BART Extension from San Jose to Millbrae + Peninsula/South Bay LRT + AV Shuttle Network
- BART Extension from Union City to Millbrae (via Dumbarton Bridge)
- BART Extension from Union City to Millbrae (via San Mateo Bridge)
- BART Extension to Cupertino
- BART Extension to Gilroy
- BART Extension to Los Gatos + Monorail from Los Gatos to Santa Cruz
- BART Extensions to San Rafael, Sunset District, San Mateo, Piedmont, and Martinez
- BART Extension to Solano County
- BART Extensions to Vacaville, Mill Valley, and Mountain View
- BART Fare Reductions + BART Safety Program + BART Express Trains
- BART Oakland Airport Connector Extension to Oakland Hills, Lake Merritt, and Alameda
- BART to Livermore
- BART Transfer Station in Oakland West of I-880 + SoMa BART
- Caltrain Conversion to BART Technology
- Coliseum Station Redesign

B

TRANSFORMATIVE PROJECTS INDEX

MTC / ABAG Horizon Project Performance Assessment, Att. C



C

PLAN BAY AREA 2050+

MTC / ABAG
Proposed Final, March 2026


SAN FRANCISCO WATERFRONT COASTAL FLOOD STUDY, CA

DRAFT INTEGRATED FEASIBILITY REPORT AND ENVIRONMENTAL IMPACT STATEMENT

JANUARY 2024

USACE TULSA DISTRICT | THE PORT OF SAN FRANCISCO

P2: 499856

US Army Corps of Engineers

PORT

D

SF WATERFRONT COASTAL FLOOD STUDY

USACE / Port of San Francisco
Draft feasibility report and EIS, January 2024

Appendix Materials

- Letter of Testimony, Doppelmayr USA, Inc., October 2026
- Metropolitan Transportation Commission and Association of Bay Area Governments, Bay Area 2050+ Plan, Released March 6, 2026
- Metropolitan Transportation Commission and Association of Bay Area Governments, 2026 Project Performance Assessment, Attachment C: Index of Transformative Projects and Strategies Submitted (*excerpt*)
- San Francisco Waterfront Coastal Flood Study-("Integrated Feasibility Report & Environmental Impact Statement (US Army Corps of Engineers, 2024))

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Letter of Testimony

Salt Lake City, October 2026

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Sincerely,

Shawn Marquardt
Sr Director of Sales
Doppelmayr USA, Inc

On behalf of the Doppelmayr Group Worldwide





PLAN BAY AREA 2050+





PLAN BAY AREA 2050+

METROPOLITAN TRANSPORTATION COMMISSION

ASSOCIATION OF BAY AREA GOVERNMENTS

PROPOSED FINAL
Released
March 6, 2026

Connecting the Bay: A Waterfront Aerial Tram Vision

Destinations and urban communities are more successful when they are connected in a meaningful and attractive way.

A Proven Idea, Reimagined for San Francisco

Along the River Seine in Paris, a 5.5-kilometer stretch from Notre Dame to the Eiffel Tower is seamlessly connected by the Bateaux Mouches river boats, linking museums, cultural landmarks, shopping districts, and iconic bridges. This elevated-yet-separated experience removes people from surface congestion and underground transit while offering a memorable way to move through the city.

San Francisco's waterfront presents a similar opportunity. An **aerial tram system** would provide a scenic, efficient, and accessible connection for residents, commuters, and visitors—linking destinations while easing pressure on streets and tunnels.

A Phased Waterfront Network

The WREN team proposes a **multi-phase aerial tram system**, beginning in San Francisco and designed for future expansion to the East Bay and Peninsula.

Phase 1 – Southeast Waterfront
Piers 30/32 to Candlestick Point, serving Oracle Park, Chase Center, UCSF, Dogpatch, Hunters Point, India Basin, and Shoreline Park.

Phase 2 – Northeast Waterfront
Extension from Piers 30/32 to the Ferry Building, Exploratorium, Port of San Francisco, and Cruise Terminal.

Phase 3 – Northern Waterfront
Service to Fisherman's Wharf, Alcatraz ferry terminals, Fort Mason, Presidio Tunnel Tops, and the Palace of Fine Arts.

A Must-Ride Bay Area Experience

With iconic views, frequent access points, and reliable service, the waterfront aerial tram would become both a practical transportation option and a signature civic experience—connecting people to the Bay, its neighborhoods, and its landmarks in a way that is efficient, inspiring, and uniquely San Francisco.

Copyright © 2025, The WREN Group

Outlook

Supplemental Comments - Plan Bay Area 2050+

From Ralph I. Miller <[redacted]>
Date Thu 12/18/2025 4:37 PM
To Plan BayArea Info <info@planbayarea.org>

2 attachments (6 MB)
MTC-Aerial Trams-Supplemental Comment_251218.pdf; Destination Communities.pdf;

You don't often get email from [redacted]. Learn why this is important

External Email

Plan Bay Area 2050+

Public Information Office

Draft Plan Comments

375 Beale Street, Suite 800

San Francisco, CA. 94105

The San Francisco Bay Area 2050+ Plan presents a timely opportunity to explore innovative, resilient, and equitable transportation solutions that can support the region's long-term mobility, sustainability, and economic goals. In alignment with the Metropolitan Transportation Commission's commitment to reducing congestion, advancing climate objectives, and improving access across the Bay Area, this proposal introduces the concept of an aerial tram system as a complementary transit mode. The following materials outline how an aerial tram could enhance regional connectivity, serve challenging corridors, and contribute to a forward-looking, multimodal transportation network for the Bay Area.

Respectfully Submitted By: Clive Jones and Ralph Miller on behalf of The WREN Group.

Ralph I. Miller
Mobile [redacted]

To:

Plan Bay Area 2050+

Public Information Office

Draft Plan Comments

375 Beale Street, Suite 800

San Francisco, CA. 94105

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Respectfully Submitted By: Clive Jones and Ralph Miller on behalf of The WREN Group.

Suggested Aerial Cable Transit (ACT) Network for San Francisco–Oakland



ACT System Types

There are four primary types of aerial cableway systems commonly used for Aerial Cable Transit (ACT) in urban environments: mono-cable gondola, bi-cable gondola, tri-cable gondola (3S), and jig-back (dual-line) tramway. Each of these options was evaluated for suitability within the San Francisco Bay Area context. Based on performance, capacity, and operating characteristics, the tri-cable gondola (3S) system was selected as the preferred technology.

Tri-Cable Gondola (3S)

The tri-cable gondola (3S) is a specialized cableway system designed for long spans and high-profile alignments. It builds on bi-cable (2S) technology by adding a second fixed track cable on each side, significantly improving stability—particularly in windy conditions. The system typically uses larger passenger cabins with detachable grips that circulate continuously between terminal and intermediate stations.



Compared to bi-cable systems, 3S technology allows for longer distances between towers and higher vehicle capacities, making it well suited for major urban connections.

Typical System Characteristics

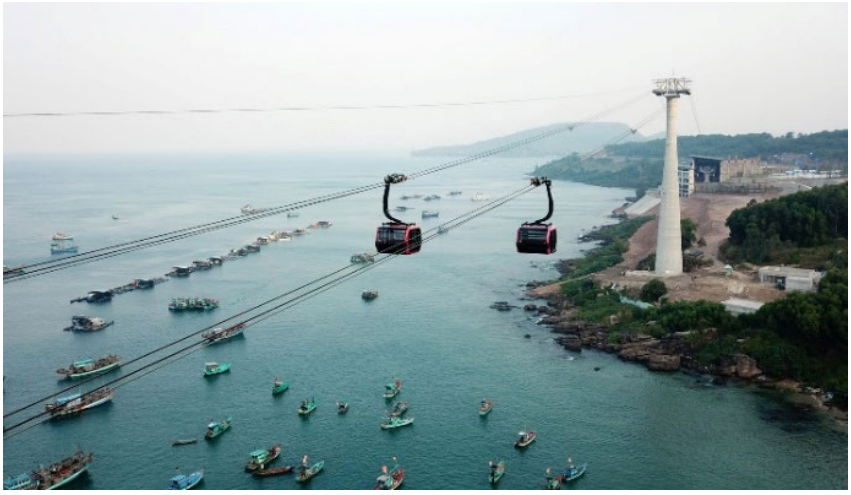
- **Carrying capacity:** 4,000–5,000 passengers per hour, per direction
- **Vehicle capacity:** 20–35 passengers
- **Headways:** 15–45 seconds
- **Maximum speed:** Up to 18 mph
- **Right-of-way width:** Approximately 60–65 feet

Suitability for the San Francisco–Oakland Corridor

Due to its combination of relatively high capacity, operational stability, and flexibility to accommodate commuter traffic, special events, tourism, and everyday urban transit needs, the 3S system is particularly well suited to linking San Francisco and Oakland.



A strong real-world example of this technology is the 3S gondola currently operating at Hon Thom Nature Park in Vietnam. This system spans 4.9 miles, supported by six intermediate towers. It operates 70 fully enclosed glass cabins, each accommodating 25–30 passengers, and travels at speeds approaching 20 miles per hour.



A Transbay ACT system using similar technology would scale this approach, with an estimated fleet of more than 200 cabins to meet Bay Area capacity and reliability requirements.

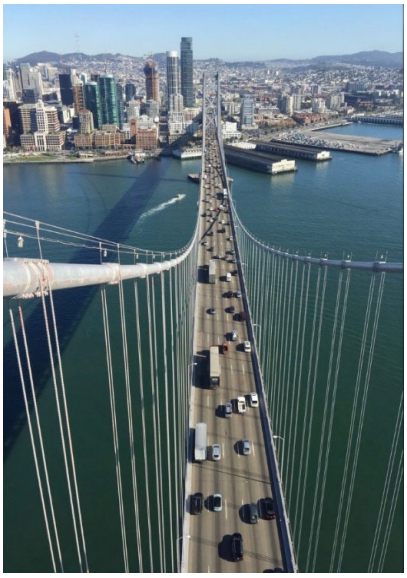
Broad-Range Transbay ACT System and Southeast Extension – Overview

Based on the recommended ACT routing and potential extensions, we developed a spreadsheet outlining key system parameters along with a preliminary range of costs. Many of the land-based components of the program are relatively low-tech and can be implemented with minimal disruption to existing infrastructure.

Challenges

The primary technical challenge is the Bay Bridge crossing. Fortunately, recent precedent demonstrates that this challenge is both manageable and achievable. The Hon Thom 3S system, for example, sets a new benchmark, with intermediate tower heights reaching 164 meters—remarkably close to the Bay Bridge tower heights of approximately 143 meters on the west span and 160 meters on the east span.





While it may be technically possible to attach aerial tram towers directly to the existing Bay Bridge structure, our studies indicate that constructing new towers adjacent to the current bridge towers—on the south side—would better support the operational and design needs of a Transbay ACT system. This alignment would also create a truly memorable passenger experience, offering unparalleled views across the Bay. (On a personal note, having once taken the elevator to the top of the Golden Gate Bridge's south tower, I can attest that the experience is unforgettable.)

The accompanying materials include representative east–west views from the top of Bay Bridge Tower 2, as well as views from the proposed Yerba Buena ACT station site.

For the Southeast San Francisco and Oakland extensions, the challenges are less technical and more organizational, centering on coordination and collaboration among private stakeholders, port authorities, and San Francisco and Oakland government agencies.

Opportunities

Districts 9 and 10 have historically been underserved in regional transit planning, and the Transbay ACT system presents a meaningful opportunity to address that gap. While reducing automobile traffic and travel time across the Bay Bridge is a significant benefit, the advantages of the system extend well beyond congestion relief.

The ACT network would help catalyze development on Treasure Island, along the Southeast San Francisco waterfront, and at key Oakland gateway sites—supporting the creation of much-needed housing, jobs, and economic activity. Just as importantly, it would provide residents and visitors with a car-free, reliable, and enjoyable way to access workplaces, destinations, events, and gathering places throughout the Bay Area.

Critical Needs for Districts 9 and 10

Reducing congestion on the Bay Bridge and through the BART Transbay tunnel is an important regional priority, but those travel options are largely a matter of choice for many residents. This is not the case in Southeast San Francisco. In Districts 9 and 10, more than 250,000 residents—representing approximately 90,000 households—lack convenient access to high-capacity transit.

As illustrated in the data below, residents in San Francisco Districts 1–8 make approximately 22.6 million annual work trips using subway or elevated transit systems. In contrast, residents of Districts 9 and 10 are not offered comparable transit opportunities. This disparity represents a significant equity issue and highlights a long-standing gap in the City's transportation network that the Transbay ACT system could begin to address.

Means of Transport to Work in San Francisco

	Districts 1 -8				District 9 - Central East				District 10 - Southeast			
Mode of Transport	Persons	Daily Trips to Work	Annual Work Trips	% by Mode	Persons	Daily Trips to Work	Annual Work Trips	% by Mode	Persons	Daily Trips to Work	Annual Work Trips	% by Mode
Car	141,324	282,648	73,488,480	42%	23,509	47,018	12,224,680	38%	37,981	75,962	19,750,120	69%
Bus or TrolleyBus	82,139	164,278	42,712,280	24%	13,916	27,832	7,236,320	22%	14,073	28,146	7,317,960	26%
Subway or Elevated	43,497	86,994	22,618,440	13%	0	0	0	0%	-	-	-	0%
Railroad	4,135	8,270	2,150,200	1%	3,064	6,128	1,593,280	5%	541	1,082	281,320	1%
Ferryboat	167	334	86,840	0%	119	238	61,880	0%	10	20	5,200	0%
Bicycle	13,771	27,542	7,160,920	4%	5,886	11,772	3,060,720	9%	641	1,282	333,320	1%
Motorcycle	3,630	7,260	1,887,600	1%	704	1,408	366,080	1%	257	514	133,640	0%
TaxiCab	5,213	10,426	2,710,760	2%	1,052	2,104	547,040	2%	90	180	46,800	0%
Walk	42,480	84,960	22,089,600	13%	13,910	27,820	7,233,200	22%	1,314	2,628	683,280	2%
Total Commuters	336,356	672,712	174,905,120	100%	62,160	124,320	32,323,200	100%	54,907	109,814	28,551,640	100%
Population	615,060				130,000				124,940			
% Commuting to Work	55%				48%				44%			
Households	267,283				56,716				35,674			

As shown, a very preliminary estimate for the core San Francisco Bay Area Transbay ACT system is approximately **$1.7 billion**. While this represents a significant investment, we believe it is accompanied by meaningful offsets. These include projected ridership revenues and the increased real estate value generated at station locations and within adjacent large-scale developments—particularly on Treasure Island and along the Southeast Waterfront.

Southeast ACT Ridership Opportunity						
				Travelers	Trips	Annual Trips
Employee Travel						
SF Residents from Districts 1-8 to Employment in D9&10				3,364	6,727	1,749,051
Residents of D9-10 to Place of Work				23,413	46,827	12,174,968
		Subtotal		26,777	53,554	13,924,019
Work Related Travel (visitors, customers, suppliers to D9&10)					16,066	4,177,206
Total Work Based ACT Travel						18,101,225
Household Related Travel				18,478	36,956	13,488,940
Total D9&10 Resident and Employment Related Ridership						31,590,165
Visitors						
Bay Area Residents		7,500,000	4%	600,000		1,200,000
Tourists		22,600,000	4%	1,808,000		3,616,000
Events						
Oracle Park + Chase Center (Games, Concerts, etc.)		7,500,000	15%	1,125,000		2,250,000
	Subtotal					7,066,000
Total Ridership Based on Current Conditions						38,656,165
Average per Day						105,907
New Population in D9&10				60,000		
Ridership from New Resident population			40%	24,000	48,000	17,520,000
Buildout Ridership						56,176,165
Average per Day						156,045

Preliminary Routing and Cost Estimates for Transbay ACT System						
ACT Core Plan	Distance	Support Towers	Cost ($millions)			
		Separation distance (ft.)	Stations	Support Towers (80-100 ft. elev). Bridge supports at 450 ft)	Equipment and Installation (per mile)	Total
Asssumptions		2,400	$ 60	$ 20	$ 30	
CORE SYSTEM						
Downtown San Francisco (4th Street)			$ 70			$ 70
to Pier 26	1.1	2		$ 40	$ 33	$ 73
Pier 26 Base and Engine Station			$ 90			$ 90
San Francisco Bay Crossing						
Pier 26 to Tower 1	0.2			$ 40	$ 6	$ 46
Tower 1 to Tower 2	0.5			$ 40	$ 14	$ 54
Tower 2 to Tower 3	0.5			$ 40	$ 14	$ 54
Tower 3 to Tower 4	0.5			$ 40	$ 14	$ 54
Tower 4 to Yerba Buena Station	0.5				$ 15	$ 15
Yerba Buena Station			$ 60			$ 60
Surface transport to/ from TI						
YB to Bay Bridge East Tower	0.7	1		$ 40	$ 21	$ 61
East Tower to Bay Bridge Station	1.8	3		$ 60	$ 54	$ 114
Bay Bridge Engine Station			$ 90			$ 90
Bay Bridge Station to Macarthur BART	2.0	3		$ 60	$ 60	$ 120
Macarthur BART Station			$ 70			$ 70
Subtotal	7.7	9	$ 380	$ 360	$ 230	$ 970
Contingency, Right of Way 45%						$ 436
Soft Costs 35%						$ 339
Allowance						$ 1,700
Per Mile						$ 222
Source: KBCG						

Each station is envisioned as an active, mixed-use hub, incorporating retail, dining, and destination amenities appropriate to its location. In addition, we have held preliminary discussions with leading ACT system manufacturers, including Doppelmayr and Leitner/POMA. Based on their feedback, our current cost assumptions may be conservative, suggesting that further cost efficiencies and offsets could be achievable as the project advances.

Comparisons

Horizons previously completed a comprehensive and well-documented evaluation of several proposed Transbay transportation alternatives. We reference their work not as a critique, but as a way to broaden the discussion around feasible and innovative solutions.

As summarized below, the alternatives evaluated by Horizons range in estimated cost from approximately **$10 billion to $98 billion**. While each of these options would add peak-hour Transbay capacity, they do so at a substantially higher cost. In this context, a Transbay Aerial Cable Transit system offers a comparatively cost-effective approach to expanding capacity while also delivering additional urban, economic, and placemaking benefits.

Comparison of Transbay Transportation Alternatives

		Cost ($billions)		Additional Peak hour Capacity		$ Per Additional Peak Hour Trip	
Horizon Concepts		Min	Max	vehicles/Hr	Trips/Hr	Min	Max
1	New San Mateo Bridge	$ 10.0	$ 17.0	2,000	4,000	$ 2,500,000	$ 4,250,000
2	Mid Bay Bridge	$ 15.0	$ 20.0	6,000	12,000	$ 1,250,000	$ 1,666,667
3	Market St. Redundancy	$ 32.0	$ 48.0		25,000	$ 1,280,000	$ 1,920,000
4	New Markets	$ 33.0	$ 49.0		25,000	$ 1,320,000	$ 1,960,000
5	Greater Regional Rail (GRR)	$ 43.0	$ 49.0		28,000	$ 1,535,714	$ 1,750,000
6	Southern Crossing	$ 39.0	$ 53.0	4,000	33,000	$ 1,181,818	$ 1,606,061
7	BART New Markets +GRR	$ 76.0	$ 98.0		53,000	$ 1,433,962	$ 1,849,057
TACT	Transbay Aerial Cable Transit	$ 1.4	$ 2.0		6,000	$ 233,333	$ 333,333
Note: vehicle Trips Assume 2 persons per vehicle							
Source: Horizon, KBCG							

We compared the costs of the TACT system and the cost per additional peak hour trip is less than 20% of the other approaches. Also, the TACT system can be built in 2-3 years at most, so it is a very viable mid term solution to Bay Area Transbay congestion.

Extensions

The following extensions are intended to extend the reach into neighborhoods less well served by transit but with great potential.

Preliminary Routing and Cost Estimates for Transbay ACT System Extensions

ACT Core Plan		Distance	Support Towers	Cost ($millions)			
			Separation distance (ft.)	Stations	Support Towers (80-100 ft. elev). Bridge supports at 450 ft)	Equipment and Installation (per mile)	Total
Asssumptions		miles	2,400	$ 60	$ 20	$ 30	
Downtown Oakland Extension							
Bay Bridge Station to West Oakland		1	2		$ 40	$ 30	$ 70
West Oakland Station				$ 60	$ -	$ -	$ 60
West Oakland to Downtown		1.1	2		$ 40	$ 33	$ 73
Downtown Oakland Station				$ 60	$ -	$ -	$ 60
Branch to Jack London Square/AMTRAK		0.8	2	$ 60	$ 40	$ 24	$ 124
Lake Merritt		0.8	2	$ 60	$ 40	$ 24	$ 124
	Subtotal	3.7	8	$ 240	$ 160	$ 111	$ 511
Contingency, Right of Way	60%						$ 307
Soft Costs	40%						$ 204
Allowance							$ 1,020
Per Mile							$ 276
Southern SF Waterfront Extension							
Pier 26 to CalTrain/ Oracle Park		0.7	2		$ 40	$ 21	$ 61
Oracle Park/ Caltrain Station				$ 60			$ 60
Oracle Park to Mission Bay		0.8	2		$ 40	$ 24	$ 64
Mission Bay/ Chase Center Station				$ 60			$ 60
Mission Bay to Dogpatch		1	2		$ 40	$ 30	$ 70
Dogpatch Station				$ 60			$ 60
Dogpatch to Hunters Point		1	2		$ 40	$ 30	$ 70
Hunters Point Station				$ 60			$ 60
Hunters Point to Candlestick		2	4		$ 80	$ 60	$ 140
Candlestick Point Base and Engine Station				$ 90			$ 90
	Subtotal	5.5	12	$ 330	$ 240	$ 165	$ 735
Contingency, Right of Way	45%						$ 331
Soft Costs	35%						$ 257
Allowance							$ 1,320
Per Mile							$ 240
Northern SF Waterfront Extension							
Pier 26 to Ferry Buiding		0.5	1	$ 60	$ 20	$ 15	$ 95
to Exploratorium		0.5	1	$ 60	$ 20	$ 15	$ 95
to Fisherman's Wharf/ Engine Station		1	2	$ 90	$ 40	$ 30	$ 160
to Aquatic Park/Cable Car Turnaround		1	2	$ 60	$ 40	$ 30	$ 130
to Fort Mason, PFA/Crissy Field		2.5	6	$ 120	$ 120	$ 75	$ 315
	Subtotal	5.5	12	$ 390	$ 240	$ 165	$ 795
Contingency/Right of Way	70%						$ 557
Soft Costs	50%						$ 398
Allowance							$ 1,750
Per Mile							$ 318

Source: KBCG

Benefits

An Aerial Cable Transit (ACT) system in the Bay Area would deliver a wide range of transportation, economic, environmental, and community benefits, including:

- **Improved access to housing and jobs** by providing convenient, reliable connections to both market-rate and affordable housing developments, as well as employment centers across the region—particularly in underserved areas such as San Francisco Districts 9 and 10.
- **A meaningful boost to tourism**, highlighted by the proposed Waterfront "E" line: an approximately 30-minute, scenic journey along and above the Southeast waterfront and across the Bay. This signature experience would introduce a new, iconic attraction and support the continued recovery of the Bay Area's tourism economy.
- **A more predictable and dependable transit option** that enables residents and employees to travel when and where they need to, with seamless connections to walking routes and existing transit services serving nearby employment, commercial, and cultural destinations.
- **Reduced automobile traffic** across the Bay Bridge and along key waterfront corridors, contributing to less congestion and improved air quality.
- **Stronger connections between emerging and established communities**, linking Treasure Island, Hunters Point, and Candlestick with central San Francisco and Oakland. While not the initial focus of the ACT concept, implementation of the system would help resolve several access and financing challenges currently affecting Treasure Island.
- **A new and inspiring perspective on San Francisco Bay**, offering residents, visitors, and schoolchildren sweeping views of the region's landscape and landmarks from an entirely new vantage point.
- **Regional connectivity**, with direct or proximate links to existing transit systems including cable cars, ferries, BART, Caltrain, the Transbay Transit Center, and Amtrak.
- **An elevated travel experience** that rises above street-level congestion, noise, and visual clutter. Operating along and over the Bayfront, ACT provides a calm, safe, secure, and on-time way to reach central San Francisco, Oakland, and waterfront destinations.
- **High-frequency service**, with headways of less than one minute, ensuring that cabins are available almost immediately at every station.
- **New civic landmarks**, with each ACT station designed as a distinctive architectural and artistic expression reflecting the Bay Area's culture, history, and innovation. Stations would serve as active community hubs, supporting small businesses, dining, retail, and educational opportunities.
- **Minimal construction disruption** compared to surface transportation improvements, with little to no impact on existing traffic patterns or land uses.
- **Proven, reliable technology**, successfully deployed in cities such as Medellín and Bogotá (Colombia), La Paz (Bolivia), Mexico City, and numerous locations across North Africa, Europe, and Asia.
- **No requirement for public financing**, while still engaging the public sector in station siting and the coordination of aerial rights-of-way along proposed routes.
- **Phased implementation**, beginning with the Southeast Waterfront segment as the first leg of the Transbay system, achievable within approximately three years, followed by extensions to central San Francisco, Treasure Island, and central Oakland. Additional routes could be evaluated over time.

Finally, the ACT system contributes meaningfully to the region's **climate action goals** by reducing carbon emissions and operating independently of projected sea-level rise, making it both a sustainable and resilient transportation solution.

Future Opportunities

The ACT system has been designed with flexibility and long-term expansion in mind, allowing it to evolve alongside the Bay Area's transportation and development needs, including tourism.



Notes:

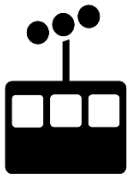
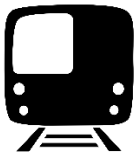
- **Engine stations** for the ACT system are proposed at Pier 26 beneath the west end of the Bay Bridge, near the eastern end of the Bay Bridge adjacent to the toll plaza, and in the Hunters Point/Candlestick Park area to serve the Southeast Waterfront.
- **Boarding and deplaning stations** are indicated as black circles on the accompanying diagrams.
- **Optional routes**, shown in green, include a loop around Treasure Island as well as an extension to the MacArthur BART station, further strengthening regional connectivity.
- **Support towers** would typically be spaced at intervals of approximately one-quarter to one-half mile, depending on terrain and alignment requirements.
- Along the **Bay Bridge crossing**, ACT towers would be constructed adjacent to the south side of the bridge's four existing towers. These new towers would be fully independent structures, designed to avoid any impact on the structural integrity or operation of the bridge itself.

Together, these future opportunities demonstrate how the ACT system can be thoughtfully expanded to enhance mobility, resilience, and connectivity throughout the Bay Area over time.

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Attachment C: Index of Transformative Projects & Strategies Submitted

Project names may have been updated slightly since submission. Incomplete submissions were omitted from this list. Not all projects shown met the criteria for the Transformative Projects competition.

Transformative Projects	
 **Aerial**	Aerial Tram Lines (San Francisco to North Bay and East Bay) Air Shuttle Network (Livermore to Central Valley) BART First/Last Mile Gondola Services Drone Delivery Network Dumbarton Gondola Line Electric Vertical Take Off and Landing Aircraft and Ports Flying Car Transit Network Mountain View International Airport Oakland/Alameda Gondola Network Regional Helicopter Network
 **Autonomous Technologies**	Automated Bus and Rail Service + Frequency Increase Autonomous TNC Service in Urban Areas AV Shuttle Circulators AV Shuttle System AV Shuttle System for BART Station Areas Benicia Autonomous Bus Network Contra Costa Autonomous Shuttle Program I-80 Corridor Overhaul Mountain View AV Shuttle System
 **BART**	AV Shuttles at Rockridge and 12th St BART Stations BART Evening Frequency Increase BART Extension from Civic Center to Ocean Beach BART Extension from E. Santa Clara to Eastridge Transit Center BART Extension from Santa Clara to Tasman Drive BART Extension from Hayward to Millbrae BART Extension from Millbrae to San Jose **(x4)** BART Extension from Millbrae to Santa Clara BART Extension from Milpitas to Martinez (via I-680) BART Extension from Milpitas to Redwood City BART Extension from Richmond to Concord BART Extension from San Jose to Millbrae + Peninsula/South Bay LRT + AV Shuttle Network BART Extension from Union City to Millbrae (via Dumbarton Bridge) BART Extension from Union City to Millbrae (via San Mateo Bridge) BART Extension to Cupertino BART Extension to Gilroy BART Extension to Los Gatos + Monorail from Los Gatos to Santa Cruz BART Extensions to San Rafael, Sunset District, San Mateo, Piedmont, and Martinez BART Extension to Solano County BART Extensions to Vacaville, Mill Valley, and Mountain View BART Fare Reductions + BART Safety Program + BART Express Trains BART Oakland Airport Connector Extension to Oakland Hills, Lake Merritt, and Alameda BART to Livermore BART Transfer Station in Oakland West of I-880 + SoMa BART Caltrain Conversion to BART Technology Coliseum Station Redesign

SAN FRANCISCO WATERFRONT COASTAL FLOOD STUDY, CA

DRAFT INTEGRATED FEASIBILITY REPORT AND ENVIRONMENTAL IMPACT STATEMENT

JANUARY 2024



USACE TULSA DISTRICT | THE PORT OF SAN FRANCISCO

P2: 499856

US Army Corps of Engineers

PORT OF SAN FRANCISCO

COVER SHEET

San Francisco Waterfront Coastal Flood Study
Draft Integrated Feasibility Report and Environmental Impact Statement

City and County of San Francisco, California

Lead Agency: US Army Corps of Engineers, Tulsa District (USACE)

Cooperating Agencies: Environmental Protection Agency Region 9 (Formally Accepted), Federal Emergency Management Agency Region IX (Planning and Implementation Branch), National Marine Fisheries Service (Formally Accepted), National Park Service, US Fish and Wildlife Service

Participating Agency: California Department of Fish and Wildlife, California Regional Water Quality Control Board, California State Lands Commission, San Francisco Bay Conservation and Development Commission, and San Francisco Planning Department

Abstract: Low-lying assets and economic activity along the San Francisco Waterfront are at risk of flooding from coastal storms, extreme high tides, and sea level rise. The frequency and depth of tidal flooding along the shoreline is only expected to increase as sea levels continue to rise. The San Francisco Waterfront Coastal Flood Study, CA coastal flood risk management study (SFWCFS) is authorized to investigate the feasibility of managing tidal and fluvial flooding and sea level rise along 7.5 miles of the San Francisco Waterfront, from Aquatic Park to Herons Head Park, in the City of San Francisco, San Francisco County, California. This report has been prepared by the Tulsa District, Southwestern Division of the U.S. Army Corps of Engineers (USACE), in partnership with the Port of San Francisco (POSF) to document the study results and findings, including the formulation of alternatives, the costs and benefits of alternatives considered, the selection process of the Tentatively Selected Plan and to disclose the impacts the alternatives may have on the human and natural environment. Short- and long-term impacts to existing aquatic habitats, fish and wildlife including federally protected species and their habitat, water, air, aesthetics, noise, transportation corridors, recreation, historic, and socioeconomic resources are expected. Many of the impacts to other resources will be minimized or avoided through project design. Compensatory mitigation is needed for aquatic habitats, water quality, and air quality. Long-term benefits are anticipated to each of the socioeconomic resources such as life safety, critical infrastructure, utilities, historic resources, historically disadvantaged communities, recreation, and the local economy through the management of coastal flooding and sea level rise. All comments on this Draft Integrated Feasibility Report and Environmental Impact Statement are required to be submitted by _____, 2024.

For more information on this Draft Integrated Feasibility Report and Environmental Impact Statement and the tribal, agency, and public involvement process conducted in conjunction with its preparation, write or call:

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Executive Summary

ES-1 Purpose and Need

This study is prepared as a partial response to the study authority, investigating only a segment of the authorized San Francisco Bay shoreline. The purpose of the Study is to investigate the feasibility of managing tidal and fluvial flooding and sea level rise along 7.5 miles of the San Francisco Bay shoreline. The project area is at risk of flooding from bay water during coastal storms, extreme tides, and future sea level rise, with the potential for extensive damage to public infrastructure and private property and associated impacts to the San Francisco waterfront. The risk is expected to increase over time as sea levels rise in the bay.

This study is being conducted under the authority of Section 110 of Rivers and Harbors Act of 1950, Section 142 of Water Resources Development Act (WRDA) 1976 as amended by Section 705 of WRDA 1986 and Section 8325 of WRDA 2022, and Section 203 of WRDA 2020 that authorize an investigation of the feasibility of providing protection against tidal and fluvial flooding and measures to adapt to rising sea levels in San Francisco Bay including the City and County of San Francisco.

Low-lying assets and economic activity along the San Francisco Waterfront are at risk of flooding from coastal storms and extreme high tides, and from the potential failure of the century-old San Francisco seawall, which could result from structural deterioration or earthquake induced shoreline instability (liquefaction or lateral spreading). The San Francisco Bay Area is a seismically active region, and a major earthquake could happen within the study area at any time.

The waterfront is currently at risk of coastal overtopping and damages to property and critical infrastructure because of coastal storms, including the contribution of stillwater, waves and wave runup, which will be exacerbated by rising sea levels. The rate of RSLC is uncertain and could rise from 1 to 10 feet by 2140.

By 2040 under the High SLC curve, over 500 structures will be vulnerable to flooding from the 1% annual exceedance probability (AEP) event, which is an extreme storm with a 1% chance of happening in any given year. Some of these assets include San Francisco Municipal Transportation Agency (SFMTA) facilities and track, City facilities, and commercial real estate. Under the High SLC curve, average annual damages exceed $100 million by 2046; this is driven both by potential damages from infrequent, high water level events, but also from repetitive flooding occurring in low-lying areas.

By 2090 under the High SLC curve, there could be up to three feet of sea level change. This increases both the spatial extent of infrequent storm events and the effects of frequent flooding events.

Absent any federal action, coastal storm risk to the study area will increase. The rate and severity of increasing risks is directly connected to rates of RSLC. Without any federal action, the study area may be subject to intense inundation by a 1% AEP flood event by 2140, though the extent of inundation is dependent on the rate of SLC (Figure 1).

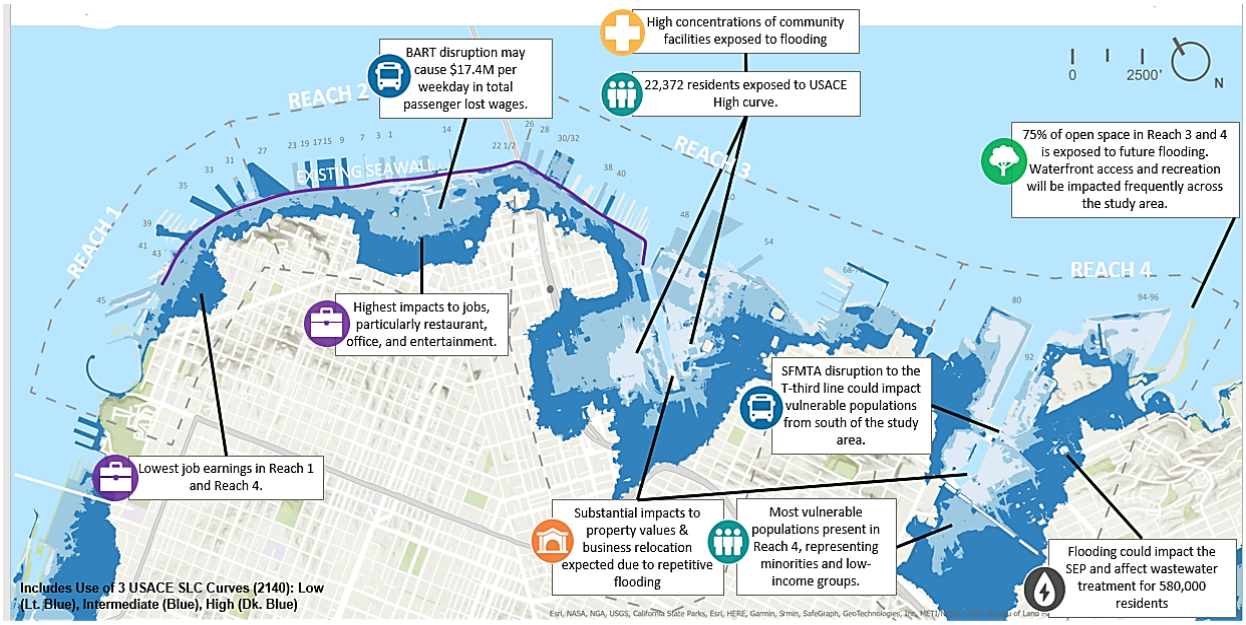


Figure 1 - Extent of inundation expected under 1% AEP flood event in FWOP Conditions under the three RSLC curves

Note: The shades of blue reflect the three SLR curves, with the lightest blue being the USACE low curve, and darkest the high curve.

ES-2 Plan Formulation

Plan formulation in response to the study authority was conducted in two broad phases. An initial planning iteration considered distinctly different conceptual approaches to manage the coastal flood risk in the region. The USACE San Francisco District PDT conducted an initial screening of measures including a deployable water management structure at the Golden Gate Bridge, an offshore wave attenuator, several scales of offshore barriers, perimeter plans along the Bay coastline and two forms of retreat.

In early 2021, when USACE developed new guidance for the study to support development of the perimeter plan to balance cost effective implementation and performance under uncertain timing of RSLC. The guidance included the following formulation direction:

- Develop multi-hazard formulation strategies that reflect timing, location, and severity differences in risk.
- Develop at least one stand-alone nonstructural alternative.
- Incorporate engineering with nature, when practicable.
- Formulate with all 3 USACE RSLC projections, plus additional State of CA projections if a Locally Preferred Plan (LPP) is requested.

As a result of this guidance, the PDT developed a plan formulation strategy that is described in the following section.

ES-2.1 Plan Formulation Strategy

Coastal flooding will increase at an uncertain rate over the period of analysis. Although coastal flood events may occur in the study area, the scale of flood event is primarily influenced by the water surface elevations that result from a coastal flood event in combination with sea level rise. The plan formulation strategy sought to identify different approaches to reduce flood risk now and into the future with an array of alternatives that would inform whether early, phased, or later interventions would be most cost effective and avoid or minimize study area impacts.

Formulation of alternatives to reduce coastal flood risk included:

- An overall approach to defend, accommodate, or retreat from coastal flood risk consisting of structural and nonstructural measures and natural and nature-based features along different lines of defense including:
    - the existing shoreline,
    - a more bayward alignment, and
    - an inland alignment requiring partial retreat of buildings and infrastructure over time;
- Varied scales of features to reflect uncertain timing of RSLC; and
- Phased implementation of features within most alternatives.

ES-3 Array of Alternatives

Consistent with study guidance, the following alternative plans were developed by the Project Delivery Team and evaluated under three USACE RSLC scenarios:

Alternative A No Action

Alternative B Nonstructural (e.g., floodproofing)

Alternatives C and D

Alternative C Defend, Scaled for Lower Risk (low rate of SLC)

Alternative D Defend, Scaled for Low-Moderate Risk (intermediate rate of SLC)

Alternatives E, F, and G

Alternative E Defend Existing Shoreline, Scaled for Higher Risk (high SLC)

Alternative F Manage the Water, Scaled for Higher Risk (high SLC)

Alternative G Partial Retreat, Scaled for Higher Risk (high SLC)

Alternatives D, E, F, and G were all designed to be adaptive, with a second action occurring in 2090.

The PDT identified representative scales of RSLC as building blocks of 1.5 feet, 3.5 feet, and 7 feet of SLC and are depicted in Table 1.

Table 1-1 - Sea Level Change Performance by Alternative

Alternative	2040 Target Performance	2040 Finish Elevation	2090 Target Performance	2090 Finish Elevation
Alternative A	No Action			
Alternative B	Floodproof areas at risk of 1% AEP coastal flooding; retreat areas at risk of monthly coastal flooding; add assets as risk increases over time.			
Alternative C	1.5’ SLC	13.5’ NAVD88	N/A	N/A
Alternative D	1.5’ SLC	13.5’ NAVD88	3.5’ SLC	15.5’ NAVD88
Alternative E	3.5’ SLC	15.5’ NAVD88	7.0’ SLC	19.0’ NAVD88
Alternative F	3.5’ SLC	15.5’ NAVD88	7.0’ SLC	19.0’ NAVD88
Alternative G	3.5’ SLC	15.5’ NAVD88	7.0’ SLC	19.0’ NAVD88

The features of these alternatives are summarized in Chapter 3, Plan Formulation and Evaluation. More detailed information on these alternatives can be found in *Appendix A: Plan Formulation*.

ES-4 Tentatively Selected Plan

The PDT evaluated the alternatives listed above and identified the three NED plans (one for each RSLC curve) and then added metrics for the RED, OSE, and EQ accounts to determine a Total Net Benefits Plan (TNBP). The TNBP was formulated by combining the features of the initial array of alternatives to create a plan that maximizes total net benefits across all possible SLC scenarios and was selected as the Tentatively Selected Plan (TSP).

The TSP is a cost effective, hybridized plan that combines retreat and defend measures, scaled to perform under the lowest initial risk and to adapt to risk of a higher rate of RSLC as a potential subsequent action. Initial actions are shown in Figure 2.

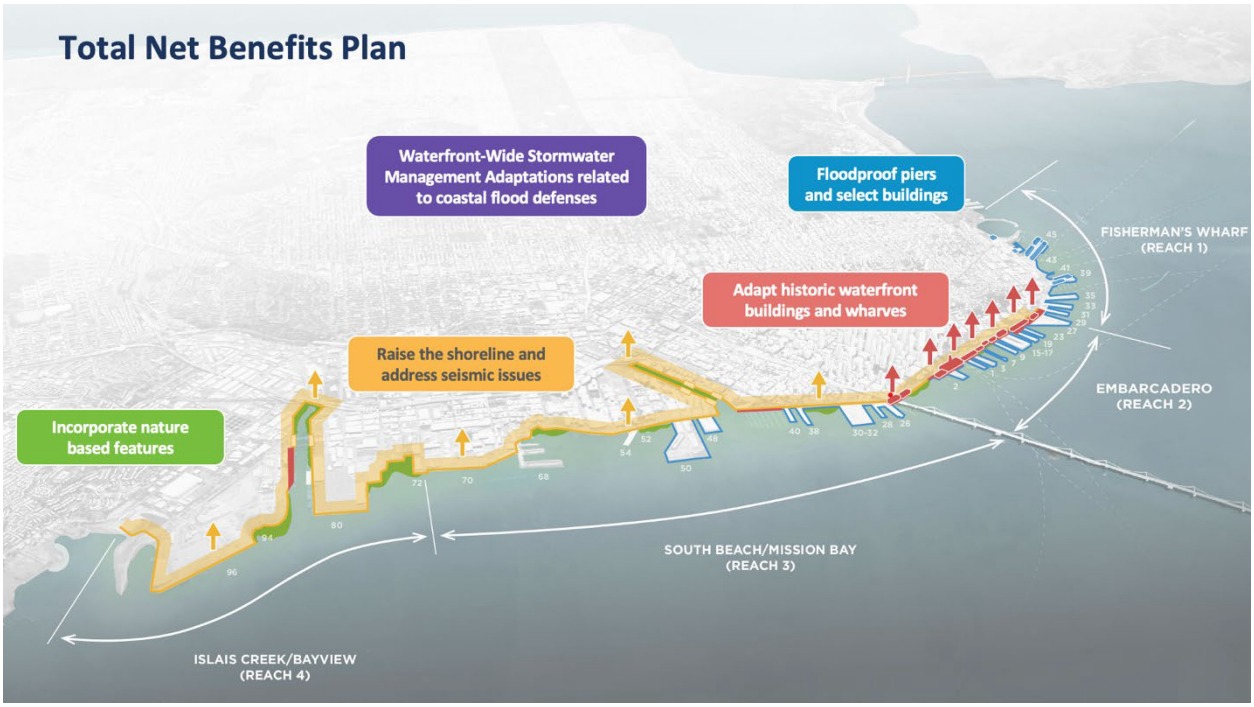


Figure 2 - TSP Initial Actions

Table 2 illustrates the conceptual framework for the range of TSP subsequent actions.

Table 1-2 - TSP First and Second Actions

Table 2: Conceptual Framework for TSP Subsequent Actions				
Reach	**First Action**	**Second Action Low RSLC**	**Second Action Intermediate RSLC**	**Second Action High RSLC**
Fisherman's Wharf, Reach 1	Alternative B	No action	Alternative B (Additional NS)	Alternative G 19’
Embarcadero, Reach 2	Alternative G 15.5’	No action	No action	Alternative G 19’
South Beach/Mission Bay, Reach 3	Alternative D 13.5’	No action	Alternative D 15.5’	Alternative E 19’
Islais Creek/Bayview, Reach 4	Alternative D 13.5’	No action	Alternative D 15.5’	Alternative E 19’

Further technical engineering, environmental, and economic details can be found in the appendices. Chapter 5 describes how the TSP complies with relevant environmental laws, regulations, and executive orders. The TSP includes adaptive action at Year 50 to refine the feature scales and alignments if coastal flood risk increases and could vary in its ultimate implementation.

The TSP manages coastal flood risk through a suite of Coastal Flood Risk Management (CFRM) measures that function as a system, based on rising sea levels, and are implemented over time based on the risk of sea level rise. The TNBP with seismic ground improvements is proposed as the TSP because it is responsive to the study guidance and aligns with a resilience strategy that maximizes effectiveness across a broad array of future risk scenarios.

Further refinement of the TSP to vary scale and implementation time of measures at the sub-reach geographic level will likely increase cost effectiveness of the plan. Potential refinements will be explored in the next phase of study when performance metrics are available to support tradeoff analysis. A waiver of policy will be required to recommend a plan other than the NED plan as the TSP, and a request for that waiver is currently under review by the Office of the Assistant Secretary of the Army for Civil Works (OASACW).

ES-5 Pertinent Data

The physical quantities and extents of the TSP features are summarized in Table 3.

Table 1-3 - Physical quantities and extents of 2040 TSP actions

Feature	Volume (CY)	Area (SF)	Length (Miles)
Levees	98,979	-	2.92
Combi Wall	33,788	-	1.96
T-Wall	979	-	0.78
Sidewalk	16,585	1,739,070	2.60
Wharf	-	609,840	-
Building Raise	-	326,435	-

Plan costs were estimated using the MicroComputer Aided Cost Estimating System, Second Generation (MCACES 2nd Generation, or MII) cost engineering model. The detailed cost estimate is based on a combination of MII's Cost Book, estimator-created site-specific cost items, and local subcontractor and material supplier cost quotes. Cost contingencies were developed through a standard Cost and Schedule Risk Analysis (CSRA). Appendices C and F include details of the engineering and real estate cost estimates, respectively.

At current price levels (Fiscal Year 2024 price level), the Tentatively Selected Plan has an estimated project first cost of $15.4B and an annualized cost of $525,000,000 based on 2.75% discount rate. The annualized cost includes planning, engineering and design, construction management, interest during construction, and operation and maintenance,

including contingencies. The Tentatively Selected Plan provides a range of annualized net benefits between -$120,000,000 and $353,000,000 and has a benefit cost ratio range of .27 to 2.26 depending on which sea level curve is realized. This includes costs of future actions to sustain benefits as sea levels rise. The plan would be cost shared as 65 percent Federal ($8,810,880,000) and 35 percent Non-Federal ($4,744,320,000). Within the non-federal share, the costs for the value of lands, easements, rights-of-way, and relocations are estimated to be $1,370,100,000. The cost of operation and maintenance is estimated at $67,000,000 annually.

Table 1-4 - Tentatively Selected Plan First Cost

(FY 24 Price Level)

Total First Cost	**$13,555,200,000**
Lands & Damages**	$91,700,000
Relocations	$1,278,400,000
Fish & Wildlife Facilities	$23,900,000
Breakwaters & Seawalls	$9,965,100,000
Levees & Floodwalls	$96,100,000
Pumping Plant	$281,300,000
Bank Stabilization	$4,800,000
Cultural Resource Preservation	TBD
Mitigation	TBD
Buildings, Grounds, & Utilities	$13,700,000
Remaining Construction Items	$54,000,000
Planning, Engineering, & Design	$1,139,900,000
Construction Management	$606,200,000

**Lands and Damages costs are referenced from the Appendix F: Real Estate Plan

Table 1-5 - Project Annual Costs

FY24 Price Level; 2.75% Interest)

First Cost*	**$13,555,200,000**
Interest During Construction	$1,984,000,000
Fully Funded Cost	$20,524,300,000
Annual Operation, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R)	$67,000,000
Total Annual Cost	$525,000,000

* Note: First Cost is presented as the initial action construction cost, including seismic costs at current price levels, consistent with Planning and Economic uses.

ES-5.1 Construction and Engineering Risk

HTRW concerns exist in the project area and will require additional investigation and testing prior to construction. Per USACE policy, the NFS will be required to provide a clean site prior to advertisement of any construction contract.

As previously stated, construction will occur along and adjacent to the Embarcadero Roadway. This will cause traffic to be reduced in those areas or completely rerouted, thus congesting other parts of the city further inland. Lack of staging areas will also be a construction risk for the project, specifically from Crane Cove Park to Fisherman's Wharf. All materials will need to be stored in locations outside of these areas and hauled to the worksite or delivered on-site when needed.

ES-5.2 Cost-Sharing

Project First Cost is the constant dollar cost of the TSP at current price levels and is the cost used in the authorizing document for a project. The "Total Project Cost" is the constant dollar fully funded cost with escalation to the estimated midpoint of construction. Total Project Cost is the cost estimate used in Project Partnership Agreements (PPA) for implementation of design and construction of a project. Total Project Cost is the cost estimate provided to a NFS for their use in financial planning as it provides information regarding the overall non-Federal cost sharing obligation. For this project, the TSP First Cost was calculated to be $13,555,200,000, while the TSP Total Project Cost (Fully Funded) was determined to be $20,524,300,000.

In accordance with the cost share provisions in Section 103 of the WRDA of 1986, as amended (33 U.S.C. 2213), project design and implementation are cost shared 65 percent Federal and 35 percent non-Federal. The non-Federal costs include credit for the value of LERRDs. Total LERRDs are estimated to be $1,370,100,000. The cost

share apportionments for the Project First Costs and Total Project Costs are provided in **Table 6** and **Table 7** respectively.

Table 1-6 - Apportionment of Project First Cost
(FY 24 Price Level)

Project First Cost	**$13,555,200,000**
Federal Share (65%)	$8,810,880,000
Non-Federal Share (35%)	$4,744,320,000
Less: LERRD Cost	$1,370,100,000
Non-Federal Cash Contribution	$3,374,220,000

Table 1-7 - Total Project Cost (Fully Funded) Apportionment
(FY 24 Price levels, fully funded to FY 26)

Total Project Cost (Fully Funded)	**$20,524,300,000**
Federal Share (65%)	$13,340,795,000
Non-Federal Share (35%)	$7,183,505,000

ES-5.3 PED and Construction Sequencing

At the completion of this feasibility study, and upon approval by the Chief of Engineers, the Recommended Plan would be provided to Congress for authorization and funding. If authorized and funded by Congress, subsequent phases of the project would include PED, Construction, and Operations and Maintenance.

Completion of PED and construction of the Recommended Plan, specifically the pace of construction, is highly dependent on Congressional approval and funding. Assuming an ample funding stream, the initial actions of the TSP could be designed and then constructed over a period of about 14 years. Phased implementation will consider the priorities of the NFS, communities benefitted by the project, resource agencies, and efficiencies in the construction and/or contracting process. Ultimately, implementation activities will be optimized to consider the size and frequency of funding infusions, environmental clearance of individual components including the requirements of the California Environmental Quality Act (CEQA), and beneficial sequencing.

USACE and/or the NFS will complete detailed analyses and design in the PED phase that will inform the final design and ultimately construction. POSF, as the NFS, may seek approval to design and/or construct portions of the TSP under the authority of Section 221 of the Flood Control Act of 1970, as amended and Section 204 of WRDA 1986, as amended. Detailed analyses in the PED phase will include but are not limited to:

- A review of changed conditions since the completion of the study that may affect project design
- Updated engineering modeling
- Detailed surveys of physical and engineering data
- Detailed environmental and cultural resources surveys
- Detailed assessment of structures identified for nonstructural measures
- Additional environmental coordination that may be required if there are environmental, cultural, and/or historic resource impacts that were not identified during this Study

ES-5.4 Monitoring and Adaptation

Adaptive actions are proposed to be implemented at the 50-year mark after the initial actions are implemented, although the timing could and likely would vary based on the initial recommended action implemented in each reach and under different RSLC rates.

A monitoring plan will be developed to track the rate of relative SLR in the area, and to support decisions about scale and timing of adaptation. Appendix G proposes a Monitoring and Adaptation Plan that will define the appropriate personnel, method, and data to monitor the coastal flood risk in the area and processes to initiate subsequent actions defined in the Resilience Strategy.

ES-5.5 Environmental Considerations

The TSP utilizes a combination of CFRM and NNBF to reduce risks from coastal flood hazards across the study period. It is expected that in-water and shore-based construction activities will be required to construct these features. Because the protection predominately remains at the existing shorefront, the TSP minimizes the need for building demolition, replacement, floodproofing, and relocations throughout the study area in the first construction period. In 2040, more shore-based measures are constructed including t-walls, vertical walls (mostly around piers), and berms. New lengths of seawall will also be constructed; however, these are intended to occur landward of the existing seawall and thus, should not require in-water activities. As compared to the other action alternatives analyzed, the TSP has the greatest acreage of seismic ground improvements, but the least amount of roadway impacts in 2040. In-water work would include the replacement of 14 acres of wharf, as well as placement of ecological armoring (i.e., NNBF).

In 2090, the major extent of seawall replacement is constructed, which does include extension bayward of the existing seawall in select areas. Thus, five acres of bay fill is proposed in some areas of seawall construction. The majority of non-structural measures such as building demolition, relocation, and floodproofing occur in 2090 for

the TSP when some of the line of defense is moved landward of the existing shoreline. Shore-based construction includes additional t-wall and berm, as well as seismic ground improvements and roadway impacts.

In general, shore-based construction and landward retreat is expected to have greater impacts to human resources such as transportation, communities, recreation, and access, etc., while in-water construction would have more impacts to natural resources such as marine mammals, fish, essential fish habitat, threatened and endangered species, water quality, etc. Construction impacts are mostly temporary and localized, with the construction area expected to return to baseline conditions upon completion. However, some impacts are expected to be permanent, and significant and unavoidable. The addition of NNBF would help to offset the adverse impacts to natural resources and include features such as marsh enhancement, ecological armoring, naturalized shorelines, and ecotone levees. However, the loss of open bay habitat with bay fill in 2090 is likely to result in the need for compensatory mitigation unless the offset from NNBF is enough to compensate for the habitat loss. Addition and augmentation of marsh at Heron's Head Park would significantly improve suitable and preferred habitat for threatened and endangered federally listed and state-listed species, both terrestrial and aquatic, as well as provide new habitat areas for migratory birds. The inclusion of NNBF would be beneficial to resident and transient species, including special status species, as it provides new or expanded habitat in an otherwise urbanized area.

ES-5.6 Views of the Non-Federal Sponsor

The Port of San Francisco (POSF) as lead agency for the City and County of San Francisco (City) supports publishing the San Francisco Waterfront Coastal Flood Study Draft IFR/EIS and continuation of their partnership with USACE in engaging the public with and further improving the TSP, with a focus on reducing costs and environmental impacts and increasing benefits where possible.

POSF is grateful to USACE and was particularly pleased that USACE allowed POSF staff and consultants to play such an active role in the PDT. The POSF is eager to work with USACE to advance public engagement and to receive robust feedback from the public, resource agencies, other practitioners in the resilience field and any other commenter who has suggestions about how to improve the TSP as we advance towards a final report from the Chief of Engineers to Congress.

City issues for further consideration include:

A Design Process which enables the City to play a significant role in waterfront design, potentially through Water Resources Development Act Sections 221 and 204. The City is particularly interested in leading the design process for what is implemented "on top" of future coastal flood defenses (e.g., roadway configuration, alignment and approach to bulkhead buildings and piers, parks and open space, utilities, etc.).

Shoreline Elevations, Reaches 3 & 4: Initial actions in Reaches 3 & 4 are scaled to the USACE Intermediate SLC projection but require very robust ground improvements. To manage construction impacts and provide for efficient project delivery, the City team would like to explore higher shoreline elevations in these areas.

Reach 1 Modification: The City team believes that there is value in extending the structural measures utilized for Reach 2 several hundred feet into Reach 1 to provide similar life safety, historic preservation, inland drainage, and flood risk reduction benefits as part of the 1st Action.

Sub-reach Optimization: POSF believes that there is an opportunity to optimize the Plan at the sub-reach level to reduce costs and impacts and increase benefits.

Historic Finger Piers: The TSP currently includes short floodwalls to protect the historic pier sheds. POSF is interested in exploring 1) how the POSF can utilize public-private partnerships to rehabilitate piers before, concurrent with or after implementation of the TSP, and 2) full pier replacement for a limited number of assets to ensure their preservation and use through the end of their useful life.

Pier 70 Historic Resources: The TSP currently includes demolition of two significant historic buildings in the Pier 68/70 Shipyard. POSF is interested in exploring approaches to avoid these demolitions including adjusting the alignment of coastal berm features in this area to avoid demolition of historic resources.

Environmental Remediation: Implementation of the TSP will require further site investigation to determine the nature and extent of hazardous materials in the footprint of the plan. The City team wishes to explore options other than avoidance of hazardous materials that would enable implementation of the TSP and associated expenditures by the City or responsible parties to address hazardous materials where they have not already been remediated within the TSP footprint. The City team also wishes to collaborate with USACE to understand and address the risk of rising groundwater tables on contaminated sites in the near-shore area.

EWN: The City team has a strong interest in incorporating NNBFs, both to reduce flood risk and to mitigate project impacts. Many of these features are currently included in the Draft Report and EIS as independent measures.

Inland Drainage Scope & Cost: The infrastructure improvements necessary to manage inland drainage do not currently consider the effect of the non-structural alternative in Reach 1 (Fisherman's Wharf) and hydraulic connection to neighborhoods outside of the study area. The City team also wishes to advance additional cost estimates and additional modeling of inland drainage systems (the combined sewer) in a TSP scenario to inform decision-making and to achieve a higher level of certainty in the estimated cost.

New Waterfront Open Space: There is a desire to explore opportunities for improved public realm both within and outside of the footprint of the TSP, which could include parks inland of the alignment, within the existing right-of-way and promenade, on pile-supported structures, or on top of new Bay fill.

Bay Fill: There is an interest in exploring up to 50' of additional Bay fill for the area roughly between Broadway Street and Bay Street and along Rincon Park (roughly from Howard Street to Harrison Street) in Reach #2 to minimize Embarcadero Roadway and light rail impacts and to avoid the SFPUC transport storage boxes if needed. This is currently included in the environmental analysis as Alternative F.

Tenant Impacts: Given the number of Port tenants likely to be impacted by construction and the importance of the waterfront to the City's economic vitality, POSF has a strong desire to develop an implementation plan that includes a thoughtful approach to tenant access during construction when possible and tenant relocation when needed.

Light Rail Impacts: The San Francisco Municipal Transportation Agency team has emphasized the importance of avoiding transit impacts that would affect transit access to the MUNI Metro East rail facility and to the Southeast community, for example along the southern Embarcadero (south of the Bay Bridge) and across the 4th Street bridge over Mission Creek and to minimize transportation impacts to the multi-modal transportation system during the construction period.

Seismic Performance of Critical Infrastructure near the TSP: The City would like to continue evaluating the seismic performance of key infrastructure close to the alignment of the TSP – such as SFMTA light rail track in fill areas outside of the TSP footprint.

ES-6 Next Steps

The SFWCFS is the first USACE coastal flood risk management study in the nation where sea level rise is the primary driver of projected coastal and combined flood risk. This SFWCFS is also one of the first coastal flood risk management studies in a major urban area under which plan formulation is focused on maximizing net benefits across multiple planning criteria including effects on the nation's economy, the regional economy, other social effects, and environmental quality.

The recommendations contained in this Draft IFR/EIS report reflect the information available at this time and current USACE policies governing formulation of individual projects and may be modified by the Chief of Engineers before they are transmitted to the Congress as proposals for authorization and implementing funding. The Draft IFR/EIS report is a draft for public review.

This Draft IFR/EIS presents a sea level rise adaptation plan based on a series of actions over time with monitoring of climate change and sea level rise to inform subsequent action. The opportunities afforded by the potential investment recommended under the TSP are numerous: a waterfront that is more resilient to flood

and seismic risks, improved connections to the Bay, equitable engagement and investment, improved habitat along the shoreline, adaptation of historic resources, a safe space for future investment in downtown and other waterfront neighborhoods, and improved mobility along the waterfront.

San Francisco already enjoys one of the most inviting waterfronts along the California coast and in the nation, with over 24 million visitors annually prior to the COVID-19 pandemic. The risk management investment has the potential to provide improved experiences and sustain its diverse population.

Much work lies ahead. The PDT must invite and consider public and resource agency comments, and additional technical and policy comments from USACE experts and City and regional agencies and refine the TSP as appropriate. The PDT will then refine the TSP in response to comments to refine the Plan. A Final report will be prepared and ultimately, the Chief of Engineers will decide whether to forward the Recommended Plan to Congress (currently expected in 2026). Congress must then decide whether to authorize and fund the Recommended Plan.

If authorized and funded by Congress, future phases of work will include a Preconstruction, Engineering and Design (PED) phase and a Construction phase. During the PED phase, USACE and the City will develop a phasing and implementation plan to design and construct elements (or geographic segments) of the Recommended Plan based on risk and related factors.

During the remainder of the SFWCFS and the PED phase, City departments will continue to engage the public in the design of the future Port waterfront, including design of streets, open spaces and Bay access, ecological improvements, and improvements and modifications to historic properties, consistent with local values and priorities. The City will be responsible for addressing hazardous materials in the future construction right-of-way and paying for any improvements (“betterments”) to the Recommended Plan requested by the City which USACE determines do not have a federal interest.

This effort will extend over decades and require active engagement with stakeholders across the City and the region. USACE and the City welcome that engagement.

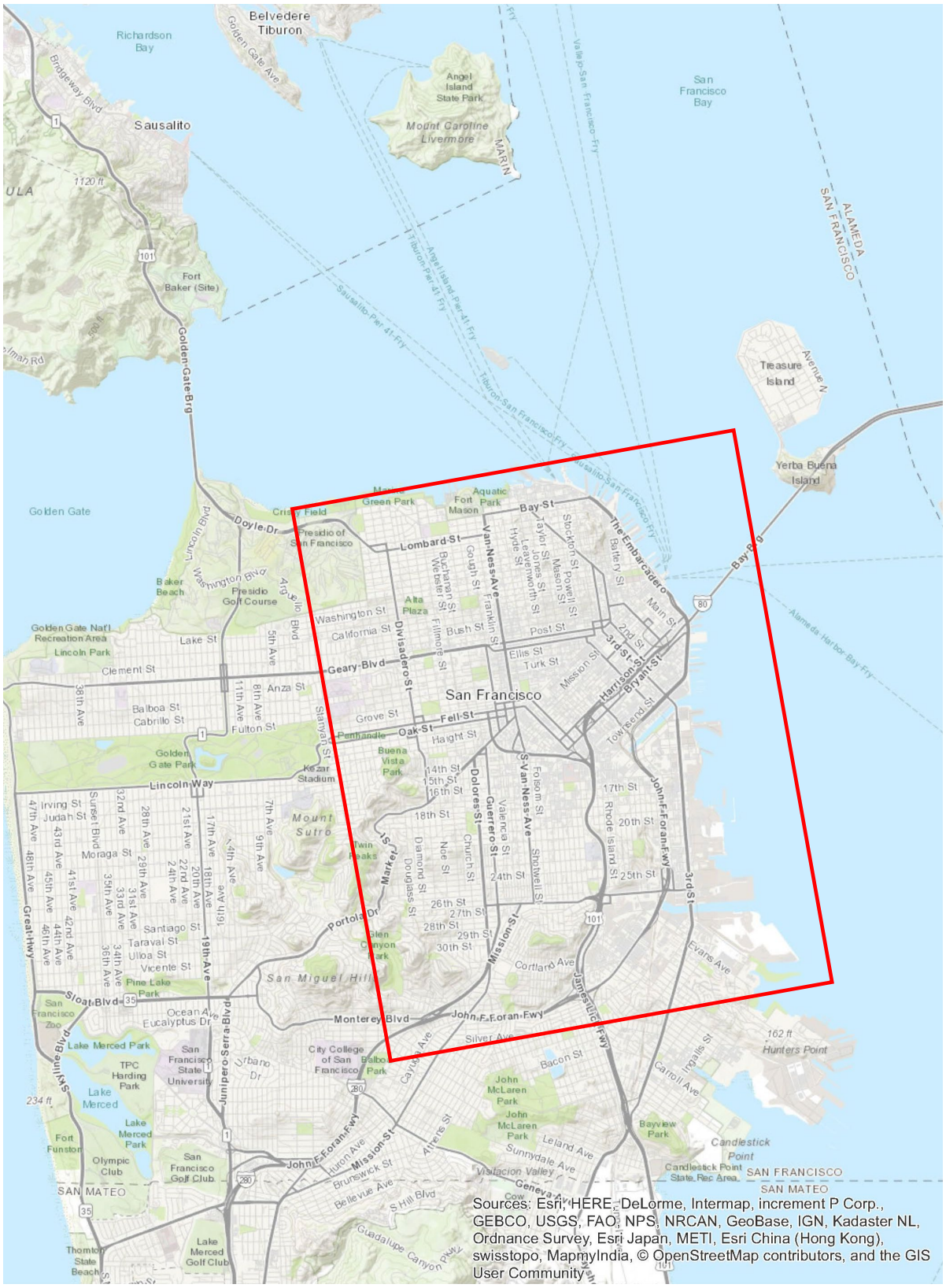


Figure 1-1: San Francisco Waterfront Coastal Flood Study Area



Figure 1-2: San Francisco Waterfront Study Area

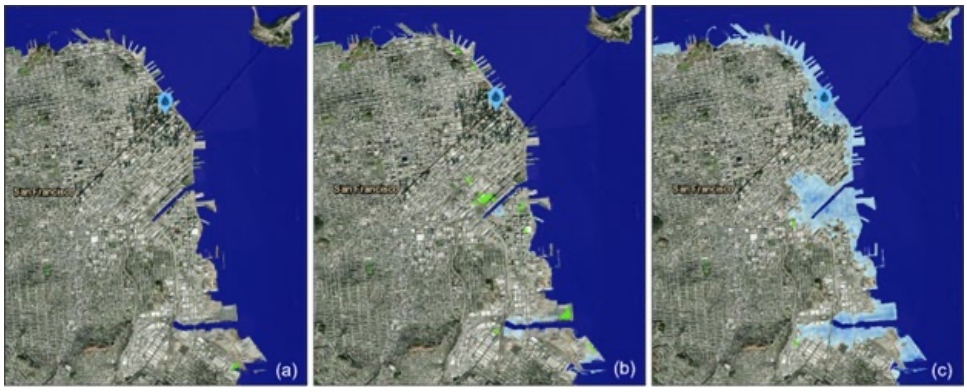


Figure 2-1: NOAA SLR Inundation Viewer of the Study Area for MHHW Conditions for Present Day (a), 3 ft of SLR (b), and 7 ft SLR (c).

2.4.3. Soils and Minerals

The San Francisco Bay area is comprised of a combination of residual (i.e., have formed in place) and depositional (i.e., transported from somewhere else) soils that are predominately clay, sand, loam, and peat-like organic matter (Hayes 2005). Much of the residual soil is fine in texture and formed from sedimentary rocks which over-time weathered to clay minerals and clay-like soils rich in nutrients. Depositional soils occur along the wetlands where fine, clay-sized sediments were transported via marine currents or streams, and large-particle sand that were deposited by streams or carried by wind. Loamy soils are an optimal blend of sand, silt, and clay and are typically found in alluvial or depositional valley and bay fronts around the bay. Soils along the California coast contain approximately four percent organic material, while this lowers with inland soils to about one to two percent (Hayes 2005).

California hosts a diversity of mineral resources that can be categorized into metals, industrial minerals, and construction aggregate. Metals include gold, silver, iron, and copper. Industrial minerals include boron compounds, rare-earth elements, clay, limestone, gypsum, salt, and dimension stone. Construction aggregate is comprised of sand, gravel, and crushed stone (CGS 2019).

2.4.4. Hydrology and Hydraulics

San Francisco Bay is characterized by broad narrow shoals and narrow channels that result in a complex tidal system with a complex bathymetry that contribute to large spatial variability in flow properties. The interactions among tidal processes, bathymetric complexities, and shoreline orientation amplify tidal ranges, with tides increasing with the spatial distance from the Golden Gate inlet (Conomos 1979). The elevation of tidal ranges along the study area varies by approximately 0.5 ft between Aquatic Park and Heron's Head (May et al. 2023). The Bay is a partially to well mixed estuary with substantial longitudinal density gradients (Walters et al. 1985) dominated by seasonally varying river inflow (Conomos et al. 1985). Tidal currents are generated by mixed semi-diurnal and diurnal tides with the bay experiencing two tidal cycles daily with two high

and two low tides of unequal height. Additionally, the bay experiences pronounced spring-neap tidal variability (Rajasekar 2016). The NOAA tidal gauge near the Presidio (Station ID: 9414290) reports a mean tidal range of 4.09 ft and diurnal range of 5.84 ft (NOAA 2023b). Water level variations in the bay are driven primarily by five tidal and oceanic cycles including the mixed semidiurnal tidal cycle, two-week spring-neap cycle, seasonal spring/summer (low levels) and fall/winter (higher levels) cycles, El Nino and La Nina, and the Pacific Decadal Oscillation (atmospheric shift on decadal time scale).

The wave climate in San Francisco Bay is predominantly driven by wind and ocean swells from the Pacific Ocean. The steep topography, hills, and valleys throughout the San Francisco Bay Area drive complex wind patterns and because of the large size of the Bay, those winds can sufficiently generate wind-driven waves ranging from 3 to 5 ft high in vulnerable (i.e., exposed) areas of the shoreline. The most impactful waves to the study area shoreline are those driven by easterly (i.e., offshore; Ferry building and southward), north and northeasterly (northern waterfront), and southeasterly winds (southern waterfront; May et al. 2023). The strongest winds occur during the spring, lowest are typically experienced in the fall, while the winter produces the most variable wind directions. In general, wind-driven waves can impact shorelines across the study area (May et al. 2023).

Climate change is likely to increase extreme flooding events (Seneviratne et al. 2012), particularly in low-lying coastal areas (Wong et al. 2014). Rapid urbanization, as within the study area, further increases flood risk with growing concentrations of people and assets in the city (Revi et al. 2014). Coastal flooding events occur when extreme water levels develop following storm surges, tides, seasonal cycles, interannual anomalies, or a combination of these, driven by large-scale climate variability and SLR (Kasmalkar et al. 2020).

2.4.5. Water Quality

Water quality describes the condition of water, including chemical, physical, and biological characteristics typically with respect to suitability for a purpose, and is measured by several factors including salinity, turbidity, bacteria, dissolved oxygen (DO), contaminants, etc. (NOAA 2023a). Water quality in the San Francisco Bay Region is saline and predominated by ocean influences; however, substantial runoff from freshwater during heavy rains are also prevalent. The freshwater inundation can temporarily reduce salinity in the study area (Bay Institute 2003). Physical barriers, such as the Golden Gate Bridge, influence sedimentation and water quality characteristics by altering the behavior of currents which affect circulation, flushing, and water exchange.

Suspended sediments are a key component of the estuarine system, which tend to have higher levels of turbidity or suspended sediment loads due to discharges from rivers, drainages, and their shallow nature. Suspended sediment concentrations are variable in San Francisco Bay and strongly correlate to season and water depth (Buchanan and Ganju 2006; Buchanan and Ganju 2005; McKee et al. 2006), ranging from 1,000 milligrams per liter (mg/L) near the bottom to 10 mg/L near the surface (Buchanan and Ganju 2006).

Contaminants are prominent in the bay and are transported by a variety of sources including, but not limited to, urban uses, industrial outfalls, municipal wastewater outfalls, municipal stormwater, upstream farming, upstream historic and current mining discharges, and legacy pollutants. Approximately 40 percent of California drains into San Francisco Bay including point and non-point source pollutants that distribute up to 40,000 metric tons of at least 65 different pollutants (BCDC 2020). The study area is listed as an impaired water body by the San Francisco Water Board. The pollutants recorded in the Central San Francisco Bay, including the study area, are chlordane, dichlorodiphenyltrichloroethane (DDT), dieldrin, hydrogen sulfide, lead, mercury, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), selenium, silver, furans, and dioxins. Pollutant concentrations vary seasonally and annually, dependent on the source and degradation characteristics.

2.4.6. Groundwater

The study area overlies seven small groundwater basins. Local groundwater supply comes from the Westside Basin, a series of aquifers extending from Golden Gate Park southward to San Bruno. Groundwater is pumped from the Westside Groundwater Basin from depths of approximately 400 feet below the surface, blended with surface water supplies from San Francisco, treated, and distributed to the city for drinking water (SFPUC 2021a). Most of the groundwater supplies in the study area are confined between two substantial layers of clay that act as aquitards. Aquitards have low permeability which allow groundwater to be confined and under high pressure. Shallow groundwater in the study area is poor quality and is not used for supplying drinking water. Young Bay Mud acts as an aquitard, separating shallow groundwater from deeper aquifers used for municipal water supply and generally acts as a barrier to the vertical migration of contaminants. Shallow groundwater levels are influenced by seasonal variations in precipitation, tidal levels, local irrigation, groundwater pumping, and other factors, and vary across the study area.

2.4.7. Geology and Geomorphology

Geology is the study of the structure, evolution, and dynamics of Earth and its natural mineral and energy properties (USGS 2022a), while geomorphology is the study of the physical features of the Earth’s surface and their relation to the geological structure (Stetler 2014). San Francisco is part of the California Coast Ranges geomorphic provinces and is characterized by a series of northwest-trending ridges and valleys that run nearly parallel to the San Andres fault zone (Norris and Webb 1990). The San Francisco Bay lies within a depression created by an expansion between the San Andres and Hayward fault systems. Much of the province is composed of marine sedimentary deposits and volcanic rocks (Norris and Webb 1990). Within this province, the Northern Coast Ranges, where project activities would occur, the geologic structure contains the Alcatraz terrane. The Alcatraz terrane is an amalgamation of semi coherent blocks that consists of shale, greenstone, basalt, chert, sandstone, graywacke, and serpentine. Much of these units originated from ancient seafloor sediments that were displaced and deformed through tectonic forces (CCSF 2017).

The sediments within San Francisco Bay originate from erosion of surrounding hills or from later marine and riverine deposits. Generally, the upper several feet of the sediment profile in San Francisco Bay consists of more recently deposited marine and riverine sediments. The thickness of various underlying historic sediment formations varies throughout the San Francisco Bay/Delta Estuary and it can be several hundred feet thick. Large areas of San Francisco Bay contain Bay Mud, a marine clay-silt deposit, that lie beneath softer, more recently deposited muds (USACE 2015). Bay mud is prone to cyclic softening during an earthquake, which can lead to lateral spreading and vertical settlement along the shoreline during a seismic event. Bay mud can be divided into younger and older, varying in engineering properties, dependent on thickness and consolidation (CCSF 2017).

San Francisco Bay surficial sediments have been deposited since industrialization began in California, and, thus, may have been exposed to anthropogenic sources of pollutants. Recent sand deposits may also be exposed to anthropogenic sources of pollutants but typically do not accumulate significant pollutant concentrations.

2.4.8. Noise and Vibration

Noise levels in the study area are influenced by traffic, transit vehicles, construction, aircraft, watercraft, industrial, commercial, and other sources associated with a densely populated urban environment. The influence of each of these sources of noise on ambient levels depends on the proximity of receivers to transportation corridors and developed areas.

Sources of vibration include heavy trucks and transit vehicles producing vibration from contact between the moving wheel and the travel surface (rail or road). The levels of vibration associated with these sources are generally perceptible only within short distances, generally less than 100 feet from the source. Construction activities that require pile driving can produce vibration at distances of greater than 100 feet from the source, depending on the method of installation and the size of pile used.

2.4.9. Cultural Resources

2.4.9.1. Historic Properties

The Embarcadero Historic District is a nationally recognized historic district that has shaped the growth and design of San Francisco and the Bay Area. The district contains important historic assets (buildings and structures, including the seawall itself) with their own individual character and significance. These historic assets help define the public's waterfront experience and provide unique settings for commercial, cultural, and public uses. Along the Embarcadero seawall, there are 60 recognized historic assets including the seawall, bulkhead wharves, piers, and buildings.

These buildings and structures are recognized locally and nationally as historic resources not only for their age, engineering, and architectural character, but also for their role in key historic events. The Embarcadero Historic District was the setting for the Pacific Coast Maritime Strike of 1934 (Big Strike), which had local and national impacts on politics and labor policy. It has also been a driver of commercial growth in

San Francisco and the West Coast, acting as a center of local, national, and international transportation.

The Union Iron Works Historic District at Pier 70 is a nationally recognized historic district which was the location of ship construction and repair for 150 years from the late 1860s through 2017. The Union Iron Works Historic District features contributing resources including buildings, piers, slips, cranes, segments of a railroad network, and landscape elements. Building 113/4 (the Machine Shop), Building 101 (the Bethlehem Steel Administration Building), and Building 104 are among the most significant resources in the area.

Over the period of significance from 1884-1945, the southeastern portion of the Union Iron Works Historic District was owned and operated by Pacific Rolling Mills (1868-1900), Risdon Iron and Locomotive Works (1900-1911) and the United States Navy, which established the WWII U.S. Destroyer Plant (called the New Yard). The Port acquired the property through two primary means. The Port acquired some of the property through the Burton Act transfer from the State in 1969. The Port also acquired property owned by Bethlehem Steel for the nominal sum of $1 (Port of San Francisco 2023).

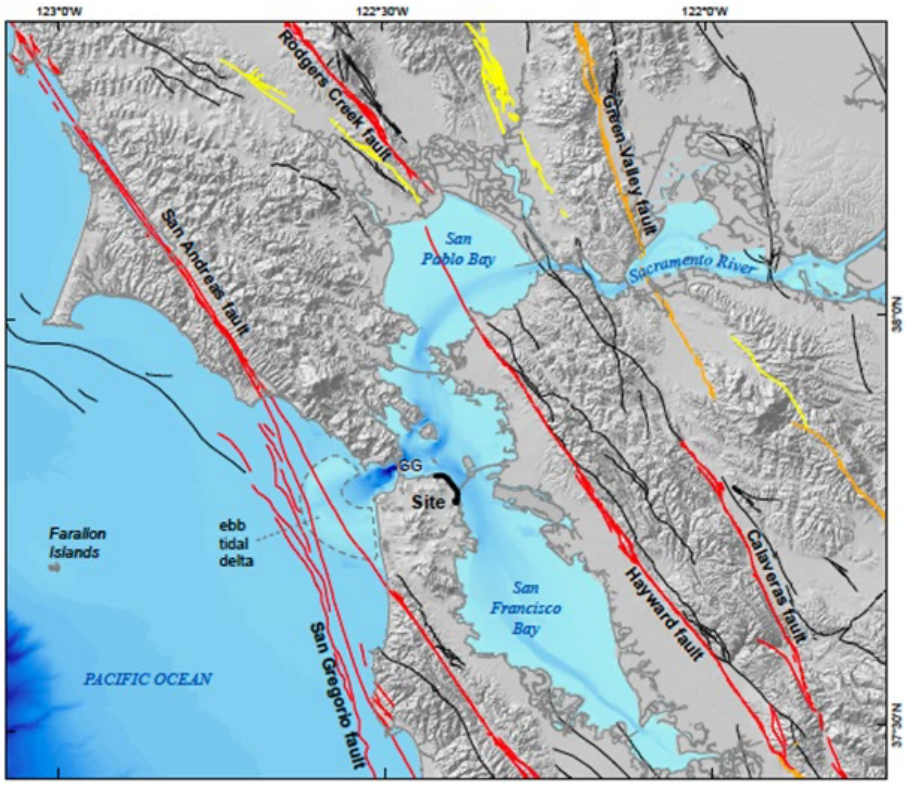
Additionally, property parcel data was obtained from the San Francisco Planning Department's Property Information Map to identify properties that are 45 years old or older.

- A total of 2,846 parcels were identified in the study area, which includes:
- A total of 2,846 parcels were identified in the study area. This includes resources listed in or eligible for listing in the NRHP as well as resources listed in or eligible for listing in the CRHR, as follows:
- 17 NRHP-listed properties, and nine NRHP-listed districts;
- Three NRHP-eligible structures (bridges), and five NRHP-eligible districts;
- Nine CRHR-eligible districts;
- 544 parcels with CEQA historical resources not yet evaluated for NRHP eligibility;
- 306 properties determined not eligible for the NRHP;
- 1,191 parcels that require further research to classify them among the preceding categories because they are of historic age (i.e., constructed in 1990 or earlier) and unevaluated;
- 214 parcels exempt because parcel data indicates that they are not recorded as historic age (i.e., constructed in 1990 or later);
- 528 parcels exempt because they are vacant; and
- Eight parcels that are unknown because their geospatial location could not be determined.

since 1906. It shook for only 15 seconds and resulted in over 6 billion dollars of damages across the greater Bay Area and Monterey Bay.

3.3.1.2. Earthquake Hazard Overview

There are numerous fault lines crossing the Bay Area, most from northwest to southeast, with the San Andreas and the Hayward faults being the most active and well-known. The POSF's waterfront is located between the two faults. Both the 1906 earthquake (Magnitude 7.9)[4] and 1989 earthquake (6.9) were located along the San Andreas Fault. The Hayward Fault located across the Bay has not experienced a major earthquake since the 1868 Hayward earthquake (6.5). This fault can produce a magnitude 7.3 earthquake, and since it has not experienced major activity for over 150 years, it is considered the fault most likely to generate a strong earthquake in the near future (USGS, 2015). The most recent U.S. Geological Survey (USGS) earthquake forecast for the Bay area indicates a 72 percent probability of at least one Magnitude 6.7 or greater earthquake striking the region before 2043 (Working Group California Earthquake Probabilities, 2014).



Basemap source: Topographic and bathymetric data from U.S. Geological Survey

Figure 3-2: Regional Topography and Faults

[4] For each increment of 1 on the Richter scale, an earthquake feels 10 times stronger. So, a 7.9 magnitude earthquake is nearly 4 orders of magnitude stronger than a 3.0 earthquake, or 10,000 times stronger.

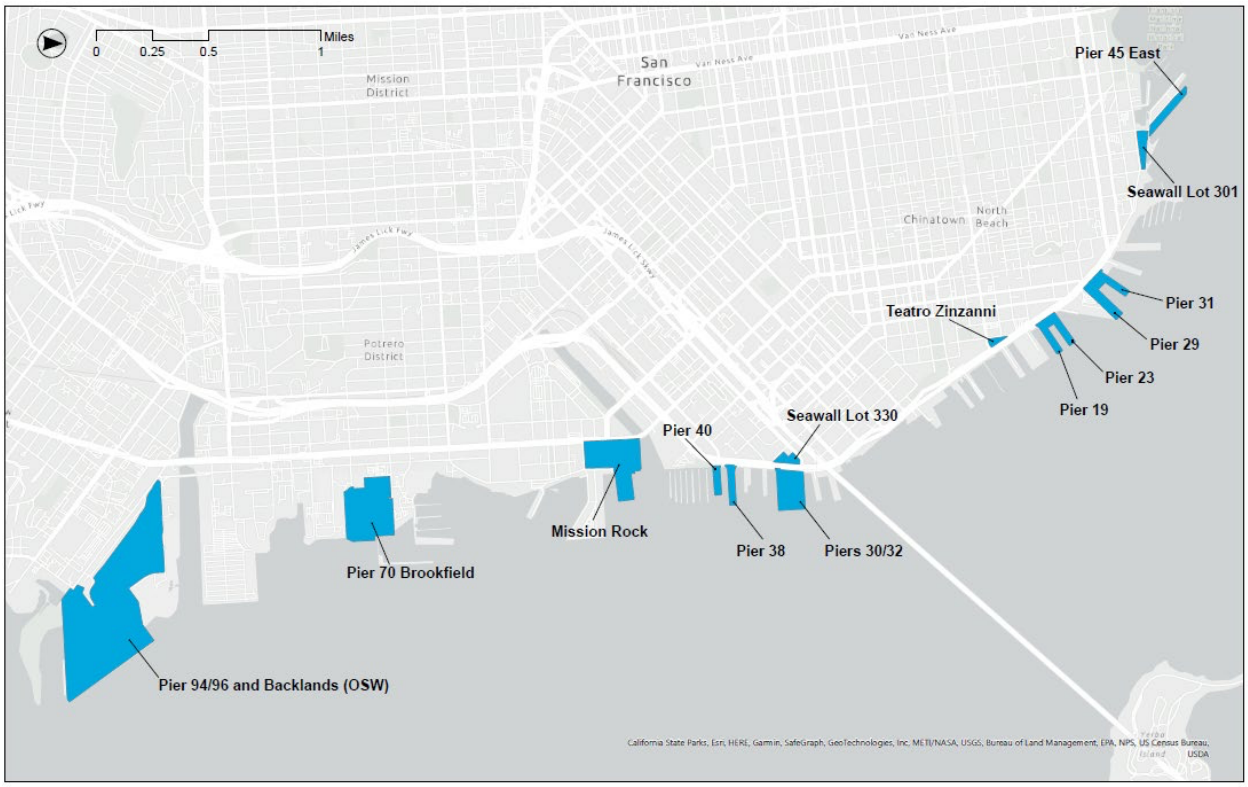


Figure 3-5: Planned Development along the Waterfront on POSF Property

POSF requires consideration of SLC for all new developments. The City requires a similar assessment for all projects along the shoreline. As a result, all new projects along the San Francisco shoreline will incorporate coastal flood risk management measures that include raising grades, raising shorelines, adaptation spaces along the shoreline, monitoring of flood events/coastal storms, and the requirement for funds to be set aside and used for SLC adaptation, when needed, and flood proofing at specific sites.

Planned Resilience Projects

In 2018, San Francisco voters passed Proposition A, a $425 million municipal bond measure, to fund seawall earthquake safety and resilience projects along the Embarcadero waterfront. This money is being used for planning, design, and implementation of Early Projects along the Embarcadero, focused on immediate life safety, disaster response, and earthquake resilience.

POSF identified 23 Embarcadero Early Projects to reduce earthquake and flood risk focused on improving earthquake safety, building City and regional disaster response capability, and reducing near-term coastal flood risk. The estimated total cost range to deliver all 23 projects is estimated between $650 million and $3 billion, more than current funding available from Proposition A and other available funding sources.

Table 3-3: Summary of RED Damages for FWOP Condition
(FY 2023 Price Levels; 2.5% Discount Rate)

	Present Value		
	Low SLC	**Intermediate SLC**	**High SLC**
Revenue Losses for Critical Infrastructure	$130,000,000	$250,000,000	$500,000,000
Direct Output Losses	$24,000,000	$170,000,000	$1,100,000,000
Cascading Regional Output Loss (CA)	$18,000,000	$150,000,000	$1,100,000,000
TOTAL Losses	$172,000,000	$570,000,000	$2,700,000,000
Job Losses	150	1,200	8,500

Reach-by-Reach Exposure to Flood Risk

As the 1% floodplain increases with SLR, the exposure of people, structures, businesses, roads, and critical infrastructure to this flood risk also increases. A reach-by-reach summary of exposure under the three USACE RSLC projections is provided in the following subsections.

Reach 1

The magnitude of flooding and associated exposure in Reach 1 is lowest across the study area (**Table 3-4** and **Figure 3-6**). However, Reach 1 contains some of the lowest baseline job earnings (16% of jobs earn $1,250 per month or less) and are dependent on tourism across the waterfront for viability. Such jobs are generally not resilient to disruption (regardless of source) because of limited healthcare benefits and no ability to telecommute.

Table 3-4: Reach 1 Exposure to Flood Risk, 2090

	USACE Low	**USACE Intermediate**	**USACE High**
Health and Safety			
Social Vulnerability	High concentration of non-white (38%) and aged (over 65) (16%) residents affected.		
Residents Exposed	42	86	1,283
Disaster Response Assets Exposed	0	1	11
Economic Vitality			

Direct Job Exposure (mostly restaurant)	159	437	4,212
Legacy Business Exposure	0	2	5
Leisure and Recreation (44,670 daily estimated users)			
Streets Exposed (miles; access)	0	0.3	3.5
Parks and Open Space Exposed (acres)	0.8	2.5	10.2

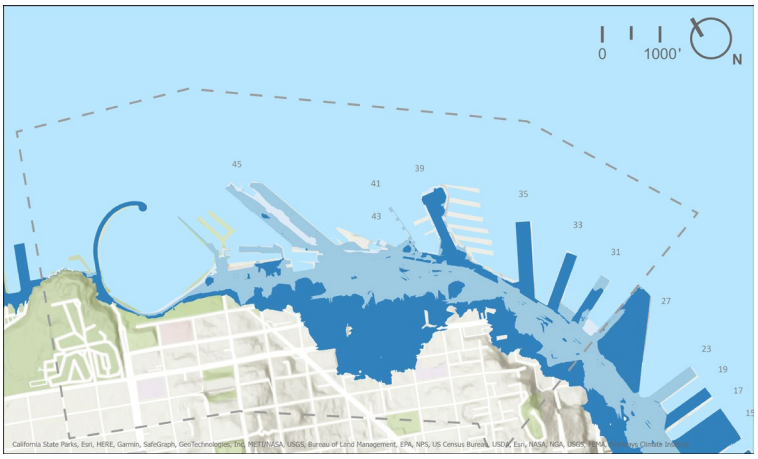


Figure 3-6: Reach 1 Inundation Map

Reach 2

Reach 2 experiences a daily net job inflow of 220,000 workers that rely on a functioning transportation network. Disruption to Embarcadero Station may occur as early as 2040 with a 1 % AEP flood event. Additionally, this reach has potential to see the most jobs lost due to flooding (**Table 3-5** and **Figure 3-7**).

Table 3-5: Reach 2 Exposure to Flood Risk, 2090

	USACE Low	USACE Intermediate	USACE High
Health and Safety			
Social Vulnerability	High concentration of non-white (42%) and aged (over 65) (18%) residents affected.		

Residents Exposed	341	1,566	4,709
Disaster Response Assets Exposed	1	5	15
Economic Vitality			
Direct Job Exposure (mostly office)	3,912	25,309	75,518
Legacy Business Exposure	0	2	5
Leisure and Recreation (12,030 daily estimated users)			
Streets Exposed (miles; access)	0.8	3.4	8.4
Parks and Open Space Exposed (acres)	3.2	12.6	25.3

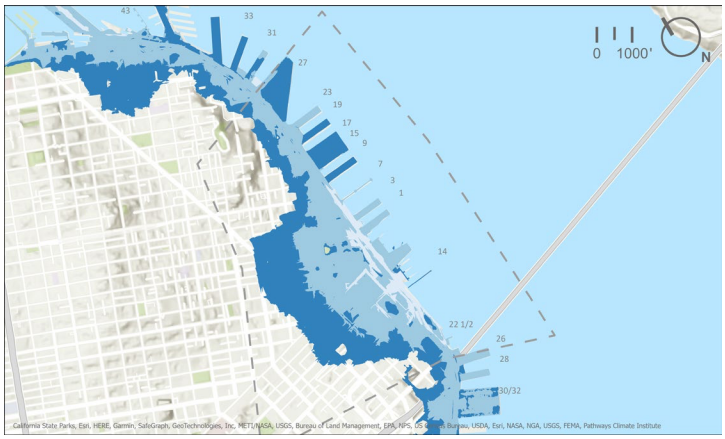


Figure 3-7: Reach 2 Inundation Map

Reach 3

Reach 3 sees the earliest and largest displacement of residents along the waterfront, with potentially permanent residential relocation occurring by 2080. This is significant because Reach 3 also contains 75% of all affordable housing units across the study area. This reach is also a main transportation corridor connecting more than 27,500 people through this area daily via the Muni Metro T Third Line, and high-use roadways and Third Street and Fourth Street bridges (**Table 3-6** and **Figure 3-8**).

Table 3-6: Reach 3 Exposure to Flood Risk, 2090

	USACE Low	USACE Intermediate	USACE High
Health and Safety			
Social Vulnerability	High concentration of non-white (48%) and linguistically isolated (13%) residents affected.		
Residents Exposed	1,242	5,301	15,965
Disaster Response Assets Exposed	0	1	16
Economic Vitality			
Direct Job Exposure (mostly entertainment)	1,275	7,487	28,456
Legacy Business Exposure	1	2	6
Leisure and Recreation (39,940 daily estimated users)			
Streets Exposed (miles; access)	2.3	8.3	22.2
Parks and Open Space Exposed (acres)	7.2	13.4	35.0

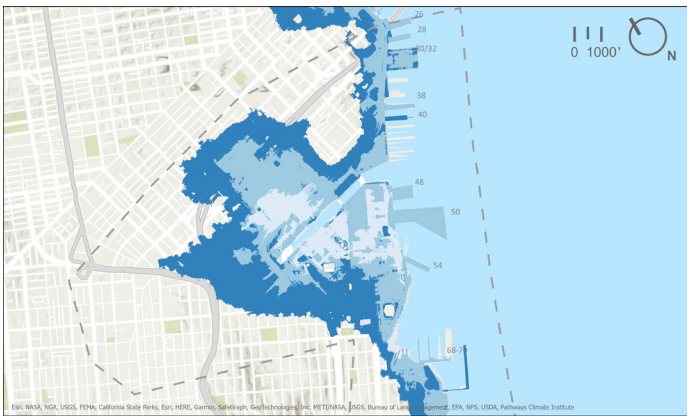


Figure 3-8: Reach 3 Inundation Map

Reach 4

Reach 4 is the first to see significant number of properties affected by repetitive flooding, putting industrial and maritime functions and jobs at risk. The Southeast Treatment Plant (wastewater), which serves approximately 2/3 of San Francisco, is

exposed to the 1% AEP event under all three SLC curves. The surrounding neighborhoods are Bayview, Dog Patch, and Potrero Hill. Adaptation considerations for residents and businesses center around equity and environmental justice concerns, job loss, HTRW, gentrification, and open space access (**Table 3-7** and **Figure 3-9**).

Table 3-7: Reach 4 Exposure to Flood Risk

	USACE Low	USACE Intermediate	USACE High
Health and Safety			
Social Vulnerability	Highest concentration of non-white (41%) and single parent families with children (20%) residents affected.		
Residents Exposed	266	336	558
Disaster Response Assets Exposed	5	5	9
Economic Vitality			
Direct Job Exposure (mostly entertainment)	1,430	2,412	4,650
Legacy Business Exposure	0	0	4
Leisure and Recreation (6,800 daily estimated users)			
Streets Exposed (miles; access)	2.3	4.0	8.0
Parks and Open Space Exposed (acres)	21.6	25.0	31.1

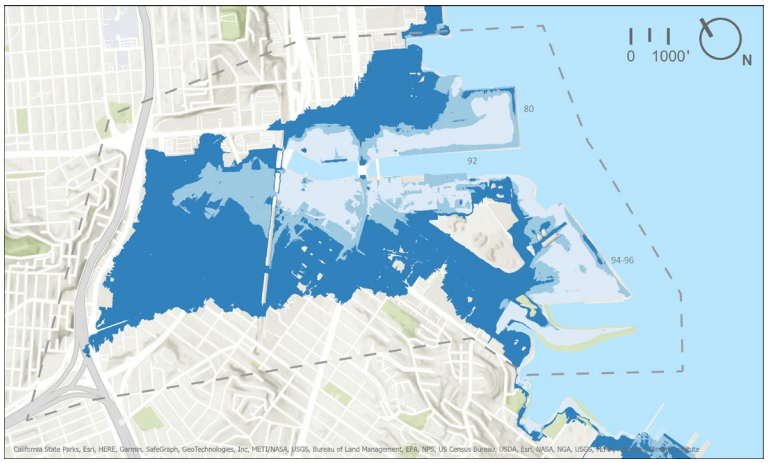


Figure 3-9: Reach 4 Inundation Map

3.3.2. Study Area Opportunities

Opportunities are positive conditions in the study area that may result from implementation of a Federal project. This study presents opportunities to:

- Provide resilience and related benefits to communities that have historically been subject to disinvestment and environmental injustice
- Design coastal flood defenses that also reduce earthquake risk to the waterfront and structures connected to the shoreline
- Align multiple federal and regional agencies to coordinate resilience investment in infrastructure sustainability and hardiness over multiple scenarios and conditions – with efficiency gains through coordinated actions and expenditures
- Educate the public and stakeholders about current and future flood risk and create incentives for residents and businesses in the future floodplain to take individual action to reduce flood risk exposure
- Design coastal flood defenses that also improve wildlife habitat and reduce shoreline erosion through addition of Natural and Nature-Based Features that mimic coastal processes
- Develop innovative strategies for adapting vulnerable historic maritime resources to SLR consistent with the Secretary of the Interior Standards for Treatment of Historic Properties
- Recognize the cultural experiences and traditions of diverse waterfront communities and incorporate them into the planning and design of adaptation strategies

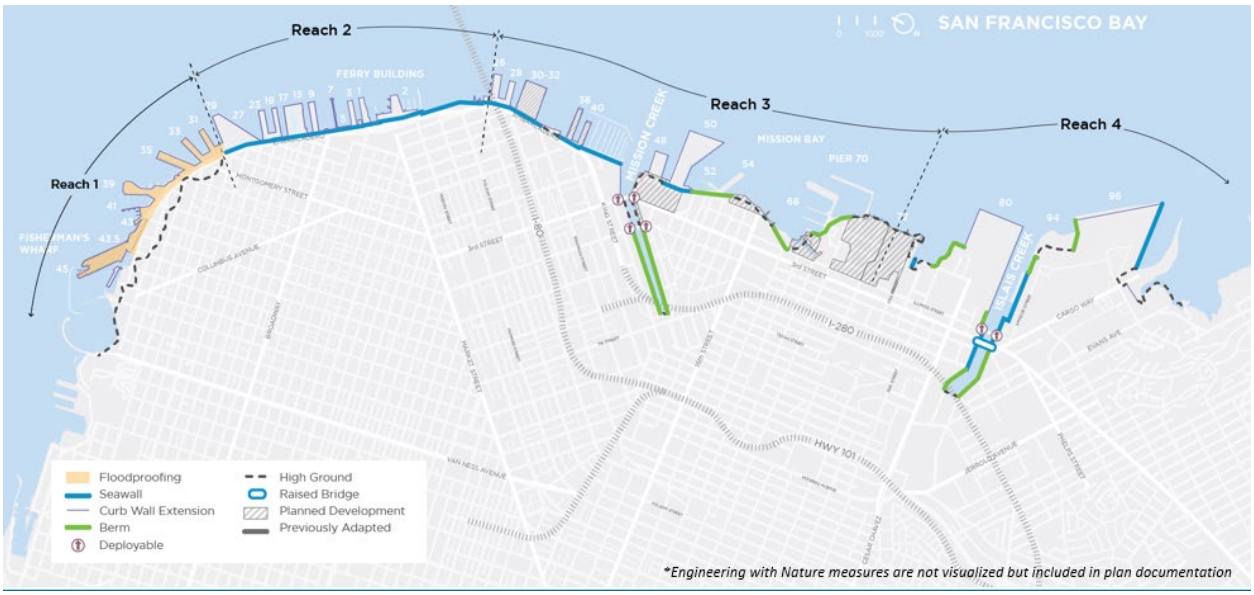


Figure 5-2: TSP Initial Actions

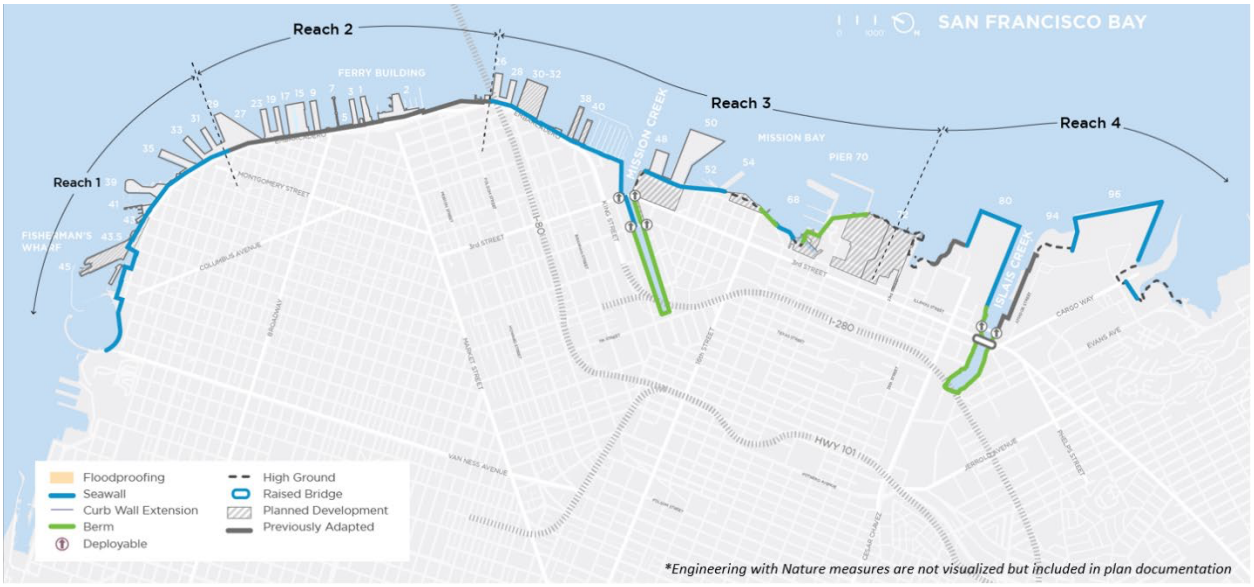


Figure 5-3: TSP Subsequent Actions

The features of the TSP by reach for initial actions and subsequent actions are described below.

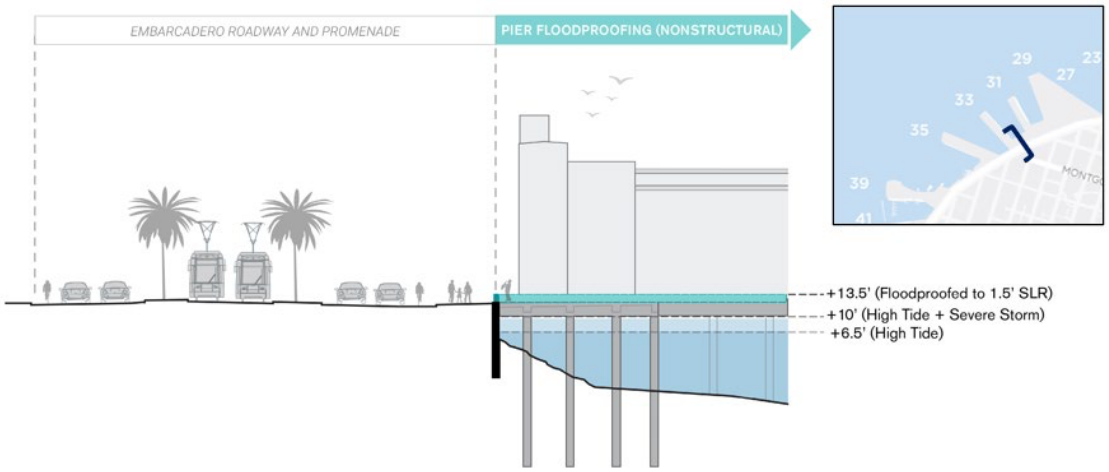
5.1.1. Embarcadero (Reaches 1 and 2)

In Fisherman's Wharf, the TSP initially relies on floodproofing buildings, and later elevates the shoreline with floodwalls. Along the Embarcadero, the TSP elevates the shoreline in place by raising and reconstructing the bulkhead walls and pile-supported wharves north of the Bay Bridge while gradually transitioning down from the new shoreline elevation back to the existing city grade to retain visual and physical access to the waterfront. The plan includes reconstruction and redesign of the Embarcadero roadway – surface design of the Embarcadero roadway and promenade will be determined in future project phases. The Ferry Building and bulkhead buildings are raised in place. Piers are floodproofed with concrete curbs around the perimeter to reduce flood risk.

The TSP in Reaches 1 and 2 includes the following **initial actions** (**Figure 5-4** to **Figure 5-7**).

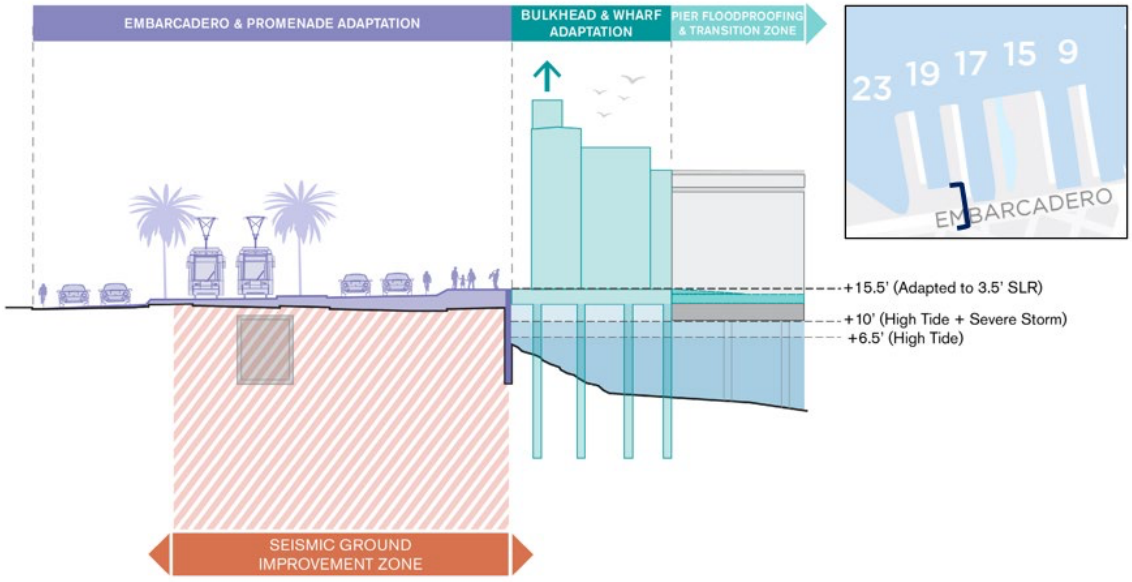
- From Pier 27-29 to the Bay Bridge, raise the shoreline along the Embarcadero by 3.5 to 7.5 feet to defend against 3.5 feet of SLR (finish elevation of 15.5 feet NAVD88) using raised and rebuilt bulkhead walls and wharves, approximately aligned with the location of the existing structures. Provide Embarcadero Promenade and Bay Trail access atop and adjacent to the raised ground and wharves.
- Perform ground improvement in Reach 2 to mitigate lateral spreading and liquefaction hazards along the coastal flood defense alignment to meet the required seismic performance objectives. Reach 1 would not receive any ground improvement mitigation.
- Construct 2-foot-tall concrete curb around perimeter of piers from Pier 47 to Pier 24.
- Replace existing wharves with new ductile concrete wharves with deck elevation to match top of new bulkhead seawall. Transition grade from raised wharf and bulkhead building to existing pier elevation.
- Raising the shoreline in place could require reconstruction of the full Embarcadero roadway and results in a likely reduction of overall roadway width; however, alternative design configurations are possible that would eliminate disturbance of the roadway. Design of the mobility corridor and specific utilization of the available space will be done during the Preconstruction Engineering and Design (PED) phase.
- Elevate buildings on wharves north of the Bay Bridge, including the Ferry Building, Agriculture Building, bulkhead buildings and more.
- Floodproof a subset of buildings in Fisherman's Wharf, such as the Dolphin Club and buildings at Pier 45, Pier 39, and Pier 31.

- Consider removal or floodproofing of select additional buildings in Fisherman's Wharf based on risk profile, age, condition, and historic status.
- Build infrastructure to manage stormwater. Coordinate with SFPUC, Public Works, and other stakeholders on changes to the combined sewer system, expanded green corridors, and other features to reduce inland flood risk exacerbated by the coastal flood defense structures.



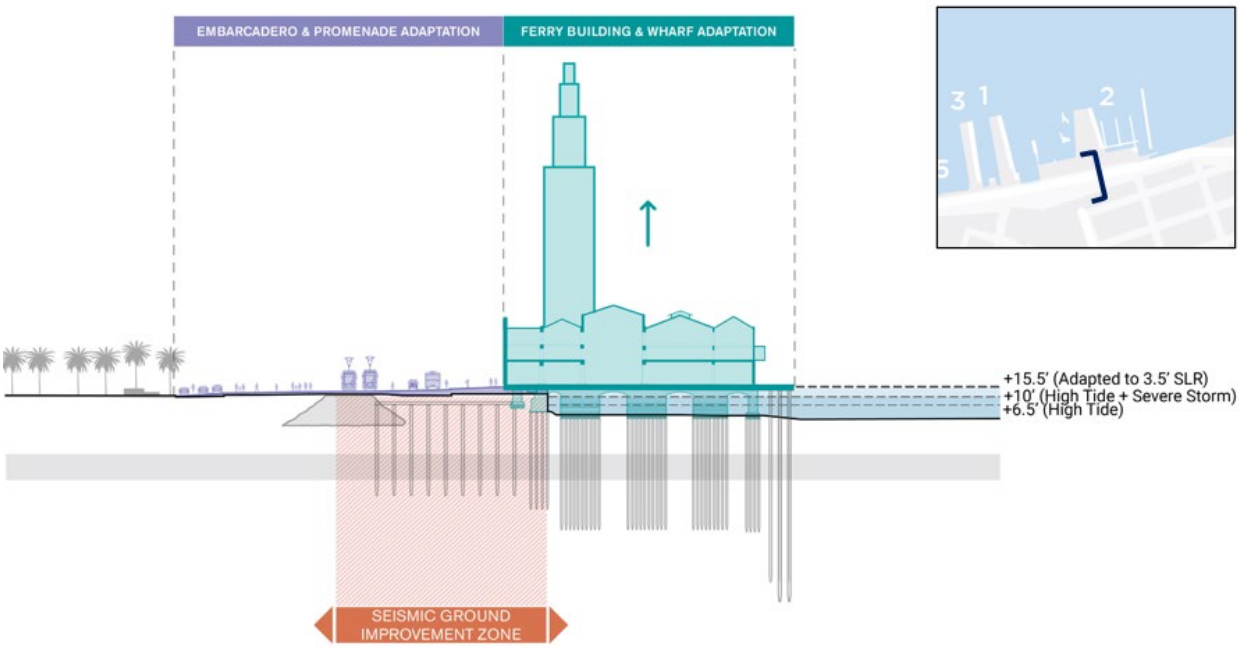
Gray and black represent existing conditions; teal represents TSP first actions

Figure 5-4: TSP First Actions: Fisherman's Wharf to Telegraph Hill (Reach 1), Typical Cross Section within Embarcadero Historic District



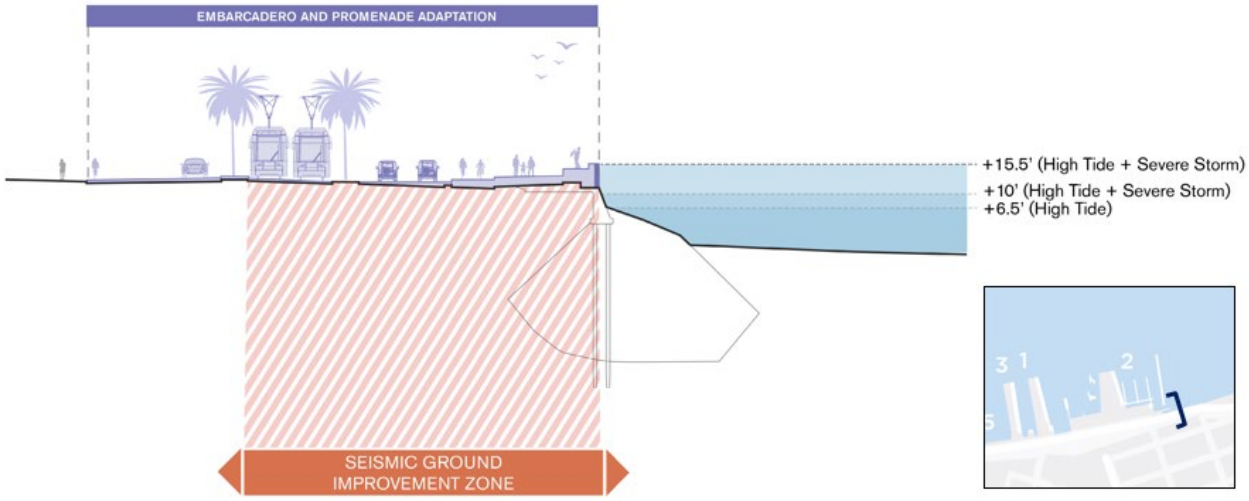
Gray and black represent existing conditions; orange, purple, and teal represent TSP first actions

Figure 5-5: TSP First Actions: Telegraph Hill to Bay Bridge (Reach 2), Typical Cross Section within Embarcadero Historic District



Gray and black represent existing conditions; orange, purple, and teal represent TSP first actions

Figure 5-6: TSP First Actions: Telegraph Hill to Bay Bridge (Reach 2), Ferry Building



Gray and black represent existing conditions; orange and purple represent TSP first actions.

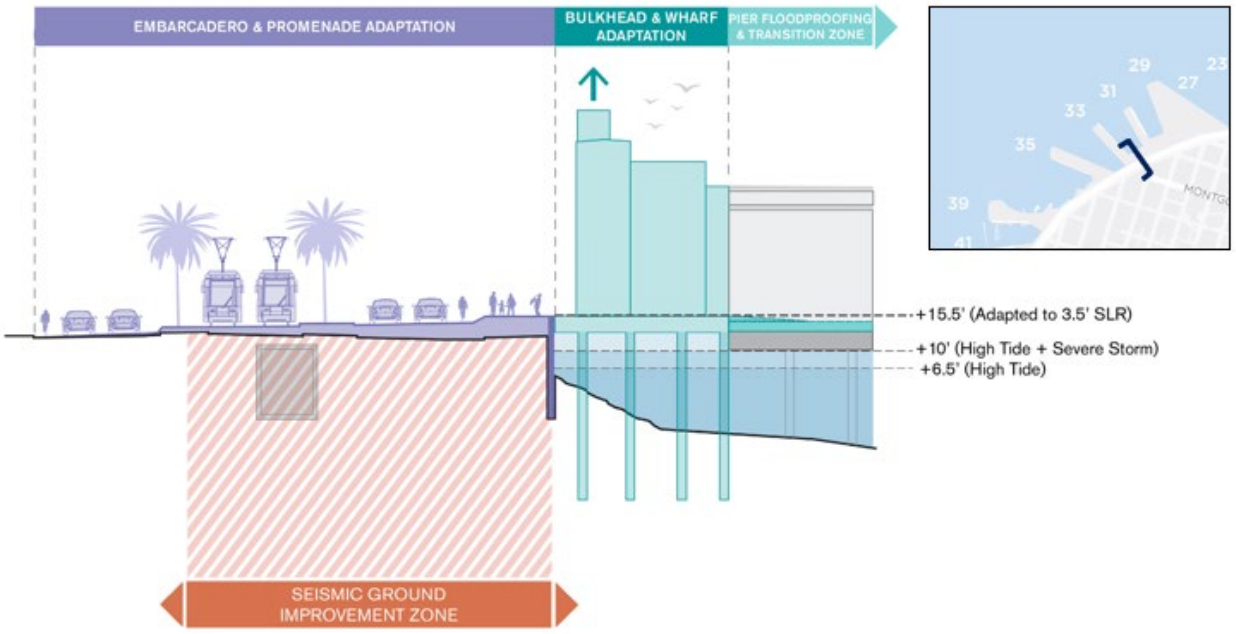
Figure 5-7: TSP First Actions: Telegraph Hill to Bay Bridge (Reach 2), Rincon Park

The TSP in Reaches 1 and 2 includes the following **subsequent actions** (**Figure 5-8**):

- North of Pier 27-29, raise the shoreline by 1.5 to 4.5 feet to defend against 3.5 feet of SLR (15.5 feet NAVD88) using 1.5 to 4.5-foot-tall floodwalls and raised and rebuilt bulkhead walls and wharves, approximately aligned with the location

of these existing structures. Provide Embarcadero Promenade and Bay Trail access along or adjacent to the flood defense structure.

- Perform ground improvement in Reach 1 to mitigate lateral spreading and liquefaction hazards along the coastal flood defense alignment to meet the required seismic performance objectives.
- Consider elevation, floodproofing, or demolition of buildings bayside of the coastal flood defense in Fisherman's Wharf based on risk profile, age, condition, and historic status.
- Build infrastructure to manage stormwater. Coordinate with SFPUC, Public Works, and other stakeholders on changes to the combined sewer system, new pumps, green infrastructure, and other resilient building and street design opportunities and other features to reduce inland flood risk exacerbated by the coastal flood defense structures.
- As sea levels rise, additional adaptations may be needed before the end of the period of analysis (2140), but these are not anticipated to be included in the project to be authorized for funding at this time. For the purposes of analysis, these are assumed to further raise the coastal flood defense using primarily vertical extension walls.



Gray and black represent post-first-action conditions; orange, purple, and teal represent TSP subsequent actions. Further design studies will be needed to incorporate bicycle infrastructure planning efforts, vehicular access considerations, and urban design considerations.

Figure 5-8: TSP Subsequent Actions: Fisherman's Wharf to Telegraph Hill (Reach 1), Typical Cross Section within Embarcadero Historic District

5.1.2. Mission Creek / Mission Bay (Reach 3)

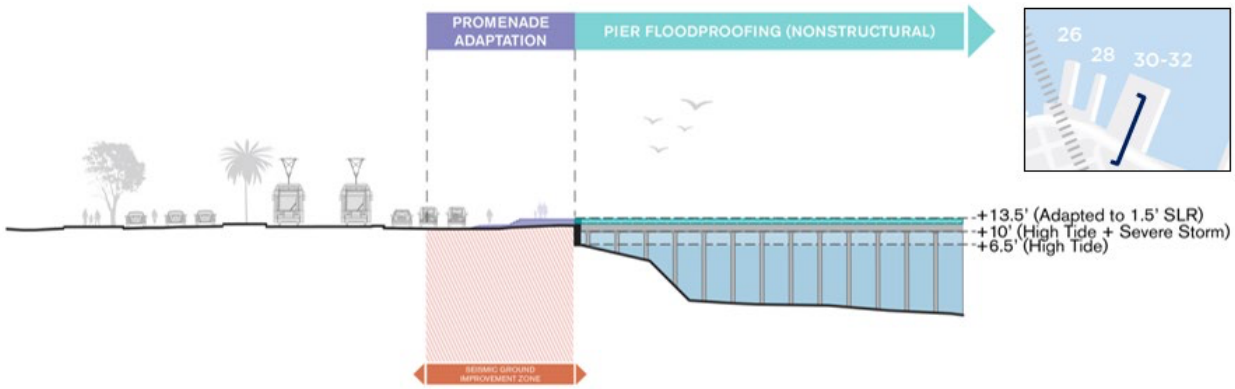
In the Mission Creek / Mission Bay geography, the TSP defends existing city and community assets in place by elevating the creek and Bay shorelines with naturalized or embankment shorelines, floodwalls, and raised and rebuilt bulkhead walls and wharves. The coastal defense will tie into existing and planned high ground at Bayfront, Agua Vista, and Crane Cove Parks, and at the Mission Rock and Pier 70 development areas. The plan also includes partial reconstruction and redesign of the Embarcadero roadway south of the Bay Bridge.

The TSP in Reach 3 includes the following **initial actions** (**Figure 5-9** to **Figure 5-11**):

- Raise the Bay and creek shorelines to defend against 1.5 feet of SLR (13.5 feet NAVD88) using a combination of 1.5- to 4.5-foot-tall walls, naturalized or embankment shorelines, and raised and rebuilt bulkhead walls and wharves, depending on existing shoreline elevations. Provide Bay Trail access atop and adjacent to bayside naturalized or embankment shorelines and wharves.
- Install 2-foot-tall concrete curbs around the perimeters of piers from Pier 26 to Pier 50.
- Perform ground improvement to mitigate lateral spreading and liquefaction hazards along the coastal flood defense alignment to meet the required seismic performance objectives.
- Install deployable closure structures at the northern and southern abutments of 3rd and 4th Street bridges over the creek to defend landward buildings and infrastructure from flood damage. Service across bridges will be disrupted for hours to days during high water events. The likelihood of closure is anticipated to be approximately one closure on average every 25-200 years (0.5-4% annual chance) by 2060.[8]
- Tie measures into existing high ground and planned development projects at Bayfront, Agua Vista, and Crane Cove Parks, and at the Mission Rock and Pier 70 development areas.
- Enhance wildlife habitat on naturalized or embankment shorelines along the shoreline using NNBFs.
- Remove select buildings at Pier 68/70 shipyard for construction of coastal naturalized or embankment shoreline or adjust the alignment of coastal naturalized or embankment shoreline features to avoid historic resources where the structures have ground floor elevations that are above 13.5 feet NAVD88.
- Build infrastructure to manage stormwater. Coordinate with SFPUC, Public Works, and other stakeholders on changes to the combined sewer system,

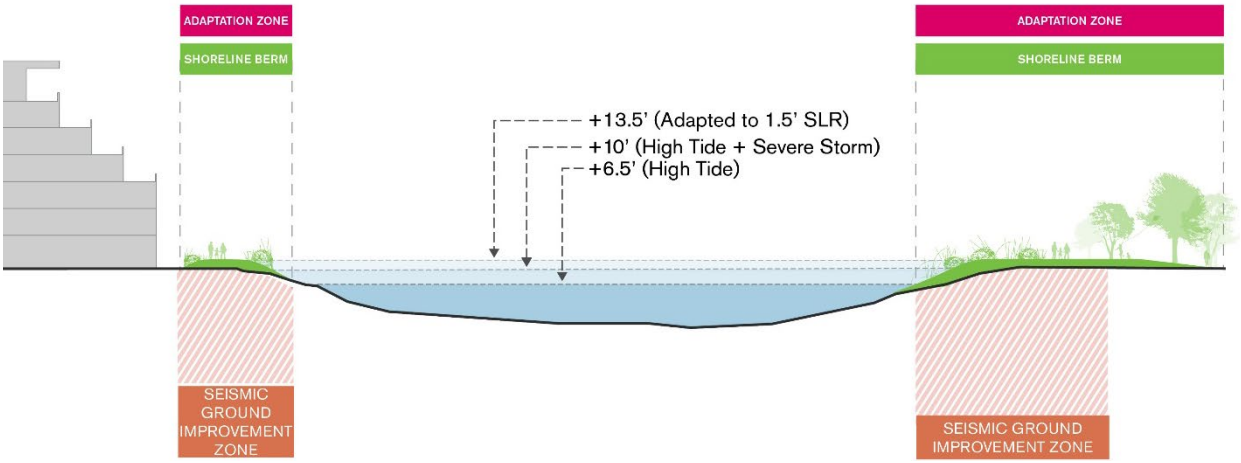
[8] Based on USACE intermediate and high RSLC.

expanded green corridors, and other features to reduce inland flood risk exacerbated by the coastal flood defense structures.



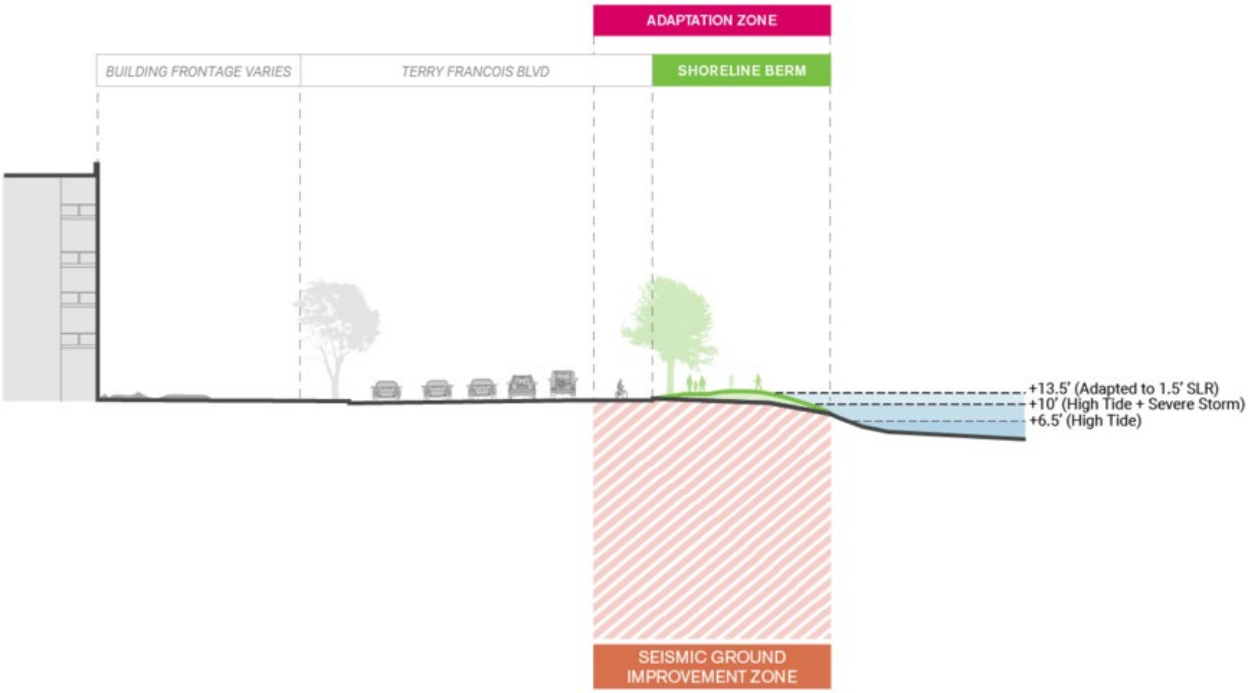
Gray and black represent existing conditions; orange, purple, and teal represent TSP first actions

Figure 5-9: TSP First Actions: Bay Bridge to Potrero Point (Reach 3), Pier 30/32



Gray and black represent existing conditions; orange, pink, and green represent TSP first actions

Figure 5-10: TSP First Actions: Bay Bridge to Potrero Point (Reach 3), Mission Creek



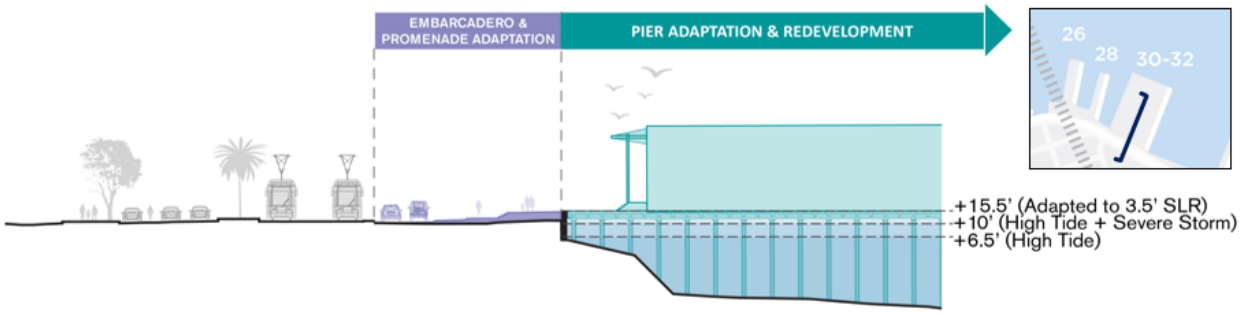
Gray and black represent existing conditions; orange, pink, and green represent TSP first actions

Figure 5-11: TSP First Actions: Bay Bridge to Potrero Point (Reach 3), Terry Francois Boulevard

The TSP in Reach 3 includes the following **subsequent actions** (**Figure 5-12** to **Figure 5-14**):

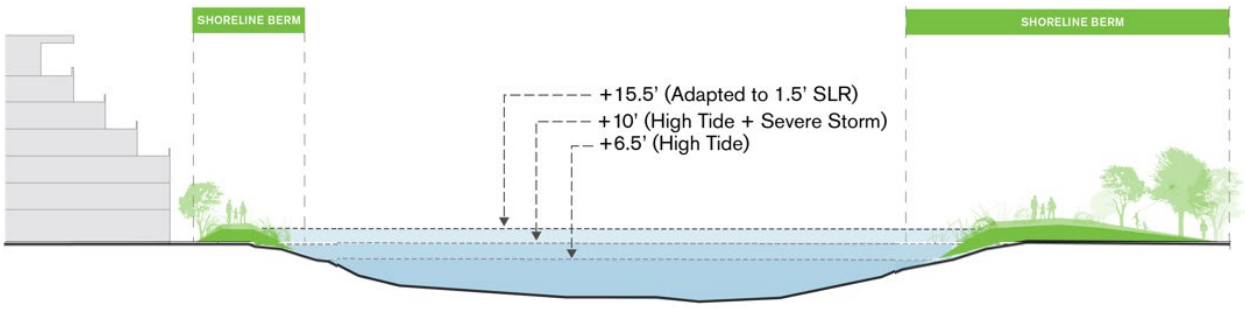
- Raise the Bay and creek shorelines an additional 2 feet to defend against 3.5 feet of SLR (15.5 feet NAVD88) using naturalized or embankment shorelines and seawalls, as well as raising and rebuilding bulkhead walls and wharves. Provide Bay Trail access atop and adjacent to the naturalized or embankment shorelines and wharves.
- Perform ground improvement as required to mitigate lateral spreading and liquefaction hazards along the coastal flood defense alignment to meet the required seismic performance objectives.
- Maintain current roadway capacity along Terry Francois Boulevard and reduce one lane of parking to provide space shoreline elevation and regrading. Final surface design to be conducted in future design phases.
- Consider modest amount of new Bay fill along the Bay edge at Terry Francois Boulevard and north bank of Mission Creek from the 4th Street Bridge to South Beach Harbor.

- Incorporate NNBFs along the creek and Bay shorelines to serve a coastal flood risk management function by reducing wave runup, while also enhancing public access and wildlife habitat.
- Elevate bulkhead buildings from Pier 26 through Pier 50. Consider elevation, floodproofing, or demolition of other buildings along the bayside shoreline overlapping or adjacent to the coastal flood defense alignment based on risk profile, age, condition, and historic status.
- Consider building additional infrastructure to manage stormwater and reduce inland flood risk exacerbated by the coastal flood defense structures.
- As sea levels rise, additional adaptations may be needed before the end of the period of analysis (2140), but these are not anticipated to be included in the project to be authorized for funding at this time. For the purposes of analysis, these are assumed to further raise the coastal flood defense using primarily vertical extension walls.



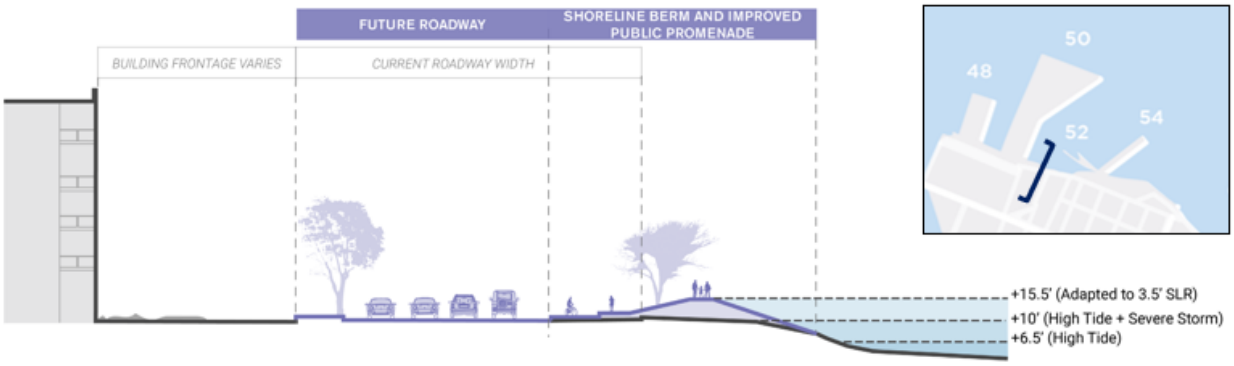
Gray and black represent post-first-action conditions; purple and teal represent TSP subsequent actions and example potential actions in coordination with development partners

Figure 5-12: TSP Subsequent Actions: Bay Bridge to Potrero Point (Reach 3), Pier 30/32



Gray and black represent post-first-action conditions; green represents TSP subsequent actions

Figure 5-13: TSP Subsequent Actions: Bay Bridge to Potrero Point (Reach 3), Mission Creek



Gray and black represent post-first-action conditions; purple represents TSP subsequent actions

Figure 5-14: TSP Subsequent Actions: Bay Bridge to Potrero Point (Reach 3), Terry Francois Boulevard

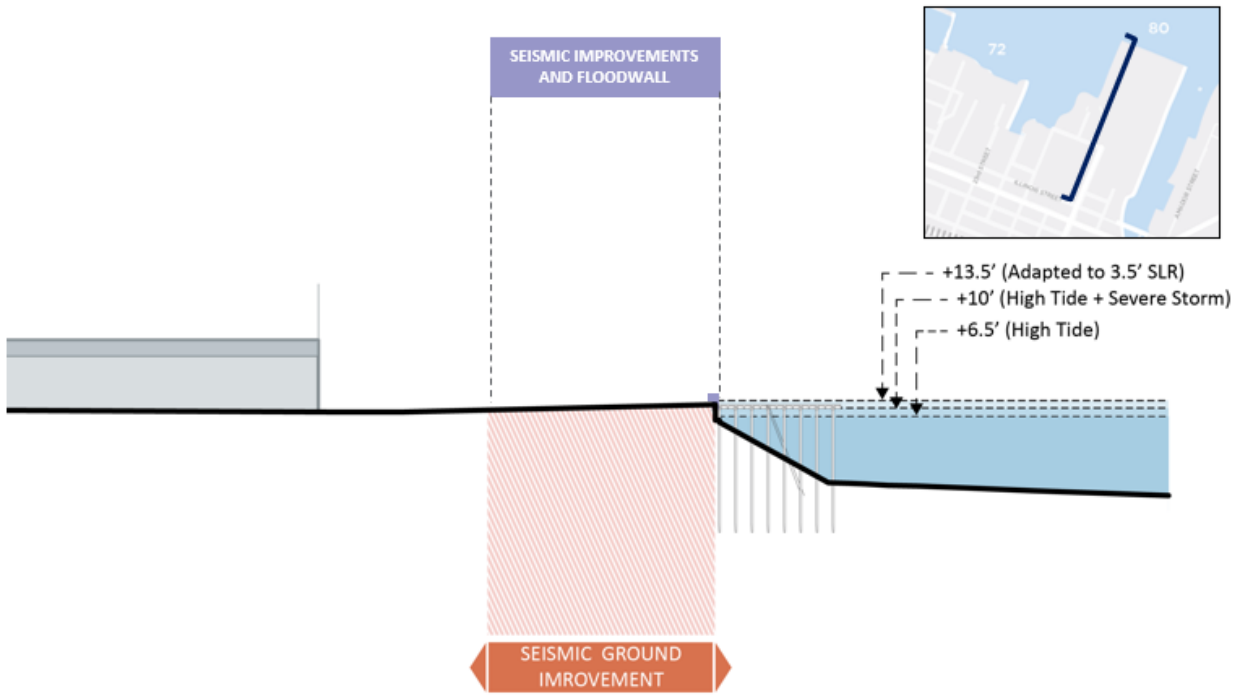
5.1.3. Islais Creek / Bayview (Reach 4)

In the Islais Creek / Bayview geography, the TSP defends the existing shoreline to retain residential and commercial land uses in place, including Port land uses and maritime facilities. The flood defenses consist of raising the shoreline using naturalized or embankment shorelines, bulkhead walls, raising and rebuilding marginal wharves, deployable closure structures, and tying into existing or planned high ground, near Potrero Power Station and behind the Pier 94 Wetlands (Port backlands). This area of the waterfront contains large parcels independent of the combined sewer system, such that the elevated shoreline will require modification to handle stormwater in a safe and effective manner.

The TSP in Reach 4 includes the following **initial actions** (**Figure 5-15** to **Figure 5-17**):

- Elevate the Bay and creek shorelines using a combination of 2.5- to 5.5-foot-tall naturalized or embankment shorelines, floodwalls, and curb extensions to defend against 1.5 feet of SLR (13.5 feet NAVD88). Defenses tie into high ground at Warm Water Cove, the western end of Islais Creek, Pier 94 Wetlands, Heron's Head Park, and near the southern boundary of the study area.
- Install 2-foot-tall concrete curb at edge of Pier 80 and Pier 94-96 to provide coastal flood protection while maintaining function for maritime uses.
- Perform ground improvement to mitigate lateral spreading and liquefaction hazards along the coastal flood defense alignment to meet the required seismic performance objectives.
- Incorporate NNBFs into Warm Water Cove, at the interface between Pier 94 Wetlands and Pier 96, and along portions of the Islais Creek bank.
- Install deployable closure structures at the north and south abutments of Illinois Street Bridge to be activated in advance of a coastal storm.

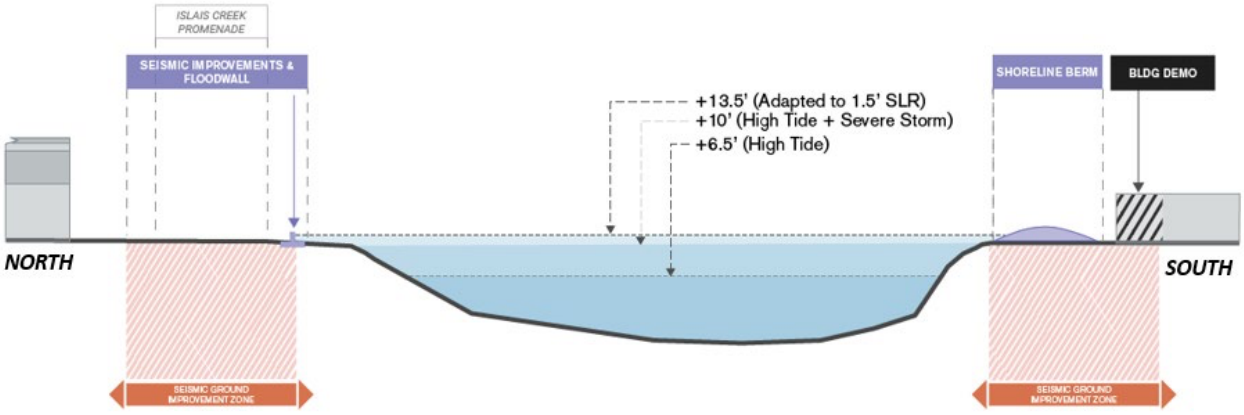
- 3rd Street Bridge will be rebuilt at a higher elevation[9] per the SF Public Works existing project, outside of the SFWCFS (FWOP Condition).
- Reconstruct Pier 90 and 92 wharves at 13.5' NAVD88 elevation and incorporate them into the coastal defense system.
- Consider removing portions of warehouses near the south banks of Islais Creek and west of the bridges to make room for naturalized or embankment shoreline features, as well as portions of the Pier 96 building that extends south of the pier edge, and one building straddling the wharf edge at Pier 90.
- Build infrastructure to manage stormwater. Coordinate with SFPUC, Public Works, and other stakeholders on changes to the combined sewer system, expanded green corridors, and other features to reduce inland flood risk exacerbated by the coastal flood defense structures.



Gray and black represent existing conditions; orange and purple represent TSP first actions

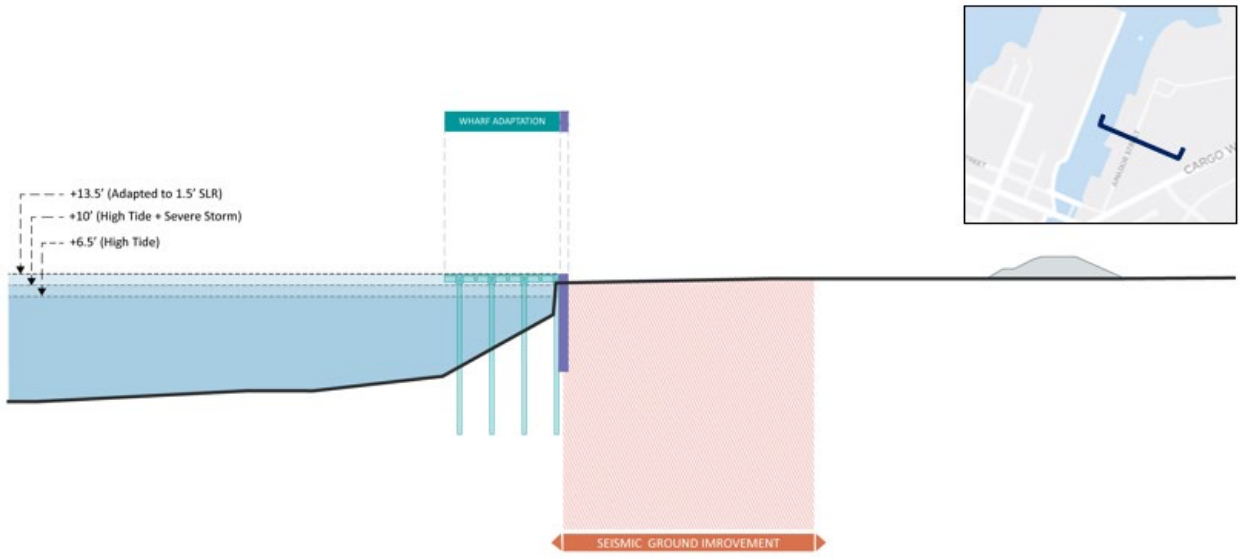
Figure 5-15: TSP First Actions: Potrero Point to Heron's Head Park (Reach 4), Pier 80

[9] Rebuilding of 3rd Street Bridge at higher elevation is external to the SFWCFS project (i.e., it is part of the "Future Without Project" condition).



Gray and black represent existing conditions; orange and purple represent TSP first actions

Figure 5-16: TSP First Actions: Potrero Point to Heron's Head Park (Reach 4), Islais Creek



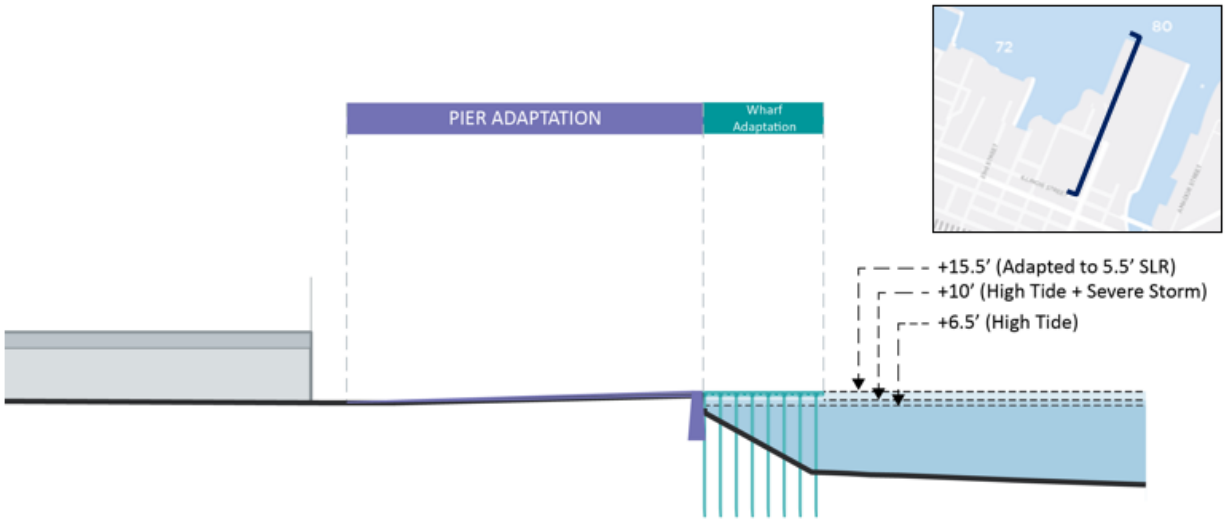
Gray and black represent existing conditions; orange, purple and teal represent TSP first actions

Figure 5-17: TSP First Actions: Potrero Point to Heron's Head Park (Reach 4), Pier 92

The TSP in Reach 4 includes the following **subsequent actions** (**Figure 5-18** and **Figure 5-19**):

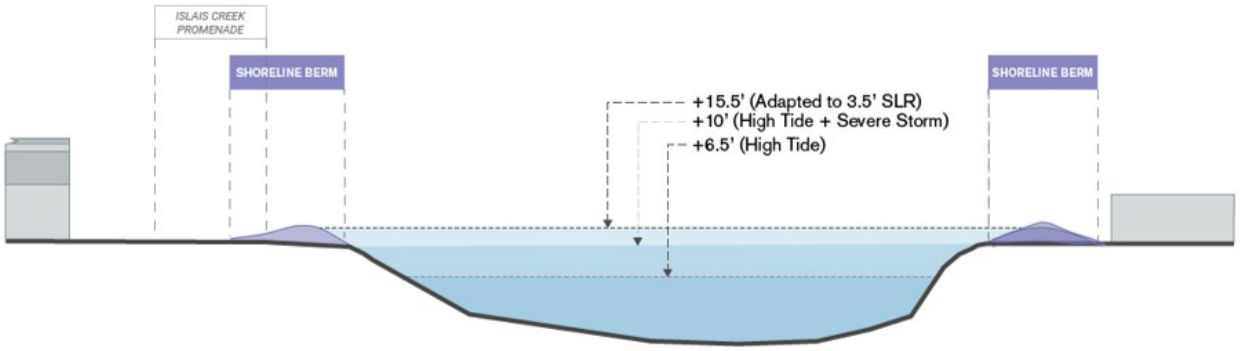
- Elevate the Bay and creek shorelines an additional 2 feet using a combination of naturalized or embankment shorelines, floodwalls, and raised bulkhead walls and wharves to defend against 3.5 feet of SLR (15.5 feet NAVD88).
- Perform ground improvement as required to mitigate lateral spreading and liquefaction hazards along the coastal flood defense alignment to meet the required seismic performance objectives.

- Construct naturalized or embankment shorelines along the banks of Islais Creek west of the Illinois Street bridge and from Illinois Street Bridge to Pier 80.
- Incorporate NNBFs into the shoreline along the banks of Islais Creek and Pier 94 wetlands to serve a coastal flood risk management function by breaking and attenuating waves, while also enhancing public access and wildlife habitat.
- Adapt Pier 80 and Piers 94-96 by installing a new raised bulkhead wall and wharves.
- Consider removing buildings that straddle the alignment of the new bulkhead wall based on risk profile, age, condition, and historic status.
- Consider building additional infrastructure to manage stormwater and reduce inland flood risk exacerbated by the coastal flood defense structures.
- As sea levels rise, additional adaptations may be needed before the end of the period of analysis (2140), but these are not anticipated to be included in the project to be authorized for funding at this time. For the purposes of analysis, these are assumed to further raise the coastal flood defense using primarily vertical extension walls.



Gray and black represent post-first-action conditions; orange and purple represent TSP subsequent actions

Figure 5-18: TSP Subsequent Actions: Potrero Point to Heron's Head Park (Reach 4), Pier 80



Gray and black represent post-first-action conditions; orange and purple represent TSP subsequent actions

Figure 5-19: TSP Subsequent Actions: Potrero Point to Heron's Head Park (Reach 4), Islais Creek

5.2. Risk Communication

The TSP will not eliminate flood risk, and so residual risk of flooding will remain a threat to life and property. It is essential that flood risk be proactively communicated to residents in accessible and thoughtful ways.

There are numerous existing agencies and programs that can be leveraged to communicate flood risk in the study area. The California Governor's Office of Emergency Services is responsible for coastal flood risk communication in California. The San Francisco Office of Emergency Management plays a similar role for the City of San Francisco. These agencies provide real-time flood information, emergency alerts, and emergency information to residents, and assist with flood risk and emergency preparation, response, and recovery.

Figure 5-20 illustrates the shared responsibility for flood risk management.

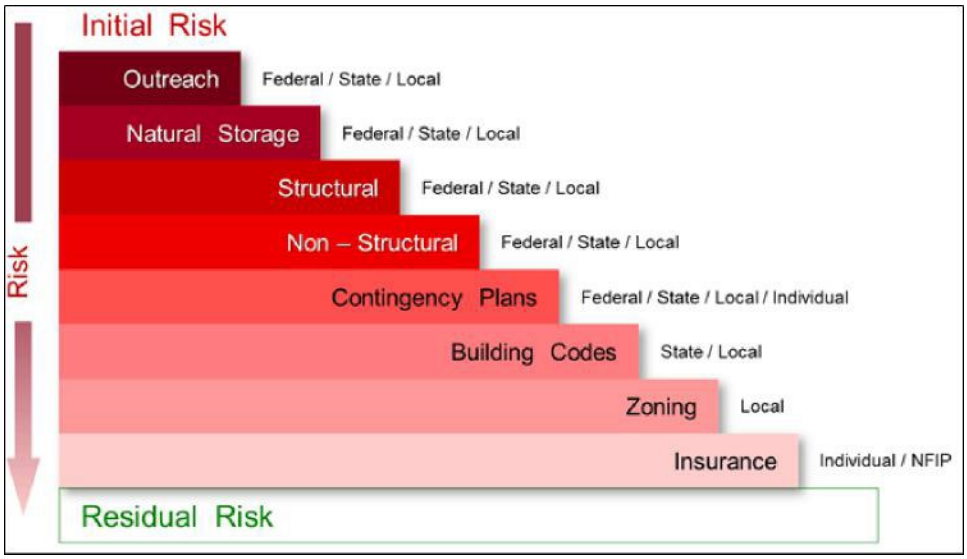


Figure 5-20: Shared Responsibility of Coastal Flood Risk Management

5.3. Costs

Plan costs were estimated using the Micro Computer Aided Cost Estimating System, Second Generation (MCACES 2nd Generation, or MII) cost engineering model. The detailed cost estimate is based on a combination of MII's Cost Book, estimator-created site-specific cost items, and local subcontractor and material supplier cost quotes. Cost contingencies were developed through a standard Cost and Schedule Risk Analysis (CSRA). Appendices C and F include details of the engineering and real estate cost estimates, respectively.

At Fiscal Year 2024 price levels, the TSP has an estimated project first cost of $13,555,200,000 for the 2040 first action (**Table 5-1**) and an annualized cost of $525,000 based on 2.5% discount rate (**Table 5-2**). The annualized cost includes planning, engineering and design, construction management, interest during construction, and operation and maintenance, including contingencies. **Table 5-3** shows the range of costs of the TSP first and second actions for the Low to High RSLC.

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