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

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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).

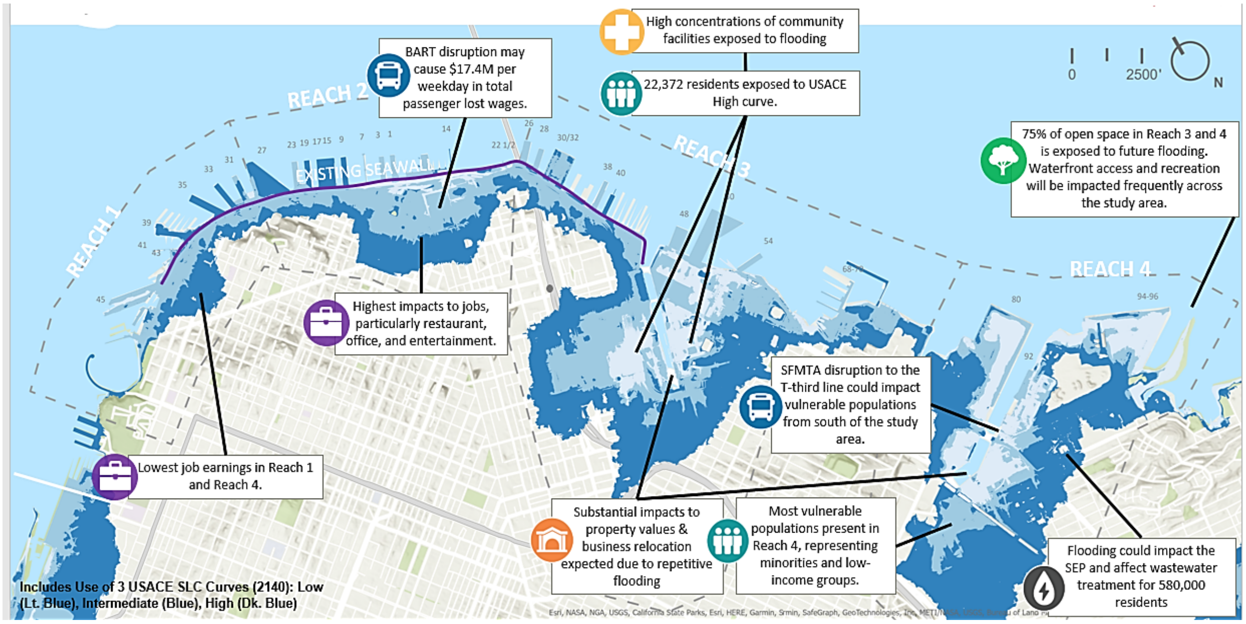

Figure 1 - Extent of inundation expected under 1% AEP flood event in FWOP Conditions under the three RSLC curves

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.

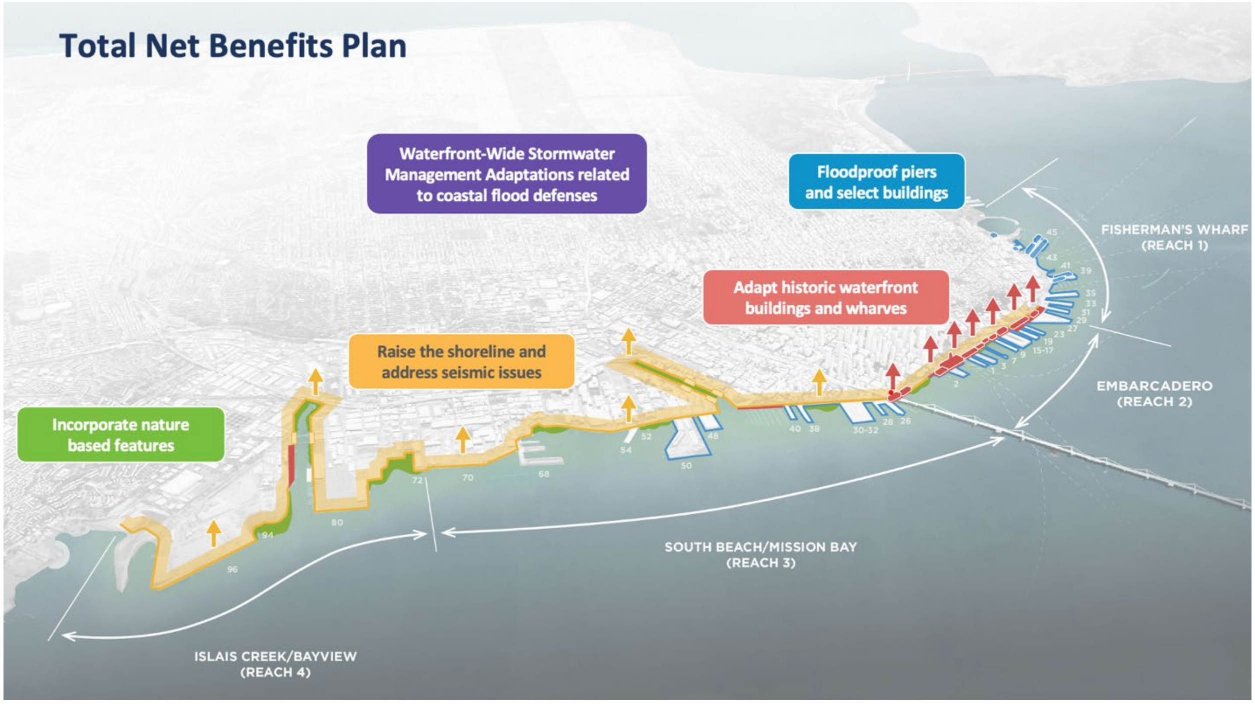

Figure 2 - TSP Initial Actions

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.

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**Items marked with an asterisk are applicable to the satisfaction of National Environmental Policy Act (NEPA) requirements*

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Appendices

Acronyms and Abbreviations

Acronym	Definition
ACS	American Community Survey
AEP	Annual Exceedance Probability
APRI	A. Phillip Randolph Institute
AR	Atmospheric River
ARA	Abbreviated Risk Analysis
ASA(CW)	Assistant Secretary of the Army (Civil Works)
BA	Biological Assessment
BAAQMD	Bay Area Air Quality Management District
BART	Bay Area Rapid Transit
BCDC	San Francisco Bay Conservation and Development Commission
BCR	Benefit-Cost Ratio
BO	Biological Opinion
CAC	Childrens Advocacy Center
CALTRANS	California Department of Transportation
CAR	Coordination Act Report
CB	Comprehensive Benefits
CCC	California Coastal Commission
CCCARTO	Chubb Custom Cartography
CCSF	City and County of San Francisco
CDFW	California Department of Fish and Wildlife
CEQ	Council on Environmental Quality

CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
CGS	California Geological Survey
CH	Critical Habitat
CNRA	California National Resources Agency
CSD	Combined Sewer Discharge
CSO	Combined Sewer Outflow
CZMA	Coastal Zone Management Act
cy	cubic yards
DDT	Dichlorodiphenyltrichloroethane
DO	Dissolved Oxygen
DOI	(U.S.) Department of the Interior
DOT	(U.S.) Department of Transportation
EAD	Equivalent Annual Damages
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
ENWG	Engineering with Nature Working Group
EO	Executive Order
EOP	Environmental Operating Principles
EPA	Environmental Protection Agency
EQ	Environmental Quality

ESA	Endangered Species Act
EWN	Engineering With Nature
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FMP	Fisheries Management Plan
FWOP	Future Without Project
FWP	Future With Project
FY	Fiscal Year
GIS	Geographic Information System
G2CRM	Generation 2 Coastal Risk Model
GHG	Greenhouse Gas
HAP	Hazardous Air Pollutants
HAPC	Habitats of Particular Concern
HCR	Hazards and Climate Resilience Plan
HTRW	Hazardous, Toxic, and Radioactive Waste
IFR	Integrated Feasibility Report
IO	Input-output
IFR	Integrated Feasibility Report
IPCC	Intergovernmental Panel on Climate Change
IWR	(USACE) Institute for Water Resources
LERRD	Lands, Easements, Rights-of-Way, Relocations, and Disposal Areas
LF	Linear Feet (Foot)
LOD	Line of Defense
LPP	Locally Preferred Plan

LPW	Low Pressure Water
LUST	Leaking Underground Storage Tank
MAPP	Monitoring, Adaptation, and Phasing Plan
MCACES/MII	Micro-Computer Aided Cost Estimating System, Second Generation
MCS	Monte Carlo Simulation
MCX	Cost Estimating Center of Expertise
MGD	Million Gallons Per Day
MHHW	Mean Higher High Water
MHRA	Multi-Hazard Risk Assessment
MLLW	Mean Lower Low Water
MMC	Marine Mammal Commission
MMPA	Marine Mammal Protection Act
MOU	Memorandum of Understanding
MTC	Metropolitan Transportation Commission
Muni	San Francisco Municipal Railway
NAAQS	National Ambient Air Quality Standards
NAVD88	North America Vertical Datum of 1988
NED	National Economic Development
NEPA	National Environmental Policy Act
NFIP	National Flood Insurance Program
NFS	Non-Federal Sponsor
NGO	Non-Governmental Organization
NMFS	National Marine Fisheries Service
NNBF	Natural and Nature-Based Features

NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NRC	National Research Council
NRHP	National Register of Historic Places
NTDE	National Tide Datum Epoch
OMB	Office of Management and Budget
OMRR&R	Operations, Maintenance, Repair, Rehabilitation and Replacement
OPC	California Ocean Protection Council
OSE	Other Social Effects
P&G	Principles and Guidelines
PAH	Polycyclic Aromatic Hydrocarbon
PAL	Planning Aid Letter
PCB	Polychlorinated Biphenyl
PCX	Planning Center of Expertise
PDSI	Palmer Drought Severity Index
PDT	Project Delivery Team
PED	Preconstruction Engineering and Design
PG&E	Pacific Gas and Electric
PGN	Planning Guidance Notebook
PLCA	Probabilistic Life Cycle Analysis
POA	period of analysis
POSF	Port of San Francisco
PPA	Project Partnership Agreement
PSE	Protective System Element

PV	Present Value
RAWG	Regulatory Agency Working Group
RED	Regional Economic Development
RCP	Representative Concentration Pathway
ROD	Record of Decision
RSLC	Relative Sea Level Change
RWQCB	Regional Water Quality Control Board
SAV	Submerged Aquatic Vegetation
SFBAAB	San Francisco Bay Area Air Basin
SFBR	San Francisco Bay Railroad
SFFD	San Francisco Fire Department
SFMTA	San Francisco Municipal Transportation Agency
SFPD	San Francisco Police Department
SFPUC	San Francisco Public Utilities Commission
SFWCFS	San Francisco Waterfront Coastal Flood Study
SLC	Sea Level Change
SLR	Sea Level Rise
SMART	Specific, Measurable, Attainable, Risk-Informed, and Timely
SOMA	South of Market
TAC	Toxic Air Contaminant
T&E	Threatened and Endangered
TNBP	Total Net Benefits Plan
TSP	Tentatively Selected Plan
USACE	United States Army Corps of Engineers

USFWS	U.S. Fish and Wildlife Service
USGCRP	U.S. Global Change Research Program
USGS	U.S. Geological Survey
WETA	Water Emergency Transportation Authority
WRDA	Water Resources Development Act
WSE	Water Surface Elevations

1. Introduction

1.1. Introduction to this Report

The U.S. Army Corps of Engineers (USACE) prepared this Draft Integrated Feasibility Report (IFR) and Environmental Impact Statement (EIS) for the San Francisco Waterfront Coastal Flood Study (SFWCFS) in conjunction with the Non-Federal Sponsor (NFS), the Port of San Francisco (POSF), acting as lead agency for the City and County of San Francisco (CCSF). It is a requirement of USACE planning policy and the National Environmental Policy Act (NEPA) of 1969 to make a report available for public review that describes analysis, risks, assumptions, and decision made by the Study team during the planning process.

Federal water and related land resources projects are formulated to alleviate problems and take advantage of opportunities in ways that contribute to this objective. Pursuant to this goal, this report: 1) summarizes the problems, needs, and opportunities for flood risk mitigation in the San Francisco Waterfront Study Area; 2) presents and discusses the results of the plan formulation process for the study; 3) identifies specific details of a Tentatively Selected Plan (TSP), including inherent risks; and 4) will be used to assist in determining the extent of the federal interest and local support for the plan.

1.2. Overview of the USACE Project Delivery Process

The standard USACE project delivery consists of the agency leading the study, design, and construction of authorized water resource projects. Non-Federal Sponsors (NFSs) typically share in study and construction costs, providing the land and other real estate interests and identifying locally preferred alternatives if different than the USACE identified plan. Congress has also enacted provisions that allow non-Federal sponsors to conduct feasibility studies and/or to design and construct water resources projects.[1]

Congressional authorization and appropriations processes are critical actions in a multistep process to deliver a USACE project. The standard process consists of the following basic steps:

- Congressional study authorization is obtained in a Water Resources Development Act (WRDA) or similar authorization legislation.

[1] Congress has approved two mechanisms for Non-Federal sponsors to participate in study, design, and construction. Section 203 of WRDA 1986, as amended, permits non-Federal sponsors to conduct feasibility studies subject to approval of the Assistant Secretary of the Army for Civil Works. Section 204 of WRDA 1986, as amended, authorizes a non-federal interest to carry out a Federally authorized water resources development project, with potential credit or reimbursement, subject to certain requirements. Section 221 of the Flood Control Act of 1970, as amended, is a comprehensive authority that addresses the affording of credit for the value of in-kind contributions related to study, design or construction provided by a non-Federal sponsor toward its required cost share if those in-kind contributions are determined to be integral to a study or project.

- USACE performs a feasibility study if funds are appropriated.
- Congressional construction authorization is pursued. USACE can perform preconstruction, engineering, and design while awaiting construction authorization if funds are appropriated.
- Congress authorizes construction in a WRDA or similar authorization legislation, and USACE constructs the project, if funds are appropriated.
- The process is not automatic and is reliant on appropriations by Congress to perform the study and construct the project. Without Congressional authorization USACE cannot proceed with the next step.

This feasibility study is the first stage of development for a potential Federal water resources development project. This study follows the USACE Specific, Measurable, Attainable, Risk Informed, and Timely (SMART) planning process which targets a feasibility study to be completed within three years, but due the innovative nature of this feasibility study to address the multi hazard risk considerations and the diversity of the geographic regions and stakeholders, this study was approved to complete the process in seven years. The purpose of the feasibility study is to identify, evaluate and recommend to decision makers an appropriate, coordinated, and workable solution to identified problems and opportunities. The Federal objective of any USACE project planning is to contribute to National Economic Development (NED) consistent with protecting the Nation’s environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements.

A feasibility study works progressively through the six-step planning process in four main phases. The four phases of the study process are: Scoping, Alternative Evaluation and Analysis; Feasibility-Level Analysis, and Chief’s Report development. There are four key decision points or milestones that mark significant decisions along the way to an effective and efficient study: Alternatives Milestone, TSP Milestone, Agency Decision Milestone, and Chief’s Report Milestone.

A feasibility report documents the study results and findings, including the formulation of alternatives, the selection process of the recommended alternative, and the costs and benefits of that recommended plan. The final feasibility report provides a sound and documented basis for decision makers and stakeholders regarding the recommended solution. A feasibility study ends when the Chief of Engineers signs a Chief’s Report and submits the Final Feasibility Report, and associated NEPA documentation to the Assistant Secretary of the Army for Civil Works (ASA(CW)). The ASA(CW) then submits the report documentation to the Office of Management and Budget (OMB), where they review the report to ensure it is consistent with Administration policies and priorities and provides clearance to release the report to Congress. The ASA(CW) then submits the report to Congress for consideration of authorization to construct the recommended project.

The USACE planning process parallels the NEPA process. NEPA requires that all federal agencies use a systematic, interdisciplinary approach to protect the human environment. This approach promotes the integrated use of natural and social science in planning and decision-making. The NEPA process involves a scoping phase, public involvement, and a determination of whether environmental effects of a federal action are likely to be significant. Where net environmental effects on the quality of the human environment of a major Federal action are projected to be significant, an EIS is prepared in the NEPA process to look at different action alternatives and evaluate the relative significance of the environmental effects of the alternatives. Federal agencies have been encouraged to integrate their planning processes with the NEPA process; therefore, this document presents an IFR and EIS.

The IFR-EIS provides a site-specific NEPA review of the first action measures and general overview of the impacts anticipated for the second actions if the conditions, construction methodologies, timing, etc. that exist today continue to exist at the time of construction (50+ years in the future). The DIFR-EIS includes an analysis of both the first and second actions even though only the first action is being recommended for authorization and funding. The purpose of including both actions was to present sufficient information regarding overall impacts of the second action so that decision-makers can make a reasoned judgment on the merits of the overall potential flood defense system being considered (e.g., “hard look requirement”) and make a reasoned choice among alternatives in consideration of potential adaptation in the future. This follows the CEQ guidance to consider connected actions or reasonably foreseeable actions even though the second action is expected to occur more than 50 years in the future. Since the authorization would not include a second action, the ROD would only cover the first actions. Once the triggers for adaptation are reached, USACE will begin subsequent NEPA reviews of any proposed second actions, which involves preparation of one or more additional NEPA documents (either an EIS or Environmental Assessment) prepared in accordance with CEQ regulations in place at that time, which would include providing for additional public review periods and resource agency coordination.

If during PED any project changes are found to be outside the scope of the recommended plan and the Chief’s Discretionary Authority, a re-review of the original decision and authority will need to be completed following USACE policies at the time the change is identified. If design changes induce impacts greater than those described in the FIFR-EIS, supplementation of the IFR-EIS may be required following the CEQ regulations at the time the change is identified, and a new ROD signed.

1.3. Study Authority

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

Section 110 of the Rivers and Harbors Act of 1950 states:

> *“The Secretary of the Army is hereby authorized and directed to cause preliminary examinations and surveys to be made at the following-named*

> *localities, the cost thereof to be paid from appropriations heretofore or hereafter made for such purposes : Provided, That no preliminary examination, survey, project, or estimate for new works other than those designated in this title or some prior Act or joint resolution shall be made: Provided further, That after the regular or formal reports made as required by law on any examination, survey, project, or work under way or proposed are submitted, no supplemental or additional report or estimate shall be made unless authorized by law: Provided further, That the Government shall not be deemed to have entered upon any project for the improvement of any waterway or harbor mentioned in this title until the project for the proposed work shall have been adopted by law: Provided further, That reports of surveys on beach erosion and shore protection shall include an estimate of the public interests involved, and such plan of improvement as is found justified, together with the equitable distribution of costs in each case: And provided further, That this section shall not be construed to interfere with the performance of any duties vested in the Federal Power Commission under existing law: ...San Francisco Bay, including San Pablo Bay, Suisun Bay, and other adjacent bays, and tributaries thereto, California."*

Section 142 of WRDA 1976, as amended by section 705 of WRDA 1986, states:

> *"The Secretary of the Army, acting through the Chief of Engineers, is authorized and directed to investigate the flood and related problems to those lands lying below the plane of mean higher high water along the San Francisco Bay shoreline of San Mateo, Santa Clara, Alameda, Napa, San Francisco, Marin, Sonoma and Solano Counties to the confluence of the Sacramento and San Joaquin Rivers with a view toward determining the feasibility of and the Federal interest in providing protection against tidal and fluvial flooding. The investigation shall evaluate the effects of any proposed improvements on wildlife preservation, agriculture, municipal and urban interests in coordination with Federal, State, regional, and local agencies with particular reference to preservation of existing marshland in the San Francisco Bay region."*

Section 8325(b) of WRDA 2022 states:

> *"(b) IMPLEMENTATION. — In carrying out a study under section 142 of the Water Resources Development Act of 1976 (90 Stat. 2930; 100 Stat. 4158), pursuant to section 203(a)(1)(A) of the Water Resources Development Act of 2020 (as amended by this section), the Secretary shall not differentiate between damages related to high tide flooding and coastal storm flooding for the purposes of determining the Federal interest or cost share."*

Section 203 of WRDA 2020, as amended by Section 8325(b) of WRDA 2022, states:

> *"a) the Secretary shall expedite the completion of the following feasibility studies, as modified by this section, and if the Secretary determines that a project that is the subject of the feasibility study is justified in a completed*

report, may proceed directly to preconstruction planning, engineering, and design of the project"

(1) San Francisco Bay, California – The study for flood risk reduction authorized by section 142 of the Water Resources Development Act of 1976 (90 Stat. 2930), is modified to authorize the Secretary to—

(A) investigate the bay and ocean shorelines of San Mateo, San Francisco, and Marin Counties for the purposes of providing flood protection against tidal and fluvial flooding;

(B) with respect to the bay and ocean shorelines of San Mateo, San Francisco, and Marin Counties, investigate measures to adapt to rising sea levels; and

(C) with respect to the bay and ocean shorelines, and streams running to the bay and ocean shorelines, of San Mateo, San Francisco, and Marin Counties, investigate the effects of proposed flood protection and other measures or improvements on—

(i) the local economy;

(ii) habitat restoration, enhancement, or expansion efforts or opportunities;

(iii) public infrastructure protection and improvement;

(iv) stormwater runoff capacity and control measures, including those that may mitigate flooding;

(v) erosion of beaches and coasts; and

(vi) any other measures or improvements relevant to adapting to rising sea levels."

1.4. Non-Federal Sponsor

The Port of San Francisco (POSF) is the NFS for this study. The POSF oversees the administration of the public trust for the State of California under the Burton Act, ensuring that public trust uses such as maritime, public access, historic resources, visitor-serving uses, and water-related and dependent uses are preserved and maintained along the waterfront. The POSF is also an enterprise agency of the City and County of San Francisco (CCSF); they raise funds by leasing property and charging fees within their jurisdiction to preserve and enhance uses that are important to the public trust and to the City of San Francisco (City). The POSF and the City and County of San Francisco participate in implementation of the City's Hazards and Climate Resilience Plan (HCR) which identifies the hazards and risks San Francisco faces and proposes strategies to reduce risks and adapt to climate change impacts.

The HCR was adopted as San Francisco's 2020 Hazard Mitigation Plan by the Mayor and Board of Supervisors on June 16, 2020, and approved by the Federal Emergency Management Agency (FEMA) on July 21, 2020. It updated the city's 2014 Hazard

Mitigation Plan, which was coordinated with the Federal Emergency Management Agency (FEMA) to encourage proactive risk reduction efforts are implemented to mitigate post disaster consequences where possible and to increase efficiency of post disaster response and recovery programs at the federal and local level. The HCR was developed based on the following principles:

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

These principles are consistently applied across City agency planning and asset management to monitor and address risk from multiple hazards, including seismic, inland, and coastal flooding. The 2020 Hazard Mitigation Plan also reflects the proactive efforts of the CCSF to reduce FEMA post disaster response costs.

The POSF also participates in Mayor London Breed's Climate SF[2] initiative to mitigate and adapt to climate change. ClimateSF brings together key City agencies whose services could be critically impacted by climate change. These agencies are taking collective action through planning, policy, and guidance, championing a coordinated vision on climate resilience that streamlines City responses and promotes an equitable, safe, and healthy city for generations to come.

2 Mayor Breed convened Climate SF to address climate adaptation, mitigation, and resilience. Participating departments include City Administrator's Office of Resilience and Capital Planning ("ORCP"), SF Planning, Public Works, SF Environment ("SFE"), SF Municipal Transportation Agency ("SFMTA"), and the SF Public Utilities Commission ("SFPUC"). Each agency has dedicated a staff person to participate in the adaptation planning process, identify department issues of concern, develop department-specific information to support the Study, and brief senior management in support of a recommendation to Mayor Breed and the Board of Supervisors.

1.5. Study Area

The study area extends approximately 7.5 miles from Aquatic Park in the northeast to just past Heron's Head Park in the south (**Figure 1-1)**. The study area is divided into four reaches and 15 subareas for conducting and evaluating coastal process and economic analyses, as shown in **Figure 1-2**. These reaches were chosen based on hydrologic separability, identifiable geographic references, specific wave action within each reach, and major differences in physical structure inventory with the reach. These reaches also provide a neighborhood-scale approach to communicate risks, impacts, and alternatives. Reach delineations and associated sub-areas include the following:

- **Reach 1:** Covers Aquatic Park, Fisherman's Wharf, Pier 31 to Pier 35, and the North Beach neighborhood. This reach contains unique open space, recreational opportunities, historic resources, and tourism attractions that are recognized as global icons.
- **Reach 2:** Includes the Northeast Waterfront and Financial District. This area comprises a significant portion of the Embarcadero Historic District from Pier 27 to the Bay Bridge and includes popular sites such as the Exploratorium, Embarcadero Promenade, and the San Francisco Ferry Building. Through this reach, many transportation hubs and businesses in the Financial District make this area central to San Francisco's economy.
- **Reach 3:** Contains South Beach, Mission Creek, Mission Rock, Mission Bay, and Pier 70, and includes the South Beach, SoMa, and Mission Bay neighborhoods. This area is known for the Giants' baseball stadium, Chase Center, and access to Mission Creek and the Bay. It is one of the densest residential areas within the study area, with high numbers of vulnerable populations and a number of community facilities such as the Delancey Street Foundation and SoMa Recreation Center. This reach is also the site of new mixed-use waterfront development projects such as Mission Rock and Pier 70 aimed to provide greater public access, jobs, services, and affordable housing opportunities.
- **Reach 4:** Encompasses Pier 80, Islais Creek, Cargo Way, Pier 96, and Heron's Head Park. This area is comprised of industrial uses along the waterfront and provides critical industrial, maritime, and commercial Port functions. The Islais Creek subarea and adjacent Potrero Hill, Bayview, and Hunters Point neighborhoods are ethnically diverse and has been subjected to considerable historical and environmental injustices. It also has strong economic and cultural life, with high rates of women- and minority-owned businesses, numerous community benefit organizations, worship centers, and arts and culture organizations.

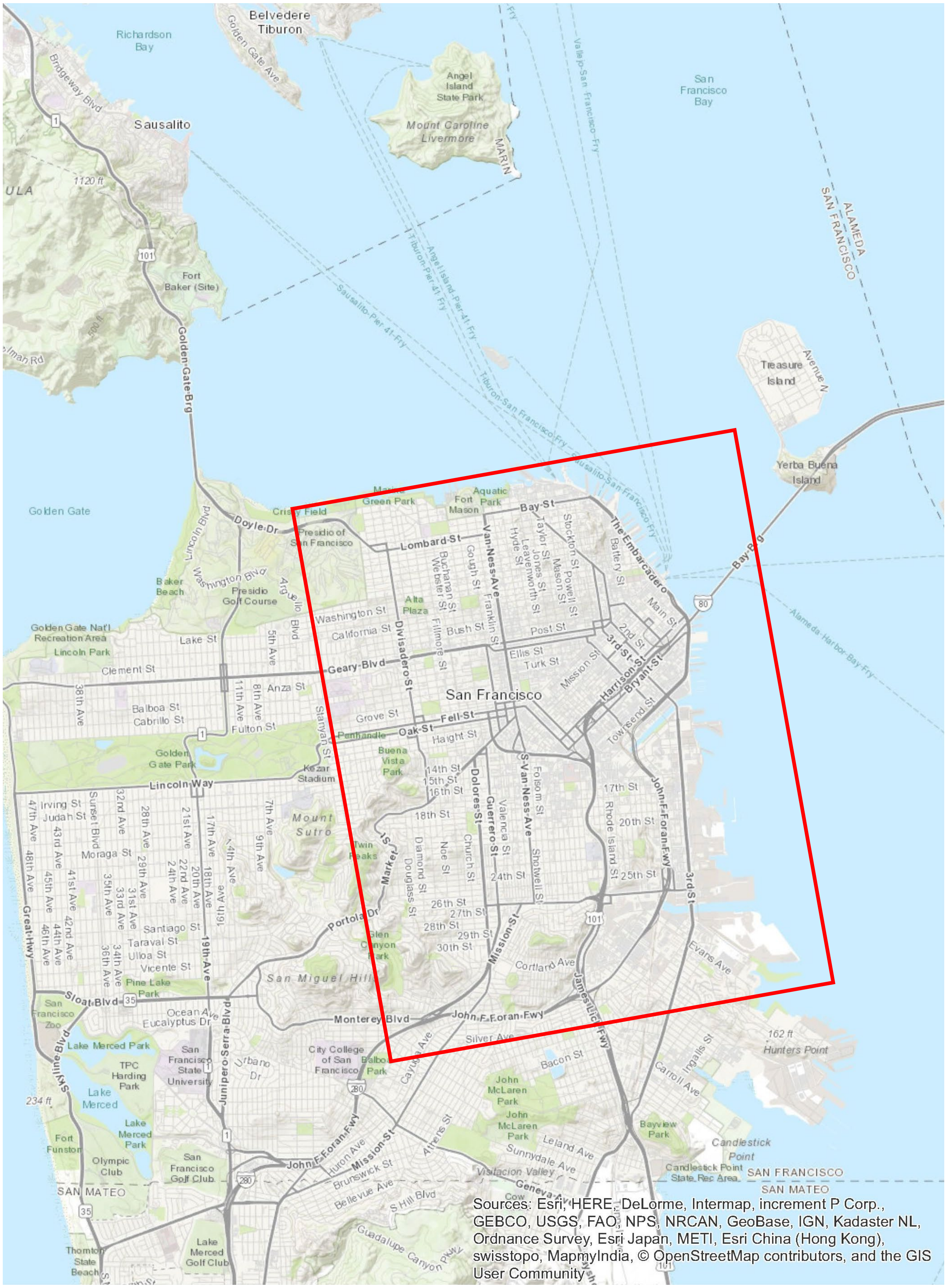


Figure 1-1: San Francisco Waterfront Coastal Flood Study Area

Figure 1-2: San Francisco Waterfront Study Area

1.6. Purpose and Need*

This study is prepared as an interim 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 (SLR) 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 SLR. Flooding along the waterfront could cause extensive damage to public infrastructure and private property, loss of life and deterioration of public health and safety, degradation of the natural environment, and adverse changes to the social and economic character of the waterfront community. The risk is expected to increase over time as sea levels rise in the bay.

1.7. Study Scope

The USACE and POSF have partnered to study coastal flood risk along 7.5 miles of San Francisco's bayside shoreline including areas between Aquatic Park and Heron's Head Park. The Study is one of several coordinated waterfront resiliency efforts being undertaken by the POSF in partnership with other federal, state, and local agencies to plan and reduce the risk of anticipated seismic activity, coastal flood damages, and SLR along the waterfront.

1.8. Prior and Existing Reports, Studies, and Projects

This study is one of many ongoing efforts to improve coastal flood and disaster resilience along the San Francisco waterfront. The San Francisco Waterfront Plan and the Waterfront Resilience Program are led by the POSF and include the study area, as well as areas both north and south of this study boundary.

The Port is using funds from the 2018 voter-approved Seawall Earthquake Safety General Obligation Bond to improve earthquake safety and performance of the Embarcadero Seawall and align with this study to address near-term flood risk while planning for long-term resilience and SLC adaptation along the city's waterfront.

These efforts include but are not limited to:

- CCSF. (2016). *San Francisco Sea Level Rise Action Plan*
- POSF. (1997). *Waterfront Land Use Plan*
- POSF. (2012). *Sea Level Rise and Adaptation Study*
- POSF. (2015). *Waterfront Land Use Plan Review, 1997- 2014*
- POSF. (2016). *Presentation to the San Francisco Port Commission on the Preliminary Results of the Earthquake Vulnerability Study of the Northern Waterfront Seawall.*
- POSF (2020). *Multi-Hazard Risk Assessment*

- City and County of San Francisco (2020). *Sea Level Rise Vulnerability and Consequences Assessment.*
- *City and County of San Francisco (2020). Islais Creek Southeast Mobility Adaptation Strategy.*

Other pertinent Federal studies and projects are described in the following paragraphs.

San Francisco Harbor Project. San Francisco Bay is one of the critical maritime thoroughfares in the nation, supporting international trade, commercial and recreational fishing, and recreation. For over a century, navigational channels were created, deepened, and maintained by dredging to enable ships to navigate safely into and out of ports, harbors, and marinas without running aground. Successfully accomplishing this mission, which requires maintaining the federal channels to their regulatory depths, is critical to the region's maritime trade and to the regional and national economies. Over 60 million tons of waterborne commerce traverse the San Francisco Bar entrance channel annually. Regular dredging the region's channels, ports, and associated docking, and berthing and other facilities is needed to maintain adequate depths for vessels to maneuver in a safe and efficient manner.

The San Francisco Harbor project consists of a deep-draft navigation channel (the Main Ship Channel) immediately offshore San Francisco Bay on the San Francisco Bar and in-Bay components. The original project was adopted by various Congressional Acts from 1868 to 1922 and provided for channel dredging and rock removal. The project was modified to existing dimensions by Rivers and Harbors Acts of 1927, 1935, 1937,1939, and 1965. The San Francisco Bar entrance is located approximately five miles west of the Golden Gate Bridge in the waters leading into San Francisco Bay and was last deepened in 1974 to a 55-foot project depth at Mean Lower Low Water (MLLW). This high use, deep draft channel requires annual maintenance dredging to be performed to maintain the 55-foot project depth. This critical channel, which is the gateway to San Francisco Bay, is 2,000 feet wide by 16,000 feet long (USACE and RWQCB, 2015). In addition to the San Francisco Bar entrance channel, there are eleven in-Bay components. These components are dredged infrequently.

The Islais Creek entrance channel is located 2.5 miles south of the Bay Bridge. The original channel was adopted by the Rivers and Harbors Act of 1927 and modified by the Rivers and Harbors Act of 1935 and consists of a flared channel approaching the mouth of Islais Creek, 3,300 feet wide at the Bay end and 500 feet wide at the U.S. Pipehead Line end, and 35 feet deep. The primary users of the channel were commercial shipping firms operating out of Piers 80, 84, 86, 88, 90, 92, and 96 (USACE, 1975). Dredging of the channel was very infrequent. Enlargement of the entrance channel was considered, and a draft EIS was issued in October 1973.

Final Environmental Assessment/Environmental Impact Report for Maintenance Dredging of the Federal Navigation Channels in San Francisco Bay, 2015-2024. Sediment accumulation in these channels can impede navigability. Maintenance dredging removes this sediment and returns the channels to regulatory depths to provide safe, reliable, and efficient waterborne transportation systems (channels, harbors, and waterways) for the movement of commerce, national security needs, and recreation. Therefore, USACE's purpose in this project is to continue maintenance dredging of the Federal navigation channels in San Francisco Bay consistent with the goals and adopted plans of the Long-Term Maintenance Strategy while adequately protecting the environment, including listed species.

Fisherman's Wharf. This project provides protection to the existing fishing fleet and the federally owned historic fleet (National Park Service) at Fisherman's Wharf, San Francisco, California. Originally constructed in 1988, the project includes a 1,509-foot - long solid concrete sheet-pile breakwater, which is located along the west side of Pier 45, and a segmented concrete sheet-pile breakwater, which is located on the northeastern side of Pier 45. The latter has one 252-foot-long segment and one 150-foot-long segment. A Section 216 study was conducted in Fiscal Year (FY) 2007 to identify relationships and impacts between the Corps' project and the National Park Service's San Francisco Municipal Pier.

San Francisco Waterfront Seawall Section 103 Study. This study was initiated in 2013 under the continuing authority of Section 103 of the River and Harbor Act of 1962, as amended. The study included a portion of the Embarcadero along the San Francisco waterfront. The study focused on two areas of concern – a low point approximately 40 feet wide between two buildings near Pier 5 and a half-mile low section of seawall between the Agricultural Building and Pier 22 1/2. The study was put on hold in 2018 due to the funding and initiation of this Congressionally authorized feasibility study under the Investigations account that includes the entire 7.5-mile waterfront.

Pier Repair/Removal Program. Section 5051 of WRDA 2007 provides discretionary authority to the Secretary of the Army, in cooperation with POSF, to carry out a project for repair and removal, as appropriate, of Piers 30-32, 35, 36, 70 (including Wharves 7 and 8) and 80 in San Francisco, California, substantially in accordance with POSF's Redevelopment Plan. The first phase of the project consisted of removing the deteriorated and partially collapsed Pier 36 using funding provided in FY 2010. Built in 1909 of both reinforced concrete and wood elements, Pier 36 was originally 721-feet long and 201-feet wide. Removal of Pier 36 made way for construction of the Brannan Street Wharf public park, the centerpiece of the South Beach Waterfront neighborhood redevelopment plan. A letter report on the removal of Pier 70 was completed in 2016, but the work was not undertaken due to the redevelopment of Pier 70.

Pier 70 Central Basin Section 107 Study. This study was conducted under the continuing authority of Section 107 of the Rivers and Harbors Act of 1960, as amended. The purpose of the study was to determine the feasibility of dredging the central basin at Pier 70 to an increased depth to reduce the impacts of shoaling to allow vessels to access the Pier 70 shipyard safely and efficiently without the use of high tide. A draft integrated Detailed Project Report and Environmental Assessment was completed in 2017 but the study was terminated after the dry dock closed.

1.9. Public and Agency Participation

1.9.1. Public Involvement

Public involvement is required by NEPA before a Federal agency undertakes an action affecting the environment. The purpose of public involvement is to enable citizen input regarding potential alternatives and effects of agency actions, and to bolster informed agency decision-making. Throughout this study, USACE and POSF have actively involved agencies, stakeholders, and the public through various meetings and engagements. A more in-depth discussion of the public involvement process is presented in Chapter 7 *Public Coordination and Views* as well as in Appendix H *Public Involvement*.

1.9.2. Agency Involvement

USACE and the POSF established a Regulatory Agency Working Group (RAWG), with participation by other Federal, State, and local agencies. The RAWG serves as a forum, to strive for common objectives and goals, to develop ways to address risks that are adaptive, accountable, and transparent, and to provide for early identification of permitting and policy issues. The RAWG includes POSF, USACE, Bay Conservation and Development Commission (BCDC), California Department of Fish and Wildlife (CDFW), Environmental Protection Agency (EPA), National Park Service (NPS), National Marine Fisheries Service (NMFS), Regional Water Quality Control board (RWQCB), State Historic Preservation Office (SHPO), State Lands Office (SLC), and U.S. Fish and Wildlife Service (USFWS). USACE asked Federal and State agencies to participate as cooperating or participating agencies in the preparation of the EIS.

Additionally, an Engineering with Nature (EWN) Working Group (ENWG) was set up by the USACE to identify where and which NNBFs should be considered within the study area and help describe how NNBFs contribute to regional habitat goals and project benefits. The ENWG included 15 individuals from Federal, state, and local agencies, universities, non-governmental organizations, and private industry who have been identified as experts in the field of EWN and ecological restoration.

1.9.3. Public Release of This Report

A Notice of Intent (NOI) to prepare an integrated feasibility report and environmental impact statement (EIS) for the San Francisco Waterfront Coastal Flood Study was published in the Federal Register on July 27, 2023. A Notice of Availability for this report was published in the Federal Register on January 26, 2024. The public and agencies are invited to participate in public meetings and submit comments during the comment period. An estimated four public meetings will be held during the public comment period. Public feedback will be reviewed and considered in preparation of the final IFR/EIS. A summary of comments received will be included in the final version of this report.

2. Existing and Future Without Project Conditions*

This chapter presents a summary of existing conditions in the Study Area and as they are projected to exist if a project is not implemented in the study area. The existing conditions also represents the affected environment for the purposes of NEPA. The future without-project (FWOP) condition is a forecast of future conditions without construction of a Federal project. The future without-project (FWOP) condition is the consequence of taking no Federal action during the period of analysis. The FWOP is used a baseline for the analysis and comparison of alternatives developed for this study. For the purposes of simplicity in this report and to serve multiple audiences, the term “no-action” will be used in combination with “future without-project condition” and understood as described in the sentence above.

This chapter is organized by four types of resources: 1) Natural Environment, 2) Physical Environment, 3) Built Environment (Infrastructure), and 4) Human Environment (Demographics and Socioeconomics). Resources within each Planning Region are described in each subsection.

2.1. General Setting

The San Francisco Waterfront study area extends for 7.5 miles from Hyde Street Pier in the north to India Basin in the south. The POSF holds this land in public trust for the use and enjoyment of the people of California, and develops, markets, leases, administers, manages, and maintains over 1,000 acres of land. This land adjacent to San Francisco Bay includes some of the region’s most popular open spaces and attractions, two national historic districts, hundreds of small businesses, nearby housing, and maritime and industrial uses. The POSF’s jurisdiction also includes important regional and citywide assets, including transportation networks like Bay Area Rapid Transit (BART) and San Francisco Municipal Railway (Muni); critical utilities, including drinking water and wastewater; key disaster response facilities and state and regional maritime assets and functions.

The San Francisco shoreline has been altered considerably since the late 18th century. Yerba Buena Cove, Mission Bay, and the marshlands of Islais Creek have all been filled over time to create more developable land (termed “Bay fill”) and maritime access. As the Bay water rises, the low-lying areas that have been previously filled will be the first to flood. In addition to the flooding risks in this area, the waterfront is characterized by a range of shoreline types (bulkheads, rip rap revetments, natural slopes, etc.) which results in varying levels of seismic hazard associated with liquefaction, lateral spreading, and ground shaking. Today, the shoreline has multiple shoreline types and structures, varies in elevation with several high and low points, and faces many coastal conditions.

2.2. Future Without Project Conditions

The affected environment for all natural resources includes the San Francisco Bay area and San Francisco Bay watershed located in San Francisco County. The resources described in the following sections are not expected to change under the Future Without Project (FWOP) condition, therefore the resource descriptions apply to both existing and the No Action Alternative conditions, except for SLR. The timing and ability to know what changes would occur from existing conditions to the 50- and 100-year project condition (2040 and 2090) with SLR are difficult to predict, thus, it was assumed environmental conditions are likely to worsen over time (i.e., result in habitat loss or degradation). This section focuses on describing existing conditions expected within the first 50 years of the study period.

Under the existing conditions and No Action Alternative, the measures proposed to protect against SLR would not be constructed. Rather, smaller-scale measures would be implemented that are likely to be inefficient at providing adequate protection from flooding to existing features along the San Francisco waterfront.

2.3. Natural Environment

The natural environment includes a discussion of the existing conditions for wildlife, special status species, special status areas, and other relevant environmental resources within Study Area. The affected environment for all natural resources includes the San Francisco Bay area and San Francisco Bay watershed located in San Francisco County.

2.3.1. Aquatic Resources

Aquatic resources refers to a range of habitats and natural water resources that are of potential use to humans including, but not limited to, wetlands, streams, lakes, rivers, springs, seeps, reservoirs, and ponds (Britannica 2023).

Intertidal habitats are the regions of the bay that lie between low and high tides (NOAA 2022b). The Central Bay basin includes natural and artificial intertidal habitats such as sandy beaches, natural and artificial rock (quarried rip-rap), concrete bulkheads, concrete, composite, and wood pier pilings, and mud flats. These habitats provide highly diverse locations for marine flora and fauna to forage, rest, reproduce, and refuge. The Central Bay basin’s proximity to the Pacific Ocean has resulted in an intertidal zone inhabited by many coastal and estuarine species.

Subtidal habitats are submerged areas beneath the San Francisco Bay water surface and include mud, shell, sand, rocks, artificial structures, shellfish beds, eelgrass beds, macroalgal beds, and the water column above the bay bottom (Cosentino-Manning et al. 2010). Soft substrate comprises the majority of the bay’s bottom (approximately 90%) and ranges between soft mud with high silt and clay content and areas of coarser sand. These latter tend to occur in locations subjected to high tidal or current flow. Soft mud locations are typically located in areas of reduced energy that enable deposition of sediments that have been suspended in the water column, such as in protected slips, under wharfs, and behind breakwaters and groins. Artificial structures include a variety of man-made objects designed to protect shorelines and shoreline structures, for transportation, recreation, and restoration (oyster shell and artificial reefs; Cosentino-Manning et al. 2010). Red and brown algae are found attached to submerged intertidal hard substrate, including pier pilings. Eelgrass is the most extensive submerged aquatic vegetation in San Francisco Bay (Cosentino-Manning et al. 2010), albeit very few beds are documented or known to occur within the study area (Merkel and Associates 2014). Small, isolated beds are known to occur along the southern extent of the study area, such as Heron's Head Park.

The open water (pelagic) environment of the San Francisco Bay is near the Pacific Ocean and is very similar to the open water coastal environment. Pelagic habitat is the predominant marine habitat in the Bay and includes the area between the water surface and the seafloor, which can be further subdivided into shallow water/shoal and deep-water/channel areas. The water column is predominantly inhabited by planktonic organisms that float or swim in the water, fish, marine birds, and marine mammals.

Wetlands are important aquatic habitats for fish, invertebrates, birds, and mammals. In the study area wetlands are located predominantly in reaches 3 and 4 at Pier 94, Heron's Head Park, Warm Water Cover, and on the north and south banks of Islais Creek.

2.3.2. Upland Resources

The California annual grassland community, also known as non-native grassland, is typically composed of a dense cover of introduced annual grasses and ruderal (woody) forbs (broad-leaved plants) adapted to colonizing and persisting in disturbed upland habitats. California annual grassland community can provide cover, foraging, and nesting habitat for a variety of bird species, as well as reptiles and small mammals. Coastal scrub is present only at the easternmost portion of the study area, within India Basin Open Space. Coastal scrub commonly includes buckwheat (*Eriogonum spp*.), sage (*Salvia spp*.), bush monkeyflower (*Mimulus aurantiacus*) and poison oak (*Toxicodendron diversilobum*). Coastal saltmarsh is a wetland type flood and drained by saltwater between high and low tides and is composed of a variety of terrestrial and aquatic species (NOAA 2022c). Coastal saltmarshes can be fully tidal, or brackish if they occur near the mouth of a freshwater source. Coastal saltmarshes in the Central and South Bay are remnants of their former extent. Where salt marshes are still present, they support high densities and high diversity of wildlife. Additionally, they provide habitat for the Ridgway's rail (*Rallus obsoletus*) and salt marsh harvest mouse (*Reithrodontomys raviventris*), both of which are federally and state-endangered and state fully protected species.

2.3.3. Special Status Species

Special status species are plant and wildlife species considered sufficiently rare, such that they require special consideration and/or protection and should be, or currently are, listed as rare, threatened, or endangered by the federal and/or state governments. Such species are legally protected under the federal and/or state ESA or other regulations listed below, or are species considered sufficiently rare by the regulatory and scientific community to qualify for protection. The USFWS's Information for Planning and Consultation (IPaC) database lists the threatened and endangered species and trust resources that may occur within the study area boundary, while NMFS provided a list of species with an official letter. Based on the IPaC report and species directory, there are

27 USFWS listed species (threatened, endangered, or candidate), 14 additional NMFS listed species, and two designated critical habitats found to potentially occur within the study area (**Table 2-1**).

Table 2-1: Federal Threatened, Endangered, or Candidate Species Identified By USFWS And NMFS That May Occur in the Study Area

Common Name Scientific Name	**Federal Status**	**Jurisdiction**
Salt marsh harvest mouse *Reithrodontomys raviventris*	Endangered	USFWS
California Ridgeway's Rail *Rallus obsoletus*	Endangered	USFWS
California least tern *Sterna antillarum browni*	Endangered	USFWS
Marbled murrelet *Brachyrampuhus marmoratus*	Threatened	USFWS
Western snowy plover *Charadrius nivosus*	Threatened	USFWS
Alameda whipsnake *Masticophis lateralis euryxanthus*	Threatened	USFWS
San Francisco garter snake *Thamnophis sirtalis tetrataenia*	Endangered	USFWS
Green sea turtle *Chelonia mydas*	Threatened	USFWS
California red-legged frog *Rana draytonii*	Threatened	USFWS
Delta smelt *Hypomesus transpacificus*	Threatened	USFWS
Tidewater goby *Eucyclogobius newberryi*	Endangered	USFWS
Sacremento River Chinook salmon CH, winter-run Evolutionary Significant Unit (ESU) *Oncorhynchus tshawytscha*	Endangered	NMFS
Central Valley Chinook salmon, spring-run ESU *O. tshawytscha*	Threatened	NMFS
Central California Coast Steelhead trout, Distinct Population Segment (DPS) *Oncorhynchus mykiss*	Threatened	NMFS
California Central Valley Steelhead trout DPS *O. mykiss*	Threatened	NMFS

Common Name Scientific Name	**Federal Status**	**Jurisdiction**
North American Green sturgeon, southern DPS CH *Acipenser medirostris*	Threatened	NMFS
Monarch butterfly *Danaus plexippus*	Candidate	USFWS
California seablite *Suaeda californica*	Endangered	USFWS
Franciscan manzanita *Arctostaphylos franciscana*	Endangered	USFWS
Marin dwarf-flax *Hesperolinon congestum*	Threatened	USFWS
Marsh sandwort *Arenaria paludicola*	Endangered	USFWS
Presidio clarkia *Clarkia franciscana*	Endangered	USFWS
Presidio manzanita *Arctostaphylos hookeri var. ravenii*	Endangered	USFWS
Robust spineflower *Chorizanthe robusta var. robusta*	Endangered	USFWS
San Francisco lessignia *Lessingia germanorum*	Endangered	USFWS
Showy Indian clover *Trifolium amoenum*	Endangered	USFWS
Sonoma sunshine *Blennosperma bakeri*	Endangered	USFWS
White-rayed pentachaeta *Pentachaeta bellidiflora*	Endangered	USFWS

Two critical habitats occur within the study area – green sturgeon and chinook salmon. All of San Francisco Bay adjacent to the study area is considered CH for green sturgeon, while Chinook salmon critical habitat includes waters in the northern two reaches. Additional information on ESA-listed species can be found in *Appendix D: Environmental and Cultural Resources*.

In California, animal or plant species of conservation concern may be listed as threatened or endangered under the authority of the California Endangered Species Act of 1984 (CESA; Cal. Code Regs. tit. 14 §§ 783.0-787.9). The California Natural Diversity Database online BIOS Quicktool was used to evaluate the state-protected threatened and endangered species likely present in the study area. It was determined the study area provided suitable habitat for seven CESA protected animal and plant species which include California Ridgeway's rail, bank swallow (*Riparia riparia*), California black rail (*Laterallus jamaicensis coturniculus*), longfin smelt (*Spirinchus* *thaleichthys*), Chinook salmon – Central Valley spring-run, marsh sandwort, and marine western flax (*Hesperolinon congestum*).

San Francisco Bay is a migration highway for over 250 species of birds, many of which are small songbirds (e.g., warblers, thrushes, tanagers, sparrows) and some threatened species (GGAS 2023). A variety of birds use this area to forage in the many microclimates while others use the Bay area as a resting stop-over. The San Francisco Bay is the largest estuary on the Pacific Coast, thus, is an ideal refuge for shorebirds, raptors, and songbirds.

There are two pinniped and four species of cetaceans likely to occur in or near the study area, which include harbor seals (*Phoca vitulina richardii*), California sea lion (*Zalophus californianus*), harbor porpoise (*Phocoena phocoena*), common bottlenose dolphin (*Tursiops truncatus*), California gray whale (*Eschrichtius robustus),* and humpback whale (*Megoptera noveangliae*), respectively.

Essential Fish Habitat (EFH) includes “waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity” (NMFS 2021; GMFMC & NMFS 2016). The study area falls within EFH for 20 species of commercially important fish and sharks managed under the Pacific Groundfish, Coastal Pelagic, and Pacific Coast Fisheries Management Plans. Of the fish species considered by NMFS to potentially occur within the study area, EFH habitat for these species consists of all waters and substrate from mean higher high water (MHHW) to 3,500 water depth, seamounts, and areas designated as Habitats of Particular Concern (HAPC). There are four HAPCs within the study area, including the San Francisco Estuary (estuary HAPC), seagrass, rocky reef, and marine and estuarine submerged aquatic vegetation HAPC. The study area includes 0.29 acres of seagrass HAPC, and the entire in-water study area is considered salmon EFH and estuary HAPC (Hanshew 2019, NOAA 2016).

2.4. Physical Environment

The following sections discuss the physical environment within the study area, including air quality, climate, geology and geomorphology, soils and minerals, hydrology and hydraulics, water quality, groundwater, noise and vibration, cultural resources, and hazardous, toxic, and radioactive waste.

2.4.1. Air Quality

The study area is in the San Francisco Bay Area Air Basin (SFBAAB), which is regulated primarily by the Bay Area Air Quality Management District (BAAQMD). The determination of the criteria air pollutants relevant to the action was based on an assessment of existing air quality conditions in the SFBAAB. The determination of toxic air contaminants (TACs; also known as hazardous air pollutants [HAPs]) relevant to the action was based on BAAQMD guidance and study conditions.

The attainment status for criteria air pollutants in the study area varies and is summarized in **Table 2-2**.

Table 2-2: Federal Pollutant Attainment Status of Study Area
Source: EPA 2020

Pollutant	Attainment Status
Ozone (8 hours)	Nonattainment (marginal)
CO	Attainment
PM_{10}	Attainment/Unclassified
$PM_{2.5}$	Nonattainment (moderate)

The EPA defines the HAPs as pollutants that are known or suspected to cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental effects (EPA 2017). California law uses the term TAC, which is defined as an air pollutant that “may cause or contribute to an increase in mortality or an increase in serious illness or pose a present or potential hazard to human health.” Controlling air toxic emissions became a national priority whereby Congress mandated the EPA regulate 187 air pollutants. HAPs can be emitted from stationary and mobile sources, such as refineries and heavy-duty vehicles. The primary source of TACs in the study area are diesel-powered on-road haul trucks and off-road construction equipment.

2.4.2. Climate

Climate refers to the long-term weather conditions that describe a region, whereas weather relates to short-term changes in the atmosphere (NOAA 2020).

San Francisco is straddled by sharp topography and marine environments that create a unique variety of microclimates. The San Francisco Bay area climate is classified as Mediterranean and is characterized by relatively dry, cool summers and mild winters (Null 1995). In the summertime, San Francisco experiences cool marine air and persistent coastal stratus and fog, with average temperatures between 60- and 70-degrees Fahrenheit (Null 1995). The cool marine air is influenced by the upwelling of cold water along the California coast, driven by oceanographic conditions that cause a net transport of surface water away from the shore that are consequently replaced by cold, upwelled water (Null 1995, Ahrens 1991). Winter temperatures are temperate with highs between 55- and 60-degrees Fahrenheit and lows between 45- to 50-degrees Fahrenheit (Null 1995).

Rainfall in San Francisco is seasonal, with over 80 percent occurring between November and March (Null 1995). Winter rains typically occur because of fronts primarily from the west-northwest and occasionally from the Gulf of Alaska. Spring and fall rain are infrequent, with most storms producing light precipitation during these periods (Null 1995). In general, hydrometeorological patterns in California are often associated with phenomena known as atmospheric river events. Atmospheric rivers (ARs) are narrow bands of low-level systems with high precipitable water content that extend from the tropics into the mid-latitudes (Climate 2015). In general, California’s hydrometeorological data indicate robust patterns of AR events promote heavy rains and flooding. Conversely, drought conditions prevail when ARs are persistently low or weak (Climate 2015). Annual precipitation has been cyclical in the Bay area, varying from approximately 5 inches to 37 inches over the last century, but on average the region receives 20 to 23 inches of rain annually. Droughts are also common in the San Francisco Bay Area, which can be tracked in the U.S. Drought Monitor. Over the last two decades, drought intensity has become more prevalent in the San Francisco Bay area.

The San Francisco Bay is a large estuary with varying salinity, influenced by seasonality, local bathymetry, proximity to the Pacific Ocean, precipitation, and river discharge. In 2016, the U.S. Geological Survey released water quality data including water temperature and salinity measurements sampled from discrete locations across the San Francisco Bay over the course of nearly 47 years (1969 – 2016). Water temperatures have been recorded in the range of roughly 48.5 to 67.5 degrees Fahrenheit. Salinity at this location is most often in the range of 25 – 33 parts per thousand (ppt).

Sea level rise is a primary impact of global climate change (Knowles 2010) and is a present and future risk to the U.S. (Hall et al. 2019). This combined with land subsidence, and other coastal flood factors such as storm surge, waves, rising water tables, river flows, and rainfall are likely to result in a dramatic net increase in the exposure and vulnerability of coastal populations (USGCRP 2017; Sweet et al. 2022). It is generally accepted that global climate warming will increase rates of sea level rise; however, the range in projected rates is wide due mainly to uncertainty in the amount of meltwater from land-based ice in Greenland and Antarctica (Knowles 2010). The National Oceanic and Atmospheric Administration's (NOAA) Office for Coastal Management provides a web mapping tool to visualize community-level impacts from coastal flooding and SLR. The present day mean higher high water (MHHW) conditions were compared to 3 ft and 7 ft of SLR for the study area (**Figure 2-1**) using the NOAA SLR viewer (https://coast.noaa.gov/slr/) to be consistent with the USACE intermediate and high relative sea level change projections.

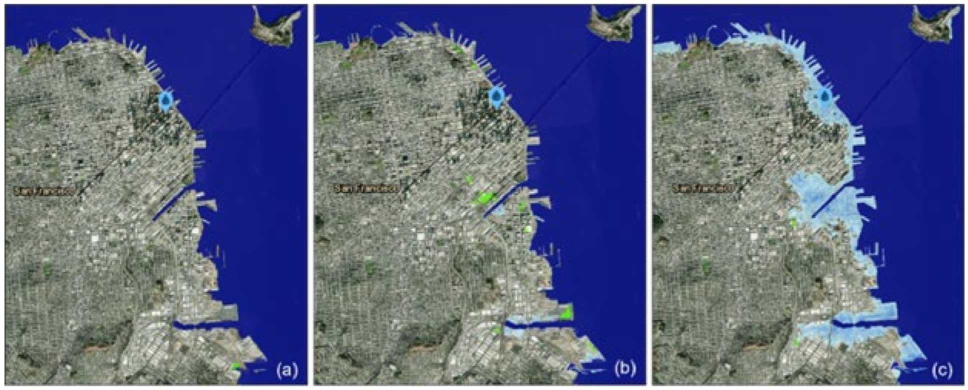


Figure 2-1: NOAA SLR Inundation Viewer of the Study Area for MHHW Conditions for Present Day (a), 3 ft of SLR (b), and 7 ft SLR (c).

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.

2.4.9.2. Archaeological Resources

The San Francisco Bay Area was traditionally inhabited by the Ohlone people, who spoke various dialects of Costanoan languages. These languages are part of the Utian language family, which is part of a larger language family, Penutian, with languages and dialects spoken by Native Americans across California, Oregon, and Washington (Callaghan 1967). The territory of the Ohlone people extended along the coast, from the Golden Gate on the north to just below Carmel on the south, as well as through several inland valleys (Levy 1978). As with most other California groups, the Ohlone were primarily hunter-gatherers. Spanish colonization and subsequent rule by Mexico and the U.S. translated into dramatic disruptions in the traditional subsistence patterns, customs, and practices of the Ohlone. In addition, European diseases caused a rapid decline in the Ohlone population (Milliken 1995). Although they have yet to receive formal recognition from the federal government, the Ohlone persevered and are actively maintaining their ancestral heritage through political advocacy and education. Many Ohlone are active in maintaining their traditions and advocating for Native American issues.

Based on a records search of the Northwest Information Center (2020), a total of 14 previously recorded archaeological resources are located in or adjacent to the study area. All 14 are historic-aged archaeological resources, and consist of remnants of historical maritime, commercial, residential, transportation infrastructure, and shipwrecks. Review of the *Geoarchaeological Assessment and Prehistoric Site Sensitivity Model for the City and County of San Francisco, California* (Meyer and Brandy 2019) reveals that much of the study area has moderate to high sensitivity for both buried and submerged archaeological resources and low sensitivity for surface-exposed archaeological resources.

2.4.10. Hazardous, Toxic, and Radioactive Waste

The study area was evaluated for hazardous, toxic, and radioactive waste (HTRW) through a records search of Federal, state, and local databases to identify sites that include locations where releases of hazardous substances or petroleum products have occurred into the soil, groundwater, or surface water. No environmental sampling of soil or groundwater was performed as part of this evaluation. The results of the records search identified over 157 potential environmental contamination sites within the study area. Of the potential sites identified, approximately 61 are located within the project area with known impacts to the soil or groundwater due to hazardous substances. For the sites located within the study area, additional information was obtained from the EnviroStor and GeoTracker databases for the purpose of determining potential impacts from these sites in relation to potential future construction activities. The potential for these sites to impact the construction activities was determined based on the presence of suspected soil and/or groundwater contamination, mobility within the soil-groundwater-air matrix, and the potential for construction activities to affect the contaminated media. As a result, 18 sites were identified within the Project footprint with the potential to impact the future construction activities. An additional 34 Leaking Underground Storage Tank (LUST) Sites that have received regulatory closure were identified within the project footprint. Although these LUST sites have received regulatory closure, there is potential for waste/contamination to remain in the soil and groundwater that may require special management and disposal related to future construction activities. Additional details on HTRW sites can be found in *Appendix D-1-6: Hazardous, Toxic and Radioactive Waste, located within Appendix D: Environmental and Cultural Resources*.

2.5. Built Environment

The built environment is defined broadly as man-made resources and infrastructure that define the urban fabric, support communities, and enable economic activity. This definition includes transportation infrastructure, utilities, recreation, aesthetics, land use planning, ports and marine facilities, and existing coastal defenses.

2.5.1. Embarcadero Seawall

The Embarcadero Seawall (seawall) was constructed by the State of California in segments from 1878 to 1929 and transferred to the City in 1968. The seawall was built by dredging a trench through the "young Bay mud" formation, filling that trench with rock and rubble, capping the fill with a timber pile bulkhead wall and wharves, and then filling the tidal marshland area behind the seawall. Spanning three miles from Fisherman's Wharf to Mission Creek, the seawall is one of San Francisco's oldest pieces of infrastructure. The seawall helped create over 500 acres of new land between San Francisco Bay and 1st Street.

The Embarcadero seawall generally reduces coastal flooding along San Francisco's shoreline when coastal storms or extremely high tides occur. It is largely invisible as it underpins the waterfront adjacent to San Francisco Bay. The seawall acts as a retaining wall and stabilizes the land that was filled (created) behind it. Portions of the seawall that existed at the time of the 1906 earthquake settled and moved several feet toward the Bay.

2.5.2. Utilities

Utilities include low-pressure (potable) water, combined sewer system, waste management, and energy.

2.5.2.1. Potable Water

Potable, or low-pressure water (LPW) is vital to the community's development and daily functions. All types of businesses—office buildings, hotels, restaurants, and industry—depend on potable water to stay open. The SFPUC Water Enterprise operates San Francisco's water distribution system, which includes reservoirs and storage tanks, pump stations, fire hydrants, distribution pipelines, isolation valves, and automatic air valves. In the study area, critical LPW assets include the Bay Bridge Pump Station, water mains, low pressure fire hydrants, and automatic air valves (CH2M/Arcadis, 2020h).

From a coastal flooding perspective, the Bay Bridge Pump Station is most vulnerable to flood damage (and service disruption) while underground pipes are vulnerable to rising ground water. The Bay Bridge Pump Station, located in Reach 3, is the sole provider of potable water to Treasure Island and Yerba Buena Island. If the facility is damaged, around 3,200 residential customers could lose potable water service (U.S. Census, 2020).

2.5.2.2. Combined Sewer System

Through the San Francisco Public Utilities Commission, the City operates and maintains a predominantly combined sewer system with major infrastructure including three treatment plants, 27 pump stations, 1,000 miles of sewer mains, 17 miles of transport/storage (T/S) structures and 36 combined sewer discharge structures and over 85 green infrastructure facilities.

The combined sewer system collects both wastewater and stormwater for most of the City. The wastewater is collected, stored, conveyed to, and treated at one of three treatment plants, two of which are located in the study area. The Southeast Treatment Plant is the City's largest wastewater treatment facility (43 million gallons per day (MGD) average dry weather capacity in 2022, 250 MGD peak wet weather capacity) and is located within the study area. The North Point Wet Weather Treatment Plant is also located in the study area, is used only during wet weather, and has a peak wet weather treatment capacity of 150 MGD. Local gravity sewers convey combined wastewater flows to T/S boxes, which meters to the treatment plants. Once system capacity is exceeded during wet weather events, discharges through one of the combined sewer discharge structures occur with equivalent to primary treatment. Generally, only during the most prolonged intense rainstorms is the combined capacity of the treatment plants and T/S boxes exceeded. Instead of allowing the excess water to back up through the sewers into homes and streets, water is discharged into either the Bay or Ocean through combined sewer discharge (CSD) structures.

Wastewater service is critical in supporting residents, commerce, and industries. In addition to providing wastewater service to SFPUC customers, the combined sewer system is also an essential stormwater drainage system for the City; together, the collection system and outfalls provide drainage for public streets, sidewalks, parks, and public/private facilities during wet weather events.

Some of the City's most critical wastewater conveyance and treatment facilities are in the waterfront area. This includes several miles of local gravity sewer systems, T/S boxes, tunnels, a force main, combined sewer gravity mains, CSD structures, pump stations, and two treatment facilities. These assets are arranged by Reach as follows:

- Reach 1 critical wastewater assets consist of the North Shore Pump Station, the North Point Wet Weather Facility, the North Beach Tunnel, a part of the Jackson T/S Box and one CSD outfall structure.
- Reach 2 includes the Jackson T/S Box, the North Shore Force Main, a part of the Channel T/S Box and three CSD structures.

- Reach 3 includes the Channel T/S Box, the Channel Pump Station, the Channel Force Main, the smaller Mission Bay, Berry Street, Harriet Street and Mariposa Pump Station, the Mariposa T/S Box and several CSD structures.
- Reach 4 encompasses part of the Channel Force Main, the Bruce Flynn Pump Station, the Booster Pump Station, the Southeast Bay Outfall, the Islais Creek T/S Box, the Southeast Treatment Plant and Bay Outfall, and several CSD structures.

2.5.2.3. Waste Management

Recology, or Recycle Central, is located on Pier 96 (Reach 4), and provides collection and sorting of recyclable materials including containers, mixed paper, and cardboard to commercial and residential customers in San Francisco. The facility, which opened in 2002, was designed and constructed in partnership with the City of San Francisco and is a key asset to the City's zero waste goal. Recology covers over 185,000 square feet and processes about 750 tons of material each day, employing over 180 people, many from the nearby Bayview Hunters point neighborhood.

2.5.2.4. Energy

The San Francisco Public Utilities Commission (SFPUC) and Pacific Gas and Electric Company (PG&E) provide energy to the study area and the City of San Francisco. The SFPUC manages two retail electric service programs: Hetch Hetchy Power and CleanPowerSF. Together, these programs provide more than 70% of the electricity consumed in San Francisco today. For over 100 years, Hetch Hetchy Power has generated clean, 100% greenhouse gas-free electricity for San Francisco. It powers critical municipal services such as Muni and San Francisco General Hospital, affordable and public housing sites, and new developments like The Shipyard and Salesforce Transit Center.

Launched in 2016, CleanPowerSF is San Francisco's community choice aggregation program and serves more than 380,000 residential and commercial customers with clean, renewable electricity at competitive rates. CleanPowerSF's current resource portfolio includes solar, wind, hydroelectric, and geothermal power.

PG&E provides power through a combination of energy resources, including natural gas, nuclear, biomass and waste, geothermal, small, and large hydroelectric, solar, and wind resources (PG&E 2019).

2.5.3. Transportation Infrastructure

The study area provides a variety of transportation facilities and services, both on the water and throughout the city. Transportation is overseen primarily by the San Francisco Municipal Transportation Agency, with additional responsibilities overlapping with San Francisco Public Works, the San Francisco County Transportation Authority, and POSF. Additional regional transportation provide service to, from, and within San Francisco, including Alameda-Contra Costa Transit District (AC Transit), Bay Area

Rapid Transit (BART), Caltrain, Golden Gate Transit (GGT), Water Emergency Transportation Authority (WETA), and San Mateo County Transit (SamTrans). The transportation network consists of roadways, local and regional transit facilities, and bicycle and pedestrian networks.

The roadway network includes freeways, major arterials, transit preferential streets, secondary arterials, recreational streets, collector and local streets, primary emergency priority routes, and freight truck routes. Detailed descriptions of these functional classifications are provided in the Transportation Element of the General Plan (City and County of San Francisco 2014b). The study area includes the Embarcadero, Jefferson St, Beach St, Broadway, Washington St, Harrison St, Bryant St, Third St, Fourth St, Terry A. Francois Blvd, Cesar Chaves, Cargo Way, Evans Avenue, Amador Road, and Illinois St.

The city has designated on-street bicycle facilities in the study area that are part of the San Francisco Bicycle Network. On-street bicycle facilities include Class I bikeways (bike paths with an exclusive right-of-way for use by bicyclists or pedestrians), Class II bike lanes (bike lanes striped within the paved areas of roadways and established for the preferential use of bicyclists), Class III bikeways (signed bike routes that allow bicycles to share travel lanes with vehicles), and Class IV cycle tracks (areas for exclusive use by bicyclists that include physical separation from motor vehicle traffic). There are: one Class I bikeways in the study area, six Class II bike lanes, seven Class III bike routes, and four Class IV bikeways.

2.5.3.1. Recreation and Access

The San Francisco Bay is a major destination for recreationists, including water-based activities such as cruising, wakeboarding, sailing, windsurfing, and kiteboarding as well as fishing both from land and boat, and land-based tourism and recreation at public parks and open spaces. In total, CCSF is home to approximately 5,890 acres of parkland and open space areas (San Francisco 2014).

The Port oversees public access, parks and open spaces, natural and cultural resources, and much of CCSF’s last remaining critical industrial uses. The Exploratorium, Oracle Park, the Ferry Building, Chase Center, Heron’s Head Park and EcoCenter, and Fisherman’s Wharf are all within the study area. The Embarcadero Promenade and the Blue-Greenway, both elements of the San Francisco Bay Trail, are significant recreation resources for CCSF. These are among the most heavily used trails for walking, jogging, and cycling in the city, providing miles of access along San Francisco Bay.

2.5.3.2. Aesthetics

Port maritime and water-dependent uses stretch along the entire waterfront, preserving San Francisco’s working waterfront character and heritage. The POSF waterfront is distinctly urban in character. The Port’s linear stretch of property extends through a diverse cross-section of San Francisco districts and neighborhoods that define much of the urban character and scale. Distinguishing features of the waterfront include the pier facilities and maritime operations that connect to the larger San Francisco urban landscape. San Francisco's street grid provides a direct connection from the City's neighborhoods to the network of historic piers, maritime facilities, and open spaces that extend along and over the Bay. This juxtaposition creates what is generally considered a visually pleasing waterfront experience.

The Embarcadero and Terry A. Francois Boulevard form a break in the city landscape that creates two distinct identities: City neighborhoods on the west side and the POSF waterfront features on the east side. The Bay and piers create visual contrasts to the city streets and upland neighborhoods that adjoin the Embarcadero and Terry A. Francois Boulevard. These contrasts help give the San Francisco waterfront its unique identity.

The Port waterfront has distinct land use and architectural characteristics. Fisherman's Wharf is characterized by many simply detailed one-story industrial buildings. The bulkhead buildings and piers along The Embarcadero, with the Ferry Building as the centerpiece, reflect the port's historic civic significance. The South Beach and Rincon Hill neighborhoods and entertainment venues such as Oracle Park and Chase Center highlight the transformation of former industrial areas to new residential neighborhoods and City attractions. Mission Rock is an emerging new mixed-used neighborhood in Mission Bay with parks, commercial and residential uses. Pier 70 is an emerging mixed-use district in the Dogpatch neighborhood with parks, commercial and residential uses and is home to the Union Iron Works Historic District which showcases the architectural, maritime, and labor history of the area. The Islais Creek area in the Bayview community is characterized by large industrial buildings and facilities.

The open spaces along the POSF waterfront within the study area vary in character, largely related to the physical form of the waterfront's edge. From Fisherman's Wharf to just south of China Basin Channel, the waterfront is a built edge supported by the Embarcadero Seawall and pile-supported pier decks. The built seawall ends at the Mission Bay waterfront, transitioning to a solid landform that meets the water. The natural shoreline areas include those along Mission Creek, along the northeast shoreline of Pier 94, and at Heron's Head Park.

2.5.3.3. Port and Maritime Facilities

The POSF is an enterprise agency within CCSF, meaning that revenues generated through rent, maritime fees and other income streams are used to fully fund POSF's annual budget (Operating & Capital). San Francisco port and maritime facilities encompass several different types of infrastructure along the waterfront, including piers, wharfs, and bulkhead and shed buildings.

The POSF's seven maritime industries – fishing, cruise, harbor services, temporary and ceremonial, excursion, water recreation, and ferry and water taxi – serve State purposes, and have important regional economic and social value.

2.6. Human Environment

The human environment describes the socioeconomic and community profile, public health and safety, and environmental justice in the study area.

2.6.1. Socioeconomic and Community Profile

The study area is highly developed and characterized by multiple land uses. It encompasses several neighborhoods, including North Beach/Fisherman's Wharf, the Financial District, South of Market (SoMa)/Mission Bay, Potrero Hill/Central Waterfront, and Bayview North/Islais Creek (City and County of San Francisco 2020). Neighborhoods in the study area include commercial land uses, residential buildings, City tourist attractions, high-density housing, mixed-use spaces, and mixed industrial and residential use. Occupied housing units in the city and study area are occupied primarily by renters, approximately 62.4 percent and 70.9 percent, respectively.

Community resources and services within the study area include the:

- emergency water system for firefighting
- San Francisco Fire Department stations 4, 8, 9, 13, 25, and 35
- San Francisco Police Department headquarters and county jail
- open space, trails, and parks
- Port of San Francisco facilities and several piers

Additional community resources and services include regional and local transportation infrastructure (e.g., the Bay Bridge, Bay Area Rapid Transit [BART], San Francisco Municipal Railway [Muni], Caltrain); wastewater infrastructure (e.g., pump stations, the Southeast Wastewater Treatment Plant, the North Point Wet-Weather Treatment Plant); the Recology Recycle Center; University of California, San Francisco Medical Center at Mission Bay; Oracle Park and Chase Center; and tourist attractions (e.g., the Ferry Building, the Embarcadero Promenade, Fisherman's Wharf, the Exploratorium, historic buildings and piers, restaurants, hotels); Mission Bay branch of the San Francisco Public Library; childcare facilities; and recreation centers (EcoCenter at Heron's Head Park).

2.6.1.1. Population Characteristics

Racial and ethnic data were collected for 883,305 persons in CCSF (U.S. Census Bureau 2019). Of these, 353,597 (40.0 percent) identified themselves as White; 301,051 (34.1 percent) Asian; 134,664 (15.3 percent) as Hispanic or Latino; 43,953 (5.0 percent) Black or African American; 1,187 (0.1 percent) American Indian and Alaska Native; 2,085 (0.2 percent) Native Hawaiian and Other Pacific Islanders; 3,259 (0.4 percent) "Some Other Race"; and 43,599 (4.9 percent) "Two or More Races."

The study area has a total population of 58,876 within 12 census tracts. Residents in the study area identify themselves as White (43.0 percent), Asian (24.4 percent), Hispanic or Latino (16.0 percent), Black or African American (10.6 percent), Native Hawaiian and Other Pacific Islanders (0.6 percent), American Indian and Alaskan Native (0.1 percent), "Some Other Race" (0.1 percent), and "Two or More Races" (4.6 percent).

2.6.1.2. Housing

There are 401,478 housing units in CCSF, of which 362,827 (90.4 percent) are occupied and 38,651 (9.6 percent) are vacant (U.S. Census Bureau 2019. The average household size within the occupied housing units is 2.4 persons; 136,242 (37.6 percent) of the housing units are owner occupied, and 226,585 (62.4 percent) are renter occupied.

Overall, the study area has a slightly lower percentage of occupied units (86.8 percent) compared to the city (90.4 percent). Of the occupied units, the study area has a lower percentage of owner-occupied housing units (29.1 percent) compared to the city (37.6 percent) but a greater proportion (70.9 percent) of renter-occupied housing units (62.4 percent). In addition, the average household size within the study area (2.1 persons) was slightly smaller than that of the city (2.4 persons).

2.6.1.3. Employment and Income

Per capita income in CCSF is $71,606, and the median household income is $112,376 (U.S. Census Bureau 2019). As of 2019, 10.0 percent of the citizens within the city were living below the poverty level, which equates to 87,087 residents. Low-income limits in San Francisco are defined as $82,200 for an individual and $117,400 for a family of four in 2018, based on 80% of the area's median income (City and County of San Francisco 2020).

2.6.2. Public Health and Safety

The bayside waterfront is immediately adjacent to the densely populated Financial District and South of Market neighborhoods and is anticipated to serve several critical functions during an emergency. The high number of commuters to the City will require a safe place to congregate and stage medical treatment and evacuation across the bay following an earthquake. Existing ferry terminals and small craft harbors are identified by local disaster response plans as critical facilities for the first 72 hours following a major disaster. Additionally, the deep draft berths along the port are identified as critical logistic hubs to aid in the City's recovery following a disaster, thus enabling export of debris and import of supplies.

Existing critical disaster response infrastructure along the waterfront includes:

- Aquatic Park: used as a gathering area for disaster response (storm, seismic, fire);
- Fisherman's Wharf: police boat dock facility, refueling dock;
- Ferry Terminal: staging and regional ferry service;
- Pier 41: ferry access – important resource for disaster response/evacuation;
- Pier 50: Port operations center – critical for disaster response;
- Pier 94 and 96: FEMA disaster response area; and

- Pier 22.5: Fireboat station.

The San Francisco Fire Department (SFFD) and San Francisco Police Department (SFPD) provide fire protection and emergency services and public safety services, respectively, within the City and the study area. In addition, there are several other public services, including the University of California Mission Bay campus, schools, non-profit organizations, and child centers, within the study area.

The SFPD, located on the first floor of the Public Safety Campus, provides public safety services for the study area and CCSF. The SFPD is the 11th largest police department in the U.S. and serves a population of approximately 1.5 million, comprising daytime commuters, tourists, and visitors (City and County of San Francisco 2020c). The SFPD has 10 districts, each with its own station. Three police districts, Bayview, Southern, and Central, cover the study area. SFPD headquarters, the Southern Police District Station, and SFPD Marine Unit headquarters and berths are located within the study area.

The SFFD is responsible for fire protection and emergency medical services for CCSF, including the study area. In addition to the SFFD, several privately operated ambulance companies are authorized to provide advanced life support services. The SFFD consists of two divisions, divided into ten battalions and 45 active stations (City and County of San Francisco 2020b). Division 2 serves the northern and western regions of the city and San Francisco County, and Division 3 serves the eastern and southern regions (City and County of San Francisco 2020b). Fire Stations 4 and 35 are within the study area.

2.6.3. Environmental Justice

To evaluate potential environmental justice issues within the study area, a demographic profile of the relevant census tracts was developed to identify the low-income and minority populations present. For the purposes of this analysis, a census tract included a population to be evaluated for environmental justice issues if:

- The total minority population of the census tract was more than 50 percent of the total population or substantially higher (i.e., more than 15 percent) than that of the City or county where it was located or
- The proportion of the census tract population that was 100 percent below the poverty level was substantially higher (i.e., more than 15 percent) than of the City or county where it was located.

Because the City has a minority population that totals more than 50 percent, the “substantially higher” criterion (i.e., more than 15 percent) was used in this analysis.

Based on census tract information for the study area, the total percentage of individuals living below the poverty threshold is higher in the study area (13.6 percent) compared to the city as a whole (10.0 percent). However, using the “substantially higher than the city” criterion for population below the poverty level, only census tract 231.03 within the Bayview Neighborhood, which has approximately 32.7 percent of people below the poverty level, meets the low-income criteria for environmental justice.

Minorities represent approximately 60.0 percent of the total population of the city and approximately 56.4 percent of that of the study area. The 2014–2018 American Community Survey 5-year estimates indicate that the proportion of the populations within the study area composed of minority populations ranges from 21.8 percent (census tract 102) to 96.2 percent (census tract 231.03). Using the “substantially higher” criterion, census tracts 231.03 and 612, located within the Bayview Neighborhood, meet the minority criteria for environmental justice in the study, because the percentage of minority populations is more than 15 percent greater than the proportion of minority populations in the city.

San Francisco has developed an Environmental Justice Communities Map for areas with a high environmental justice burden[3]. This map includes several communities within the Study Area, including Fisherman’s Wharf, SoMa, Potrero Hill, Islais Creek, and Bayview.

[3] https://generalplan.sfplanning.org/images/environmental-justice-framework/Environmental_Justice_Communities-Map.pdf

3. Plan Formulation and Evaluation*

Plan formulation is an iterative process whereby project measures (specific project features) are conceived, developed, and evaluated to satisfy specific objectives, and then combinations of measures are evaluated to develop comprehensive alternative plans. This chapter details the identification of problems and opportunities in the study area, planning objectives and constraints, and the development of management measures and alternative plans to provide solutions to the identified problems and opportunities.

3.1. Planning Framework

The USACE Civil Works planning process follows a standard approach to formulate potential water resource solutions to ensure federal projects comply with applicable laws and guidance. The 1983 Economic and Environmental Principles and Guidelines for Water and Related Land Implementation Studies (Principles and Guidelines, or P&G) established by the U.S. Water Resources Council on March 10, 1983, were developed to guide the formulation and evaluation studies of the major Federal water resources development agencies. ER 1105-2-100 Planning Guidance Notebook and the Planning Manual Part II: Risk-Informed Planning lay out an iterative planning process for all USACE Civil Works studies to develop and evaluate alternative plans (IWR 2017).

The P&G established four accounts to facilitate the evaluation and display of the economic benefits and effects of alternative plans. These four accounts are: National Economic Development (NED), Regional Economic Development (RED), Other Social Effects (OSE), and Environmental Quality (EQ). Benefits and effects of all four accounts (WRC 1983) were considered during the plan formulation process, and plan selection emphasized the plan that reasonably maximizes net NED benefits. Per guidance in the memorandum from the Assistant Secretary of the Army for Civil Works (ASA(CW)), dated 5 January 2021, Comprehensive Documentation of Benefits in Decision Document, studies should also identify a plan that reasonably maximizes benefits in the NED, EQ, RED, and OSE, accounts. The four benefits categories are summarized below:

- NED account: Includes consideration of a measure's potential to meet the planning objective to reduce storm damages, as well as decrease costs of emergency services, lower flood insurance premiums, and considers project costs. Costs and benefits used to fully evaluate the NED objective are not calculated at this stage; however, estimates can be made to gauge the overall cost-effectiveness of a measure for this initial screening. Effects of RSLC and a measure's adaptability to such change are considered under the NED account.
- RED account: Includes consideration of the potential regional economic impacts of flooding along the San Francisco Waterfront, the Bay Area, and the larger

California economy. RED impacts are regional losses in employment and/or income under the FWOP condition. Based on guidance from this handbook, the RED analysis evaluates the regional economic consequences of coastal flooding and sea level rise using Federal Emergency Management Agency (FEMA) benefit-cost analysis methodologies.

- OSE account: Includes considerations for the preservation of life, health, and public safety; community cohesion and growth; tax and property values; and the displacement of businesses and public facilities. For evaluation purposes, the OSE account is inclusive of the planning objectives to maintain recreation and safe evacuation routes, and the planning constraint to avoid conflict with legal requirements.
- EQ account: Considers ecosystem restoration, water circulation, noise level changes, public facilities and services, aesthetic values, natural resources, air and water quality, cultural and historic preservation, and other factors covered by NEPA.

The P&G also require that alternative plans are formulated and evaluated in consideration of four criteria: completeness, effectiveness, efficiency, and acceptability.

- Completeness is the extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects.
- Effectiveness is the extent to which an alternative plan solves the specific problems and achieves the specified opportunities.
- Efficiency is the extent to which an alternative plan is the most cost-effective means of solving the water resources problems and realizing opportunities consistent with protecting the nation's environment.
- Acceptability is the workability of the alternative plan with respect to acceptance by State, local entities and the public and compatibility with existing laws, regulations, and public policies.

ASA(CW) and USACE policy and guidance require:

- A plan that maximizes total net benefits (Total Net Benefits Plan, TNBP)
- A plan that maximizes net benefits consistent with the study purpose (NED plan)
- A nonstructural plan, which considers modified floodplain management practices, elevation, relocation, buyout/acquisition, dry flood proofing and wet flood proofing

If requested by the NFS, a locally preferred plan (LPP) may be recommended to include different types or scales of features than the NED or plan that reasonably maximizes total net benefits.

Specific guidance for this study was issued ASA(CW) and USACE on 15 December 2021. This included the following guidance for the formulation process:

- Update Future Without Project Conditions:
    - Update future without project conditions for the study area to account for relative sea level change (RSLC), seismic and frequent (storm, tidal and fluvial) flooding multi-hazard risks.
    - Calibration and independent verification of Coastal H&H modeling will include tidal and storm flooding, with assessments of timing, location, and severity in the study area prior to detailed economic analysis.
    - RSLC scenarios will be incorporated in accordance with USACE policies (ER1100-2-8162, EP1100-2-1).
    - Seismic risks to the existing seawall and other flood risk structures will be characterized.
    - Assess impacts to the regional economy, vulnerable populations, environmental quality, and critical public infrastructure in addition to National Economic Development (NED) impacts.
    - Identify reasonable and prudent actions that would be expected to strategically mitigate extreme storm impacts in advance of the base year.
    - Use of a 100-year period of economic and engineering analysis, due to actions triggered by sea level and flood risk and long-life infrastructure investment.
- Formulation:
    - Develop multi-hazard formulation strategies that reflect timing, location, and severity differences in risk.
    - Distinguish between measures to address seismic risks associated with the flood problem; other alternatives that show them coupled; this facilitates the compare & contrast between the alternatives.
    - Develop at least one stand-alone non-structural 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. Formulate measures and alternatives that can be implemented incrementally for varying topography and locations to address varying degrees of risk. Individually and in combination they should describe flexibility in scale and timing of actions (initial and future adaptations) for the desired risk reduction performance as required under Planning Guidance Notebook.

- Evaluation:
    - Evaluate and document benefits in accordance with "Comprehensive Documentation of Benefits in Decision Documents" memorandum, dated 5 January 2021.
    - Conduct the benefit analysis using the 3 USACE Sea Level Rise (SLR) curves, with benefit cost analysis based on initial and future adaptations.
    - Use the California Regional SLR curves for the LPP.
    - Evaluate differences in timing of actions and scaling of project features to reflect the pros and cons of adaptability and flexibility of the recommended alternative in regard to realized RSLC.

3.2. Planning Horizon and Period of Analysis

The P&G provide the instructions and rules for Federal water resources planning timeframes. One P&G requirement is to evaluate the effects of alternative plans based on a comparison between the most likely future conditions with and without those plans in place. To make this type of comparison, descriptions (often called forecasts) must be developed for two different future conditions: the FWOP condition and the future with project (FWP) condition. The FWOP condition describes what is assumed to be in place if none of the study's alternative plans are implemented and is the same as the "no action" alternative that is required to be considered by the Federal regulations implementing NEPA. The FWP condition describes what is expected to occur as a result of implementing each alternative plan. The differences between the FWOP and FWP conditions are the effects of an alternative. Measuring these differences across alternative plans enables comparison and, ultimately, plan selection and refinement.

The planning horizon encompasses the study period, the implementation period, the economic period of analysis (or POA), and the effective life of the project. The timeframe used when forecasting FWOP and FWP conditions is the POA, or the period over which plan effects are measured (**Figure 3-1**).

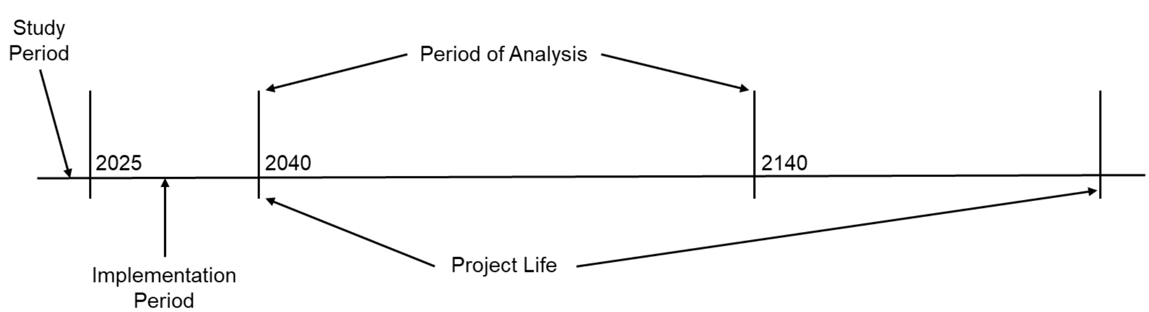


Figure 3-1: Planning Horizon

The POA for water resources projects typically extends 50 years following construction. Although project structures will often function for longer than 50 years, forecasting economic and physical conditions and impacts beyond 50 years becomes uncertain, since conditions may change considerably over that length of time. As directed by the USACE guidance for this study, the POA for this study extends 100 years from 2040 until 2140 due to actions triggered by sea level and flood risk and long-life infrastructure investment. For the purposes of analysis, and depending on the alternative, project implementation is expected to begin with refined design beginning in 2025, and construction occurring from 2030 through 2040. The base year is assumed to be 2040, the year the alternative is in place and functioning and benefits are produced. Project performance is quantified by estimating future damages through 2140 for a POA of 100 years. Most alternatives were formulated to include adaptation to the plan alignment or features at the midpoint of the POA (2090) and have a subsequent construction phase. This phasing is detailed more fully in the alternative descriptions, as appropriate.

Alternative plans are proposed with a 2040 first action and a 2090 second action as a planning construct to enable fair comparison of plan effects. Adaptive actions may be taken considerably sooner or later than 2090 depending upon the risk conditions. Future refinements to the TSP will include a more refined implementation and adaptation strategy.

3.3. Problems and Opportunities

Problems and opportunities have been identified from technical analyses such as the multi-hazard risk assessment (MHRA) prepared for POSF, and through several other avenues, including coordination with POSF, and extensive consultation with agencies, stakeholders, and the public.

POSF and USACE conducted a series of meetings with regulatory agencies, city and regional agencies, other stakeholders, and the public to gauge key concerns, interests, and preferences around flooding and SLC adaptation along the waterfront, and to identify any potential regulatory implementation challenges. This included meetings with CCSF and resource agency representatives on important resources at risk due to relative sea level change (RSLC), coastal storms, and seismic damages along the waterfront. POSF met with community members along the study area to gather information about coastal storm risk and seismic concerns by region. Community feedback was considered as the PDT identified criteria for screening and evaluation of measures.

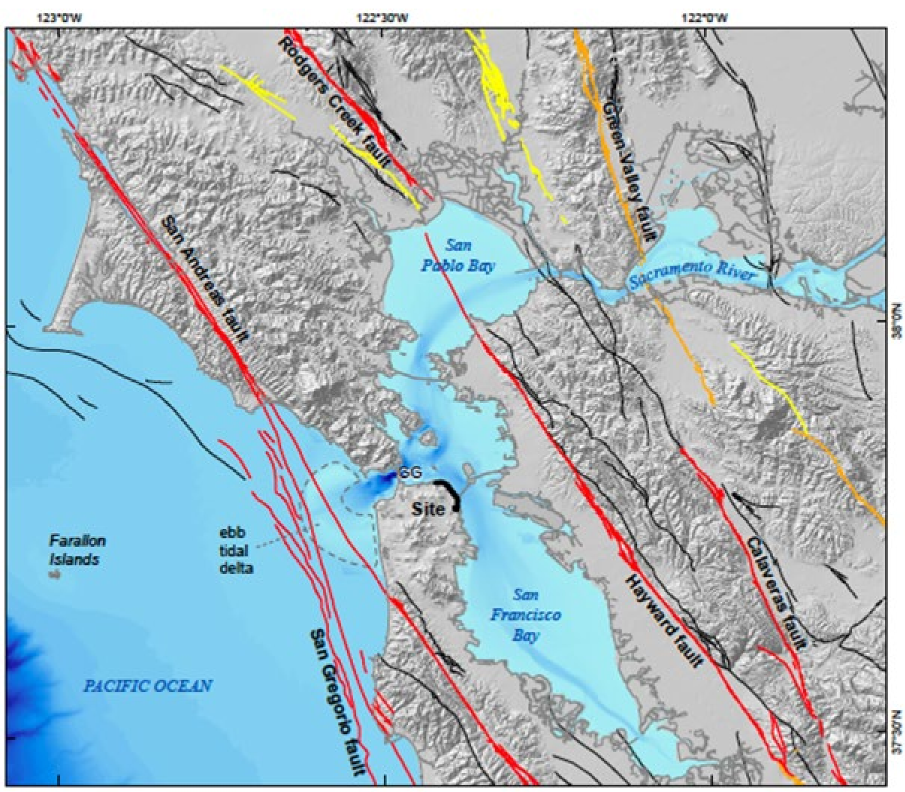
3.3.1. Study Area Problems

3.3.1.1. Seismic Risk

The Bay Area is a seismically active region. A major earthquake could happen at any time. The 1906 earthquake that shook San Francisco lasted less than one minute, yet the impact was disastrous. In addition to the immediate damage, the earthquake ignited fires that burned across the city for three days, destroying nearly 500 city blocks. The 1989 Loma Prieta earthquake is the largest seismic event to occur in the Bay Area 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.

Along the waterfront, the ground's earthquake response will vary based on how far below the ground bedrock is located, as well as the type and thickness of the layers of soil and mud, pockets of sand, the presence of Bay fill above the bedrock, and the depth of the groundwater table. There are three main kinds of ways the ground responds to an earthquake: ground shaking, liquefaction, and lateral spreading.

Ground motion / shaking is produced by waves of energy that are generated by a sudden slip on a fault (i.e., fractures in the earth's crust) or by a sudden release of pressure along the fault that travels through the earth and along its surface. Ground shaking could affect Port facilities along the waterfront more than buildings built inland on firmer soil. Softer ground, such as Bay mud, can amplify the shaking. For example, along the Embarcadero, this effect is greatest near the Ferry Building where the layer of Bay mud is thick and the bedrock is more than 240 feet below the surface. The ground shaking intensity could be more than double that observed in areas underlain with shallow rock, such as found near Telegraph Hill. Tall and flexible structures, such as the Ferry Building clocktower, may resonate with the soft soil and experience higher levels of shaking than stiff structures. (CH2M/Arcadis Team, 2020e)

Liquefaction occurs when water-saturated sediment (like sand) temporarily loses strength and acts like a fluid. Strong ground shaking during an earthquake can trigger this effect across large geographic areas. As a result of liquefaction, buildings, roads, and utility lines may lose their foundational support and the likelihood of significant damage increases. The Marina neighborhood in San Francisco experienced significant liquefaction during the 1989 Loma Prieta earthquake and filled areas of the Embarcadero and Mission Bay waterfronts experienced liquefaction in the 1906 Earthquake.

Lateral Spreading occurs when gently sloping or retained slopes experience strength loss and acceleration during an earthquake and the ground moves horizontally and vertically in the downslope or retained direction. This can cause large areas of land to separate from each other, creating cracks in the ground surface, and rapid settlement of the ground as it moves. Lateral spreading poses a significant risk to the Embarcadero Roadway and adjacent Port marine structures and increases the likelihood that buried utilities, such as water, sewer, wastewater, and gas pipelines will rupture. Filled areas of the Embarcadero waterfront experienced lateral spreading in the 1906 Earthquake.

Key Findings from Recent Studies

The POSF completed the MHRA along the Embarcadero waterfront from Hyde Street Pier to South Beach Harbor to better understand the earthquake risks and how they vary along the oldest stretches of the aging Embarcadero Seawall. Along the Mission Creek / Mission Bay and Islais Creek / Bayview waterfront, earthquake risk findings are drawn from the Initial Southern Waterfront Earthquake Assessment and best available science USGS studies (USGS, CGS, 2014).

The MHRA found that up to 40,000 people could be at risk on Port property if an earthquake occurs during the day (CH2M/Arcadis Team 2020). The Ferry Building area (Subarea 2-2) and Embarcadero roadway were identified as having particularly high earthquake risk, notably with respect to threatening life safety, disaster response efforts, and day-today functions along this waterfront. The Embarcadero-related earthquake losses are a near-term problem with over $0.9 billion in losses estimated by 2050 and $1.5 billion estimated by 2100 (CH2M/Arcadis Team 2020).

The Initial Southern Waterfront Earthquake Assessment examined earthquake hazards and potential vulnerabilities from Pier 48 to Heron's Head Park (Subareas 3-2 through 4-5). The assessment was targeted toward specific POSF facilities, including Piers 50, 80, 92, and 94-96. Piers 80 and 94-96 are filled piers primarily with perimeter sand dikes and pile supported bulkhead wharves with high liquefaction and lateral spreading risk. Liquefaction and lateral spreading are also expected at Pier 92, with potential damage to landside equipment and buildings. This study estimates the scale of construction funding to fully mitigate seismic risk at Piers 50, 80, and 94-96 to be greater than $100 million per facility as estimated in 2022.

3.3.1.3. Flood Risk

San Francisco Bay (Bay) is the largest estuary in the western U.S., with a 300-foot-deep Golden Gate inlet that connects the Bay with the Pacific Ocean. The tides, ocean-driven swells, and extreme ocean water levels all enter the Bay through this single inlet. The large expanse of the Bay combined with the complex topography surrounding the Bay can transform storm-driven winds in a multitude of directions depending on the primary driver of the onshore or offshore winds or the track of the large storm system descending on the Bay Area. The water levels and wave heights of the Bay exhibit a high degree of variability driven by many factors, including the bathymetry, astronomical and oceanic cycles (e.g., El Niño Southern Oscillation, Pacific Decadal Oscillation), windspeeds and direction, and atmospheric events such as extratropical cyclones and atmospheric rivers. In the Bay, no single storm event produces the highest water level and highest wave hazard along the entire 400-mile shoreline of the Bay.

Coastal flood hazards relevant to the 7.5-mile San Francisco Waterfront study area are organized below into four interrelated categories: coastal flooding, inundation, waves, and erosion.

Coastal flooding occurs when Bay water levels rise above the shoreline along the waterfront, overtopping the shoreline and temporarily flooding inland areas. Most of the developed areas along the shoreline are built on Bay fill, are generally low-lying and flat, and only a few inches to a few feet above the Bay's existing highest annual tides (Port of San Francisco 2020). Because of this, the extent of flooding and the potential damage and disruption that can occur are sensitive to small changes in Bay water level elevation (e.g., ± 6 inches) once the shoreline is overtopped. Coastal flooding already occurs approximately annually along the lowest spots of the shoreline, such as near Pier 14 by the Agriculture Building, where Bay water levels and waves overtop the shoreline and cause disruption of pedestrian and vehicle traffic along the Embarcadero promenade and roadway.

The existing risk of coastal storm damages are currently isolated to low-lying areas along the waterfront where land elevations are less than +10 feet North American Vertical Datum of 1988 (NAVD88), which is the average height of the seawall. The height of the seawall varies, as do heights along the entire waterfront. Specific low points along each reach are as follows: Reach 1 (9.7 feet); Reach 2 (8.1 feet); Reach 3 (6.6 feet); Reach 4 (6.9 feet). An example of past overtopping of the seawall occurred during an extreme tide in November 2015, resulting in Bay waters flooding the Embarcadero promenade along the waterfront near the Ferry Building. This event damaged steel plate joints, shut down at least one lane of traffic along the Embarcadero corridor, and posed a safety hazard to pedestrians. Additionally, in March 2023, a winter storm with high winds, led to extreme wave activity causing substantial shoreline overtopping at low tide (**Figure 3-3**).

Figure 3-3: Overtopping of Seawall in March 2023

Coastal inundation refers to the permanent inundation of land by high tides, such as areas that are below mean higher high water. Under existing conditions, only the wetland areas, including fringe wetland areas along Islais Creek and Mission Creek are inundated on a regular basis. However, as sea levels rise, the area inundated by the high tides will increase.

Waves in the Bay include both longer period ocean-driven swell propagating through the Golden Gate, and locally generated, wind-driven waves. Ocean-driven swell waves propagate parallel to the northern San Francisco shoreline and may pose a hazard to the Aquatic Park municipal pier and the port’s finger piers. Although these waves temporarily increase Bay water levels, they are not a significant direct wave hazard along the shoreline.

Wind-driven waves within the Bay are the dominant wave hazard. The wind climate above the Bay and the larger Bay Area is highly variable, and the steep topography, hills, and valleys throughout the Bay Area drive complex local wind patterns. Due to the large size of the Bay, the winds have sufficient fetch to generate wind-driven waves that are 3 to 5 feet high along the most exposed sections of the Bay shoreline when windspeeds are high and the wind is blowing toward the shoreline. Strong windspeeds in almost any direction will impact a section of the Bay shoreline.

Understanding waves and local wave conditions is a crucial part of coastal flood risk management along the shoreline, both with respect to infrastructure design (including coastal defense structures) and understanding residual risk. Waves are essentially energy passing through a fluid (in this case, water). They can be measured and experienced as wave runup, as splashing and overtopping, as a dynamic force on piers, wharves, and other coastal structures, and as waves that propagate inland once a shoreline is overtopped.

- ***Wave runup*** is the culmination of the wave breaking process as waves approach sloped or vertical shorelines. Wave runup includes both wave setup (the mean increase in water level as waves get slower and increase in height near the shoreline) and swash (the decelerating water that surges up the shoreline during and after the wave breaks). The slope and roughness (e.g., smooth, cobbled rock, vegetated) of the natural shoreline or engineered structures are key parameters in defining how high the waves can runup the shoreline. Smooth vertical walls have the highest potential wave runup elevations, whereas a slopped shoreline with riprap armoring will dissipate wave energy and reduce the wave runup potential.
- ***Wave overtopping*** occurs when the wave runup elevation exceeds the height of the shoreline (e.g., the top of a naturalized or embankment shoreline or floodwall) potentially flooding inland areas. Overtopping can range from a spray to a splash to a stream of water, depending on shoreline, Bay water level, and wave characteristics. Waves overtop low spots along the shoreline under existing conditions. Marginal wharves along parts of the San Francisco shoreline act as a barrier, blocking waves from overtopping the adjacent bulkhead wall.
- ***Overland wave propagation*** occurs along natural, gently sloped shorelines when water levels are high enough to allow waves to travel inland across the shoreline as opposed to breaking and running up the face of a more sloped or vertical structure. Under existing conditions, overland wave propagation only occurs in small areas where the shoreline is not hardened, for example, along the Pier 94 wetlands and portions of Heron’s Head Park. As waves propagate inland over wetlands and vegetated areas, they generally decrease in height due to wave energy dissipation. However, waves that propagate over inundated areas with sufficient water depth and limited obstructions (e.g., parking lots) may increase in height.
- ***Waves*** are also a powerful and *dynamic force* that can cause significant structural damage. Along the shoreline, waves crash into the piers and wharves causing them to shake and vibrate. This contributes to wear and tear on the structures. Waves can cause damage gradually over time, and they can cause

abrupt damage during an extreme storm event. The degree of damage depends on the storm conditions, the direction of the waves, and a structure's condition.

Coastal erosion occurs when currents and waves wear down and carry away earthen or engineered materials along the shoreline. In areas with a natural or naturalized shoreline, like the Pier 94 Wetlands or Heron's Head Park, erosion can lead to inland migration of the shoreline. For engineered coastal defenses (e.g., a floodwall or seawall), erosion is of particular concern at the toe of the structure, because erosion can weaken the foundation of the structure and increase the risk of failure.

Groundwater shoaling occurs when a water table gains elevation and becomes shallower from the land surface. **Groundwater emergence** occurs when the water table intersects the land surface, resulting in either the formation of a new spring, seep, ponding, or evaporative deposit, depending on the nearby climate and topography. With sea level rise, the water table at the shoreline will rise to meet the new sea level. This is because the lowest elevation of the coastal water table is likely on average near or above mean sea level in most coastal areas, unless losses other than discharge to the coast reverse flow such that saline water flows inland and causes intrusion (e.g., pumping or evaporation). Shallow and emergent groundwater represent hazards for surficial flooding, water quality, transportation, and shallow buried infrastructure. Understanding the characteristics of groundwater and influence that relative sea level change and the 6-foot tidal range will have on the existing condition is important to ensuring coastal flood risk reduction solutions do not exacerbate flood risk from another source.

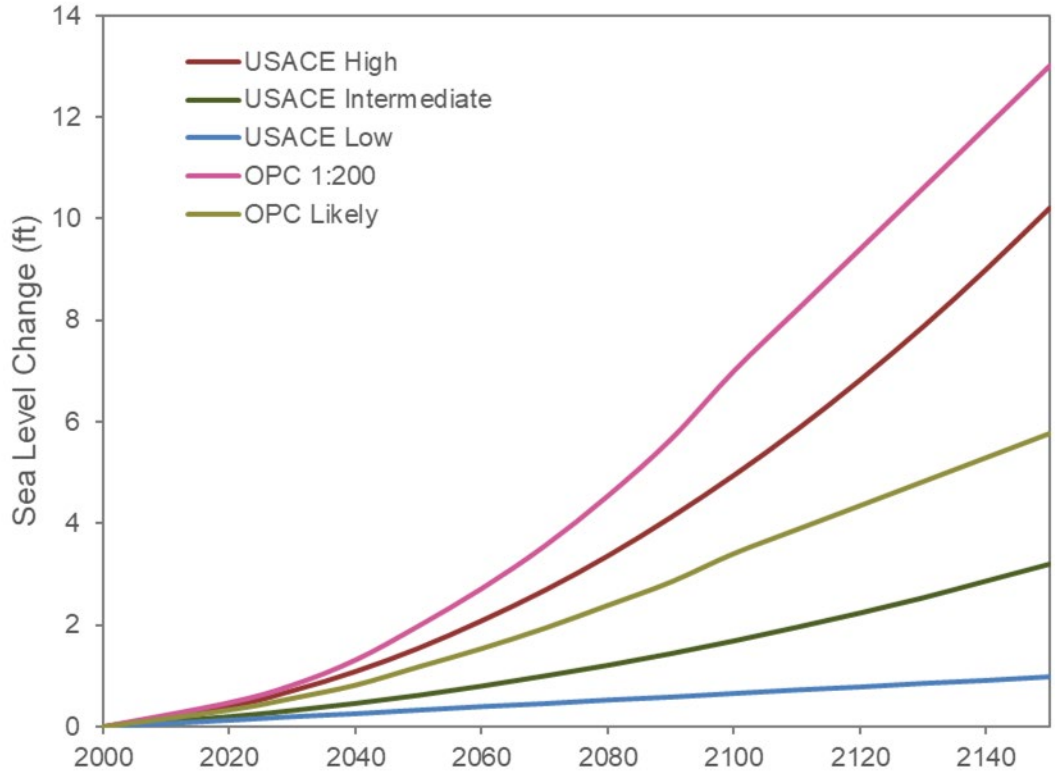
3.3.1.4. Sea Level Change and Flood Risk

The National Oceanic and Atmospheric Administration (NOAA) San Francisco Presidio tide gauge was selected to formulate the RSLC strategy based on its proximity to the study area. The observed SLR trend for the gauge from 1897 to 2020 is 1.97 mm/year with a 95% confidence interval of ± 0.17 mm/year (NOAA 2022).

The PDT formulated alternatives considering five RSLC curves (**Figure 3-4**) to address USACE requirements, as well as the requirements of the State of California and CCSF (Port of San Francisco 2020; CPC 2020). The three USACE RSLC curves are based on science presented in the National Research Council's (NRC) 2012 report, using best available science at the time of publication, including local tide gauge and other information to develop regional projections based on the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment (IPCC 2007; NRC 2012; USACE 2019).The three USACE curves were derived from the USACE SLC Calculator using the guidance provided in ER 1100-2-8162 (USACE 2019; 2020).

The State of California curves reflect the likely projection and 1-in-200 projection for San Francisco (OPC and CNRA 2018). Currently, the California SLC projections are based on NOAA's 2017 report (W.V. Sweet et al. 2017), which relies on the IPCC Fifth Assessment (IPCC 2014). The state of California is in the process of updating its recommendations based on the 2022 Federal Interagency Sea Level Rise Report (W.V. Sweet et al. 2022), which relies on the IPCC Sixth Assessment (IPCC 2021).

IPCC revised the approach for estimating potential climate change between the Fourth, Fifth, and Sixth Assessments. No simple comparison is available to translate the previous NRC (2012) scenarios used to compute the USACE RSLCs to the IPCC (2014) or IPCC (2021) scenarios that form the basis of the State of California's recommendations. However, collectively, the three USACE SLC curves and two California SLC curves are similar to the SLC scenarios recently updated by the Federal Interagency Sea Level Rise Task Force (W.V. Sweet et al. 2022).



This figure displays both OPC and USACE RSLC Curves baselined to the year 2000 for the purposes of illustration. Inputs for analysis were developed in accordance with USACE requirements, detailed in the Coastal Storms Report within Appendix B.

Figure 3-4: USACE and the State of California RSLC Scenarios

Table 3-1 shows the increase in sea level (in feet) under various projections for the time horizons evaluated. The table is organized from most conservative (swift) to least conservative (slow) SLR projections. For example, the State of California 1-in-200 projection predicts 1.4 feet of SLR by 2040, whereas the USACE Low projection predicts that 1.4 feet of SLR may not occur until later in the next century, after the 100-year period of analysis.

Table 3-1: Increase in Sea Level (in Feet) Across Time Horizons and SLC Curves

Time Period	State of CA 1-in-200	USACE High	State of CA Likely	USACE Intermediate	USACE Low
2040	1.4	**1.1**	0.8	**0.5**	**0.3**
2065	3.3	**2.4**	1.8	**0.9**	**0.4**
2090	5.8	**4.1**	2.9	**1.4**	**0.6**
2115	8.6	**6.3**	4.1	**2.1**	**0.8**
2140	11.7	**9.0**	5.3	**2.9**	**0.9**

Note: Cell color scheme identifies similar SLR increments. Darker colors indicate greater increases in sea level.

Most analyses of flooding, and flood-related damage and loss, focus on extreme events with relatively rare occurrence frequencies, such as the 1% AEP water level. The San Francisco waterfront required analysis of increasing flood risks due to more frequent events, given the characteristics of this study area and the RSLC rates considered. In the Bay, the difference between mean higher high water and the 1% AEP water level is on the same order of magnitude as future SLR by the year 2100.

Future flooding by lower magnitude, high-frequency events could result in more damage and disruption to shoreline communities and infrastructure than higher magnitude, lower frequency events (William V. Sweet et al. 2016; Ghanbari et al. 2019; Taherkhani et al. 2020). High-frequency events include very frequent events (such as the 6-month to 1-month water level), and near daily events or high tide flooding.

For example, if sea level rises by 6 inches, a 1% AEP water level will become about a 4% AEP water level in the Bay (Vandever et al. 2017; CCSF 2020). If sea levels rise by 24 inches, Bay Area coastal communities could experience multiple flood events, in addition to 90 to 150 days of high tide flooding, each year (Ghanbari et al. 2019; Sidder 2019). With SLR, the same flooding thresholds could be overtopped frequently throughout the entire year. This more frequent flooding will cause chronic and cumulative damages (FEMA 2015; Sievanen et al. 2018; Sidder 2019), and ultimately the frequent flooding will transition to permanent inundation by regular high tides.

3.3.1.5. Combined Sewer System

High coastal water levels could impact the city’s combined sewer system. Potential impacts of high coastal waters in the Bay Area (with or without coincident rain events) include overtopping seawalls, water backing up into storm drains, ponding, delays in stormwater drainage to receiving bodies, surface flooding, pressurization of storm drains, damage to underground pipes, and sinkholes. CCSF’s impact assessment states that discharge capacity of outfalls will be reduced under rising sea level scenarios (CCSF 2020). The PDT will work with the local infrastructure owner to quantitatively or semi-quantitatively evaluate the FWOP overland flood flows.

As sea level rises, the ability for the system to discharge to the Bay and creek by gravity will be hampered by the hydraulic gradient. Climate change effects and altered sea levels will affect the operation and viability of the current system and these operational issues will be expected in the absence of a Federal project or other corrective action. If corrective actions are coordinated with the Federal project, local and other Federal cost savings are expected to result from the collaborative problem solving and effective deployment of capital.

3.3.1.6. Transportation and Critical Infrastructure

Nuisance flooding impacts and major storms pose flood risk to the Muni and BART underground transit systems and to core transportation corridors such as the Embarcadero and Third Street transit corridor. As sea levels continue to rise, flooding frequency, magnitude, and duration will likely increase, which exacerbates risk to the BART Transbay Tube, Muni light rail, key utility infrastructure, Water Emergency Transportation Authority (WETA) and Golden Gate Ferry service, and waterfront businesses and neighborhoods that depend on the seawall. If flooded, base assumptions of flood risks include:

- Electrical, mechanical and communications equipment will need full replacement once flooded due to complete failure or decreased service life.
- Time required to return the system to limited operations (25% normal capacity), which is dependent upon full pump out of flood waters, cleanup of debris, and minor repairs to allow limited operations.
- Full operations timeframe (weeks/months) to return full operations (100% normal capacity), replacing all damaged equipment to mitigate future reliability issues.
- Prior studies are being used to estimate economic losses for BART/Muni transit delays associated with coastal flood risk and RSLC.
- WETA and Golden Gate Ferry service is expected to lose ridership and revenue due to system disruption caused by flood damage at ferry terminals. Revenue losses are estimated using disruption time estimates from Hazus[5] and assumptions of the ability to berth elsewhere along the waterfront.

3.3.1.7. Shallow Groundwater Response to Sea Level Change

As described in a recent study by May et al. (2022), the response of shallow groundwater to SLR is a relatively new field of study. In nearshore coastal areas like San Francisco, where shallow aquifers are unconfined, the groundwater table will rise as sea levels rise. This threat can flood communities from below, damaging buried infrastructure and roadway subgrades, increasing infiltration into sewer systems, flooding below grade structures, mobilizing contaminants, and emerging aboveground

[5] Hazus is a national standardized risk model. HAZUS identifies areas with high risk for natural hazards and estimates physical, economic, and social impacts of earthquakes, hurricanes, floods, and tsunamis.

as an urban flood hazard, even before coastal floodwaters overtop the shoreline. Several studies have identified various locations where emergent groundwater is happening today and is projected in the Bay Area (Plane, Hill, and May 2019; Christine May 2020; CL May et al. 2022).

Groundwater rise will contribute to inland flooding in low-lying coastal communities, with impacts often occurring earlier, and farther inland, than coastal flooding from overtopping of the Bay shoreline (Befus et al. 2020; Bosserelle, Morgan, and Hughes 2022; Plane, Hill, and May 2019; Rahimi et al. 2020). Rising groundwater has the potential to impact coastal communities long before the groundwater rises aboveground and creates a new flood hazard (Christine May et al. 2020; Michael et al. 2017; Plane, Hill, and May 2019; Rotzoll and Fletcher 2013). The significance of rising groundwater and groundwater inundation may create the need to re-evaluate SLR driven flooding in some communities to develop effective flood risk reduction strategies (Habel et al. 2020). Failing to account for groundwater rise on the landward side of flood risk reduction structures (e.g., levees and seawalls) could result in maladaptation if the community continues to flood from below.

3.3.1.8. Inland Drainage

San Francisco operates a combined sewer system that collects and treats both sanitary and stormwater flows in the same network of conveyance structures, including pipelines, storage structures, pumps, treatment plants, gravity outfalls, and pumped outfalls. As noted earlier, the level of service goal for the collection system is to manage flows resulting from the city's 5-year, 3-hour rainfall event, which has a total depth of 1.3 inches over a duration of 3 hours and a peak intensity of 3.13 inches per hour. Some areas along the shoreline are served by separate stormwater pipes. The sanitary flows and some stormwater generated in these areas flow to the City’s Southeast Wastewater Pollution Control Plant, but much of the stormwater flows are either discharged directly to the Bay or captured and treated by green infrastructure facilities. These areas include the POSF’s piers and much of Mission Bay.

In a future without a Federal project, modeled results[6] show projected SLR could increase shoreline overtopping over time, which may enter the combined sewer system

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[6] The study is intended as a planning level tool to illustrate the potential for inundation and coastal flooding under a variety of future sea level rise and storm surge scenarios. The results depict possible future inundation that could occur if nothing is done to adapt or prepare for sea level rise over the next century. The study was performed using a hydrologic and hydraulic computer model, using a digital elevation model created from 2010 LiDAR data and information on existing City-owned infrastructure. The model’s calculations take into account projected sea level rise and storm surge causing elevated bay levels. Model outputs do not account for all the complex and dynamic San Francisco Bay processes or future conditions such as erosion, subsidence, shoreline protection upgrades, or other changes to San Francisco Bay or the region that may occur in response to sea level rise. The model outputs do not account for future conditions such as new construction, City infrastructure upgrades, or other changes that may affect flooding. Although care was taken to capture relevant topographic features and structures in the City, site specific conditions such as property-line solid walls and fences may not be accounted for.

through catch basins in flooded areas and over combined sewer discharge (CSD) structure weirs.

Alongside SLR, changes in the Bay Area's storm rainfall intensity could push more stormwater through the CSD outfalls and the city may experience more surface flooding. With greater increases in SLR and rainfall intensities, model data predicts that SLR could counter the increase in rainfall intensity and surface flooding, and the CSD discharge volume could decrease. Eventually, it is possible that the CSD outfalls would no longer discharge flow by gravity into the Bay in the level of service storm.

3.3.1.9. Assumed Coastal Resilience Actions

Seawall

The long-term seawall rehabilitation program includes the incorporation of limited coastal flood risk management measures independent of this study. However, any actions are considered to be limited in scope and scale for the FWOP, and only implemented in areas that are at high risk of failure or will have sustained damage due a future coastal storm or seismic event. Available funding for such repairs is limited. Assumptions are as follows:

- POSF will make life-safety improvements along portions of the waterfront, through retrofit of existing marine structures but these projects not expected to significantly change elevations.
- The first phase of the Waterfront Resilience Program will address the most critical life-safety upgrades to the Seawall and is estimated to cost $500 million. The proposed Seawall Earthquake Safety and Disaster Prevention Program Bond (Seawall Bond) will fund the majority of this work and leverage other funding sources including private, state, and federal funds.
- Possible improvements include strengthening the ground below and landside of the Seawall, constructing new Seawall segments along limited extents of the waterfront, strengthening, or replacing bulkhead walls and wharves along the Embarcadero Promenade, and relocating or replacing critical utilities.

Hazards and Climate Resilience Plan

This feasibility study is one critical piece of a larger CCSF commitment to resiliency planning and proactive coordination of City agencies to build and maintain vital City and community functions over the next 100 years.

The climate resilience goals of POSF are formalized in the city of San Francisco's Hazards and Climate Resilience Plan (HCR). The HCR was developed to serve as a roadmap to address the impacts of natural hazards and climate change on the assets and people within the city of San Francisco. It identifies the hazards and risks San

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Rainfall intensity was increased by applying a percent increase to the existing Intensity-Duration-Frequency curve.

Francisco faces and proposes multiple strategies to reduce risks and adapt to climate change impacts. https://onesanfrancisco.org/resiliency/overview.

As described above, the HCR was adopted as San Francisco's 2020 Hazard Mitigation Plan by the Mayor and Board of Supervisors on June 16, 2020, and approved by FEMA on July 21, 2020. It updated the city's 2014 Hazard Mitigation Plan, which was coordinated with FEMA to encourage proactive risk reduction efforts are implemented to mitigate post-disaster consequences where possible and to increase efficiency of post-disaster response and recovery programs at the federal and local level. The HCR was developed based on principles including Equity & Health, Community Cohesion, Affordability and Economic Viability, Climate Mitigation, Biodiversity and Connection to Nature, Science-Grounded Innovation and Good Governance. These principles are consistently applied across CCSF agency planning and asset management to monitor and address risk from multiple hazards, including seismic and inland and coastal flooding. The 2020 Hazard Mitigation Plan also reflects the proactive efforts of the City of San Francisco to reduce FEMA post-disaster response costs.

3.3.1.10. Waterfront Development Projects

This section describes the actions that CCSF, as well as individual public and private property and asset owners, would take to address SLR and coastal flood hazards in the project area in the absence of a federal project. CCSF would be expected to act rationally within the constraints of available funding sources to continue operation of essential services within and outside of the flooded areas. Individual actors (property owners, agencies, business owners, and residents) are expected to dynamically react to the increasing risk of flood damages, thereby repairing damage from infrequent flood events and eventually taking proactive steps to prevent repetitive damage through floodproofing actions. When the frequency of flooding becomes too great, and impact too disruptive to commerce within the urban study area, it is reasonable to assume zones within the floodplain will be abandoned and converted to land uses compatible with frequent inundation.

There are many development projects underway up and down the waterfront on POSF-owned land, as shown on **Figure 3-5**. Some of these projects are in the planning phase, such as those proposed at Pier 45/Seawall Lot 301, Piers 19-31, Piers 30-32/Seawall Lot 330, and Piers 94-96/Backlands. Others are approved and are either under construction or waiting for improved real estate market conditions, such as Mission Rock, Pier 70 Brookfield, and Teatro Zinzanni. These new projects not only bring new investment to the city, but also will provide more places for people to live, work, shop, and visit.

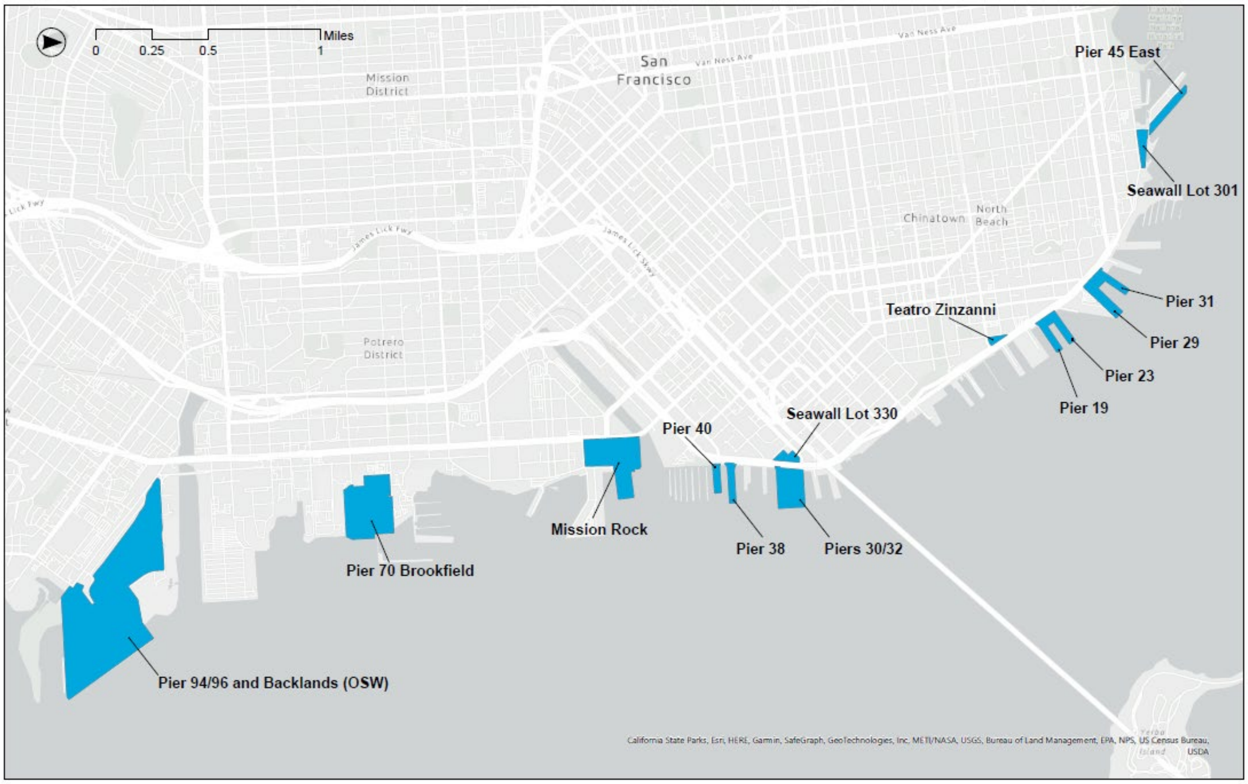


Figure 3-5: Planned Development along the Waterfront on POSF Property

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.

POSF prioritized seven Embarcadero Early Projects to move forward through pre-design. The projects include earthquake safety projects to reduce loss of life in an earthquake, earthquake resilience projects to reduce damages from earthquakes to buildings and structures, and a near-term flood improvement project, the Downtown Coastal Resilience Project.

The seven projects are:

- Wharf J9 Replacement and Resilient Shoreline Project
- Pier 15 Bulkhead Wall and Wharf Substructure Earthquake Safety Retrofit Project
- Pier 9 Bulkhead Wall and Wharf Substructure Earthquake Safety Retrofit Project
- Ferry Building Seawall and Substructure Earthquake Reliability Project
- Downtown Coastal Resilience Project
- Pier 24½ to Pier 28½ Bulkhead Wall and Wharf Substructure Earthquake Safety Project
- Emergency Fire Water System Fireboat Manifold Earthquake Resilience Project

These projects are not included in the FWOP condition because the City has not completed analysis of these projects under the California Environmental Quality Act nor approved funding for construction. As plan refinement progresses, the PDT will continue to evaluate how projects such as the Wharf J9 Replacement and Resilient Shoreline Project and the Downtown Coastal Resilience Project will align with elements of the TSP. POSF does not have other significant sources of funding to pay for flood resilience projects, outside of the potential SFWCFS Recommended Plan. POSF has a significant maintenance capital backlog of $1.1 billion, with an annual budget of $10-20 million for port upkeep and capital state of good repair. Projects that are completed or are scheduled to be completed by 2040, were not part of the FWOP condition modeling in G2CRM but were part of the existing/FWOP conditions utilized during formulation of measures and alternatives in the study.

With any available funds, POSF will continue to prioritize immediate life safety and resilience projects over time, similar to the Embarcadero Early Projects. While the City and POSF have a demonstrated commitment to managing flood risk, the coastal flood resilience structures required to manage flood risk along the POSF’s 7.5-mile shoreline over the 100-year POA exceeds the capacity of the City or POSF to implement without federal participation.

The Heron’s Head Park Shoreline Resilience Project aims to bring a living shoreline approach to address significant subsidence and erosion since the park’s creation over 20 years ago. POSF completed planning, design, and permitting of a nature-based solution to shoreline erosion at Heron’s Head Park in 2021. The Heron’s Head Park Shoreline Resilience Project will restore the former type and extent of habitat and provide new habitat in the form of coarse sand/gravel beach, new wetland vegetation to reinforce shoreline and pond edges, and subtidal oyster reefs. The coarse material shoreline will enable wetlands to migrate with rising sea level so that some wetland habitat and public access areas remain through mid-century. This project was considered as an existing/FWOP condition and utilized during formulation of measures and alternatives in the study.

The objectives of the Heron's Head Park Shoreline Resilience Project are:

- Protect the southern shoreline from continued erosion
- Restore native wetland plant habitat by growing, planting, and caring for key wetland species
- Create capacity for adaptation to SLR
- Create youth employment and community engagement opportunities

To achieve these objectives, the project includes the following elements:

- Dynamically stable sand and gravel beach
- Oyster reef balls, which are structures fabricated of special concrete, sand, rock, and shell
- Wetland revegetation
- Youth employment in hands-on habitat restoration and community outreach
- Post-construction monitoring and habitat stewardship

3.3.1.11. FWOP Condition Flood Damages

National Economic Development Flood Damages

NED flood damages were estimated using the Generation II Coastal Risk Model (G2CRM) computer model. Details on the G2CRM model and its use in estimating flood damages for this study can be found in *Appendix E: Economic and Social Considerations*.

The study area is estimated to incur over $22 billion in present value damage under the High SLC curve, almost $6 billion in present value (PV) damage under the Intermediate SLC curve, and $3.6 billion in PV damage under the Low SLC curve. Of note under the Low curve is that 72% of those damages are in the seismic category, meaning less than 30% of the total damage is due to flooding or rising sea levels forcing retreat. Under the High curve, though, the majority of the damage (84%) is driven by flooding or increasing sea levels. (**Table 3-2**).

Table 3-2: FWOP Total Present Value NED Damages by Reach
(FY 2023 Price Levels; 2.5% Discount Rate)

Reach	USACE Low SLC	USACE Intermediate SLC	USACE High SLC
Reach 1 – Fisherman's Wharf	$375,852,000	$430,227,000	$1,588,650,000
Reach 2 – Embarcadero/Market Street	$729,221,000	$1,576,334,000	$7,849,736,000
Reach 3 – Mission Creek/Mission Bay	$898,963,000	$2,113,359,000	$9,517,446,000
Reach 4 – Islais Creek/Bayview	$1,606,779,000	$1,834,863,000	$3,634,008,000
Total	**$3,610,815,000**	**$5,954,783,000**	**$22,589,840,000**

Regional Economic Development Flood Damages

In addition to the analysis of NED damages described above, the potential regional economic impacts of flooding along the San Francisco Waterfront study area were analyzed. The analysis identified how these economic impacts from flooding, also known as Regional Economic Development (RED), affect the Bay area and the larger California economy.

The RED analysis consists of three categories: impacts to critical infrastructure, direct economic impacts, and cascading regional economic impacts. Impacts to critical infrastructure are calculated in G2CRM and are generally expressed in terms of revenue loss to specific public and private transportation and utility assets. Direct economic impacts include direct economic output losses and direct job impacts. Direct economic output losses are also modeled in G2CRM, while direct job impacts are produced by the Impact Analysis for Planning (IMPLAN) software using the G2CRM direct output losses as a model input. These direct losses occur when a building sustains damage and cannot be occupied during repairs and restoration of flooded components. Cascading regional economic impacts include indirect and induced impacts on economic output and jobs, both estimated with IMPLAN, again using the G2CRM direct output losses as a model input. Indirect effects represent impacts on business-to-business purchases in the supply chain, whereas induced effects stem from changes in household income spending, after removal of taxes, savings, and commuter income.

Table 3-3 summarizes the RED damages for the FWOP condition.

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

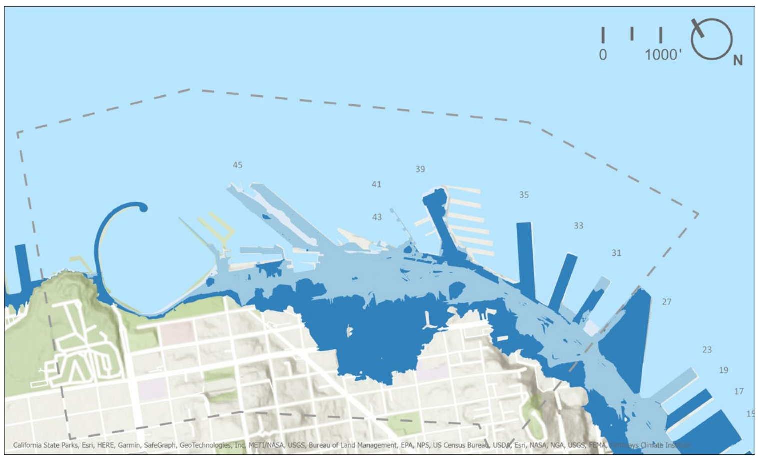


Figure 3-6: Reach 1 Inundation Map

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

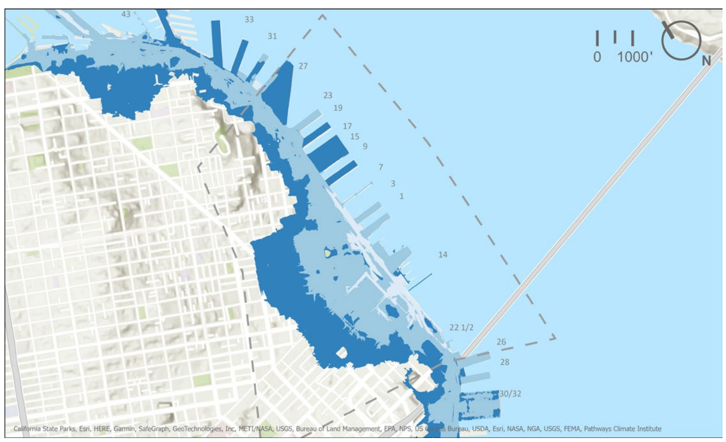


Figure 3-7: Reach 2 Inundation Map

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

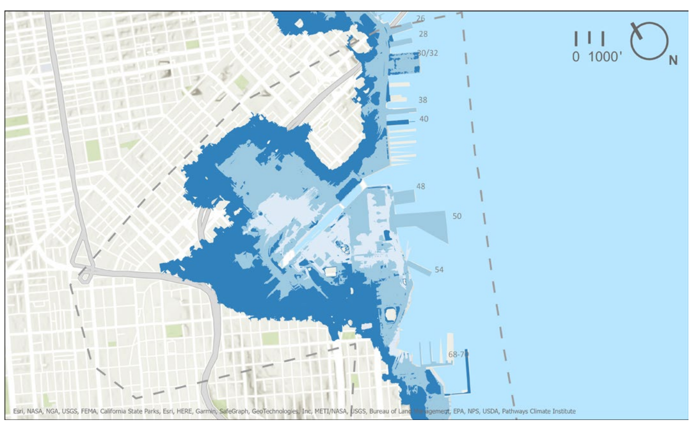


Figure 3-8: Reach 3 Inundation Map

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

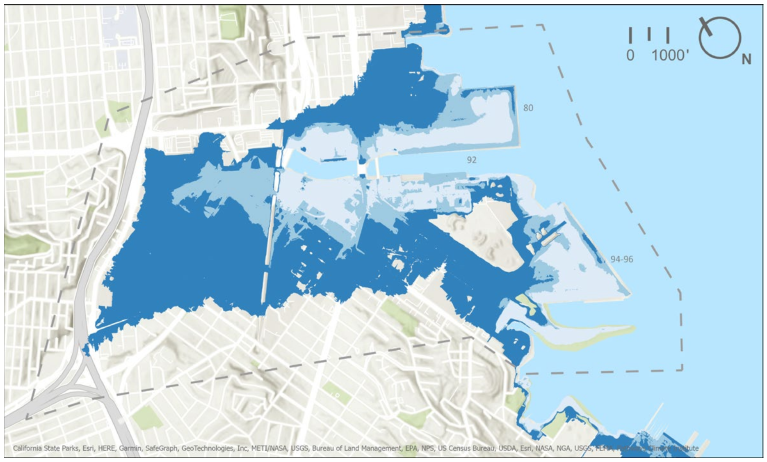


Figure 3-9: Reach 4 Inundation Map

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

- Redesign streets and open space for water retention and storage and green infrastructure to address overland flooding issues and reduce transport of land-based pollutants into the Bay
- Expand waterfront access, open space, and recreation, and enhance the quality and experience of waterfront public space, including the San Francisco Bay Trail and San Francisco Bay Water Trail
- Minimize carbon emissions from major construction by exploring and utilizing proven technology in materials and landscape design

3.4. Planning Goals, Objectives, and Constraints

3.4.1. Planning Goals

Three broad study goals were identified to develop and implement a resilience strategy to address the multiple risks within the study area. These goals complement the larger resilience efforts proposed by the City of San Francisco in their Resilient SF initiative that will align City agency actions to achieve long term capability to survive, adapt and grow within an area with multiple hazards:

- Plan and Prepare: Characterize the multiple study area risks and consequences to inform the range of potential responses and appropriate timing of risk reduction investments to complement and sustain the area's uses, economic and maritime activity, cultural and historic significance, and residential centers.
- Empower resilience investments: Define an innovative long-term menu of responses to increasing risk that will coordinate or launch cost effective resilience actions from City and regional agencies. Align investment with future needs for cost effective and timely implementation.
- Develop a cost-effective method for addressing flooding risk dominated by uncertain timing of RSLC.

3.4.2. Federal Objective

In accordance with ER 1105-2-103, the Federal objective for water resource investments must reflect national priorities, encourage economic development, and protect the environment. In addition, federal investments in water resources should reasonably maximize all benefits, with appropriate consideration of costs. Public benefits encompass environmental, economic, and social goals, including monetary and non-monetary effects, and allow for the consideration of quantitative and qualitative metrics (CEQ, 2013).

The Federal objective is to maximize economic, environmental, and social net benefits to the nation, and as such, it does not seek to identify specific targets within objectives. The planning process includes formulation of alternative plans to maximize benefits relative to costs.

3.4.3. Planning Objectives

The overarching goal of this study is to formulate alternatives for coastal flood risk management to determine if Federal participation in reduction of the damage to assets caused by coastal flooding within the study area is feasible.

Specific study objectives have been developed to provide a means of determining whether individual management measures can solve the study area's problems while taking advantage of the opportunities identified and avoiding the constraints. The following study objectives have been developed based on the problems, opportunities, goals, and Federal objectives:

- Reduce risk to human health and safety from coastal hazards and flooding due to sea level rise, wave run up and precipitation (combined flooding) in the City of San Francisco
- Reduce costs and risks to NED associated with coastal hazards and combined flooding to business, residents, and infrastructure in the City of San Francisco
- Improve the resilience of the local and regional economy to impacts from coastal hazards and combined flooding
- Maximize social benefits and improve resilience of affected communities to impacts from coastal hazards and combined flooding
- Minimize disproportionate impacts to vulnerable communities, including low income and communities of color
- Minimize disruption to maritime facilities and functions caused by coastal hazards and combined flooding, through resilience strategies that support cargo shipping, cruise, ferry and water taxis, excursion boats, fishing, ship repair, berthing, harbor services, recreational boating, and other water-dependent activities
- Maximize resilience of City transportation infrastructure that is essential to the daily operations and functioning of the city
- Minimize damages from coastal hazards and combined flooding to historic resources and preserve the maritime history of the waterfront
- Maximize ability and flexibility to respond to uncertain rates of RSLC
- Leverage public investment in coastal flood risk reduction to reduce earthquake risks
- Maximize environmental benefits, sustainable approaches in project design and construction, and consideration of coastal processes
- Promote and enhance public access to the San Francisco waterfront and the Bay and minimize disruptions to waterfront access and use

- Preserve, defend, and adapt existing housing, community services and facilities (e.g., libraries, community centers, health centers, homeless shelters, etc.), and cultural and historic resources from rising sea levels and coastal flooding

3.4.4. USACE Resilience Objective

The second objective of this study focuses on resilience. In EP 1100-1-2 USACE Resilience Initiative Roadmap 16 Oct 2017, USACE has identified four key principles of resilience from the many definitions of resilience that exist. These principles – Prepare, Absorb, Recover, and Adapt – identify the temporal aspects and actions that are necessary to build community resilience capacity.

Prepare: The study will outline the likely FWOP condition and assess structural and nonstructural actions that may reduce that risk. Communities and agencies can make informed choices to address existing coastal flooding risk. Proactive measures, either through individual action, land use policies, and / or coordinated action, can increase preparedness ahead of flood events and make assets within areas prone to future coastal flooding with SLR more resilient to these hazards.

Absorb: This study includes measures that will reduce risk and sustain function of infrastructure and community resources during and after exposure to coastal flooding.

Recover: This study evaluates solutions which not only reduce damages, but also reduce the resulting downtime of key community and area resources and critical infrastructure following coastal flooding events, and allow quicker recovery before, during and after storms.

Adapt: This study recognizes adaptation as a key component for risk reduction under uncertain timing of RSLC and will identify compatible structural and nonstructural measures that may be implemented as risk increases. A monitoring plan, with pre-identified technical experts to assess risk and adapt area defenses, will improve cost effective response at appropriate points in times.

3.4.5. Federal Environmental Objectives

USACE strives to balance the environmental and development needs of the nation in full compliance with NEPA and other authorities provided by Congress and the Executive Branch. Public participation is encouraged early in the planning process to help define problems and environmental concerns relative to the study. Therefore, significant environmental resources and values that would likely be impacted, favorably as well as adversely, by an alternative under consideration are identified early in the planning process. All plans are formulated to avoid, to the fullest extent practicable, any adverse impact on significant resources. Significant adverse impacts that cannot be avoided are mitigated as required by Section 906(d) of WRDA 1986.

This document is an integrated feasibility report and environmental document. As with a separate NEPA document, it discusses and documents the environmental effects of the recommended plan and summarizes compliance with Federal statutes and regulations.

3.4.6. Environmental Operating Principles

Consistent with NEPA, USACE has formalized its commitment to the environment by creating a set of "Environmental Operating Principles (EOP) applicable to all its decision making and programs. These principles foster unity of purpose regarding environmental issues and ensure that environmental conservation, preservation, and restoration are considered in all USACE activities. This feasibility report includes a discussion of the USACE EOP and how the study addresses them.

3.4.7. Planning Constraints

A constraint is a restriction that limits the extent of the planning process; it is a statement of effects that alternative plans should avoid. Constraints are designed to avoid undesirable changes between FWOP and FWP. All studies must avoid conflict with Federal regulations, as stated in Federal law, USACE regulations, and executive orders. The following constraints have been developed for this study:

- Avoid actions that may violate authority of the Port Commission to fulfill its public trust responsibilities consistent with the Burton Act (Chapter 1333 of the Statutes of 1968)
- Maintain permitted public access, such as the San Francisco Bay Trail, San Francisco Bay Water Trail, and Blue Greenway
- Maintain ecological functions and minimize ecological disruptions in the Bay
- Minimize aesthetic impacts to the study area and its resources
- Minimize impacts to cultural, historic and community resources that sustain national and regional continuity wherever possible
- Do not exacerbate ability of inland drainage system to manage stormwater runoff and do not increase combined sewer overflows to Bay (Clean Water Act requirements)
- Avoid hazardous, toxic, and radioactive waste sites or address these sites consistent with an approved risk mitigation plan.

Several considerations were identified for plan formulation and evaluation that will reflect the City of San Francisco's overall planning values and priorities and will support community resilience, which is an integral component of the long-term vision for the study area.

- State law requires municipalities to adopt a Housing Element that identifies programs for preservation, improvement, and development of housing, and a

Housing Element implementation program that conserves and improves the condition of affordable housing, including mitigating loss of housing units[7]

- Avoid major loss of existing housing or impacting available space for additional housing creation. Regional and local housing mandates (as described in Plan Bay Area and the Housing Element of the SF General Plan) set housing targets for San Francisco, tied to funding and policy triggers. Achieving those targets necessitates that the City avoid major loss of existing housing and create available space through zoning.

3.5. Plan Formulation Strategy

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 the conceptual approaches 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.

The second and most significant phase of plan formulation assessed cost-effective approaches. The PDT developed a focused array of alternatives and evaluated NED benefits and costs for the three RSLC conditions (USACE Low, Intermediate, and High curves) to identify the NED plan for each condition. The PDT then developed a Total Net Benefits Plan to add to the three NED plans in the final array of alternatives. The TNBP was developed as a combination of varied reach-level components of the focused array. A total benefits analysis of the final array was then conducted across all four P&G accounts for each of the three RSLC conditions to identify the TNBP. As a final step, the TSP was identified. Further development of the TSP will be conducted for the final IFR/EIS.

Figure 3-10 illustrates the plan formulation strategy. A detailed summary of the formulation and screening is provided in subsequent sections.

[7] **CA Government Code Section 65583 (excerpts).**

The housing element shall consist of an identification and analysis of existing and projected housing needs and a statement of goals, policies, quantified objectives, financial resources, and scheduled programs for the **preservation, improvement,** and development of housing.
Related to implementation programs for Housing Elements:
65583. (c)(4) Conserve and improve the condition of the existing affordable housing stock, which may include addressing ways to mitigate the loss of dwelling units demolished by public or private action.

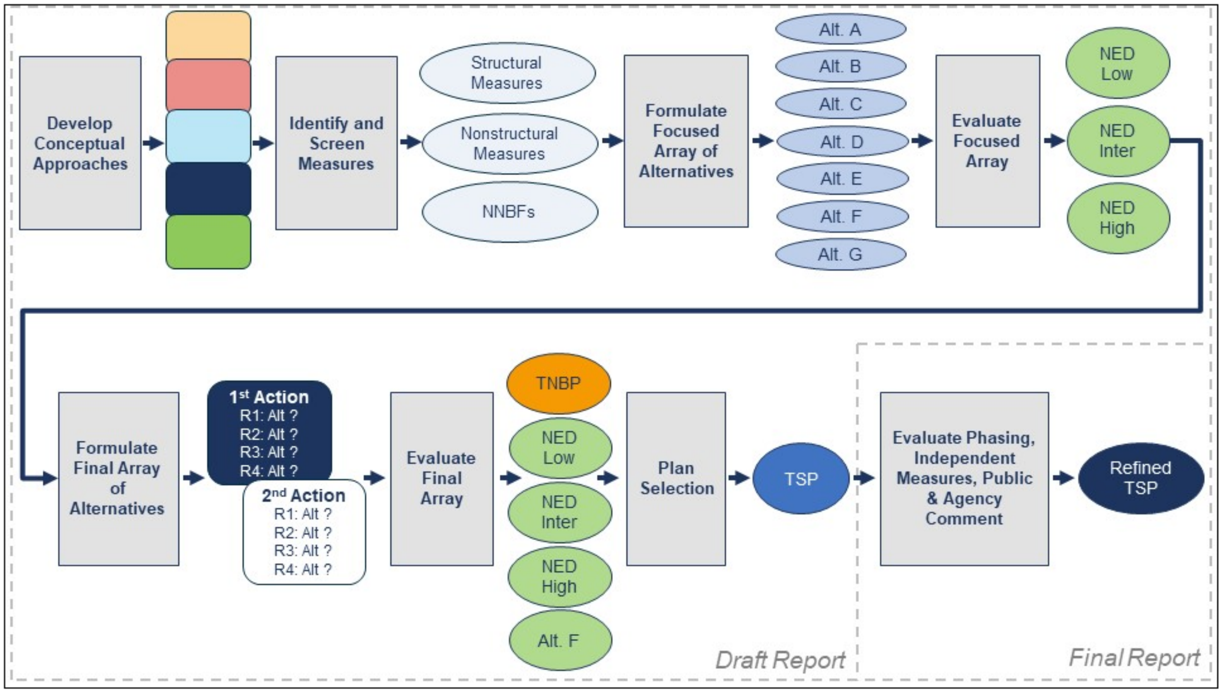


Figure 3-10: Plan Formulation Strategy

Seismic risk can be described probabilistically. Coastal flooding will increase at an uncertain rate over the POA. 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 SLR. The variability of water surface elevations (WSEs) that result from the 0.1% AEP and the 1% AEP vary by less than 2 feet in WSE. The primary risk to address is higher WSE, thus the appropriate measures would address elevated water through structural and nonstructural approaches. As a result, 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.

Three elements were applied to develop an array of alternatives for this study, which are consistent with the formulation guidance referenced above to ensure delivery of a policy-compliant report and recommendations. The three elements are:

- Overall approach to reduce risk consisting of structural and nonstructural measures and natural and nature-based features (NNBFs) (in line with the EWN philosophy) along the existing shoreline, more bayward, and more inland alignments (called lines of defense (LODs))
- Varied scales of features to reflect uncertain timing of RSLC
- Phased implementation of features within most alternatives

3.6. Conceptual Approaches

In 2018 at the start of the study, the PDT developed 11 conceptual structural approaches on a horizontal alignment, referred to as the LOD using a range of appropriate measures to form the initial array of alternatives. These initial conceptual approaches were evaluated and screened based on completeness, effectiveness, efficiency, and acceptability in consultation with representatives from City and regional agencies and resource and regulatory agencies. These conceptual approaches were presented at the Alternatives Milestone Meeting on December 3, 2018, and the San Francisco Port Commission on February 12, 2019.

In consultation with representatives from City and regional agencies, and resource and regulatory agencies, the PDT began developing conceptual alternatives based on themes. The themes used to organize the preliminary array were:

- Seismic safety and disaster response
- Historic and cultural preservation
- Transportation-mobility
- Ecological assets and services
- Community cohesiveness
- Nonstructural

Preliminary analysis of these conceptual alternatives confirmed that the perimeter plan is the most cost-effective approach to defend the study area against coastal flood risk over the 100-year POA. Work on conceptual alternatives continued through early 2021, when USACE developed new guidance for the study (see section 3.1). The guidance provided the following formulation direction:

- Develop multi-hazard formulation strategies that reflect timing, location, and severity differences in risk
- Distinguish between measures to address seismic risks associated with the flood problem; other alternatives that show them coupled; this facilitates the compare and contrast between the alternatives
- Develop at least one stand-alone nonstructural alternative
- Incorporate Engineering with Nature (EWN), when practicable
- Formulate with all three USACE RSLC projections, plus additional State of California projections if a LPP is requested. Formulate measures and alternatives that can be implemented incrementally for varying topography and locations to address varying degrees of risk. Individually, and in combination, they should describe flexibility in scale and timing of actions (initial and future adaptations) for the desired risk reduction performance as required under the Planning Guidance Notebook

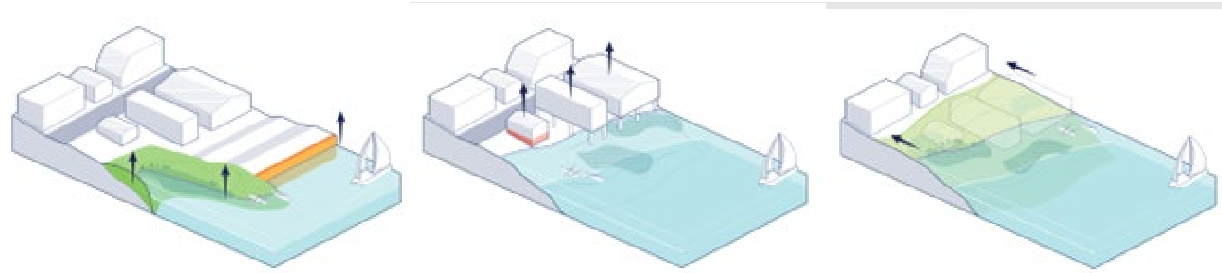
3.6.1. Approaches to Reduce Risk

Instead of formulating and evaluating a plan under one RSLC rate and assessing its performance under all rates, formulation for this study was conducted using three RSLC rates and adapting the scale or timing of the features to manage risk over 100 years.

The timing of SLC is uncertain, so the focused array was formulated to reveal lessons about cost effectively managing flood risk with uncertain timing, whether to retreat or defend, or to build big initially or to build smaller and adapt later. Four broad, conceptual, high-level approaches – Defend, Accommodate, Retreat, and Hybrid – were developed as a basis for formulating plans to address coastal flood risk. By law, at least one entirely nonstructural plan is required. The terms are defined as follows:

- **Defend** means measures will be used to block Bay waters, either at the current shoreline alignment, bayward of the current alignment, or slightly landward of the current shoreline.
- **Accommodate** can include nonstructural measures to live with water, moving the line of defense landward as managed retreat to move people and assets away from the water, or a combination of both of these approaches.
- **Retreat** scenarios are designed to “align with watersheds” by advancing the LOD and shoreline landward, while working with natural inland flooding patterns through a series of nonstructural and structural measures. Floodproofing of some buildings and infrastructure would occur in areas of lower risk, while other assets would be moved away from the current Bay shoreline in highest risk areas.
- **Hybrid** means a combination of these approaches could be used throughout the study area based on flood risk and assets.
- NNBFs can be part of all these approaches.

The Defend, Accommodate, and Managed Retreat approaches are illustrated in **Figure 3-11**.



Defend	**Accommodate**	**Retreat**
Keep coastal flood water out, stay in place	*Let coastal flood water in, stay in place*	*Let coastal flood water in, and move out of the area over time*

Figure 3-11: Approaches to Reduce Risk

3.6.2. Lines of Defense and Zones

For each structural alternative, a horizontal alignment, referred to as LOD, was developed to provide protection against coastal flooding and SLR. The LOD varies by strategy and by location throughout the waterfront (for example, the LOD can be further inland in one location, compared to right along the existing shoreline or shifted slightly toward the Bay in other locations). The selection of the LOD for each strategy was informed by a preliminary examination of local space constraints (e.g., is there enough space for a gradual versus steep elevation transition) and based on the public realm and urban design assumptions adopted for this effort.

3.6.3. Varied Scaling of Features

Within the broad conceptual approaches, the PDT formulated alternatives that vary the scale and timing of the structural and nonstructural strategies to support comparison of cost and performance under the uncertain timing of the RSLC component of the inundation risk. Thus, the array of alternatives includes variations of structural and nonstructural features that are scaled to address varying RSLC conditions.

- One plan is scaled to reduce risk for the low USACE RSLC, with a single action over the study period.
- One plan is scaled to reduce risk at the low rate of RSLC for the initial action, and then adapted to be scaled to the intermediate rate of RSLC for the latter half of the study period.
- Four plans – one nonstructural plan with two possible scales and three structural plans – are scaled to reduce risk at a target performance for intermediate USACE RSLC rate under the first action and high USACE RSLC rate for the second action.

3.6.4. Adaptation as Subsequent Actions

A final aspect of the plan formulation strategy is to identify phased implementation of the features to balance two important criteria for plan selection: cost effectiveness and adaptability to uncertainty across the POA. Adaptations were described in sufficient detail to support estimation of benefits and costs of the alternatives, and scales of adaptation correspond to the target level of performance of each alternative. At this initial stage of plan development, implementation was assumed to occur in a two-step process with the first action occurring in 2040 and second action occurring in 2090. However, a Monitoring and Adaptation Plan (MAP) will ultimately be used to model what the forecasted implementation strategy might look like given the associated risks, and to refine implementation dates for second actions. The MAP in Appendix G will ultimately address how USACE and POSF will manage the risks of RLSC over time through implementation of subsequent Federal actions, in congruence with City plans, to outline the need to identify triggers for risk assessment, management, and implementation. The MAP builds the framework to:

- Identify thresholds of RSLC that would trigger the need for an adaptation, such as additional height to manage coastal flood risk or changed alignment
- Evaluate the plan performance required to address the SLR risk based on those thresholds, considering other factors such as life of asset, other planned projects, and disruption from the construction period
- Develop the governance and executive structure to collaboratively monitor and interpret risk within the study area
- Describe coordination and involvement of resource agencies, USACE, POSF, City, and State to manage the risks over time
- Recommend approaches for Congressional authorization and future Preconstruction, Engineering and Design strategies that will enable USACE and the Port to more efficiently implement second adaptation actions given the uncertainty regarding future rates of RSLC
- Clarify appropriate scale and alignment of features to be constructed in time to reduce vulnerability to flooding in the study area

3.6.5. Treatment of Seismic Costs

Section 152 of WRDA 2020, as amended by Section 8380 of WRDA 2022, provides for the treatment of certain benefits and costs for flood risk management projects in regions of moderate or high seismic hazard. Alternatives were formulated with full consideration of applicable USACE engineering design standards needed to address seismic hazards in the study area. However, in accordance with the requirements of Section 152, as amended, the costs of the features necessary to address seismic concerns were excluded from the NED cost of alternatives and the benefit-cost ratio (BCR). These costs are included in determining the total cost of the TSP and in determining cost-sharing requirements for the TSP.

3.7. Identification and Screening of Management Measures

Management measures are features or actions that contribute to the planning objectives. Measures were formulated based on problems in each of the four reaches. They were derived from a variety of sources, including the NEPA scoping process and coordination with stakeholders. Coastal flood risk management measures consist of three basic types: structural measures, nonstructural measures, and NNBFs.

The measures considered for this study can reduce risk alone or in combination. They were screened for applicability, function and space constraints, and anticipated cost effectiveness. Smaller scales of NNBFs are considered for their function to reduce risk in specific applications and to replicate natural coastal processes that are displaced by hardened shorelines. The PDT consulted with the USACE National Nonstructural Committee and incorporated lessons learned from current nonstructural policy concerns and recent coastal flood risk management studies conducted by three USACE Districts.

Structural measures reduce flood risk by modifying the characteristics of the flood. They are physical modifications designed to reduce the frequency of damaging levels of flood inundation. In the context of coastal flooding, structural measures are often employed to defend against overtopping (flood barriers); reduce wave hazards (dissipation); reduce erosion (armoring); and facilitate the flow, storage, or removal of water that has overtopped the shoreline (pumping and drainage). They may be used alone or in combination with other measures.

Nonstructural measures can be grouped into two categories: physical and nonphysical measures. Physical nonstructural measures include actions that require modifications to a property or structure. They include structure elevation, dry and wet floodproofing, basement removal, relocation, and acquisition. Nonphysical nonstructural measures do not modify individual structures, but rather focus on behaviors and plans that reduce flood risk. They include evacuation plans, flood warning systems, flood insurance, floodplain mapping, emergency preparedness plans, risk communication, and land use regulations and zoning.

Nonstructural measures are permanent or contingent measures applied to a structure and/or its contents that prevent or provide resistance to damage from flooding. Nonstructural measures differ from structural measures in that they focus on reducing the consequences of flooding instead of focusing on reducing the flow of water into portions of the study area.

EWN is the intentional alignment of natural and engineering processes to address flooding hazards while also delivering economic, environmental, and social benefits (*Appendix I: Engineering with Nature*). **NNBF**s refer to the landscape features used to reduce flood risk while restoring natural processes and providing ecosystem benefits. NNBFs may also produce other economic, environmental, and social benefits known as NNBF co-benefits. These landscape features may be natural (produced purely by natural processes) or nature-based (produced by a combination of natural processes and human engineering) and include such features as beaches, dunes, wetlands, reefs, and islands. Landscape features can be used alone, in combination with each other, and in combination with conventional engineering measures such as levees, floodwalls, and other structures (USACE 2021b). Within this document, the term “EWN” refers to the philosophy, whereas the term “NNBF” refers to a natural and nature-based feature, measure, or action. NNBFs can be combined across a terrestrial to aquatic transect to provide multiple integrated benefits in one location. The performance of these other benefits enhance coastal flood risk management performance.

3.8. Focused Array of Alternative Plans

The measures that were screened and retained were used to develop a focused array of alternative plans consistent with the broad conceptual approaches of defend, accommodate, retreat, and hybrid; identify a phased adaptation approach; and incorporate NNBFs, as appropriate or possible.

Consistent with study guidance, the alternative plans were evaluated under three USACE RSLC scenarios: Low, Intermediate, and High. Coastal flood events have little variation in water surface elevation from small to extreme events, thus flood risk is primarily driven by RSLC in combination with coastal storms. The variation of scale and type of actions across alternatives was a strategic approach to assess the difference in performance under uncertain timing of RSLC. The economic analysis supported assessing the cost effectiveness of the risks of over- or under-building flood risk management features under each RSLC scenario. The resulting alternatives are:

Alternative A No Action

Alternative B Nonstructural

Alternatives C and D

Alternative C Defend, Scaled for Lower Risk

Alternative D Defend, Scaled for Low-Moderate Risk

Alternatives E, F, and G

Alternative E Defend Existing Shoreline, Scaled for Higher Risk

Alternative F Manage the Water, Scaled for Higher Risk

Alternative G Partial Retreat, Scaled for Higher Risk

Alternatives D, E, F, and G were all designed to be adaptive, with a second action occurring in 2090. This second action both increased the finish elevation of the structural measure, thereby providing a higher level of risk management, but also, in some cases, changed the alignment. The 2090 alignments were designed either to defend the shoreline (Alternative E), manage the water (Alternative F), or partially retreat from high-risk areas (Alternative G). As described above, the 2090 date for second actions was selected to allow for fair plan comparison; the MAP will be used to determine when second actions will actually be needed.

The alternatives were formulated to include a range of NNBFs that can dissipate wave energy and provide coastal storm risk reduction benefits (Appendix I: Engineering with Nature). Although additional NNBFs can support mitigation, these NNBFs have not been included in the alternatives.

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 3-8**.

Table 3-8: 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 **Table 3-9.** More detailed information on these alternatives can be found in *Appendix A: Plan Formulation*.

Table 3-9: Alternative Plans Features Summary

Alternative	2040 - 2089	2090 - 2140
A – No Action		
B – Nonstructural Variant 1: USACE Intermediate Curve Variant 2: USACE High Curve	Retreat assets exposed to the monthly coastal flood Floodproof (perimeter walls + dry floodproofing) assets exposed to 1% AEP coastal flood	
	<u>2040</u> Retreat: Floodproof: <u>2065</u> Retreat: Floodproof:	<u>2090</u> Retreat: Floodproof: <u>2115</u> Retreat: Floodproof:
C – Defend, Scaled for Lower Risk	Naturalized or embankment shorelines, earthen & paved (R1,2,3,4) ~ 16,000 LF Floodwalls (T-walls, sheetpile walls, concrete curbs) (R1,2,3,4)	NA

LOD primarily along existing shoreline (13.5' NAVD88)	Ground improvement Deployable closure structure ○ 3rd Street Bridge (R3) ○ 4th Street Bridge (R3) Elevated bridge ○ Illinois Street Bridge (R4) Ecological Armoring (R3,4) Perimeter walls on piers (R1,2,3) Raised/rebuilt wharf (R3 - South Beach Harbor only) Floodproof buildings <10 Elevated building <5 Demo buildings <10 Inland drainage modifications	
D – Defend, Scaled for Low-Moderate Risk *LOD primarily along existing shoreline (13.5' NAVD88, adapts to 15.5')*	Naturalized or embankment shorelines earthen & paved (R3,4) Floodwalls (T-walls, sheetpile walls, concrete curbs) (R1,2,3,4) Ground improvement Deployable closure structures ○ 3rd Street Bridge (R3) ○ 4th Street Bridge (R3) ○ Illinois Street Bridge (R4) Ecological armoring (R4) Ecotone levees (R3,4) Wetland preservation and restoration (R4) Perimeter walls on piers (R1,2,3) Raised/rebuilt wharf (R3 – harbor only, R4 – P90-92 only) Demo buildings <10 Inland drainage modifications	2' vertical extension (wall or added naturalized or embankment shoreline height) added to naturalized or embankment shoreline crests and floodwalls (R1,3,4) Raised/rebuilt wharves (R1,2, 3) Elevated bridges ○ 3rd Street Bridge (R3) ○ 4th Street Bridge (R3) ○ Illinois Street Bridge (R4) Ecological armoring (R4) Ecotone levee (R4)' Elevated buildings <20 Demo buildings <15
E – Hold the Line, Scaled for Higher Risk *LOD primarily along existing shoreline (15.5' NAVD88, adapts to 19')*	Naturalized or embankment shorelines* earthen & paved (R1,3,4) Seawalls/bulkhead walls* • w Fill (R1,2,3) • w/o Fill (R4) • *at Ferry Building, seawall along*	3.5' vertical extension (wall or added naturalized or embankment shoreline height) added to naturalized or embankment shoreline crests, floodwalls, and seawalls (R1,2,3,4)

• *<u>some shoreline extension</u> into Bay in R1,2,3* • <u>little/no retreat</u>	*bayside edge of bldg* Ground improvements – 67,500 cy Deployable closure structure • 3rd Street Bridge (R3) • 4th Street Bridge (R3) • Illinois Street Bridge (R4) Naturalized shoreline w/ space for wetland migration (R4 – Pier 94 Wetlands only) Perimeter walls on piers (R1,2,3) Raised/rebuilt wharves (R1,2,3,4) Elevated buildings <25 Demo buildings <30 Inland drainage modifications	Seawalls/bulkhead walls ○ w Fill (R2 – Rincon Park only) Elevated bridges ○ 3rd Street Bridge (R3) ○ 4th Street Bridge (R3) ○ Illinois Street Bridge (R4) Raised/rebuilt wharves (R1,2,3,4) Elevated buildings <25
F – Manage the Water, Scaled for Higher Risk *LOD primarily along existing shoreline (15.5' NAVD88, adapts to 19')* • *<u>more shoreline extension</u> into Bay in R1,2* • *<u>retreat</u> mostly on piers in R4*	Naturalized or embankment shorelines earthen & paved (R3,4) Floodwalls (R1) Seawalls/bulkhead walls • w Fill (R1,2,3) – *larger shoreline extension compared to E* • w/o Fill (R4) • *at Ferry Building, seawall further bayward of bldg* Ground improvements Water mgmt. structure (tide gates) (R3,4) Ecological armoring (R4) Ecotone levee (R4) Perimeter walls on piers (R1,2,3) Raised/rebuilt wharves (R3 - South Beach Harbor only) Floodproof buildings <25 Elevated buildings <20 Demo buildings <15 Inland drainage modifications	3.5' vertical extension (wall or added naturalized or embankment shoreline height) added to naturalized or embankment shoreline crests, floodwalls, and seawalls (R1,2,3,4) Ground improvements (R4 – where LOD moved further inland) Water mgmt. structure (permanently close the tide gates, add pumps) (R3,4) Ecotone levee with coarse beach (R3) Ecological armoring (R4) Wetland preservation and restoration (R4) Raised/rebuilt wharves (R3 - South Beach Harbor only) Demo buildings >45
G – Align with Watersheds, Scaled for Higher Risk	Naturalized or embankment shorelines* earthen & paved (R3,4) Floodwalls (R1,3,4)	2'-3.5' vertical extension (wall or added naturalized or embankment shoreline height) added to naturalized or embankment shoreline crests,

LOD primarily along existing shoreline (15.5-17' NAVD88, adapts to 19) • *little/no shoreline extension* • *more retreat in R4, esp. by 2090*	Seawalls/bulkhead walls • little/no fill (R1,2,3) • *at Ferry Building, seawall along landside edge of bldg* Ground improvements Elevated bridges ○ 3rd Street Bridge (R3) ○ 4th Street Bridge (R3) ○ Illinois Street Bridge (R4) Ecological armoring (R4) Ecotone levee (R4) Wetland preservation and restoration (R4) Perimeter walls on piers (R1,2,3) Raised/rebuilt wharves (R1,2,3) Floodproof buildings >45 Elevated buildings <20 Demo buildings <15 Inland drainage modifications	floodwalls, and seawalls (R1,2,3,4) Retreat some areas adjacent to creeks and construct new inland naturalized or embankment shorelines and floodwalls (R3,4) Ground improvements (R3,4) Wetland preservation and restoration (R3,4) Demo bridge (R4 – Illinois Street Bridge) – due to retreat of adjacent area Demo buildings >50

3.9. Evaluation of Focused Array

An NED evaluation of the focused array was conducted by the PDT. NED benefits were estimated with G2CRM and several important metrics outside of G2CRM, notably OMRR&R costs and the relative costs of future changes to the SFMTA transit system and the SFPUC combined sewer system under the FWOP and FWP scenarios.

3.9.1. Costs

Detailed cost estimates for the focused array of alternatives can be found in *Appendix C: Cost Engineering*. A summary of costs without seismic improvements are shown in **Table 3-10** and **Table 3-11**. Seismic improvement costs are not considered when calculating net benefits for this study, in accordance with the requirements of Section 152 of WRDA 2020, as amended.

Table 3-10: Reach-Level Construction Costs Without Seismic (2040) ($1,000s)

	1	2	3	4	Total
B Intermediate	16,196	20,685	319,421	47,679	403,981
B High	79,320	109,778	632,903	120,125	942,126
C	127,108	203,803	385,243	745,630	1,461,784
D	92,602	119,155	345,323	814,898	1,371,978
E	3,246,873	4,097,548	4,350,434	4,038,817	15,733,672
F	1,964,731	7,477,883	2,539,303	746,511	12,728,428
G	1,071,822	2,898,048	1,911,662	1,584,375	7,465,907

Table 3-11: Reach-Level Construction Costs Without Seismic, All Actions ($1,000s)

	1	2	3	4	Total
B Intermediate	32,985	78,264	409,445	73,384	594,078
B High	199,350	601,180	1,443,015	306,609	2,550,154
C	127,108	203,803	385,243	745,630	1,461,784
D	191,173	448,469	598,300	1,015,130	2,253,072
E	3,369,530	4,341,251	4,601,727	4,197,848	16,510,356
F	1,971,113	7,483,373	2,883,613	1,141,645	13,479,744
G	1,104,739	2,913,151	2,213,234	1,839,560	8,070,684

Though the seismic costs are not used in benefit calculation due to the WRDA language, they are still real costs that are incurred. Additionally, the amount of cost that is attributed to "seismic" is not equal across measures; some measures have a larger percentage of their total cost considered seismic while others have a lower percentage. For reference, **Table 3-12** and **Table 3-13** show the costs of the focused array of alternatives including seismic improvements.

Table 3-12: Reach-Level Construction Costs Including Seismic (2040) ($1,000s)

	1	2	3	4	Total
B Intermediate	$17,135,000	$74,209,000	$357,154,000	$59,917,000	508,415
B High	$108,463,000	$408,005,000	$1,086,188,000	$231,721,000	1,834,377
C	$674,705,000	$3,197,655,000	$1,571,509,000	$5,999,938,000	11,443,807

	1	2	3	4	Total
D	$588,950,000	$2,831,436,000	$1,536,074,000	$6,375,045,000	11,331,505
E	$3,698,638,000	$6,737,271,000	$5,500,928,000	$9,739,132,000	25,675,969
F	$2,483,870,000	$10,225,684,000	$3,117,809,000	$1,597,632,000	17,424,995
G	$1,515,981,000	$5,322,823,000	$2,792,752,000	$2,114,899,000	11,746,455

Table 3-13: Reach-Level Construction Costs Including Seismic, All Actions ($1,000s)

	1	2	3	4	Total
B Intermediate	$35,542,000	$82,445,000	$419,378,000	$76,164,000	613,529
B High	$214,659,000	$649,544,000	$1,524,279,000	$325,356,000	2,713,838
C	$676,120,000	$3,197,655,000	$1,571,509,000	$5,999,938,000	11,445,222
D	$703,735,000	$3,194,799,000	$1,819,786,000	$6,592,233,000	12,310,553
E	$3,846,161,000	$7,002,836,000	$5,778,338,000	$9,895,155,000	26,522,490
F	$2,504,141,000	$10,228,797,000	$3,487,741,000	$2,061,190,000	18,281,869
G	$1,545,799,000	$5,325,394,000	$3,233,646,000	$2,456,292,000	12,561,131

3.9.2. NED Evaluation

An NED evaluation of the alternatives was conducted waterfront-wide (i.e., for all four reaches together) to identify the NED plan for each RSLC. *Appendix A: Plan Formulation* presents the details of the NED plan evaluation. The NED plans under each RSLC curve are shown in **Table 3-14**.

Table 3-3-14: NED Plan Under Each RSLC Curve

USACE RSLC Curve	NED Plan
Low	A – No Action
Intermediate	B
High	G

3.10. Final Array of Alternatives

As discussed previously, the alternatives in the focused array were evaluated on a waterfront-wide basis that combined all four reaches. For the final array, these alternatives were evaluated at the reach-level to support the total benefits analysis across all four P&G accounts, to develop a Total Net Benefits Plan (TNBP) to maximize net benefits across all benefit categories, as required by the January 5, 2021, Policy Directive - Comprehensive Documentation of Benefits in Decision Document.

The Final Array included the distinct approaches to the coastal flood risk problem in the study area that performed well across all three RSL scenarios. Alternative A was carried forward as the NED plan under the Low RSLC scenario and for purposes of comparing baseline conditions. Alternative B was carried forward as a cost effective and scalable plan, which was the NED plan under the Intermediate RSLC scenario. Alternative F was carried forward because the benefits and impacts were too close to screen from further consideration based on the level of analysis completed during the focused array phase. Accordingly, Alternative F warranted further consideration. Alternative G was carried forward as a cost-effective and scalable plan and is considered the NED Plan for the High RSLC scenario. The final array also includes Independent Measures for Consideration, which are further described in Section 3.13.5.

3.11. Evaluation of the Final Array

Typical feasibility studies identify a NED plan by reasonably maximizing net NED benefits and considering the P&G criteria and performance differences across RED, OSE, and EQ benefit accounts.

Recent policy guidance formally requires identification of a plan that reasonably maximizes total net benefits across all four accounts. In response, the PDT developed a framework for evaluating alternative plans in a total benefits context. Key portions of the process and evaluation are presented here, and a summary of the findings is presented in subsequent sections.

The complexity of the analysis, uncertainty of RSLC timing and scaling, and the compounding complication of factors such as seismic risk, necessitated the development of a framework to guide the analysis and PDT formulation of its recommendations. The process to evaluate the final array and identify a TNBP can be described in three steps:

- Step 1: Evaluate the Final Array
- Step 2: Compare the Final Array
- Step 3: Develop the TNBP

For the first step, Evaluate the Final Array, the PDT applied considerable effort to thoroughly define quantifiable metrics to correlate to the specific study objectives to support decision making in response to this policy. Most of the EQ and OSE benefits are not quantified in dollars, thus the criteria were developed to explore performance differences across plans and to support the developing practice.

The PDT quantitatively and/or qualitatively characterized NED, RED, OSE, and EQ benefits at three RSLC rates, by geographic reach wherever possible. This effort was taken to support the development of reach-level recommendations that would allow selecting the geographic reaches that performed the best for various RSLC scenarios from among the various alternatives in the Final Array.

This large array of metrics was defined to support evaluation and comparison across alternatives but was reduced to a subset of key decision drivers once the quantification was completed. Comparison of the metrics across alternatives illustrated that many did not show meaningful differences and would not influence plan selection, and thus were deleted to streamline the matrix management. Some were informative but did not reflect priority study purposes and were also deleted from the matrix but referenced for descriptive purposes where appropriate.

For the second step, Compare the Final Array, the PDT used a Total Benefits (TB) matrix with key decision drivers described above, including summaries of findings for each alternative by reach and RSLC. During this step, the impacts of over-investment and under-investment was analyzed by examining the robustness of each alternative under each RSLC scenario, lead times for subsequent adaptation actions, and coastal life safety and seismic performance. This analysis was referred to as ”regret” analysis, since overbuilding before risk requires investment and would be inefficient, yet deferring costs until increasing risk is evident may result in insufficient time to adapt.

For the third step, Identify the TNBP, the PDT developed an approach to heat-mapping the results to support identification of the TNBP, by reach, as further described below.

As described earlier in the plan formulation strategy, the alternatives were designed to address a target height of the dominant risk of higher water surface elevations as RSL rises. This formulation strategy was applied to provide insight about cost-effective performance of plans across time under uncertain risk.

The first comparison of the TB matrix confirmed several relatively intuitive expectations of plan performance and introduced a less obvious insight. NED benefits, which primarily consist of damages avoided, vary as exposure to flood risk is reduced. NED and RED damages are damages avoided and business and regional activities that are disrupted following a flood event.

All metrics vary based on exposure to flood risk, or in other words, metrics vary across alternative depending on whether assets are located inside or outside of the LOD. Meaningful differences of metrics across alternatives were evident in benefit metrics that are not correlated with the NED benefits, which primarily consist of damages avoided.

Identification of a TNBP required multiple rounds of analysis of plan performance and refinements to identify a plan that best addresses uncertain timing of risk over the POA. The resulting range of multiple scales of actions that can address increasing risk over the POA is a resilience strategy, and the resulting TNBP is a subset of those actions that can be constructed in the near term and adapted later as suggested by monitoring of sea level rise and climate conditions.

The TB matrix measured the four benefit accounts based on exposure to flood hazard and informed the relative performance of plan components and comparison of alternative plans. The factors that led to selecting the TNBP by reach for each RSLC and the timing of investments to produce benefits and accept tradeoffs were seismic life safety, historical district preservation, minimizing construction disruption, concerns with acceptability, and preservation of maritime activity.

3.11.1. Total Benefits Evaluation

The evaluation of the focused array specifically evaluated NED benefits, which stem from:

- preventing retreat, preventing inundation losses
- protecting the various existing networks in the study area (SFMTA, SFPUC, and the existing coastal defense system)

RED, OSE, and EQ benefits are discussed comprehensively in *Appendix E*: *Economic and Social Considerations*. This section describes how these categories were evaluated comprehensively as part of a total benefits evaluation.

3.11.2. Decision Drivers

As described previously, the USACE evaluation process now includes the comprehensive documentation of all benefits as part of the decision-making process and the identification of a TNBP. A key consideration was to identify the metrics that would drive decision-making and comparative analysis. After the quantification of the RED, OSE, and EQ metrics, the PDT created a “decision drivers” matrix to help visualize the metrics by plan, reach, and SLC curve. The decision drivers matrix included only a subset of the RED and OSE metrics quantified. Working with a smaller number of metrics was assumed to simplify decision making, and metrics were removed from consideration for a variety of reasons:

- The metric didn’t change between the FWOP and any of the FWP conditions. This occurred when the damage arose outside the LODs (meaning there would be no change from the FWOP to the FWP) or if there were no damages seen in the FWOP or FWP (for instance, maritime losses were considered but were minimal in the FWOP, meaning there could be no significant difference in the FWP).
- The metric was determined to not be as important as other metrics to the PDT. This was not possible to determine before seeing the FWOP and FWP impacts. However, in some cases, the PDT could say that the difference in impacts was not worth justifying a tradeoff of NED benefits or project performance. For example, the RED metrics, while critically important to those who suffer RED losses, were determined to not support robust decision making, although they were imperative for describing the FWOP and FWP conditions.

Within the decision drivers matrix, individual cells were shown with a color and a number to show the comparative value for each metric under each alternative under each SLC curve. This was purely to allow for a simplified evaluation of metrics at a glance; robust decision-making requires a deeper understanding of these impacts and the comparison provides information for overall performance to the decision maker. The

Economics team facilitated conversations with the full PDT about how to assess performance across the metrics to consider in development of a TNBP in combination with additional information (actual magnitude of effects, when impacts would be expected, etc.) to support the use of the matrices. The colors and numbers, then, allow the viewer to see where plans differ, but that is not a sufficient condition to making a decision.

The final decision drivers are presented in **Table 3-15**.

Table 3-15: Decision Drivers

Category	Items	Metric
NED Account		
Benefits	FWOP Minus Residual Risk	Dollars ($)
Costs	Total Construction Cost	$
Efficiency	BCR	BCR
Return on Investment	Net Benefits	$
Residual Damages	Residual Damages	$
RED Account		
Business Economic Disruptions	Reduced Business Disruption Benefits	$
OSE Account		
Health and Safety	Coastal Life Safety Risk (Overtopping)	Score/Ranking Scheme
	Seismic Life Safety Risk and Resilience	Score/Ranking Scheme
Economic Vitality	Job Protection	Variance from FWOP
	Maritime Metrics	Score/Ranking Scheme
Social Connectedness	Public Transit Mobility	Score/Ranking Scheme
Community Identity	Community and Cultural Assets	Assets (number)
	Historic Asset and District Designation	Score/Ranking Scheme
Social Vulnerability and Resiliency	Vulnerable Population Exposure	People (number)/Score
	Disproportionate Effects on Vulnerable Communities	Score/Ranking Scheme
	Permanently Displaced Population	People (number)
	Compromised Disaster Response Sites	Sites (number)
	Affordable Housing	Affordable Housing Units (number)
EQ Account		
Physical Environment	HTRW Contaminated Sites	% Exposure Reduced
	Carbon Sequestration	MTCO2e
	Water Quality	Score/Ranking Scheme
	Wave Runup Reduction (EWN)	Linear Feet

Biological Environment	NNBF	Acres
	Threatened and Endangered Species	Species Benefited (number)

3.11.3. Total Benefits Matrix

For each RSLC, a total benefits (TB) matrix was created to capture the multiple benefits across NED, RED, OSE, and EQ accounts to support evaluation of the alternatives against study objectives at the plan level and at the individual reach level. The TB matrices can be found in *Appendix A: Plan Formulation*. The multiple benefits were numerically scored in units appropriate to the metric, and the relative difference in performance by alternative for each metric was reflected with color codes to support plan comparisons and tradeoff considerations. The differences across plans were applied as a deliberative tool, not a deterministic tool.

3.11.4. Total Net Benefits Plan

The TNBP was created by comparing performance of the alternative plans for each reach under each RSLC scenario and across the RSLC scenarios to assess the best series of actions to maximize benefits across all four accounts and meet the study objectives. Adaptability of the plan components over 100 years is the critical study consideration to ensure that a plan can best address risk under uncertain timing of RSLC. Although adaptation has been simplified to reflect implementation in 2090 to model the benefits and costs a MAP will be developed to define risk triggers to clarify the appropriate scale, alignment, and timing of the adaptation. This resiliency requirement drives the TNBP to include multiple potential adaptations to address many potential risk scenarios over the study period. The TNBP was formulated as a Resilience Strategy, to create a continuum of potential plan adaptations to a changing risk scenario.

The TNBP can differ from the NED plan due to:

- Maximizing net benefits across the four accounts
- Holistic approach to multiple hazards along the waterfront, and multiple Federal agency missions
- Emphasis on adaptation planning (selecting alternatives for their overall ability to function with next actions in mind)
- Early impact analysis and feedback from City agencies
- Regulatory risks to permitting, construction, and cost

As noted earlier, the NED plan is selected by subtracting the costs of the alternatives from the NED benefits by alternative to find which plan has the highest net benefits. Identification of the TNBP is not as straightforward. The January 5, 2021, Policy Directive - Comprehensive Documentation of Benefits in Decision Document states the need to determine *“a plan that maximizes net total benefits across all benefit categories,”* but because benefits are non-monetary while the costs remain monetary, they cannot simply be subtracted from each other to determine the net total benefits plan. Additionally, these metrics must be considered across the various RSLC curves.

The TNBP was developed by considering available benefits in a three-step process to assess efficient flood risk reduction under uncertain timing of risk and to assess tradeoffs of net NED benefits to achieve more benefits across other benefit categories that are consistent with stated study objectives. The three steps that incrementally analyzed available tradeoffs were:

1) Consider what plan features would maximize NED benefits without a specified RSLC scenario.
2) Consider overall value of higher net benefits (correlated with) NED based on alignment: Provide risk management to greater study area population and achieve OSE benefits to offset the loss of net NED benefits as cost of alternative increases.
3) Consider justification of specific tradeoffs in timing or actions to achieve benefits that are not correlated with NED benefits: Greater investment earlier in Reach 2 and Reach 4 to avoid disruptions and achieve OSE benefits consistent with Study objectives.

Details on the development of the TNBP can be found in *Appendix A: Plan Formulation*.

3.12. Plan Selection

The TNBP was selected as the TSP. The TNBP was developed by varying plan features and alignments by reach to achieve benefits across all four benefit categories and includes risk reduction strategies that do not maximize net NED benefits, but that support adaptability under uncertain timing of RSLC. The TNBP reasonably maximizes net benefits across all four accounts, including EQ and OSE benefit categories. EQ benefits address non-monetary effects on significant natural resources. OSE benefits are social well-being factors that influence personal and group satisfaction, well-being, happiness, public health and safety, equity, vulnerable populations, and disaster response. The TNBP is a better plan than the NED Plan under each RSLC scenario because it facilitates adaptation to achieve cost-effective risk reduction, and supports multiple study area functions over the POA, and is appropriately proposed as the TSP. The reaches where the TNBP selection differs from the NED scale approach for that reach is based upon three broad categories of justifications, listed in priority order:

a) Life Safety: The scales and alignments of measures included in the TNBP to manage flood risk also manage life safety risk from seismic events for users of piers and other structures that are better able to withstand seismic events as a function of the coastal flood risk structural actions.

b) Cost Effectiveness: Given the probability that RSLC will increase flood risk during the 100-year POA, cost effectiveness of the risk reduction strategy was assessed in a two-step evaluation:

- Net benefits of strategy quantified in terms of flood risk damages avoided over the POA, and professional judgment of the ancillary reduction in multi-hazard risk reduction that is not captured within dollar denominated metrics.
- Adaptability of measure to align additional height or changed alignment to the initial scale of the plan, to achieve cost-effective risk reduction as RSLC increases over the POA. Adaptation is a necessary component of a cost-effective risk reduction strategy under uncertain timing of RSLC.
- Construction and subsequent adaptations that would temporarily disrupt communities, transit and economic activities were considered for their overall impacts and influenced the timing and scale of plan selections to be efficient and reduce impacts. This consideration was considered in light of the probability that RSLC will increase flood risk during the 100-year POA.

c) Consistency with USACE objectives to address life safety and regional objectives that emphasize risk reduction in combination with community resilience characteristics, that include:

- Reducing life safety risk from multiple hazards and supporting emergency and disaster response capabilities.
- Addressing disparities in the impacts of all hazards.
- Helping residents and businesses stay and thrive in San Francisco.
- Restoring and leveraging local ecosystems to help mitigate hazards and support climate adaptation.

The initial action was selected to ensure flood risk is reduced without over-investment, in initial years. Additionally, the total net benefits and adaptive capacity of the initial action were considered in selection. In areas where there was little immediate flood risk, a scaled down version of nonstructural measures would reduce risk to structures and contents. In areas with high potential for multiple, non-monetized benefit streams proactive investment in larger coastal flood risk management alternatives are recommended. The discussion in the previous section suggests potential changes to the strategy that attempts to maximize net NED benefits. The leading reasons for these are:

- RED and OSE benefits correlated with flood risk may support Alternative E in the Southern Waterfront because its alignment is more bayward than Alternative G and, as such, it provides more protection for more assets, land, and people.
- Nonstructural alternatives prevent physical damage but do an incomplete job of preventing RED and OSE losses that may stem from disruption. This may support structural instead of nonstructural first actions in Reaches 1 and 4.

- Vulnerable communities in Reach 4 who live and work around Pier 94-96 and Heron's Head may be impacted by flooding in ways that a nonstructural solution does not mitigate. Disadvantaged communities have less resilience to these impacts; this can be thought of as a "multiplier effect" to the disruption impact discussed above.
- Seismic concerns in all four Reaches may support replacement of wharves, providing life safety benefits and extending the life of some culturally significant landmarks. Replacing wharves also presents the opportunity to preserve maritime berths across the waterfront.
- Resiliency concerns in all four Reaches may support larger construction earlier in the project timeframe, ensuring that measures are resilient throughout the POA. This is the opposite of lining up costs and benefits in time.
- Disaster response assets may not function in areas where nonstructural solutions are chosen. In Reach 4, there are disaster response assets that will face vulnerability in 2040, including assets located by Piers 92 and 94-96 by Islais Creek and Heron's Head Park.
- Major disruptions from construction problems should be avoided if possible. One way to do this is by building adaptable structures or building resilient structures that provide sufficient defense regardless of SLC curve. This is particularly important in Reach 2, where the Embarcadero, a major transportation corridor, will be impacted by construction.
- Structural (Alternative D) in Reaches 1 and 4 instead of nonstructural (Alternative B) as an initial action. This buys down the RED and OSE risks from disruption and provides particular benefit to disadvantaged communities in Reach 4.
- Alternative E as a 2nd Action under the High SLC Curve in Reaches 3 and 4. This reaps the benefits of not retreating from the waterfront, thus protecting businesses, people, maritime function, and disaster response assets.
- Alternative E or G as a 1st Action in Reaches 1 through 4. This provides resiliency to the waterfront against all rates of SLC and provides the most seismic life safety and maritime benefits. This will also mean that a 2nd major construction will be avoided under the High SLC curve because the larger initial actions can be more easily adapted to a higher crest elevation.

The bullets above imply that there are cost-effective plans that achieve each of these goals and that these plans may differ from the plans that maximize net NED benefits. "Cost effectiveness" defines that, for each metric, there is a least-cost plan that achieves a desired level of output.

Note that neither Alternative C nor Alternative F are mentioned above. For Alternative C, this is because of its lack of adaptability, implying it is not a plan that will provide good outcomes under all rates of RSLC. For Alternative F, it is because of the acceptability concerns the water management structures including tide gates across the two creeks (Mission and Islais). The City Resource Agencies and the NFS voiced concerns that these structures would impact HTRW sites, create water quality concerns and opposition from regulatory agencies and run into serious public opposition. For further acceptability concerns, see Appendix A, Plan Formulation Sections A.8 and A.9. Also, tide gates could influence water quality conditions by reducing tidal exchange and water connectivity that may have cascading effects including but not limited to lower dissolved oxygen, high nutrient concentrations, and intensified algal blooms (Chen and Orton 2023; Zhao et al. 2020; Choudri et al. 2015; Paalvast and van der Velde 2014). See Appendix D-1 Environmental and Cultural, Section 5.12.5 for further details.

The PDT decided first that Alternative E would be a better 2nd action than Alternative G in Reaches 3 and 4. This decision was made knowing that the net NED benefits between Alternative E 2nd action and Alternative G 2nd action are reasonably close (Alternative G had $100 million more in net benefits in Reach 3 and $400 million in Reach 4). Alternative E protects 292 assets that Alternative G would retreat from (195 in Reach 3 and 97 in Reach 4), but that also means that thousands of people will be saved from impact, millions in RED benefits will be saved (190 of the assets in the area that would be retreated from are commercial or industrial), and in Reach 4, disadvantaged communities won't have their homes and jobs displaced. The differences in OSE and RED benefits between Alternative E and Alternative G are described in more detail in *Appendix E: Economic and Social Considerations*.

Additionally, the PDT intends to refine Alternative E post-draft report. Lessons learned during the design of Alternatives E, F, and G provided more insight into ways to align and construct a cost-effective plan. Leveraging these lessons is expected to lead to a lower-cost plan with minimal changes in benefits with hybridizations on the sub-reach level.

When considering whether to "go big" with the first action in the name of resiliency, the PDT had to evaluate how feasible doing multiple adaptive actions was. If a first action could be a smaller construction but a larger coastal defense system can be brought online in response to the High rate of SLC, then the costs of the larger construction are not worth incurring up front. When discussing replacing the wharves for maritime and life safety benefits (another benefit of "going big" early), the PDT decided that these benefits were small (in the life safety category) or could be deferred to the later time period (for maritime benefits). As such, incurring the additional cost in 2040 to build a larger plan is not expected to maximize net total benefits.

A major exception to this is in Reach 2. In Reach 2, the seismic life safety risk is considered more severe due to the number of occupants in seismically vulnerable structures in the wharf zone and the Embarcadero's function as a lifeline for the city. The construction disruption is expected to be most impactful in Reach 2 because construction will impact the Embarcadero, likely shutting down lanes of traffic and impacting public transportation and key city-serving utility systems such as the transport/storage boxes for stormwater. Mitigating this risk by building something comprehensive instead of impacting the Embarcadero multiple times with construction is a large benefit to the city. As such, Alternative G is recommended as the 1st action in Reach 2.

The PDT had to decide whether nonstructural or structural was the correct 1st action in Reaches 1 and 4 because nonstructural maximized net NED benefits while structural presented numerous other sources of benefits in the RED and OSE categories. This difficult decision came down to the number of exposed assets at various flood heights, composition of those assets, number of people exposed, and existing resiliency of the communities. With these factors in mind, it was decided that Alternative B would remain the first action for Reach 1 while Alternative D would maximize net total benefits in Reach 4.

The TNBP first and second actions are shown in **Table 3-16**.

Table 3-16: TNBP First and Second Actions

Reach	First Action All RSLCs	Second Action Low RSLC	Second Action Intermediate RSLC	Second Action High RSLC
1	Alternative B	N/A	Alternative B (Additional NS)	Alternative G 19’
2	Alternative G 15.5’	N/A	N/A	Alternative G 19’
3	Alternative D 13.5’	N/A	Alternative D 15.5’	Alternative E 19’
4	Alternative D 13.5’	N/A	Alternative D 15.5’	Alternative E 19’

3.13. Plan Refinement and Value Engineering After TSP

In alignment with USACE guidance on the SMART Planning process, the PDT made necessarily broad assumptions across multiple disciplines to arrive at the TSP milestone. 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. The Port-USACE PDT has identified potential considerations for refinement post-TSP that may reduce coastal flood risk and withstand seismic risk, reduce costs and impacts, and gain additional community benefits based on professional best judgement.

While it is standard practice within a feasibility study to consider such refinements post-TSP, the PDT recognizes the value of documenting and reflecting such considerations in this Draft Report as a means of transparency for all reviewers and to reflect considerations that were informed by public feedback on Alternatives A-G (which were shared with the public in October 2022) and early input from City staff and agency leaders, along with PDT professional best judgement.

The value engineering considerations for post-TSP refinement can be grouped in four broad categories based on their intent: reduce multi-hazard risk, reduce impacts to communities and the Bay, increase historic resource benefits, and increase public access and ecological benefits.

3.13.1. Reduce Multi-Hazard Risk

After receipt of public and agency comments on this Draft Report, the PDT may consider potential opportunities to increase multi-hazard risk reduction (coastal flood risk and seismic impacts, including consideration of aging infrastructure beyond its design lifespan) by adjusting the phasing approach to install more robust coastal flood defense structures (actions currently described as TSP “subsequent actions,” which have moderately higher crest elevation, among other benefits) in targeted locations as the TSP 1st actions. Such refinement may be considered especially where near-term coastal flood risk is high along or adjacent to the current shoreline and existing coastal flood defenses. Example areas include portions of Fisherman’s Wharf and the southern edge of Pier 96.

In addition, this approach for TSP refinement may be considered where the more robust actions can be achieved at a comparable cost, which may include portions of Mission Bay shoreline and portions of the Islais Creek channel banks, pending further analysis.

The identification of targeted areas appropriate for more robust coastal flood defenses earlier in time is in line with the overall phasing approach, balancing the need for urgent risk reduction in some areas with a monitoring, adaptation, and phasing plan which will be further defined post-TSP.

3.13.2. Reduce Impacts to Communities and the Bay

Further refinements to the TSP may include opportunities to reduce project impacts to communities and to the Bay. Based on professional judgement, opportunities to reduce impacts include 1) reduction or avoidance of new Bay fill (e.g., especially from the Bay Bridge through Mission Bay), and 2) reducing community disruption (primarily through phasing and implementation planning). Such refinements may also reduce costs and regulatory complexity, pending further analysis.

3.13.3. Increase Historic Resource Benefits

Further refinement of the TSP may include opportunities to increase risk reduction for and avoid impacts to key historic resources, including individual resources and components of group resources as listed in the National Register of Historic Places. One example could be to shift the alignment of the coastal flood defense structure to be adjacent to the bayside of the Ferry Building and Agriculture Building and replace the aging wharf substructure with a more robust basement structure (rather than on new raised wharves, as proposed in the current TSP), which would be designed in further detail during PED. Another opportunity would be to change the alignment of the TSP in Pier 70 to avoid demolitions of historic resources.

3.13.4. Increase Public Access and Ecological Benefits

Further refinement of the TSP may include opportunities to increase public access to the water and to open spaces, as well as opportunities for ecological benefits. In many cases, these measures may also contribute to coastal flood risk reduction (e.g., wave dissipation, erosion reduction) and the project's mitigation strategy. Examples may include living seawall features, planted naturalized or embankment shorelines in lieu of gray structures where appropriate (e.g., along portions of Mission Bay), and targeted pockets of retreat where it may prove feasible (e.g., southwest bank of Islais Creek) if desired by adjacent communities for access to the water and open space.

3.13.5. Independent Measures

The following list of "independent measures" represents a series of measures included in the NEPA analysis separately. Each measure was included (or was similar to a measure included) in one or more alternatives, but the given alternative as a whole was not proposed for inclusion in the TSP. These measures include:

- **Living Seawalls** (e.g., textured concrete on a vertical seawall) would be designed to reduce wave hazards while supporting nearshore ecology wherever current maritime uses and pier configurations allow. This measure was originally included in Alternative E (1st action) and is applicable to portions of Reaches 1, 2, and 3. Further detail available in Appendix I: Engineering with Nature
- **2A) Robust Coastal Defense of Ferry Building and Agriculture Building** would be designed to realign the coastal flood defense structure adjacent to the bayside edge of the Ferry Building and Agriculture Building. The structures could be raised in place with a basement structure or some solid fill underneath. This approach is anticipated to be preferable from a cost and engineering perspective. This is comparable to Alternative E (1st action) and may be considered in post-TSP refinement.
- **2B) Coarse Beach at Rincon Park** connecting to Pier 14 would be designed to reduce wave hazards, support nearshore ecology, and provide public water access. Some new Bay fill is included in this measure so as to address space constraints of the transportation network at this site. This measure is similar to the measure for this location included in Alternative F (1st action). Further detail available in Appendix I: Engineering with Nature
- **3A) Bay Bridge to South Beach Harbor Raised Shoreline with Rebuilt Wharves** from Bay Bridge to the mouth of Mission Creek, raise the current shoreline (rather than extending the shoreline into the Bay). This will require redesign of the northbound lanes of the Embarcadero roadway (in collaboration with SFMTA and the Embarcadero Enhancement Project), and the approach is intended to be designed to avoid reconstruction of the light rail track. This is comparable to Alternative G (2040) for this site.

- **3B) McCovey Cove North Curb Extension** raises the shoreline in line with the current shoreline edge on the north side of McCovey Cove (along the ballpark), rather than adding fill and extending the shoreline into the creek. This is comparable to Alternative G (1st action) for this site and may be considered in post-TSP refinement.
- **3C) Planted Naturalized or Embankment Shoreline on Mission Bay** south of Pier 50 would be designed to reduce wave hazards, support nearshore ecology, and provide public water access. This measure was originally included in alternative F (1st action) and may be considered in post-TSP refinement to reduce impacts to the Bay, potentially reduce cost, and increase comprehensive benefits.
- **4A) Inland Coastal Flood Defense at Southwest Islais Creek** would include conversion of some industrial lands and public facilities to provide public water access, open space, and ecological benefits. It would also result in more permanent flood risk reduction due to a small area of gradual retreat along the creek. This is comparable to Alternative G (2nd action) between 3rd Street Bridge and the inland extent of the channel and may be considered in post-TSP refinement.

4. Effects and Consequences of Alternative Plans*

This chapter describes the environmental consequences of alternatives carried forward for detailed analysis and comparison. The alternative analysis, presented in *Chapter 3: Plan Formulation and Evaluation*, identified several plans to be carried forward, including:

- No Action – NED Low SLR Curve
- Alternative B (Non-Structural) – NED Intermediate SLR Curve
- Alternative F
- Alternative G – NED High Curve
- Total Benefits Plan – TSP
- Independent Measures for Consideration

The conceptual strategies vary greatly amongst this range of alternative. This study must present environmental consequences of initial construction actions, as well as secondary adaptable actions that are planned to be implemented at a future time-step dependent on a pre-determined SLR threat threshold that would trigger the need for additional protection. Given the level of uncertainty in changes to existing conditions, technological advancements, and changes in regulations, the consequences in this chapter are presented as if the potential impacts apply to the existing conditions described in *Chapter 2: Existing and Future Without Project Conditions*. This impact analysis briefly describes adverse and beneficial impacts, identifies any unavoidable adverse impacts, and indicates any irreversible and irretrievable commitment of resources that would be valuable for comparing environmental impacts amongst alternatives.

In this Draft IFR/EIS, environmental consequences are reported in the aggregate for both first (2040) and second (2090) actions, which may have the effect of overstating consequences because the nature of second actions (and associated impacts) will vary depending on the rate of SLC. In the Final IFR/EIS, environmental impacts will be reported separately, based on recommended first and second actions.

As described in Appendix D-1, mitigation measures to minimize the environmental consequences of alternatives will be developed where possible. Further work is required to consult with resource agencies through the RAWG and with consulting parties through the Section 106 process to develop mitigation to further minimize environmental consequences.

This chapter is intended to provide a high-level comparison of the environmental consequences for each alternative. Additional, full descriptions of expected environmental impacts, including analyses and measure level details are provided in *Appendix D: Environmental and Cultural Resources*.

4.1. No-Action Alternative

Table 4-1 describes the impacts anticipated with the No Action Alternative, which is commensurate with the FWOP conditions, as described in *Chapter 2: Existing and Future Without Project Conditions*.

Table 4-1: Summary of Potential Impacts to Resources from the No Action Alternative

Resource	Summary of No Action Potential Impacts
Air Quality & Clean Air Act	The potential for emergency maintenance activities is expected to increase because of coastal flooding. Equipment and vehicles used for emergency maintenance activities would generate emissions and, thus, could expose receptors to increased pollutant concentrations. Future road closures would also be likely to increase emissions due to increased vehicle delays and congestion. Individuals displaced from their homes because of flooding may also experience increased health risks, particularly if they are relocated to areas with higher ambient air pollution or if they become unhoused.
Climate - GHG	The potential for emergency maintenance activities is expected to increase because of coastal flooding. Equipment and vehicles used for emergency maintenance activities would generate GHG emissions. Disruption of the electrical grid could also generate GHGs, particularly if replacement power sources, such as diesel generators, are fossil fueled.
Regional climate, climate change, RSLC	The trends described in the existing and future without project conditions (Chapter 2) would continue. Climate change could lead to increased ocean and terrestrial temperatures, ocean acidification, RSLC, duration and intensity of extreme events, weather patterns, and has the potential to cause changes in the nature and character of the bay waterfront. Climate change is expected to result in more intense and frequent extreme precipitation, droughts, and heat waves within the next century (NCA 2014, 2018; Ault et al. 2014; Ault et al. 2016; Cook et al. 2016; Jones and Gutzler 2016). This is likely to cause flooding, erosion, and increases in the rate and amount of nutrients and sediments entering the bay.
Geology	No significant impacts are expected on the underlying geology or geologic processes, only minimal changes to the topographic features, geologic formations, and soils in the study area would be expected.
Geology - Sediments	No significant impacts are expected on the underlying sediment type. Sediment quality would continue to be impacted due to coastal flooding which potentially introduces contaminants into surface waters and nearby waterbodies. There is also the potential for contaminants to become trapped in sediments over time.

Resource	Summary of No Action Potential Impacts
Geology - Seismicity	The current risk from a seismic event would continue into the future which could affect life safety, infrastructure disaster response and recovery, maritime commerce, commerce, utilities, transportation, historic resources, environment (contamination), land use, recreational areas, and the economy (MHRA 2020). However, current zone, building codes, and policies would minimize some of the risk for buildings/constructions subject to those policies.
Soils & Mineral Resources	Soils and mineral resources are expected to continue as described in the existing and future without project conditions chapter (Chapter 2). Future exploration and production of oil, gas, and minerals within the study area is highly dependent on market conditions, value of existing resources, presence of production fields, and future development. It is unlikely that urbanized areas would see any increase in oil and gas production.
Hydrology & Hydraulics - Floodplains	The study area would continue to be at risk of flooding and could become more at risk due to RSLC and climate change. Without local or non-Federal interventions, it is expected that nuisance flooding in low-lying areas would continue, where the potential impacts from tidal and/or rainfall flooding would likely increase and worsen over time with climate change and RSLC. Coastal hazards such as wave overtopping, and storm surge is expected to increase over time with climate change and RSLC which would lead to more catastrophic flooding.
Hydrology & Hydraulics - Coastal hydrology, currents, & circulation	RSLC would likely increase flooding and wave hazards, resulting in increased soil erosion, modifications to the shoreline, and release of contaminants. RSLC rates may also exceed normal sediment accretion rates in saline marshes resulting in increased inundation and subsidence. Hydrology patterns may be impacted as continued water temperatures rise and trends in the Pacific Ocean circulation patterns change.
Hydrology & Hydraulics - Tides, tidal exchange, & waves	No significant impact to tides is expected. Tidal exchange and range, and wave hazards may be impacted based on RSLC whereby threats from wave hazards increase.
Hydrology & Hydraulics - Stormwater	Climate change, including more frequent and intense storms and flooding events, can increase stormwater runoff. An increase in stormwater runoff can exacerbate existing, or introduce new, contaminants into water sources and soils. Increased precipitation could overwhelm the study area's municipal stormwater management system, which can lead to backups that cause localized flooding or greater runoff of contaminants (e.g., trash, nutrients, bacteria) in waterways and soils (EPA 2023).
Water Quality	Current water quality trends could improve with changes in land use or improve through implementation of new water quality improvement programs such as TMDLs administered by Federal, state, and local agencies. However, with the existing status of water quality in the study area, it is more likely that conditions would worsen with increased flooding associated with climate change and RSLC. Increased flooding would lead to more runoff, potentially carrying contaminants, thereby lowering water quality. Climate change and RSLC introduce uncertainty of continued trends where changes in temperature, precipitation, chemical composition (e.g., ocean acidification), and increases in salinity could also impact water quality.
Groundwater	Groundwater may be significantly impacted by RSLC by causing groundwater elevations to rise.

Resource	Summary of No Action Potential Impacts
Aquatic Resources - Intertidal habitat	Intertidal habitats are expected to continue as described in the existing and future without project conditions chapter (Chapter 2). With climate change and RSLC, there could be an increase in intertidal habitats as fringe marshes and low-lying vegetated areas are converted.
Aquatic Resources - Subtidal habitat	Subtidal habitats are expected to continue as described in the existing and future without project conditions chapter (Chapter 2). With climate change and RSLC, there could be an increase in subtidal habitats as fringe marshes and low-lying vegetated areas are converted. RSLC could also potentially impact subtidal habitat suitability by increasing water depths resulting in reduced productivity and exposure to tidal exchange.
Aquatic Resources - Pelagic habitat	Changes in water quality (e.g., temperature, salinity, DO), flow patterns, and habitat due to extreme events could degrade pelagic habitat quality. Climate change could cause a shift in plankton and benthic communities which are food sources for pelagic fish and mammal species.
Aquatic Resources - Wetlands	Continued wetland losses and degradation through erosion and degrading water quality. Complete loss of Heron's Head Park wetlands and valuable habitat for threatened and endangered (T&E) species.
Aquatic Resources - Fish	Changes in water quality (e.g., salinity, dissolved oxygen) and flow patterns could disrupt fish use and cause a shift in prey availability. Fish could be impacted by increasing water temperature and ocean acidification which are anticipated to continue under climate change.
Aquatic Resources - Commercial & Recreational Fisheries	Potential impacts to commercial and recreational fisheries include changes in species abundance and diversity due to direct and indirect impacts from flooding, RSLC, and climate change. Risk of coastal flooding and hazard increases may impact facilities that support commercial and recreational fishing thereby limiting ability to fish.
Aquatic Resources - Macroinvertebrates	Changes in water quality (e.g., salinity, dissolved oxygen) could disrupt invertebrates and cause a shift in abundance or species diversity. Invertebrates could be impacted by increasing water temperature and ocean acidification which are anticipated to continue under climate change.
Upland Resources - Terrestrial vegetation	Existing land use trends are expected to continue as described in the existing and future without project conditions chapter (Chapter 2). The study area is highly urbanized with limited availability of terrestrial vegetation. RSLC may convert some lower lying upland areas to wetlands or subtidal and/or intertidal habitats.
Special Status Species - T&E Species Terrestrial	RSLC may convert some lower lying upland areas to wetlands or subtidal and/or intertidal habitats which would reduce the space available for T&E terrestrial species. This may impact important foraging habitats for Ridgway's rail, refuge for salt marsh harvest mice, and available space for California seablite. RSLC may directly impact wetlands and intertidal habitats where erosion is persistent, which impacts foraging and nesting habitat for Ridgway's rail. Increased flooding from climate change, and erosion and subsidence from RSLC, may also lead to conversion of wetland habitats to intertidal habitats and loss of low-lying upland habitats that are necessary transition areas for species such as salt marsh harvest mice.

Resource	Summary of No Action Potential Impacts
Special Status Species - T&E Species Aquatic	Climate change and RSLC may impact available foraging habitats for green sturgeon. Warming water temperatures can influence egg development and hatching rate, which may have more detrimental effects to the overall recovery of the species (NMFS 2022). Changes in flow patterns or currents may change the behavior of green sturgeon in marine environments which could make them more susceptible to human activities such as dredging and bottom disturbances (NMFS 2022). Climate change and warming water temperatures could shift prey availability for salmon and steelhead trout, as well as endangered marine mammals. Ocean acidification could have negative impacts on protected shellfish.
Special Status Species - State listed species	Continued habitat loss would reduce the space available for state listed terrestrial species, while water quality degradation is likely to contribute to loss or shift in distribution of aquatic species. The study area is highly urbanized so any continued loss in habitat may prove to have significant impacts on the distribution and abundance of state listed species. Climate change and RSLC would increase flooding in the study area which disturbs available terrestrial habitat, wetlands, and can lead to water quality degradation (e.g., lowered DO, contaminants). Additionally, increases in water temperature or salinity may also impact state listed aquatic species ability to thrive or reside in the bay.
Special Status Species - Designated Critical Habitat	Designated CH for green sturgeon and Chinook salmon in the study area would continue to be impacted by climate change, RSLC, and maritime use.
Special Status Species - Migratory Bird Treaty Act Species	The Bay is critical stop over habitat for migratory bird species. Climate change and RSLC may exacerbate conditions for some of these species by contributing to loss of critical habitat.
Special Status Species - Bald & Golden Eagles	Bald and Golden Eagles have been viewed at Heron’s Head Park and within the study area; however, impacts are unlikely within the study area.
Special Status Species - Marine Mammal Protection Act Species	Climate change and RSLC may exacerbate conditions for marine mammal species migrations and habitat use from rising seawater temperatures and ocean acidification. It is uncertain, but plausible, that long-term habitat changes would have indirect effects on prey availability.
Special Status Species - EFH & EFH-designated species	EFH impacts would be focused on loss of shallow nearshore areas including submerged aquatic vegetation (SAV). The study area supports a diverse fish community including EFH. Shellfish resources are being impacted by ocean acidification and water quality degradation which would continue with climate change and frequent flooding. Impacts to water quality during storm events would occur in addition to the changes in temperature, precipitation, flooding patterns, and chemical composition over time.
Special Status Species - HAPC	HAPC impacts would be focused on degradation of the quality of habitat through ocean acidification driven by climate change. More frequent flooding would increase contaminants delivery to HAPC which would reduce water quality.

Resource	Summary of No Action Potential Impacts
Special Status Species - SAV – Eelgrass	Due to the urbanized nature of the shoreline and water quality degradation, the amount of SAV has been greatly diminished in the study area over time. Climate change and RSLC introduce greater uncertainty of continued trends where changes in temperature, precipitation, flooding patterns, and chemical composition could impose additional impacts on water quality, algal blooms and SAV/macroalgae distribution and abundance. RSLC could also potentially impact habitat suitability for seagrasses by increasing water depths resulting in reduced light penetration, photosynthesis, and productivity (Strange 2008; USACE 2014).
Coastal Zone Management Act (CZMA) Areas	CZMA areas within the study area are extensive and would continue to be impacted by coastal flooding and the increasing threats of climate change and RSLC.
Coastal Barrier Resources System Areas	No impact as Coastal Barrier Resource System Areas are not designated within the study area.
Noise & Vibration - Noise	Emergency flood defense and response, and cleanup actions would require the use of a considerable amount of heavy equipment, which would generate noise. Buildings and infrastructure damaged by flooding would need to be demolished and the services provided would need to be relocated to other areas of the city, requiring new construction. The use of heavy equipment for flood defense on an emergency basis would very likely be substantial and could be any hour of the day or night. As such, there is a high potential for sleep interference due to emergency flood-defense and response activities. Equipment noise from redevelopment could occur at any scale or location within the city and, as such, impacts of construction noise would be expected.
Noise & Vibration - Vibration	Heavy equipment types used for flood defense and demolition would create a perceptible level of vibration in the immediate vicinity of the equipment. It is unlikely that high-impact equipment, such as pile drivers, would be used for these types of activities, although jackhammers and hoe rams may be used for demolition. The relocation of services and properties would use heavy equipment that may potentially produce vibration near sensitive receptors and historic buildings that are more susceptible to building damage. The frequency and duration of these activities would be commensurate with flooding events, which could occur on an emergency basis within residential areas with a high risk or flooding. In situations where deep support systems are needed for building foundations, vibratory or impact pile driving may be used.
Cultural Resources	Taking no action to prevent water intrusion into the San Francisco waterfront would degrade the access and use of historic properties as well as contribute to physical impacts and potential loss of resources in the Area of Potential Effect. Impacts would consist of erosion from wave energy and inundation. Resources in low-lying areas are at highest risk for adverse effects from the No Action Alternative. Resources along the waterfront in the Marina and Northeast planning districts would be at risk of flooding, particularly Fisherman’s Wharf and The Embarcadero. Identified resources in the Mission, South of Market, and South Bayshore planning district are at the highest risk for adverse effects as they are currently the lowest-lying areas and already experience flooding.

Resource	Summary of No Action Potential Impacts
Cultural Resources - Native American lands	Because no traditional cultural properties have been identified at this time, there would be no or negligible impact.
Environmental Justice	Overall, while the No Action would generate adverse effects, the distribution of these effects (displacement and flooding) would be dispersed throughout the study area. Therefore, the adverse environmental effects under the No Action would not be disproportionally felt by a minority or low-income population.
Socioeconomics & community	Flooding events would physically divide the waterfront neighborhoods, inhibiting community function and interaction throughout every reach, cause the displacement of various structures including residences, commercial and industrial businesses, and community and public facilities in every reach. These events would have a substantial adverse effect on economics, with the coastal neighborhoods experiencing loss in employment, school district funding, and county and city property and sales tax revenues.
Transportation	Several important transportation corridors would be impacted by rising sea levels and flooding that carry or provide access to vehicles, transit users (rail, bus, and ferry), bicyclists and pedestrians. Flooding and associated freeway on- and off-ramp, road, sidewalk, and bike path closures and repairs would become increasingly common and gradual retreat of these facilities is expected to occur over time as RSLC continues. There would also be several transportation facilities for maintenance and operations such as the MUNI Municipal East facility that would be subject to flooding and infrastructure affected that would lead to a high degradation of transit by the end of century (SFMTA, 2022).
Utilities	The reliability of potable water is necessary for many industries in the study area. Climate change could lead to a short-term or long-term water shortage which could significantly impact potable water-dependent industries. RSLC would continue to stress the water main system, requiring increased investment into utilities such as sewage and potable water. Corrosion from rising groundwater could shorten life expectancy of buried pipes and require more frequent inspection or replacement. If buried pipelines are compromised, saltwater infiltration from increased groundwater levels may occur and affect the quality of drinking water. Increased precipitation would challenge the study area's combined stormwater and wastewater drainage system, potentially leading to more combined sewer overflows. An increase in sewer overflows can reduce water quality (EPA 2023).
Recreation & Access	The study area would continue to be at risk of flooding and could become more at risk due to RSLC and climate change, which may impede the public's access to recreation areas. Access to the waterfront is critical for the public in the study area but flooding under RSLC may render it inaccessible. Additionally, loss of important natural recreation areas would be expected with climate change due to erosion and subsidence. Access to local piers and wharves may be temporarily inaccessible with nuisance flooding or lost with repeated storms and RSLC.

Resource	Summary of No Action Potential Impacts
Aesthetics	The aesthetics are expected to continue as described in the existing and future without project conditions chapter (Chapter 2) over time. No significant impacts are expected to the aesthetics in the study area, though climate change and/or RSLC could cause damage to structures that contribute to the aesthetics of the waterfront from repeated nuisance flooding or more significantly from storms.
HTRW	Capped and un-capped HTRW areas would be exposed to flooding and erosion from RSLC, which could result in releasing contaminants that impact water, soil, and sediment quality, as well as human health.
Land Use	Land use changes would occur either directly or indirectly as the sea levels rise. As the water levels begin to encroach into the developed waterfront, some buildings and uses are expected to be abandoned in these flooded parcels. From this retreat away from the San Francisco Bay, other parcels may alter their land use due to decreased access or connectivity from regular flooding, and transition to a land use that is better able to accommodate flooding or reduced connections. Although floodproofing some buildings can delay retreat, substantial changes to buildings, building demolition, and movement of residences, businesses, and industrial/institutional uses would be expected particularly in the Mission Creek and Islais Creek low-lying areas. Land uses included in current general plans, specific area plans, and zoning may not be achievable in the increasingly inundated locations, and planning for where these uses may instead be accommodated would be needed.
Public Health & Safety	The study area would continue to be at risk of flooding and could become more at risk due to RSLC and climate change, which may impede the publics access to critical safety infrastructures (i.e., hospitals) or the ability of public safety entities (i.e., ambulance, police) to aid the public. Currently planned life safety measures in the event of a major earthquake may not be accessible due to increased flooding. Nuisance flooding would make access to health and safety infrastructure troublesome, while severe flooding from storms may render them inaccessible. Increased flooding and rising groundwater is likely to release contaminants from HTRW sites that pose a risk to human health.

4.2. With Project Alternatives

In general, an alternative that moves the line of defense bayward (e.g., Alternative F) is expected to have greater impacts to the natural and physical resources (i.e., water quality, aquatic resources), while an alternative that moves the line of defense landward (e.g., Alternative G) or defends mostly at the existing shoreline (e.g., TNBP) would experience a higher level of adverse impacts to human resources (e.g., EJ, transportation). **Table 4-2** provides a high-level review of the anticipated disturbance associated with these alternatives for the proposed first (2040) and second (2090) actions. This is not an exhaustive description of impacts, rather provides a high-level overview and comparison of the more severe or significant impacts that each alternative as a whole may realize for each resource. Appendix D-1, Environmental and Cultural Supporting Documentation and the supporting sub-appendices, provides a detailed analysis and disclosure of the possible range of impacts from the anticipated actions if the alternative were implemented based on the design details and resource data available. Within Table 4-2 and Appendix D-1, all impacts are described as an aggregate of the first and second actions and is representative of the worst-case scenario. As more detail develops during the next phase of the study, the final EIS will more discreetly describe the first action and second actions independently rather than as an aggregate.

Table 4-2 and Appendix D-1 describe the impacts anticipated after avoidance and minimization measures have been incorporated into the designs and construction methodology of each feature. For each resource area, the environmental consequences sections in Appendix D-1 and the associated sub-appendices fully describe the avoidance and minimization measures that have been committed to. Additionally, if unavoidable impacts remain, compensatory mitigation is described in these sections, with the exception for significant ecological habitats, which are described in Appendix K.

4.3. Independent Measures

Table 4-3 describes those impacts that are unique to independent measures for consideration. In most cases, impacts overlap with the FWP alternatives; however, some unique impacts occur for independent measures. Similar to the with project alternatives described in section 4.2, Table 4-3 provides a high-level overview of the most severe or significant impacts of the independent measures and Appendix D-1 provides the more detailed analyses. The independent measures are listed below and are described in *Chapter 3: Plan Formulation and Evaluation*.

- Living Seawalls or Vertical Shorelines (hereinafter referred to as living seawalls or vertical shorelines)
- 2A) Robust Coastal Defense of Ferry Building and Agriculture Building
- 2B) Coarse Beach at Rincon Park
- 3A) Bay Bridge to South Beach Harbor Raised Shoreline with Rebuilt Wharves
- 3B) McCovey Cove North Curb Extension
- 3C) Planted Berm on Mission Bay
- 4A) Inland Coastal Flood Defense at Southwest Islais Creek

Table 4-2: Summary of Environmental Impacts for the Nonstructural and Action Alternatives in the Final Array

Resource	Alternative B	Alternative F	Alternative G	Total Net Benefits Plan (TNBP)
Air Quality and Clean Air Act (Appendix D-1-1)	Construction activities from floodproofing and eventual retreat and demolition of some buildings would generate dust and emissions, and state and local regulations can help mitigate these impacts. Sensitive receptors within 1,000 feet of construction activities may also be exposed to substantial pollutant concentrations. These would result in ***significant and unavoidable*** impacts. See Appendix D-1-1, section 2.3.3.4.1	Alternative F has the smallest construction area of the build alternatives but would result in demolition of 1.5 million square feet of buildings. Construction activities would generate dust and emissions, and state and local regulations can help mitigate these impacts. Sensitive receptors within 1,000 feet of construction activities may also be exposed to substantial pollutant concentrations. These would result in ***significant and unavoidable*** impacts. See Appendix D-1-1, section 2.3.3.5.1	Alternative G has the largest footprint of construction area and anticipated demolition of the alternatives. Construction activities would generate dust and emissions and state and local regulations can help mitigate these impacts. Sensitive receptors within 1,000 feet of construction activities may also be exposed to substantial pollutant concentrations. These would result in ***significant and unavoidable*** impacts. See Appendix D-1-1, section 2.3.3.6.1	The TNBP has the least demolition anticipated of any build alternative and a smaller construction footprint than either Alternative B or G. Construction activities would generate dust and emissions, and state and local regulations can help mitigate these impacts. Sensitive receptors within 1,000 feet of construction activities may also be exposed to substantial pollutant concentrations. These would result in ***significant and unavoidable*** impacts. See Appendix D-1-1, section 2.3.3.3.1
Climate - GHG Emissions (Appendix D-1-1)	Construction activities would contribute to greenhouse gas emissions (1,212,000 MTCO2e for the entire construction period), and while these emissions may not have substantial climate effects individually, they would incrementally contribute to global climate change.	Construction activities would contribute to greenhouse gas emissions (2,861,667 MTCO2e for the entire construction period), and while these emissions may not have substantial climate effects individually, they would incrementally contribute to global climate change.	Construction activities would contribute to greenhouse gas emissions (1,969,500 MTCO2e for the entire construction period), and while these emissions may not have substantial climate effects individually, they would incrementally contribute to global climate change. The impact is considered ***less than***	Construction activities would contribute to greenhouse gas emissions (3,821,167 MTCO2e for the entire construction period), and while these emissions may not have substantial climate effects individually, they would incrementally contribute to global climate change. The impact is **considered less**

Resource	Alternative B	Alternative F	Alternative G	Total Net Benefits Plan (TNBP)
	The impact is considered ***less than significant with mitigation***. See Appendix D-1-1, Section 2.3.3.4.3	The impact is considered ***less than significant with mitigation***. See Appendix D-1-1, Section 2.3.3.5.3	***significant with mitigation***. See Appendix D-1-1, Section 2.3.3.6.3	**than significant with mitigation**. See Appendix D-1-1, Section 2.3.3.3.3
Climate - Regional Climate, Climate Change, RSLC (Appendix D-1)	Alternative B moves assets away from flooding as SLR or manages flood risk with floodproofing and building modifications. This alternative would realize the most inland flooding of any alternative as the city adapts to rising SLR without FRM features. Proportionate to GHG emissions, Alternative B is expected to have ***less than significant*** impacts ***with mitigation*** on climate change. See Appendix D-1, Section 4.8.4	Moves the line of defense bayward from the existing shoreline and increases elevation commensurate with the threat from SLR. No inland flooding would be anticipated with any rate of SLR. Similar to GHG emissions, impacts to climate from Alternative F are anticipated to be ***less than significant with mitigation***. See Appendix D-1, Section 4.8.5	Maintains the line of defense at the existing shoreline in Reaches 1 and 2 but moves FRM defenses landward in Reaches 3 and 4. No flooding from SLR would occur beyond the FRM measures in Reaches 1-4. EWN features (700+ acres) are maximized offering carbon sequestration benefits. Like GHG emissions, impacts to climate from Alternative G are anticipated to be ***less than significant with mitigation***. See Appendix D-1, Section 4.8.6	Includes a combination of FRM measures constructed bayward and landward of the existing shoreline. No inland flooding is expected beyond the line of defense from raising sea levels. Commensurate with GHG emissions, impacts to climate from the TNBP are anticipated to be ***less than significant with mitigation***. See Appendix D-1, Section 4.8.3
Geology (Appendix D-1)	***No impact*** See Appendix D-1, Section 4.9.4	Impacts to geology are predominately from ground improvements needed to stabilize existing soils to address seismic concerns associated with the new loads born to the underlying geology. A	Impacts to geology are predominately from ground improvements needed to stabilize existing soils to address seismic concerns associated with the new loads born to the underlying geology. A variety of techniques could be used,	Impacts to geology are predominately from ground improvements needed to stabilize existing soils to address seismic concerns associated with the new loads born to the underlying geology. A variety of techniques could be used, but

Resource	Alternative B	Alternative F	Alternative G	Total Net Benefits Plan (TNBP)
		variety of techniques could be used, but all would include injecting cementitious or binding materials into soils, thereby changing geologic signature and structure and would eliminate soil development or composition present in the impacted area. This is expected to have ***less than significant*** impacts during construction as all the soils impacted are commercial fill. Long-term impacts are expected to be ***beneficial*** to soils by improving the ability to withstand seismic strains. See Appendix D-1, Section 4.9.5	but all would include injecting cementitious or binding materials into soils, thereby changing geologic signature and structure and would eliminate soil development or composition present in the impacted area. This is expected to have ***less than significant*** impacts during construction as all the soils impacted are commercial fill. Long-term impacts are expected to be ***beneficial*** to soils by improving the ability to withstand seismic strains. See Appendix D-1, Section 4.9.6	all would include injecting cementitious or binding materials into soils, thereby changing geologic signature and structure and would eliminate soil development or composition present in the impacted area. This is expected to have ***less than significant*** impacts during construction as all the soils impacted are commercial fill. Long-term impacts are expected to be ***beneficial*** to soils by improving the ability to withstand seismic strains. See Appendix D-1, Section 4.9.3
Geology - Sediments (Appendix D-1)	Alternative B would have minimal impacts on sediments during pier demolition in Reach 1, which are expected to be temporary and ***less than significant***. Pier removal would have an overall ***beneficial*** impact to sediments by removing potentially contaminated creosote piling and may relieve any scouring that	Sediments would be impacted during wharf replacement and new seawall construction during pile driving activities. These are anticipated to be ***less than significant***. In-bay fill would lead to a permanent loss of affected sediments. No measures are anticipated to result in sediment loss to the study area. Addition of EWN	Sediments would be impacted during wharf replacement during pile driving activities. This is anticipated to be ***less than significant***. No measures are anticipated to result in sediment loss to the study area. Addition of EWN features (e.g., marsh enhancement, ecological armoring) would be expected to increase sediment retention in	Sediments would be impacted during wharf replacement and localized areas of new seawall construction during pile driving activities. These are anticipated to be ***less than significant***. In-bay fill would lead to a permanent loss of affected sediments. No measures are anticipated to result in sediment loss to the study area. Addition of EWN features (e.g., marsh enhancement, ecological

Resource	Alternative B	Alternative F	Alternative G	Total Net Benefits Plan (TNBP)
	occurs as a result of high flow velocity near pilings. See Appendix D-1, Section 4.11.4	features (e.g., marsh enhancement, ecological armoring) would be expected to increase sediment retention in localized areas, offering ***beneficial*** impacts. See Appendix D-1, Section 4.11.5	localized areas, offering ***beneficial*** impacts. See Appendix D-1, Section 4.11.6	armoring) would be expected to increase sediment retention in localized areas, offering ***beneficial*** impacts. See Appendix D-1, Section 4.11.3
Geology - Seismicity (Appendix D-1)	***No impact*** See Appendix D-1, Section 4.9.4	No seismic hazard would be induced by the construction of any project feature. Overall, alternative does not impact seismicity (frequency and distribution of earthquakes) but reduces impacts from seismic activity. See Appendix D-1, Section 4.9.5	No seismic hazard would be induced by the construction of any project feature. Overall, alternative does not impact seismicity (frequency and distribution of earthquakes) but reduces impacts from seismic activity. See Appendix D-1, Section 4.9.6	No seismic hazard would be induced by the construction of any project feature. Overall, TNBP does not impact seismicity (frequency and distribution of earthquakes) but reduces impacts from seismic activity. See Appendix D-1, Section 4.9.3
Soils & Mineral Resources (Appendix D-1)	Minor surface work to floodproof, demolish, remove, and rehabilitate infrastructure would occur. Soil movement would be limited to upper layers, thus is expected to have ***less than significant*** impacts. ***No impact*** to mineral resources is anticipated.	The greatest impacts are expected during earthwork with compaction and grading from heavy machinery, addition of commercial fill material, and blending of soils. Impacts would be temporary and ***less than significant***. EWN features would be ***beneficial*** for	The greatest impacts are expected during earthwork with compaction and grading from heavy machinery, addition of commercial fill material, and blending of soils. Impacts would be temporary and ***less than significant***. EWN features would be ***beneficial*** for soil	The greatest impacts are expected during earthwork with compaction and grading from heavy machinery, addition of commercial fill material, and blending of soils. Impacts would be temporary and ***less than significant***. EWN features would be ***beneficial*** for soil biodiversity and may reduce soil erosion.

Resource	Alternative B	Alternative F	Alternative G	Total Net Benefits Plan (TNBP)
	See Appendix D-1, Section 4.10.4	soil biodiversity /and may reduce soil erosion. ***No impact*** to mineral resources is anticipated. See Appendix D-1, Section 4.10.5	biodiversity and may reduce soil erosion. ***No impact*** to mineral resources is anticipated. See Appendix D-1, Section 4.10.6	***No impact*** to mineral resources is anticipated. See Appendix D-1, Section 4.10.3
Hydrology & Hydraulics - Floodplains (Appendix D-1)	Flooding from RSLC, rainfall, and coastal hazards would still be anticipated under Alternative B. However, as flooding becomes more pronounced, assets would be floodproofed, relocated, or demolished to avoid flooding to infrastructure. Alternative B would not alter floodplains, thus would have ***no impact***. See Appendix D-1, Section 4.8.4	FRM features would be constructed bayward of the existing shoreline and would prevent inland flooding from RSLC and coastal hazards. Construction would have minor, temporary impacts to floodplains that would be ***less than significant***. See Appendix D-1, Section 4.8.5	FRM features would be constructed along the shoreline in Reaches 1 and 2, while they would be constructed landward in Reaches 3 and 4 to allow for flooding in front of the measures. This would alter floodplains to allow for more flooding in the southern reaches; however, it would not have flooding beyond the line of defense. Construction would have minor, temporary impacts to floodplains that would be ***less than significant***. See Appendix D-1, Section 4.8.6	FRM features would mostly be constructed near or on the existing shoreline. No inland flooding from RSLC or coastal hazards would be expected. Construction would have minor, temporary impacts to floodplains that would be ***less than significant***. See Appendix D-1, Section 4.8.3
Hydrology & Hydraulics - Coastal hydrology, currents, and circulation (Appendix D-1)	Pier removal is the only action anticipated to have ***less than significant*** impacts to coastal hydrology. All other non-structural actions are expected to have ***no impact.***	In-bay fill needed for extension of the seawall bayward and construction of a new seawall would likely have ***significant and unavoidable*** impacts to hydrology by changing the structure of the waterfront. Wharves	Wharves would be replaced, which are likely to have temporary impacts to hydrology during construction that would be ***less than significant*** but are not expected to induce permanent changes. Bay wide hydrodynamic	In-bay fill and construction of a new seawall bayward of the existing seawall would likely have ***significant and unavoidable*** impacts to hydrology by changing the structure of the waterfront. Wharves would be replaced, which are likely to have

Resource	Alternative B	Alternative F	Alternative G	Total Net Benefits Plan (TNBP)
	See Appendix D-1, Section 4.11.4	would be replaced, which are likely to have temporary impacts to hydrology during construction that would be ***less than significant*** but are not expected to induce permanent changes. Bay wide hydrodynamic modelling would be needed to determine the level of effects expected. See Appendix D-1, Section 4.11.5	modelling would be needed to determine the level of effects expected. See Appendix D-1, Section 4.11.6	temporary impacts to hydrology during construction that would be ***less than significant*** but are not expected to induce permanent changes. Bay wide hydrodynamic modelling would be needed to determine the level of effects expected. See Appendix D-1, Section 4.11.3
Hydrology & Hydraulics - Tides, tidal exchange, and waves (Appendix D-1)	***No impact*** See Appendix D-1, Section 4.11.4	Construction of the tidal gates and wharf would temporarily disrupt tidal flows and could increase current velocities in and around the construction site. Tidal gates would be operated to mimic existing tidal flows to the greatest extent practicable. Hydrodynamic modelling simulating tidal gate operation would be needed to determine the extent of impacts but are assumed to be ***less than significant***. Bay fill would have permanent impacts to currents and waves, while the new seawall could have long-term	Construction of wharf would temporarily lead to changes in currents and wave patterns during pile driving and pier removal, but these are expected to be ***less than significant***. All other grey measures are expected to have ***no impact***, while EWN features would have minor impacts during construction, but long-term ***beneficial*** impacts by dissipating wave and current energies. See Appendix D-1, Section 4.11.6	Construction of wharf would temporarily disrupt tidal flows and could increase current velocities in and around the construction site, the extent of impacts are assumed to be ***less than significant***. Bay fill would have permanent impacts to currents and waves, while the new seawall could have long-term impacts of waves and currents in select places that are built bayward of the existing seawall because of the change to the waterfront. Both measures are anticipated to have ***significant and unavoidable*** impacts.

Resource	Alternative B	Alternative F	Alternative G	Total Net Benefits Plan (TNBP)
		impacts of waves and currents because of the change to the waterfront. Both measures are anticipated to have ***significant and unavoidable*** impacts. See Appendix D-1, Section 4.11.5		See Appendix D-1, Section 4.11.3
Hydrology & Hydraulics - Stormwater (Appendix D-1)	Improvements to the drainage system would occur when infrastructure is relocated, floodproofed, and/or demolished. This alternative does not seek to address existing stormwater runoff but cannot make it worse long-term. Overall, construction related impacts are expected to be ***less than significant***. See Appendix D-1, Section 4.12.4	Improvements to stormwater drainage systems would be expected after construction of coastal flood risk management measures are completed. The construction of CFRM features cannot exacerbate stormwater runoff, thus, no permanent impacts would be expected. Runoff could increase during earthwork construction, but are anticipated to be ***less than significant*** See Appendix D-1, Section 4.12.5	Improvements to stormwater drainage systems would be expected after construction of coastal flood risk management measures are completed. The construction of coastal flood risk features cannot exacerbate stormwater runoff, thus, no permanent impacts would be expected. Runoff could increase during earthwork construction but are anticipated to be ***less than significant.*** The large swath of EWN features would be ***beneficial*** for stormwater by adding pervious surface for enhanced drainage.	Improvements to stormwater drainage systems are expected after construction of coastal flood risk management measures are completed. The construction of coastal flood risk features cannot exacerbate stormwater runoff, thus, no permanent impacts would be expected. Runoff could increase during earthwork construction, but are anticipated to be ***less than significant*** See Appendix D-1, Section 4.12.3

Resource	Alternative B	Alternative F	Alternative G	Total Net Benefits Plan (TNBP)
			See Appendix D-1, Section 4.12.6	
Water Quality (Appendix D-1)	Pier removal, demolition, and relocation are anticipated to have ***less than significant*** impacts to water quality. Demolition and relocation activities could result in wind-driven dust or run off that could impact water quality. Pier removal would temporarily increase turbidity and sediment suspension. Overall, pier removal is likely to have long-term ***beneficial*** impacts to water quality by removing creosote-laden pilings, thereby improving water quality. See Appendix D-1, Section 4.12.4	Bay fill, construction of the seawall, roadway construction, wharf replacement, and tide gates are all anticipated to have ***significant and unavoidable*** impacts to water quality. Bay fill permanently removes open water, while seawall and wharf construction would cause turbidity, resuspended sediments, and could suspend contamination from underlying sediments or result in debris and release of contaminating materials. Replacement of roadways would lead to changes and expansion in stormwater, sewer, and inland drainage systems. Tide gates would utilize cofferdams during construction which could lead to elevated turbidity, suspended sediments, and release of contaminants with effluent discharge during dewatering. Shore-based measures are expected to have ***less than***	Replacement of roadways would lead to changes and expansion in stormwater, sewer, and inland drainage systems. Wharf construction would cause turbidity, resuspended sediments, and could suspend contamination from underlying sediments or result in debris and release of contaminating materials during pile driving. Both measures are anticipated to have ***significant and unavoidable*** impacts. Shore-based measures are expected to have ***less than significant*** impacts with temporary increased turbidity and sediment suspension localized to the construction area. EWN features would have temporary impacts to water quality during construction, but shore-based EWN (e.g., marsh enhancement, embankment shorelines) are expected to have long-term ***beneficial*** impacts to water quality by improving clarity, minimizing runoff,	Bay fill, construction of bayward sections of the seawall, roadway construction, and wharf replacement are all anticipated to have ***significant and unavoidable*** impacts to water quality. Bay fill permanently removes open water, while seawall and wharf construction would cause turbidity, resuspended sediments, and could suspend contamination from underlying sediments or result in debris and release of contaminating materials. Replacement of roadways would lead to changes and expansion in stormwater, sewer, and inland drainage systems. Shore-based measures are expected to have ***less than significant*** impacts with temporary increased turbidity and sediment suspension localized to the construction area. See Appendix D-1, Section 4.12.3

Resource	Alternative B	Alternative F	Alternative G	Total Net Benefits Plan (TNBP)
		significant impacts with temporary increased turbidity and sediment suspension localized to the construction area. See Appendix D-1, Section 4.12.5	reducing excessive nutrients and contaminants, and stabilizing shorelines. See Appendix D-1, Section 4.12.6	
Groundwater (Appendix D-1)	Demolition, relocation, and floodproofing could have temporary impacts to shallow groundwater during excavation and dirt work that are expected to be ***less than significant***. ***No impact*** to drinking water supplies should occur. See Appendix D-1, Section 4.13.4	In-water construction activities (e.g., pile driving) are expected to have ***no impact*** to groundwater. Shore-based construction would have temporary impacts during excavation and earth work, but these are anticipated to be ***less than significant***. ***No impact*** to drinking water supplies should occur. In bay fill, construction of the seawall and tide gates are likely to adversely impact groundwater flows while activities are underway and would disconnect some existing bay drainage systems. These activities are expected to be ***less than significant with mitigation.*** See Appendix D-1, Section 4.13.5	***No impact*** to drinking water supplies should occur. Construction of the seawall is likely to adversely impact groundwater flows and would disconnect some existing bay drainage systems. These activities are expected to be ***less than significant with mitigation.*** EWN features would convert impervious surfaces to pervious which could have a long-term ***beneficial*** impact to groundwater supplies by improving drainage and transpiring sufficient quantities. See Appendix D-1, Section 4.13.6	In-water construction activities (e.g., pile driving) are expected to have ***no impact*** to groundwater. Shore-based construction would have temporary impacts during excavation and earth work, but these are anticipated to be ***less than significant***. ***No impact*** to drinking water supplies should occur. In bay fill, construction of the seawall in bayward locations, and sheetpile walls are likely to adversely impact groundwater flows while activities are underway and would disconnect some existing bay drainage systems. These activities are expected to be ***less than significant with mitigation.*** See Appendix D-1, Section 4.13.3
Aquatic Resources - Intertidal Habitat	Wood pier pilings are considered artificial	Wharf replacement would have temporary impacts to	Wharf replacement would have temporary impacts to	Wharf replacement would have temporary impacts to

Resource	Alternative B	Alternative F	Alternative G	Total Net Benefits Plan (TNBP)
(Appendix D-1)	intertidal habitats in the study area. Pier removal would permanently eliminate a small portion of artificial habitat in the study area, but given the limited extent, these impacts are expected to be ***less than significant***. ***No impact*** to natural intertidal habitat is expected. See Appendix D-1, Section 4.14.4	artificial intertidal habitat through removal of pilings; however, new wood, steel, or concrete pilings would be returned in place. Permanent loss of sessile organisms from pilings removed would occur; however, new pilings are anticipated to provide habitat for recolonization. These impacts are anticipated to be ***less than significant***. In-bay fill would have permanent impacts to intertidal habitats by removing them from the affected area which are anticipated to be ***significant and unavoidable***. Addition of the new seawall would remove existing intertidal habitat but would create new area for colonization of sessile organisms, thus, overall is expected to have ***less than significant*** impacts. ***No impact*** to tidal mud flats at Heron's Head Park is expected. See Appendix D-1, Section 4.14.5	artificial intertidal habitat through removal of pilings; however, new wood, steel or concrete pilings would be returned in place. Permanent loss of sessile organisms from pilings removed would occur; however, new pilings are anticipated to provide habitat for recolonization. These impacts are anticipated to be ***less than significant***. Addition of EWN features would have long-term ***beneficial*** impacts by increasing acreage of artificial (e.g., ecological armoring) and more naturalized (e.g., marsh enhancement, coarse beach) intertidal habitat. See Appendix D-1, Section 4.14.6	artificial intertidal habitat through removal of pilings; however, new wood, steel, or concrete pilings would be returned in place. Permanent loss of sessile organisms from pilings removed would occur; however, new pilings are anticipated to provide habitat for recolonization. These impacts are anticipated to be ***less than significant***. In-bay fill would have permanent impacts to intertidal habitats by removing them from the affected area which are anticipated to be ***significant and unavoidable***. Addition of the new seawall in localized areas would remove existing intertidal habitat but would create new area for colonization of sessile organisms, thus, overall is expected to have ***less than significant*** impacts. ***No impact*** to tidal mud flats at Heron's Head Park is expected. See Appendix D-1, Section 4.14.3

Resource	Alternative B	Alternative F	Alternative G	Total Net Benefits Plan (TNBP)
Aquatic Resources - Subtidal Habitat (Appendix D-1)	Pier removal would have temporary impacts to subtidal habitats during piling removal, which are expected to be ***less than significant***. During removal of pilings, mud bottom and the water column just above the bay bottom would result in increased turbidity and physical disturbance that would cease upon construction completion. ***No impact*** to subtidal habitat is anticipated with demolition, relocation, or floodproofing. See Appendix D-1, Section 4.14.4	Wharf replacement would have temporary impacts to subtidal habitats during pile removal and installation, with impacts expected to be ***less than significant***. Physical disturbance would occur during removal and installation, but wharf replacement is intended to remain in the same footprint as that of wharf removed. In bay fill and seawall installation would permanently remove subtidal habitat such as mud, of which would be ***significant and unavoidable*** due to loss of habitat. No loss of shellfish beds or eelgrass beds are anticipated with installation of FRM features. Installation and operation of tidal gates would temporarily impact subtidal habitat, such as bay bottom and water column, but these are expected to be minimal and ***less than significant*** overall. Shore-based measures are expected to have ***no impact*** to subtidal habitats.	Wharf replacement would have temporary impacts to subtidal habitats during pile removal and installation, with impacts expected to be ***less than significant***. Shore-based measures are expected to have ***no impact*** to subtidal habitats. Physical disturbance would occur during removal and installation, but wharf replacement is intended to remain in the same footprint as that of wharf removed. EWN features are expected to have long-term ***beneficial*** impacts by increasing acreage of subtidal habitat and improving existing habitat through marsh augmentation/enhancement and installation of a coarse beach, for example. See Appendix D-1, Section 4.14.6	Wharf replacement would have temporary impacts to subtidal habitats during pile removal and installation, with impacts expected to be ***less than significant***. Physical disturbance would occur during removal and installation, but wharf replacement is intended to remain in the same footprint as that of wharf removed. In bay fill and localized seawall installation would permanently remove subtidal habitat such as mud, of which would be ***significant and unavoidable*** due to loss of habitat. No loss of shellfish beds or eelgrass beds are anticipated with installation of FRM features. Shore-based measures are expected to have ***no impact*** to subtidal habitats. See Appendix D-1, Section 4.14.3

Resource	Alternative B	Alternative F	Alternative G	Total Net Benefits Plan (TNBP)
		See Appendix D-1, Section 4.14.5		
Aquatic Resources - Pelagic Habitat (Appendix D-1)	Pier removal, demolition, and relocation are anticipated to have ***less than significant*** impacts to pelagic habitat. Demolition and relocation activities could result in wind-driven dust or run off that could impact water quality. Pier removal would temporarily increase turbidity and sediment suspension. Overall, pier removal is likely to have long-term ***beneficial*** impacts to pelagic habitat by removing creosote-laden pilings, thereby improving water quality. See Appendix D-1, Section 4.14.4	Wharf replacement would have temporary impacts to pelagic habitats during pile removal and installation, with impacts expected to be ***less than significant***. Physical disturbance would occur during removal and installation, but wharf replacement is intended to remain in the same footprint as that of wharf removed. In bay fill and seawall installation would permanently remove pelagic habitat, of which would be ***significant and unavoidable*** due to habitat loss. Installation and operation of tidal gates would temporarily impact pelagic habitat but is expected to be minimal and ***less than significant*** overall. Shore-based measures are expected to have ***no impact*** to pelagic habitats. See Appendix D-1, Section 4.14.5	Wharf replacement would have temporary impacts to pelagic habitats during pile removal and installation, with impacts expected to be ***less than significant***. Physical disturbance would occur during removal and installation, but wharf replacement is intended to remain in the same footprint as that of wharf removed. Shore-based measures are expected to have ***no impact*** to pelagic habitats. EWN features are expected to have long-term ***beneficial*** impacts to pelagic habitat by improving water quality. See Appendix D-1, Section 4.14.6	Wharf replacement would have temporary impacts to pelagic habitats during pile removal and installation, with impacts expected to be ***less than significant***. Physical disturbance would occur during removal and installation, but wharf replacement is intended to remain in the same footprint as that of wharf removed. In bay fill and localized seawall installation would permanently remove pelagic habitat, of which would be ***significant and unavoidable*** due to loss of habitat. Shore-based measures are expected to have ***no impact*** to pelagic habitats. See Appendix D-1, Section 4.14.3

Resource	Alternative B	Alternative F	Alternative G	Total Net Benefits Plan (TNBP)
Aquatic Resources - Wetlands (Appendix D-1)	***No impact***	EWN features would be constructed at Pier 94 and Heron's Head wetlands. Temporary adverse impacts would occur during construction, but these are expected to be ***less than significant.*** Overall, long-term ***beneficial*** impacts to wetlands are expected with augmentation and enhancement through EWN features. See Appendix D-1, Section 4.16.5	EWN features would be constructed at Pier 94 and Heron's Head wetlands. Temporary adverse impacts would occur during construction, but these are expected to be ***less than significant.*** Overall, long-term ***beneficial*** impacts to wetlands are expected with augmentation and enhancement through EWN features. See Appendix D-1, Section 4.16.5	EWN features would be constructed at Pier wetlands. Temporary adverse impacts would occur during construction, but these are expected to be ***less than significant.*** Overall, long-term ***beneficial*** impacts to these wetlands are expected with augmentation and enhancement through EWN features. Heron's Head wetlands could be lost with rising sea levels as FRM measures would be constructed landward of this wetland and no augmentation/enhancement is planned. See Appendix D-1, Section 4.16.5
Aquatic Resources - Fish (Appendix D-1)	Pier removal, demolition, and relocation are anticipated to have ***less than significant*** impacts to fish. Demolition and relocation activities could result in wind-driven dust or run off that could impact water quality. Pier removal would temporarily increase turbidity and sediment suspension and would permanently remove	Wharf replacement would have temporary impacts to fish during pile removal and installation, with impacts expected to be ***less than significant***. Physical disturbance, noise, sediment suspension, and turbidity would occur during removal and installation. In bay fill and seawall installation would permanently remove fish	Wharf replacement would have temporary impacts to fish during pile removal and installation, with impacts expected to be ***less than significant***. Physical disturbance, noise, sediment suspension, and turbidity would occur during removal and installation. Temporary impacts, like wharf replacement, during construction would be expected. Shore-based	Wharf replacement would have temporary impacts to fish during pile removal and installation, with impacts expected to be ***less than significant***. Physical disturbance, noise, sediment suspension, and turbidity would occur during removal and installation. In bay fill and seawall installation would permanently remove fish habitat, of which would be ***significant and unavoidable***

Resource	Alternative B	Alternative F	Alternative G	Total Net Benefits Plan (TNBP)
	habitat for sessile organisms that may be a prey source. Overall, pier removal is likely to have long-term ***beneficial*** impacts to fish by removing a shade structure and creosote-laden pilings, thereby improving water quality. See Appendix D-1, Section 4.16.4	habitat, of which would be ***significant and unavoidable*** due to habitat loss. Temporary impacts, like wharf replacement, during construction would be expected. Installation and operation of tidal gates would temporarily impact fish but is expected to be minimal and ***less than significant*** overall. Shore-based measures are expected to have ***less than significant*** impacts to fish with the potential for wind-driven dust or runoff to increase turbidity and lower water quality temporarily. See Appendix D-1, Section 4.16.5	measures are expected to have ***less than significant*** impacts to fish with the potential for wind-driven dust or runoff to increase turbidity and lower water quality temporarily. EWN features are anticipated to have long-term ***beneficial*** impacts to fish with augmentation and enhancement of marsh habitat, improved water quality, increased habitat, and improved foraging. See Appendix D-1, Section 4.16.6	due to habitat loss. Temporary impacts, like wharf replacement, during construction would be expected. Shore-based measures are expected to have ***less than significant*** impacts to fish with the potential for wind-driven dust or runoff to increase turbidity and lower water quality temporarily. See Appendix D-1, Section 4.16.3
Aquatic Resources - Commercial and Recreational Fisheries (Appendix D-1)	Pier removal is the only action anticipated to have ***less than significant*** impacts to commercial and recreational fisheries. All other non-structural actions are expected to have ***no impact.*** Piers would continue to be useful to fisheries until SLR dictates otherwise.	Construction of the wharf and seawall would have temporary impacts to fisheries through impacts to fish which would lead to avoidance of the construction area. In-bay fill would permanently remove fish habitat which would likely impact fisheries during construction but is not	Construction of wharf replacement would have temporary impacts to fisheries through impacts to fish which would lead to avoidance of the construction area. Overall, the temporary nature of adverse impacts is expected to be ***less than significant*** for fisheries. EWN features are expected	Construction of wharf replacement and seawall would have temporary impacts to fisheries through impacts to fish which would lead to avoidance of the construction area. In-bay fill would permanently remove fish habitat which would likely impact fisheries during construction but is not anticipated to have long-term

Resource	Alternative B	Alternative F	Alternative G	Total Net Benefits Plan (TNBP)
	See Appendix D-1, Section 4.16.4	anticipated to have long-term adverse impacts. Overall, the temporary nature of adverse impacts is expected to be ***less than significant*** for fisheries. See Appendix D-1, Section 4.16.5	to have long-term ***beneficial*** impacts to fisheries by improving fish habitat. See Appendix D-1, Section 4.16.6	adverse impacts. Overall, the temporary nature of adverse impacts is expected to be ***less than significant*** for fisheries. See Appendix D-1, Section 4.16.3
Aquatic Resources - Macroinvertebrates (Appendix D-1)	Pier removal is the only action anticipated to have ***less than significant*** impacts to macroinvertebrates during pile removal. All other non-structural actions are expected to have ***no impact.*** See Appendix D-1, Section 4.16.4	Wharf replacement, bay fill, seawall, and tidal gate construction are anticipated to adversely impact macroinvertebrates through smothering, burial, and loss. Suspension/filter feeders could result in clogged breathing/feeding mechanisms, causing death or reduced growth/reproduction. Benthic fauna is expected to recover after construction ceases. Impacts are anticipated to be ***less than significant with mitigation***. See Appendix D-1, Section 4.16.5	Wharf replacement is anticipated to adversely impact macroinvertebrates through smothering, burial, and loss. Suspension/filter feeders could result in clogged breathing/feeding mechanisms, causing death or reduced growth/reproduction. Benthic fauna is expected to recover after construction ceases. Impacts are anticipated to be ***less than significant with mitigation***. EWN features would provide additional habitat, refuge, foraging, and breeding ground for macroinvertebrates and are expected to have long-term ***beneficial*** impacts. See Appendix D-1, Section 4.16.6	Wharf replacement, bay fill, and localized seawall construction are anticipated to adversely impact macroinvertebrates through smothering, burial, and loss. Suspension/filter feeders could result in clogged breathing/feeding mechanisms, causing death or reduced growth/reproduction. Benthic fauna is expected to recover after construction ceases. Impacts are anticipated to be ***less than significant with mitigation***. See Appendix D-1, Section 4.16.3

Resource	Alternative B	Alternative F	Alternative G	Total Net Benefits Plan (TNBP)
Upland Resources - Terrestrial Vegetation (Appendix D-1)	Vegetation removal would occur during construction for equipment mobilization, staging, and haul routes. Vegetation outside the construction area could be impacted by fugitive dust and emissions. Vegetation would be restored to pre-existing conditions or expanded once construction completed. Overall, impacts are expected to be ***less than significant***. See Appendix D-1, Section 4.15.4	Vegetation removal would occur during construction for equipment mobilization, staging, and haul routes. Vegetation outside the construction area could be impacted by fugitive dust and emissions. Vegetation would be restored to pre-existing conditions or expanded once construction completed. Overall, impacts are expected to be ***less than significant***. See Appendix D-1, Section 4.15.5	Vegetation removal would occur during construction for equipment mobilization, staging, and haul routes. Vegetation outside the construction area could be impacted by fugitive dust and emissions. Vegetation would be restored to pre-existing conditions or expanded once construction completed. Overall, impacts are expected to be ***less than significant***. The expanse of EWN features (700+ acres) would increase terrestrial vegetation cover substantially in Reaches 3 and 4, providing a ***beneficial*** impact to this resource. See Appendix D-1, Section 4.15.6	Vegetation removal would occur during construction for equipment mobilization, staging, and haul routes. Vegetation outside the construction area could be impacted by fugitive dust and emissions. Vegetation would be restored to pre-existing conditions or expanded once construction completed. Overall, impacts are expected to be ***less than significant***. See Appendix D-1, Section 4.15.3
Special Status Species - T&E Species Terrestrial (Appendix D-1)	Temporary impacts such as noise, physical disturbance, and habitat avoidance would occur during demolition, relocation, and floodproofing. These would occur incrementally and in localized sections as the threat of flooding	Temporary impacts such as noise, physical disturbance, and habitat avoidance would occur during construction of FRM features. These would occur incrementally and in localized sections, with habitat available elsewhere within and outside the study area.	Temporary impacts such as noise, physical disturbance, and habitat avoidance would occur during construction of FRM features. These would occur incrementally and in localized sections as the threat of flooding dictates, with habitat available elsewhere within and	Temporary impacts such as noise, physical disturbance, and habitat avoidance would occur during construction of FRM features. These would occur incrementally and in localized sections, with habitat available elsewhere within and outside the study area. Thus, impacts to terrestrial T&E species are anticipated

Resource	Alternative B	Alternative F	Alternative G	Total Net Benefits Plan (TNBP)
	dictates, with habitat available elsewhere within and outside the study area. Thus, impacts to terrestrial T&E species are anticipated to be ***less than significant***. The loss of Heron's Head would occur under the FWOP condition and is not addressed as part of this project and as a result the alternative would have no direct effect on loss of habitat. See Appendix D-1, Section 4.16.4	Thus, impacts to terrestrial T&E species are anticipated to be ***less than significant***. EWN and retreat features associated with this alternative would create additional habitat for T&E species thus having a long-term beneficial impact. No direct loss of existing habitat would occur from construction of any of the measures at Heron's Head. See Appendix D-1, Section 4.16.5	outside the study area. Thus, impacts to terrestrial T&E species are anticipated to be ***less than significant***. EWN and retreat features associated with this alternative would create additional habitat for T&E species thus having a long-term beneficial impact. No direct loss of existing habitat would occur from construction of any of the measures at Heron's Head. See Appendix D-1, Section 4.16.6	to be ***less than significant***. No EWN is planned for Heron's Head, which is significant habitat for terrestrial T&E species in the study area. The loss of Heron's Head would occur under the FWOP condition and is not addressed as part of this project and as a result the alternative would have no direct effect on loss of habitat. See Appendix D-1, Section 4.16.3
Special Status Species - T&E Species Aquatic (Appendix D-1)	Pier removal, demolition, and relocation are anticipated to have ***less than significant*** impacts to T&E aquatic species. Demolition and relocation activities could result in wind-driven dust or run off that could impact water quality. Pier removal would temporarily increase turbidity and sediment suspension and would permanently remove habitat for sessile organisms that may be a prey source for protected	Wharf replacement would have temporary impacts to aquatic T&E species during pile removal and installation and are expected to be ***less than significant.*** Physical disturbance, noise, sediment suspension, and turbidity would occur during these activities. Bay fill and seawall installation would permanently remove T&E aquatic habitat, of which would be ***significant and unavoidable*** due to habitat loss. Temporary	Wharf replacement would have temporary impacts to aquatic T&E species during pile removal and installation, with impacts expected to be ***less than significant***. Physical disturbance, noise, sediment suspension, and turbidity would occur during these activities. Shore-based measures are expected to have ***less than significant*** impacts with the potential for wind-driven dust or runoff to increase turbidity and lower water quality temporarily. EWN	Wharf replacement would have temporary impacts to aquatic T&E species during pile removal and installation, with impacts expected to be ***less than significant***. Physical disturbance, noise, sediment suspension, and turbidity would occur during removal and installation. In bay fill and localized seawall installation would permanently remove aquatic habitat, of which would be ***significant and unavoidable*** due to T&E species habitat loss. Temporary impacts, like wharf replacement, during

Resource	Alternative B	Alternative F	Alternative G	Total Net Benefits Plan (TNBP)
	fish species. Overall, pier removal is likely to have long-term ***beneficial*** impacts to T&E fish by removing a shade structure and creosote-laden pilings, thereby improving water quality. See Appendix D-1, Section 4.16.4	impacts, like wharf replacement, during construction would be expected. Installation and operation of tidal gates would temporarily impact aquatic T&E species but is expected to be minimal and ***less than significant*** overall. Shore-based measures are expected to have ***less than significant*** impacts with the potential for wind-driven dust or runoff to increase turbidity and lower water quality temporarily. See Appendix D-1, Section 4.16.5	features are anticipated to have long-term ***beneficial*** impacts to aquatic T&E species with augmentation and enhancement of marsh habitat, improved water quality, increased habitat, and improved foraging. See Appendix D-1, Section 4.16.6	construction would be expected. Shore-based measures are expected to have ***less than significant*** impacts with the potential for wind-driven dust or runoff to increase turbidity and lower water quality temporarily. See Appendix D-1, Section 4.16.3
Special Status Species - State Listed Species	Impacts to state listed species would be the same as those described for aquatic and terrestrial T&E species.	Impacts to state listed species would be the same as those described for aquatic and terrestrial T&E species.	Impacts to state listed species would be the same as those described for aquatic and terrestrial T&E species.	Impacts to state listed species would be the same as those described for aquatic and terrestrial T&E species.
Special Status Species - Designated Critical Habitat (Appendix D-1)	Pier removal is the only action anticipated to have ***less than significant*** impacts to designated CH for green sturgeon and chinook salmon. The removal of piers will have temporary adverse impacts, but these are	Wharf replacement would have temporary impacts to designated green sturgeon and chinook salmon CH during pile removal and installation, with impacts expected to be ***less than significant***. Physical disturbance,	Wharf replacement would have temporary impacts to designated green sturgeon and chinook salmon CH during pile removal and installation, with impacts expected to be ***less than significant***. Physical disturbance, noise,	Wharf replacement would have temporary impacts to designated green sturgeon and chinook salmon CH during pile removal and installation, with impacts expected to be ***less than significant***. Physical disturbance, noise, sediment

Resource	Alternative B	Alternative F	Alternative G	Total Net Benefits Plan (TNBP)
	not anticipated to adversely modify CH. All other non-structural actions are expected to have ***no impact.*** *See Appendix D-1, Section 4.16.4*	noise, sediment suspension, and turbidity would occur during removal and installation. In bay fill and seawall installation would permanently remove green sturgeon and chinook salmon CH, of which would be ***significant and unavoidable*** due to habitat loss. Temporary impacts, like wharf replacement, during construction would be expected. Installation and operation of tidal gates would temporarily impact green sturgeon CH but is expected to be minimal and ***less than significant*** overall. Shore-based measures are expected to have ***less than significant*** impacts to CH with the potential for wind-driven dust or runoff to increase turbidity and lower water quality temporarily. See Appendix D-1, Section 4.16.5	sediment suspension, and turbidity would occur during removal and installation. Shore-based measures are expected to have ***less than significant*** impacts to CH with the potential for wind-driven dust or runoff to increase turbidity and lower water quality temporarily. EWN features are anticipated to have long-term ***beneficial*** impacts to green sturgeon CH with augmentation and enhancement of marsh habitat, improved water quality, and improved foraging. See Appendix D-1, Section 4.16.6	suspension, and turbidity would occur during removal and installation. In bay fill and localized seawall installation would permanently remove green sturgeon and chinook salmon CH, of which would be ***significant and unavoidable*** due to habitat loss. Temporary impacts, like wharf replacement, during construction would be expected. Shore-based measures are expected to have ***less than significant*** impacts to CH with the potential for wind-driven dust or runoff to increase turbidity and lower water quality temporarily. See Appendix D-1, Section 4.16.3
Special Status Species - Migratory	Migratory birds would likely avoid construction	Migratory birds would likely avoid construction	Migratory birds would likely avoid construction areas	Migratory birds would likely avoid construction areas due

Resource	Alternative B	Alternative F	Alternative G	Total Net Benefits Plan (TNBP)
Bird Treaty Act Species (Appendix D-1)	areas due to noise and physical disturbance. Nesting can occur in urban areas, but these would be avoided with pre-construction surveys and avoidance. All construction related impacts would be temporary and localized and are expected to be ***less than significant***. San Francisco Bay is an important stopover for the Pacific Flyway, but because construction would occur in stages, habitat would be available in other areas. See Appendix D-1, Section 4.16.4	areas due to noise and physical disturbance. Nesting can occur in urban areas, but these would be avoided with pre-construction surveys and avoidance. All construction related impacts would be temporary and localized and are expected to be ***less than significant***. San Francisco Bay is an important stopover for the Pacific Flyway, but because construction would occur in stages, habitat would be available in other areas. See Appendix D-1, Section 4.16.5	due to noise and physical disturbance. Nesting can occur in urban areas, but these would be avoided with pre-construction surveys and avoidance. All construction related impacts would be temporary and localized and are expected to be ***less than significant***. San Francisco Bay is an important stopover for the Pacific Flyway, but because construction would occur in stages, habitat would be available in other areas. EWN features would increase the acreage of available and preferred habitat for many migratory birds species, thus would have a long-term ***beneficial*** impact. See Appendix D-1, Section 4.16.6	to noise and physical disturbance. Nesting can occur in urban areas, but these would be avoided with pre-construction surveys and avoidance. All construction related impacts would be temporary and localized and are expected to be ***less than significant***. San Francisco Bay is an important stopover for the Pacific Flyway, but because construction would occur in stages, habitat would be available in other areas. See Appendix D-1, Section 4.16.3
Special Status Species - Marine Mammal Protection Act Species (Appendix D-1)	Pier removal is the only action anticipated to have ***less than significant*** impacts to marine mammals. All other non-structural actions are expected to have ***no impact.*** Noise generated during pile and platform	Wharf replacement, bay fill, seawall, and tidal gate construction are anticipated to adversely impact marine mammals through noise, physical disturbance, habitat avoidance, turbidity, sediment suspension, and	Wharf replacement is anticipated to adversely impact marine mammals through noise, physical disturbance, habitat avoidance, turbidity, and sediment suspension, which are expected to be ***less than significant with***	Wharf replacement, bay fill, and localized seawall construction are anticipated to adversely impact marine mammals through noise, physical disturbance, habitat avoidance, turbidity, sediment suspension, and habitat loss. Habitat loss from bay fill and

Resource	Alternative B	Alternative F	Alternative G	Total Net Benefits Plan (TNBP)
	removal would have adverse impacts to marine mammals in the vicinity of the construction area. See Appendix D-1, Section 4.16.4	habitat loss. Habitat loss from bay fill and seawall construction are anticipated to be ***significant and unavoidable***, while wharf replacement and tide gate construction would be ***less than significant with mitigation***. See Appendix D-1, Section 4.16.5	***mitigation***. EWN features would provide additional and enhanced habitat for prey of marine mammals which is expected to have long-term ***beneficial*** impacts. See Appendix D-1, Section 4.16.6	seawall construction are anticipated to be ***significant and unavoidable***, while wharf replacement would be ***less than significant with mitigation***. See Appendix D-1, Section 4.16.3
Special Status Species - EFH and EFH-designated Species (Appendix D-1)	Pier removal, demolition, and relocation are anticipated to have ***less than significant*** impacts to EFH and EFH-species. Demolition and relocation activities could result in wind-driven dust or run off that could impact water quality. Pier removal would temporarily increase turbidity and sediment suspension and would permanently remove habitat for sessile organisms that may be a prey source for EFH species. Overall, pier removal is likely to have long-term ***beneficial*** impacts to EFH and EFH-species by	Wharf replacement would have temporary impacts such as physical disturbance, noise, sediment suspension, and turbidity during pile removal and installation, with impacts expected to be ***less than significant with mitigation***. In bay fill and seawall installation would permanently remove EFH habitat, of which would be ***significant and unavoidable*** to EFH species. Temporary impacts, like wharf replacement, during construction would be expected. Installation of tidal gates would temporarily impact EFH	Wharf replacement would have temporary impacts such as physical disturbance, noise, sediment suspension, and turbidity during pile removal and installation, with impacts expected to be ***less than significant with mitigation***. Shore-based measures are expected to have ***less than significant*** impacts to EFH species with the potential for wind-driven dust or runoff to increase turbidity and lower water quality temporarily. EWN features are anticipated to have long-term ***beneficial*** impacts to EFH and EFH species with augmentation and enhancement of marsh	Wharf replacement would have temporary impacts such as physical disturbance, noise, sediment suspension, and turbidity during pile removal and installation, with impacts expected to be ***less than significant with mitigation***. In bay fill and localized seawall installation would permanently remove EFH habitat, of which would be ***significant and unavoidable*** to EFH species. Temporary impacts, like wharf replacement, during construction would be expected. Shore-based measures are expected to have ***less than significant*** impacts with the potential for wind-driven dust or runoff to

Resource	Alternative B	Alternative F	Alternative G	Total Net Benefits Plan (TNBP)
	removing a shade structure and creosote-laden pilings, thereby improving water quality. See Appendix D-1, Section 4.16.4	and EFH species and is expected to be ***less than significant with mitigation***. Shore-based measures are expected to have ***less than significant*** impacts with the potential for wind-driven dust or runoff to increase turbidity and lower water quality temporarily. See Appendix D-1, Section 4.16.5	habitat, improved water quality, increased habitat, and improved foraging. See Appendix D-1, Section 4.16.6	increase turbidity and lower water quality temporarily. See Appendix D-1, Section 4.16.3
Special Status Species - HAPC (Appendix D-1)	Pier removal, demolition, and relocation are anticipated to have ***less than significant*** impacts to HAPC. Demolition and relocation activities could result in wind-driven dust or run off that could impact water quality. Pier removal would temporarily increase turbidity and sediment suspension. Overall, pier removal is likely to have long-term ***beneficial*** impacts removing creosote-laden pilings, thereby improving water quality.	Wharf replacement would have temporary impacts such as physical disturbance, sediment suspension, and turbidity during pile removal and installation, with impacts expected to be ***less than significant with mitigation***. In bay fill and seawall installation would permanently remove HAPC, of which would be ***significant and unavoidable***. Temporary impacts, like wharf replacement, during construction would be expected. Installation of tidal gates would temporarily impact HAPC	Wharf replacement would have temporary impacts such as physical disturbance, sediment suspension, and turbidity during pile removal and installation, with impacts expected to be ***less than significant with mitigation***. Shore-based measures are expected to have ***less than significant*** impacts to HAPC with the potential for wind-driven dust or runoff to increase turbidity and lower water quality temporarily. EWN features are anticipated to have long-term ***beneficial*** impacts to HAPC with improved water quality,	Wharf replacement would have temporary impacts such as physical disturbance, sediment suspension, and turbidity during pile removal and installation, with impacts expected to be ***less than significant with mitigation***. In bay fill and localized seawall installation would permanently remove HAPC, of which would be ***significant and unavoidable***. Temporary impacts, like wharf replacement, during construction would be expected. Shore-based measures are expected to have ***less than significant*** impacts with the potential for wind-driven dust or runoff to

Resource	Alternative B	Alternative F	Alternative G	Total Net Benefits Plan (TNBP)
	See Appendix D-1, Section 4.16.4	and is expected to be ***less than significant with mitigation***. Shore-based measures are expected to have ***less than significant*** impacts with the potential for wind-driven dust or runoff to increase turbidity and lower water quality temporarily. See Appendix D-1, Section 4.16.5	increased habitat, and improved foraging. See Appendix D-1, Section 4.16.6	increase turbidity and lower water quality temporarily. See Appendix D-1, Section 4.16.3
Special Status Species - SAV – Eelgrass	***No impact***	***No impact***	***No impact***	***No impact***
Coastal Zone Management Act Areas (Appendix D-1)	Pier removal is the only action anticipated to have ***less than significant*** impacts to CZMA areas; however, pier demolition is recommended in the Bay Plan and would be a long-term ***beneficial*** impact. All other non-structural actions are expected to have ***no impact*** as they are outside of CZMA jurisdiction. Locations where the project would impact CZMA areas are anticipated to be consistent with the	Wharf replacement, bay fill, and seawall construction would adversely impact and/or permanently alter CZMA areas. Wharf replacement would occupy the same footprint; thus, adverse impacts would be ***less than significant*** during construction. Bay fill and seawall construction would permanently alter CZMA areas, but mitigation measures would be incorporated to reduce impacts to ***less than significant with***	Wharf replacement would adversely impact CZMA areas during construction, but would occupy the same footprint, thus, adverse impacts would be ***less than significant***. EWN features (e.g., marsh enhancement, ecological armoring) would temporarily impact CZMA areas during construction which would be ***less than significant*** and offer long-term ***beneficial*** impacts through a net increase in wetland, intertidal and subtidal habitats, along with positive response to climate	Wharf replacement, bay fill, and seawall construction would adversely impact and/or permanently alter CZMA areas. Wharf replacement would occupy the same footprint; thus, adverse impacts would be ***less than significant with mitigation*** during construction. Bay fill and seawall construction would permanently alter CZMA areas, but mitigation measures would be incorporated to reduce impacts to ***less than significant with mitigation***. Shore-based measures in

Resource	Alternative B	Alternative F	Alternative G	Total Net Benefits Plan (TNBP)
	policies set forth in the Bay Plan. See Appendix D-1, Section 5.10	***mitigation***. Shore-based measures in contact with mean higher high water (e.g., naturalized or embankment shorelines) would have temporary impacts during construction and be ***less than significant***. Locations where the project would impact CZMA areas are anticipated to be consistent with the policies set forth in the Bay Plan, except in the case of tide gates which would required hydrodynamic modelling to determine consistency with the Bay Plan. See Appendix D-1, Section 5.10	change, shoreline protection and public safety. Shore-based measures in contact with mean higher high water (e.g., naturalized or embankment shorelines) would have temporary impacts during construction and be ***less than significant***. Locations where the project would impact CZMA areas are anticipated to be consistent with the policies set forth in the Bay Plan. See Appendix D-1, Section 5.10	contact with mean higher high water (e.g., naturalized or embankment shorelines) would have temporary impacts during construction and be ***less than significant***. Locations where the project would impact CZMA areas are anticipated to be consistent with the policies set forth in the Bay Plan. See Appendix D-1, Section 5.10
Coastal Barrier Resources System Areas	***No impact***	***No impact***	***No impact***	***No impact***
Noise and Vibration (Appendix D-1-2)	Construction including floodproofing and eventually demolition of some buildings could result in a substantial increase above ambient levels while also exceeding FTA criteria at	Construction including construction of measures and demolition of buildings in areas bayward of the LOD could result in a substantial increase above ambient levels while also	Construction for this measure including construction of measures and demolition of buildings in areas bayward of the LOD could result in a substantial increase above ambient levels while also	The TNBP has the least demolition anticipated of any build alternative, and smaller construction footprint than either B or G. Construction could still result in a substantial increase above ambient levels while also

Resource	Alternative B	Alternative F	Alternative G	Total Net Benefits Plan (TNBP)
	the nearest noise-sensitive receptors. Construction would also exceed Caltrans criteria for building damage and/or FTA criteria for vibration. Construction noise and vibration impacts would be ***less than significant with mitigation***. *See Appendix D-1-2, Section 2.2.4*	exceeding FTA criteria at the nearest noise-sensitive receptors. Construction would also exceed Caltrans criteria for building damage and/or FTA criteria for vibration. Given the pile driving in this alternative and proximity to sensitive receptors, construction noise and vibration impacts would be **significant and unavoidable**. See Appendix D-1-2, Section 2.2.5	exceeding FTA criteria at the nearest noise-sensitive receptors. Construction would also exceed Caltrans criteria for building damage and/or FTA criteria for vibration. Construction noise and vibration impacts would be ***less than significant with mitigation***. *See Appendix D-1-2, Section 2.2.6*	exceeding FTA criteria at the nearest noise-sensitive receptors. Construction would also exceed Caltrans criteria for building damage and/or FTA criteria for vibration. Construction noise and vibration impacts would be ***less than significant with mitigation***. See Appendix D-1-2, Section 2.2.3
Cultural Resources (Appendix D-1)	Inundation and wave energy resulting from sea level rise has a potential to result in the erosion and loss of archeological and above ground resources. Impacts to above ground resources could also occur from the installation of floodproofing measures, property acquisition/demolition, and the loss of properties through abandonment and neglect.	Direct physical and visual Impacts would occur from earthwork and the construction of above ground structures such as naturalized or embankment shorelines, bulkheads, perimeter walls, and tide gates at Mission and Islais Creeks. Impacts to above ground resources would occur from floodproofing measures and building acquisition/demolition. Additional impacts from the raising of wharves and buildings could result in	Direct physical and visual Impacts would occur from earthwork and the construction of above ground structures such as naturalized or embankment shorelines, bulkheads, and perimeter walls. Impacts to above ground resources would occur from floodproofing measures and building acquisition/demolition. Additional impacts from the raising of wharves, bridges, and buildings could result in physical damage and loss of integrity.	Direct physical and visual Impacts would occur from earthwork and the construction of above ground structures such as naturalized or embankment shorelines, bulkheads, and perimeter walls. Impacts to above ground resources would occur from floodproofing measures and building acquisition/demolition. Additional impacts from the raising of wharves and buildings could result in physical damage and loss of integrity.

Resource	Alternative B	Alternative F	Alternative G	Total Net Benefits Plan (TNBP)
	See Appendix D-1, Section 4.18.4	physical damage and loss of integrity. See Appendix D, Section 4.18.5	See Appendix D, Section 4.18.6	See Appendix D, Section 4.18.3
Cultural Resources - Native American Lands	***No impact***	***No impact***	***No impact***	***No impact***
Environmental Justice (Appendix D-1-3)	Total flooding would comprise 29 percent of the study area, and flooding in environmental justice census blocks would comprise 23 percent of these blocks. Future flooding, and displacement related to flooding, would be experienced across the study area, with fewer effects within environmental justice census blocks. Given the wide distribution of flooding and displacement effects, it would not be disproportionately felt by an environmental justice population. Based on the location of construction activity including, demolition, pile driving and other actions, and the distribution of	Total flooding would comprise 9 percent of the study area, and flooding in environmental justice census blocks would comprise 16 percent of said blocks. While residual flooding, and displacement related to residual flooding, would be experienced at a greater concentration within environmental justice census blocks than the study area, it would still be substantially less than the concentration of flooding effects under the FWOP. Based on the location of construction activity including, demolition, pile driving and other actions, and the distribution of residual flooding, ***there would not be disproportionate***	Total flooding would comprise 16 percent of the study area, and flooding in environmental justice census blocks would comprise 16 percent of these blocks. Therefore, residual flooding, and displacement related to flooding, would be experienced evenly throughout the study area and environmental justice blocks. Given this distribution of flooding and displacement effects, it would not be disproportionately felt by an environmental justice population. Based on the location of construction activity including, demolition, pile driving and other actions, and the distribution of residual flooding, there would not be ***disproportionate effect on***	Total flooding would comprise 5 percent of the study area, and flooding in environmental justice census blocks would comprise 7 percent of said blocks. While residual flooding, and displacement related to residual flooding, would be experienced at a greater concentration within environmental justice census blocks, this 2 percent variation would not rise to the level of high and adverse. Based on the location of construction activity including, demolition, pile driving and other actions, and the distribution of residual flooding, ***there would not be disproportionate effect on a minority or low-income population***. See Appendix D-1-3, Section 2.3.3

Resource	Alternative B	Alternative F	Alternative G	Total Net Benefits Plan (TNBP)
	residual flooding, ***there would not be disproportionate effect on a minority or low-income population***. See Appendix D-1-3, Section 2.3.4	***effect on a minority or low-income population***. See Appendix D-1-3, Section 2.3.5	***a minority or low-income population***. See Appendix D-1-3, Section 2.3.6	
Socioeconomics and Community (Appendix D-1-3)	Displacement of residences, commercial and industrial businesses, and community and public facilities as part of building acquisition and demolition would be required, with demolition of over 1.1 million square feet of buildings and pier/wharf removal. The planned removal of land uses would largely mitigate a substantial adverse effect of flooding on employment, school district funding, or county and city property and sales tax revenues, and dry floodproofing would support many coastal-lying features from being irrevocably lost. The potential productivity losses ($416,000) are less than under the FWOP scenario ($2.17	No residences or community and public facilities would be relocated, but alterations to commercial and industrial businesses, including 1.5 million square feet of demolition and 15,790 linear feet of wharf replacement, would be required. While alterations to the existing community to support some managed retreat inland along the southern waterfront are included, the new LOD would not generate construction effects that would divide the community and these features would ensure that future flood events do not physically divide the waterfront neighborhoods. Long term, these protection measures would avoid the worse effects of the FWOP on	Demolition of residences and community and public facilities would be required, removing approximately 8.4 million square feet of structure footprints. This preventive retreat-related demolition would fundamentally alter the community connectivity and character in their respective neighborhoods but would also ensure that flood events do not physically divide the waterfront neighborhoods. Long-term, these protection measures would avoid the worse effects of the FWOP on employment, school district funding, or county and city property and sales tax revenues. The potential productivity losses ($129 million) are less than under the FWOP scenario ($2.17 billion). Overall, this impact would be less severe that	Relocation of residences or community and public facilities would not be required, but alterations to commercial and industrial businesses would be required, including the demolition of 988,902 -square-feet of building footprints. By providing an aggressive LOD and retaining much of the existing shoreline, minimal displacement of existing uses is required. While alterations to the existing community are included to support some managed retreat inland along the southern waterfront, the new LOD would not generate construction effects that would divide the community and these features would ensure that future flood events do not physically divide the waterfront neighborhoods. Long term, these protection measures would avoid the worse effects of the FWOP on

Resource	Alternative B	Alternative F	Alternative G	Total Net Benefits Plan (TNBP)
	billion). Overall, this impact would be less severe that the No Action FWOP and socioeconomic effects would be ***less than significant.*** See Appendix D-1-3, Section 2.3.4	employment, school district funding, or county and city property and sales tax revenues. The potential productivity losses ($235 million) are less than under the FWOP scenario ($2.17 billion). Overall, this impact would be less severe that the No Action FWOP and socioeconomic effects would be ***less than significant.*** See Appendix D-1-3, Section 2.3.5	the No Action FWOP and socioeconomic effects would be ***less than significant.*** See Appendix D-1-3, Section 2.3.6	communities and neighborhoods, displacements, and economics. The potential productivity losses are less than under the FWOP scenario. Overall, this impact would be less severe that the No Action FWOP and the other alternatives and socioeconomic effects would be ***less than significant.*** See Appendix D-1-3, Section 2.3.3
Transportation (Appendix D-1-4)	Floodproofing and demolition of buildings would cause long-term disruptions during construction to major transportation corridors. The overall impact would be **less than significant** with mitigation. See Appendix D-1-4, Section 2.2.3.2	Construction to add bay fill, install naturalized or embankment shorelines, and roadway impact measures would impact the Embarcadero, Terry Francois Boulevard, and Illinois Street and transportation waterfront features such as the Bay Trail, ferry terminals, and transit services along with private vehicles. The overall impact would be **significant and unavoidable** for disruption to existing transportation services and **less than significant**	The bridge raise and naturalized or embankment shoreline construction in the 2040 action followed by EWN in the 2090 action would incur the most transportation disruptions. Long-term, substantial detours are expected during construction. This alternative would have an overall **significant and unavoidable impact** to transportation. See Appendix D-1-4, Section 2.2.3.4	The roadway impact along the Embarcadero and Terry Francois Boulevard would have the most impact on transportation in the project area. This measure would affect vehicles on the roadway, transit users on rail, bus and ferries, and bicycle and pedestrians along the Bay Trail. The overall impact would be **significant and unavoidable** for disruption to existing transportation services and **less than significant** with mitigation for other transportation effects.

Resource	Alternative B	Alternative F	Alternative G	Total Net Benefits Plan (TNBP)
		with mitigation for other transportation effects. See Appendix D-1-4, Section 2.2.3.3		See Appendix D-1-4, Section 2.2.3.5
Utilities (Appendix D-1)	Utilities will be relocated as needed when assets are moved, floodproofed, or demolished. This action would coincide with others and is expected to be ***less than significant***. See Appendix D-1, Section 4.22.4	Utilities would be relocated during construction of FRM measures as needed. Temporary impacts, such as intermittent, delayed, or unavailable service may occur during relocation activities; however, they would be returned to pre-existing conditions upon construction completion. Overall, these impacts are anticipated to be ***less than significant.*** No loss of drinking water would be expected. See Appendix D-1, Section 4.22.5	Utilities would be relocated during construction of FRM measures as needed. Temporary impacts, such as intermittent, delayed, or unavailable service may occur during relocation activities; however, they would be returned to pre-existing conditions upon construction completion. Overall, these impacts are anticipated to be ***less than significant.*** No loss of drinking water would be expected. See Appendix D-1, Section 4.22.6	Utilities would be relocated during construction of FRM measures as needed. Temporary impacts, such as intermittent, delayed, or unavailable service may occur during relocation activities; however, they would be returned to pre-existing conditions upon construction completion. Overall, these impacts are anticipated to be ***less than significant.*** No loss of drinking water would be expected. See Appendix D-1, Section 4.22.3
Recreation and Access (Appendix D-1)	Recreational areas (e.g., piers, bike paths) would be lost as rising sea levels regularly flood, erode, or damage these spaces. Green space would be increased as buildings are removed and relocated but are expected to be inundated	Recreational areas (e.g., piers, bike paths) would experience physical (e.g., noise, demolition, excavation) and aesthetic disturbance during construction of FRM features. This would be temporary and localized; other recreational spaces	Recreational areas (e.g., piers, bike paths) would experience physical (e.g., noise, demolition, excavation) and aesthetic disturbance during construction of FRM features. This would be temporary and localized; other recreational spaces	Recreational areas (e.g., piers, bike paths) would experience physical (e.g., noise, demolition, excavation) and aesthetic disturbance during construction of FRM features. This would be temporary and localized; other recreational spaces would be available elsewhere within or

Resource	Alternative B	Alternative F	Alternative G	Total Net Benefits Plan (TNBP)
	during storm events. Otherwise, an increase in recreational spaces would be expected as infrastructure is removed from flooding pressures. Any disturbance (e.g., noise) to recreational spaces during construction would be temporary; temporary access routes would be required during construction. Thus, impacts are anticipated to be ***less than significant***. See Appendix D-1, Section 4.23.4	would be available elsewhere within or around the study area during construction. Temporary access to piers would be required during construction in areas where access is disturbed. Construction areas would be returned to pre-existing conditions upon completion. Thus, impacts are anticipated to be ***less than significant***. See Appendix D-1, Section 4.23.5	would be available elsewhere within or around the study area during construction. Temporary access to piers would be required during construction in areas where access is disturbed. Construction areas would be returned to pre-existing conditions upon completion. Thus, impacts are anticipated to be ***less than significant***. EWN features in reaches 3 and 4 would increase recreational space and access, providing long-term ***beneficial*** impacts. See Appendix D-1, Section 4.23.6	around the study area during construction. Temporary access to piers would be required during construction in areas where access is disturbed. Construction areas would be returned to pre-existing conditions upon completion. Thus, impacts are anticipated to be ***less than significant***. See Appendix D-1, Section 4.23.3
Aesthetics (Appendix D-1)	There would be a temporary increase in construction equipment and support vehicles in the immediate area of the floodproofing or demolition sites that would likely last only a couple of months resulting in ***less than significant*** impacts. Over the long-term, floodproofing would not change the viewscape of the structure or the	The construction activity view would be visually and audibly intrusive to the surrounding viewscape and have ***significant and unavoidable*** impacts during construction (multi-year). Long-term presence of the elevated structures and new features (naturalized or embankment shorelines, pump stations, tidal gates) would change the viewscape; however,	The construction activity view would be visually and audibly intrusive to the surrounding viewscape and have ***significant and unavoidable*** impacts during construction (multi-year). Long-term presence of the elevated structures and new features (naturalized or embankment shorelines and pump stations) would change the viewscape; however, design elements	The construction activity view would be visually and audibly intrusive to the surrounding viewscape and have ***significant and unavoidable*** impacts during construction (multi-year). Long-term presence of the elevated structures and new features (naturalized or embankment shorelines and pump stations) would change the viewscape; however, design elements of each feature incorporate the use of materials and

Resource	Alternative B	Alternative F	Alternative G	Total Net Benefits Plan (TNBP)
	surrounding environment as the materials would blend with the structure's original form, color, and texture. Pier and building demolition would create a viewscape change that could be perceived as beneficial by some and adverse by others depending on their bias towards the quality and historic value of the site. Coastal views in general would be unaffected except for the demolition which may open new visual pathways. Long-term impacts are anticipated to be ***less than significant***. See Appendix D-1, Section 5.24	design elements of each feature incorporate the use of materials and architecture that blends with the surrounding landscape and with what was historically present, where appropriate (e.g., historic districts, along the Embarcadero). Some coastal views may be impacted or diminished but would still be available from other vantage points along the LOD. With the design elements, the impacts are anticipated to be ***less than significant*** over the long-term. See Appendix D-1, Section 5.24	of each feature incorporate the use of materials and architecture that blends with the surrounding landscape and with what was historically present, where appropriate (e.g., historic districts, along the Embarcadero). Some coastal views may be impacted or diminished but would still be available from other vantage points along the LOD. In Reaches 3 and 4, incorporation of EWN and retreating the LOD would convert the existing viewscape from industrial to open space and ecological habitat and open new visual pathways for coastal views and the greater viewscape, which may be perceived as beneficial to some viewers and adverse to others. With the retreat, would be available from more vantage points. With the design elements, the impacts are anticipated to be ***less than significant*** over the long-term. Section Appendix D-1, Section 5.24	architecture that blends with the surrounding landscape and with what was historically present, where appropriate (e.g., historic districts, along the Embarcadero). Some coastal views may be impacted or diminished but would still be available from other vantage points along the LOD. With the design elements, the impacts are anticipated to be ***less than significant*** over the long-term. See Appendix D-1, Section 5.24

Resource	Alternative B	Alternative F	Alternative G	Total Net Benefits Plan (TNBP)
HTRW (Appendix D-1)	Pier removal, demolition, and relocation are anticipated to have ***less than significant*** impacts to HTRW. Demolition and relocation activities could result in wind-driven dust or run off that could impact air and water quality. Pier removal would temporarily increase turbidity and sediment suspension. Overall, pier removal is likely to have long-term ***beneficial*** impacts by removing creosote-laden pilings, thereby lessening the risk of contamination. See Appendix D-1-6, Section 3.1	HTRW would be impacted during wharf replacement and new seawall construction during pile driving activities. These are anticipated to be ***less than significant*** as many HTRW sites can be mitigated. Additionally, ground disturbing activities could also impact HTRW sites that would require remediation, minimization, and/or mitigation. These activities would be expected to have ***less than significant*** impacts. In-bay fill would diminish risk of contamination from contaminated soils and sediments. Addition of EWN features (e.g., marsh enhancement, ecological armoring) would be expected to decrease contamination risks in localized areas, offering ***beneficial*** impacts. See Appendix D-1-6, Section 3.1	coastal flood risk management features would be constructed along the shoreline in Reaches 1 and 2, while they would be constructed landward in Reaches 3 and 4 to allow for flooding in front of the measures. This would allow for more flooding in the southern reaches and thereby increase risk of contamination from the numerous HTRW sites located in the southern reaches. Construction would have temporary impacts to HTRW that can be mitigated or avoided and would be ***less than significant.*** See Appendix D-1-6, Section 3.1	HTRW would be impacted during wharf replacement and localized areas of new seawall construction during pile driving activities. These are anticipated to be ***less than significant*** as many HTRW sites can be mitigated or avoided. Additionally, ground disturbing activities could also impact HTRW sites that would require remediation, minimization, and/or mitigation. These activities would be expected to have ***less than significant*** impacts. Prior to construction, the existence and extent of any HTRW will be identified and appropriately addressed, and the performance and costs of HTRW cleanup and response is not included as part of the Federal project. In-bay fill would diminish risk of contamination from contaminated soils and sediments. Addition of EWN features (e.g., marsh enhancement, ecological armoring) would be expected to decrease contamination risks in localized areas, offering ***beneficial*** impacts.

Resource	Alternative B	Alternative F	Alternative G	Total Net Benefits Plan (TNBP)
				See Appendix D-1-6, Section 3.1
Land Use (Appendix D-1-7)	Floodproofing and demolition of buildings would have a **less than significant impact** since these construction measures could be planned for and coordinated over a longer period of time compared to FWOP. See Appendix D-1-7, Section 2.3.4	Bay fill, roadway impact and wharves elevation would be the most impactful to land use followed by bulkhead wall/seawall construction. Tide gates would have operational impacts on land use for Mission Creek and Islais Creek communities. This alternative would have a **less than significant impact** on land use with mitigation. See Appendix D-1-7, Section 2.3.5	Construction for naturalized or embankment shorelines, bulkhead wall/seawall, wharves elevation and roadway impacts would lead to the most impact to land use. The naturalized or embankment shorelines in Mission Bay and Islais Creek would allow EWN to occur and abandon these communities. This alternative would have a **significant and unavoidable impact** for land use. See Appendix D-1-7, Section 2.3.6	Bulkhead wall/seawall, roadway impact, T-wall, and wharves elevation would have the most impact during construction on land use. The deployable flood gates would impact the Mission Creek and Islais Creek communities during construction and operations. Overall, land use impacts are **less than significant**. See Appendix D-1-7, Section 2.3.3
Public Health and Safety (Appendix D-1)	Public safety infrastructure would be floodproofed or relocated as the risk of SLR dictates. Flooding could impact accessibility of emergency services and increase risks to public safety. As assets retreat and are relocated those public safety assets and access would be restored. Temporary disruptions may occur	Public safety infrastructure would be protected by FRM measures from flooding perpetuated by SLR. FRM measures would prevent flooding during storm events, which would be ***beneficial*** to accessibility to and for public health and safety industries. Construction of FRM measures may temporarily change access routes for public	Public safety infrastructure would be protected by FRM measures from flooding perpetuated by SLR in Reaches 1 and 2, which would be ***beneficial*** to accessibility to and for public health and safety industries during storm events. Construction of FRM measures may temporarily change access routes for public safety industries but would not	Public safety infrastructure would be protected by FRM measures from flooding perpetuated by SLR. FRM measures would prevent flooding during storm events, which would be ***beneficial*** to accessibility to and for public health and safety industries. Construction of FRM measures may temporarily change access routes for public safety industries but would not impede or eliminate

Resource	Alternative B	Alternative F	Alternative G	Total Net Benefits Plan (TNBP)
	during construction, but these are minimal compared to those that could happen in a flooding/storm event. Overall, floodproofing, demolition, and relocation are expected to have ***less than significant*** impacts to public health and safety and would rather improve these resources as sea levels rise. See Appendix D-1,, Section 4.27.4	safety industries but would not impede or eliminate access to or from these facilities. Access would be returned to pre-existing conditions upon construction completion; thus, impacts are anticipated to be ***less than significant***. See Appendix D-1, Section 4.27.5	impede or eliminate access to or from these facilities. Reaches 3 and 4 experience retreat that would require relocation of public health facilities (e.g., hospitals) that would temporarily require attendance to different facilities. Access would be returned to pre-existing conditions upon construction completion; thus, impacts are anticipated to be ***less than significant***. See Appendix D-1, Section 4.27.6	access to or from these facilities. Access would be returned to pre-existing conditions upon construction completion; thus, impacts are anticipated to be ***less than significant***. See Appendix D-1, Section 4.27.3

Table 4-3: Summary of Environmental Impacts for the Independent Measures for Consideration

Resource	2A	2B	3A	3B	3C	4A	Vertical Shoreline/ Living Shoreline
Regional Air Quality and Clean Air Act	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.
Climate - GHG Emissions	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.
Climate - Regional Climate, Climate Change, RSLC	Impacts to regional climate are commensurate with GHG emissions.	Impacts to regional climate are commensurate with GHG emissions.	Impacts to regional climate are commensurate with GHG emissions.	Impacts to regional climate are commensurate with GHG emissions.	Impacts to regional climate are commensurate with GHG emissions.	Impacts to regional climate are commensurate with GHG emissions. ***Beneficial*** impacts through carbon sequestration are anticipated but would be minor.	Impacts to regional climate are commensurate with GHG emissions.
Geology	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	***No impact***
Geology - Sediments	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives. ***Beneficial***	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Cofferdams would be used to install panels in the dry, thus

Resource	2A	2B	3A	3B	3C	4A	Vertical Shoreline/ Living Shoreline
		impacts would be expected with sediment retention on the coarse beach.					sediments would be disturbed during installation, dewatering, and rewatering activities. These are anticipated to be ***less than significant***.
Geology - Seismicity	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	***No impact***
Soils & Mineral Resources	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	***No impact***
Hydrology & Hydraulics - Floodplains	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	***No impact***
Hydrology & Hydraulics - Coastal hydrology, currents, and circulation	Impacts do not differ from Action Alternatives.	Construction impacts are like those described in Action Alternatives. The coarse beach could	Impacts do not differ from Action Alternatives.	***No impact***	Impacts do not differ from Action Alternatives.	***No impact***	Cofferdams would be used to install panels which would temporarily disrupt coastal hydrology in

Resource	2A	2B	3A	3B	3C	4A	Vertical Shoreline/ Living Shoreline
		change hydrology, currents, and circulation by changing the shape of the waterfront. Hydrodynamic modelling would be needed to confirm the level of impacts.					the construction area (e.g., increase current velocity) but are anticipated to be ***less than significant***.
Hydrology & Hydraulics - Tides, tidal exchange, and waves	Impacts do not differ from Action Alternatives. There should be ***no impact*** to tides or tidal exchange.	Impacts from bay fill do no differ from Action Alternatives. Coarse beach (EWN) should help reduce wave energies and erosion.	Impacts do not differ from Action Alternatives. There should be ***no impact*** to tides or tidal exchange.	***No impact***	Impacts do not differ from Action Alternatives. Ecological armoring (EWN) should help reduce wave energies and erosion. There should be ***no impact*** to tides or tidal exchange.	EWN features on the shoreline would help dissipate wave energies. There should be ***no impact*** to tides or tidal exchange.	Cofferdams would be used to install panels which would temporarily disrupt wave action and tides in the construction area but are anticipated to be ***less than significant***.
Hydrology & Hydraulics - Stormwater	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	***No impact***

Resource	2A	2B	3A	3B	3C	4A	Vertical Shoreline/ Living Shoreline
		Coarse beach (EWN) would be ***beneficial*** for stormwater drainage.				EWN features would be ***beneficial*** for stormwater drainage.	
Water Quality	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Cofferdams would temporarily degrade water quality with turbidity, sediment suspension, and potentially lower dissolved oxygen and salinity in the construction area but are anticipated to be ***less than significant with mitigation***.
Groundwater	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	***No impact***
Aquatic Resources - Intertidal Habitat	Impacts do not differ from Action Alternatives.	Construction impacts do not differ from Action	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Cofferdams would temporarily restrict access

Resource	2A	2B	3A	3B	3C	4A	Vertical Shoreline/ Living Shoreline
		Alternatives. Coarse Beach (EWN) would create new intertidal habitat that would have ***beneficial*** impacts to aquatic species and shorebirds.					to intertidal habitat in the construction area and may result in habitat loss during dewatering. This is expected to be ***less than significant with mitigation***. Long-term ***beneficial*** impacts would be realized with the addition of intertidal habitat through the living shoreline.
Aquatic Resources - Subtidal Habitat	Impacts do not differ from Action Alternatives.	Construction impacts do not differ from Action Alternatives. Coarse Beach (EWN) would create new subtidal habitat that	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Cofferdams would temporarily adversely impact subtidal habitats like mud bottom and the water column in the

Resource	2A	2B	3A	3B	3C	4A	Vertical Shoreline/ Living Shoreline
		would have ***beneficial*** impacts to aquatic species and shorebirds.					construction area by increased turbidity, sediment suspension, and dewatering. This is expected to be ***less than significant with mitigation***.
Aquatic Resources - Pelagic Habitat	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	***No impact***	***No impact***	***No impact***	Cofferdams would temporarily degrade water quality and restrict access to pelagic habitat during construction. Impacts are anticipated to be ***less than significant with mitigation***. A living shoreline is expected to have long-term ***beneficial***

Resource	2A	2B	3A	3B	3C	4A	Vertical Shoreline/ Living Shoreline
							impacts by improving water quality with colonization of filtering organisms.
Aquatic Resources - Wetlands	***No impact***	***No impact***	***No impact***	***No impact***	***No impact***	***No impact***	***No impact***
Aquatic Resources - Fish	Impacts do not differ from Action Alternatives.	Construction impacts do not differ from Action Alternatives. Coarse Beach (EWN) would create new habitat that supports prey for fish creating a long-term ***beneficial*** impact to fish.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Cofferdams would temporarily degrade water quality, restrict access to important habitat, and entrap or kill fish during construction. Impacts are anticipated to be ***less than significant with mitigation***. A living shoreline is expected to have long-term ***beneficial*** impacts to fish by improving

Resource	2A	2B	3A	3B	3C	4A	Vertical Shoreline/ Living Shoreline
							water quality with colonization of filtering organisms and providing prey sources.
Aquatic Resources - Commercial and Recreational Fisheries	Impacts do not differ from Action Alternatives.	Construction impacts do not differ from Action Alternatives. Coarse beach (EWN) may improve fish prey availability which could benefit local fisheries.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Cofferdams would have adverse impacts during construction of fish which may lower the quality of fishing temporarily, this is expected to be ***less than significant*** as other areas will still be available for access to fishing. In the long-term improved water quality and prey availability to fish may improve fisheries.

Resource	2A	2B	3A	3B	3C	4A	Vertical Shoreline/ Living Shoreline
Aquatic Resources - Macroinvertebrates	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.
Upland Resources - Terrestrial Vegetation	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	***No impact***	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	***No impact***
Special Status Species - T&E Species Terrestrial	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.
Special Status Species - T&E Species Aquatic	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives. Coarse Beach (EWN) would create new habitat that supports prey for aquatic T&E species creating a long-term ***beneficial*** impact.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Cofferdams would temporarily degrade water quality, restrict access to important habitat, and entrap or kill T&E aquatic species during construction. Impacts are anticipated to be ***less than significant with mitigation***. A living shoreline is expected to

Resource	2A	2B	3A	3B	3C	4A	Vertical Shoreline/ Living Shoreline
							have long-term ***beneficial*** impacts by improving water quality with colonization of filtering organisms and providing prey sources.
Special Status Species - State Listed Species	Impacts are the same as those described for T&E species.	Impacts are the same as those described for T&E species.	Impacts are the same as those described for T&E species.	Impacts are the same as those described for T&E species.	Impacts are the same as those described for T&E species.	Impacts are the same as those described for T&E species.	Impacts are the same as those described for T&E species.
Special Status Species - Designated Critical Habitat	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.
Special Status Species - Migratory Bird Treaty Act Species	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.
Special Status Species - Marine Mammal Protection Act Species	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.

Resource	2A	2B	3A	3B	3C	4A	Vertical Shoreline/ Living Shoreline
Special Status Species - EFH and EFH-designated Species	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.
Special Status Species - HAPC	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.
Special Status Species - SAV – Eelgrass	***No impact***	***No impact***	***No impact***	***No impact***	***No impact***	***No impact***	***No impact***
Coastal Zone Management Act Areas	Impacts do not differ from Action Alternatives. Measures that would impact CZMA areas are anticipated to be consistent with the policies set forth in the Bay Plan.	Impacts do not differ from Action Alternatives. Measures that would impact CZMA areas are anticipated to be consistent with the policies set forth in the Bay Plan.	Impacts do not differ from Action Alternatives. Measures that would impact CZMA areas are anticipated to be consistent with the policies set forth in the Bay Plan.	***No impact***	Impacts do not differ from Action Alternatives. Measures that would impact CZMA areas are anticipated to be consistent with the policies set forth in the Bay Plan.	Impacts do not differ from Action Alternatives. Measures that would impact CZMA areas are anticipated to be consistent with the policies set forth in the Bay Plan.	Impacts do not differ from Action Alternatives. Measures that would impact CZMA areas are anticipated to be consistent with the policies set forth in the Bay Plan.
Coastal Barrier Resources System Areas	***No impact***	***No impact***	***No impact***	***No impact***	***No impact***	***No impact***	***No impact***
Noise and Vibration	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.

Resource	2A	2B	3A	3B	3C	4A	Vertical Shoreline/ Living Shoreline
Cultural Resources	Direct physical and visual impacts from raised buildings and constructed structures. Potential impacts to submerged resources.	Direct visual impacts from a change in setting. Potential impacts to submerged resources.	Direct physical and visual impacts from raised/demolished buildings and earthmoving. Potential impacts to submerged resources.	Direct visual impacts from a change in setting. Potential impacts from earthmoving.	Direct visual impacts from a change in setting. Potential impacts from earthmoving.	Direct visual impacts from a change in setting. Potential impacts from earthmoving.	Direct visual impacts from a change in setting.
Cultural Resources - Native American Lands	***No impact***	***No impact***	***No impact***	***No impact***	***No impact***	***No impact***	***No impact***
Environmental Justice	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.
Socioeconomics and Community	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.
Transportation	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.
Utilities	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.

Resource	2A	2B	3A	3B	3C	4A	Vertical Shoreline/ Living Shoreline
Recreation and Access	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.
Aesthetics	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.
HTRW	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.
Land Use	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.
Public Health and Safety	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	Impacts do not differ from Action Alternatives.	***No impact***	***No impact***	***No impact***	***No impact***

5. The Tentatively Selected Plan

The draft IFR-EIS has been prepared to satisfy the requirements of all applicable environmental laws and regulations, where possible, and has been prepared using the Council on Environmental Quality (CEQ) NEPA regulations (40 CFR Part 1500–1508) and the USACE's regulation ER 200-2-2 – Environmental Quality: Policy and Procedures for Implementing NEPA, 33 CFR 230. In implementing the Recommended Plan, any compliance that could not be completed during the feasibility phase will be secured during the PED phase and the USACE would continue to follow the provisions of all applicable laws, regulations, and policies related to the proposed actions.

Based on agency feedback, demonstration of full compliance of the first action measures during feasibility is likely for the following laws and executive orders (EOs): NEPA, Fish and Wildlife Coordination Act (FWCA), Endangered Species Act (ESA), Clean Water Act (CWA) Section 404, National Historic Preservation Act (NHPA), E.O. 12898 (Environmental Justice), E.O. 11988 (Floodplain Management), and E.O. 11990 (Protection of Wetlands). Full compliance may not be possible for the Magnuson-Stevens Fishery Conservation and Management Act (MSA) and CWA Section 401. There are a few measures in the project that may preclude full compliance if the agencies determine there is not sufficient level of design detail for them to make a determination. Since the TNBP is a system, the agencies will not likely make a determination on only parts of the project because their policies require considering the whole project and would not allow a multi-part review. Full compliance cannot be achieved and must be addressed during PED for the following laws: Marine Mammal Protection Act (MMPA), Clean Air Act (CAA), and Coastal Zone Management Act (CZMA) due to lack of detailed design required to complete the analysis.

This chapter presents a summary of the TSP including the features of the plan and its implementation, components of the plan, and factors regarding implementation of the TSP. Further technical engineering, environmental, and economic details can be found in the appendices. *Chapter 6: Environmental Compliance* 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.

5.1. Plan Components

After careful evaluation of the alternatives and their tradeoffs, the PDT selected the TNBP as the TSP. A waiver of policy is 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).

The TNBP manages coastal flood risk through a suite of measures that function as a system, based on rising sea levels, and are implemented over time based on the risk of SLR. Also, the TNBP is proposed with seismic ground improvements 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.

The TSP as described here follows the planning assumptions required for analysis, using 2040 and 2090 as approximate first and subsequent action years. However, the PDT recognizes that the TSP subsequent actions will be reconsidered over time based on monitoring SLR and other changing conditions, as described in *Appendix G: Monitoring and Adaptation Plan*. **Figure 5-1** illustrates the conceptual framework for the range of TSP subsequent actions. As shown in **Figure 5-1**, the TSP first actions are independent of the RSLC curve. However, due to the uncertainty of RSLC, the PDT assumed the Intermediate-High RSLC second actions in describing the TSP and for analysis in the NEPA process. This is in line with the extrapolation of observed SLR in this region, which is trending above the USACE Intermediate curve and below the USACE High curve, as described in *Appendix J: Climate*. The Intermediate-High RSLC second actions described in the TSP for the NEPA process were selected to reflect impacts beyond those associated with the Intermediate RSLC second actions without overstating the potential benefits.

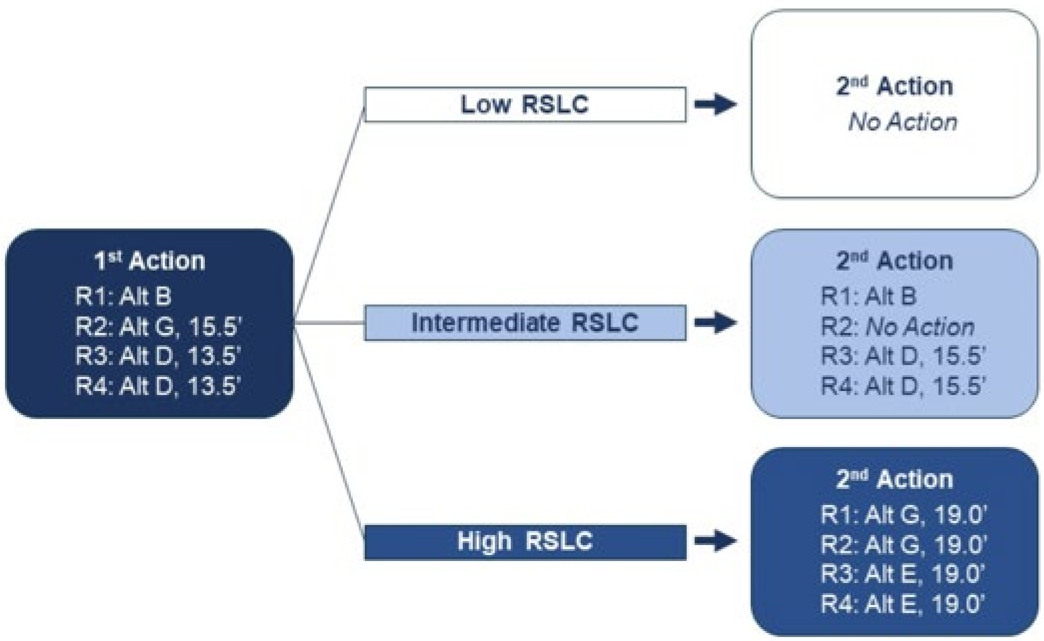


Figure 5-1: Conceptual Framework for TSP First Actions and Potential Range of TSP Subsequent Actions

The TSP includes NNBFs for coastal flood risk reduction, and it can be further optimized for NNBFs by reviewing the full range of NNBFs across all alternatives, selecting the best NNBFs to maximize coastal flood risk reduction and net benefits (*Appendix I: Engineering with Nature*), and incorporating them as part of future planned refinements.

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 (**Figure 5-2**) are proposed to align expenditures and subsequent actions (**Figure 5-3**) that add height or adapt measures with the arrival of increased risk in later years.

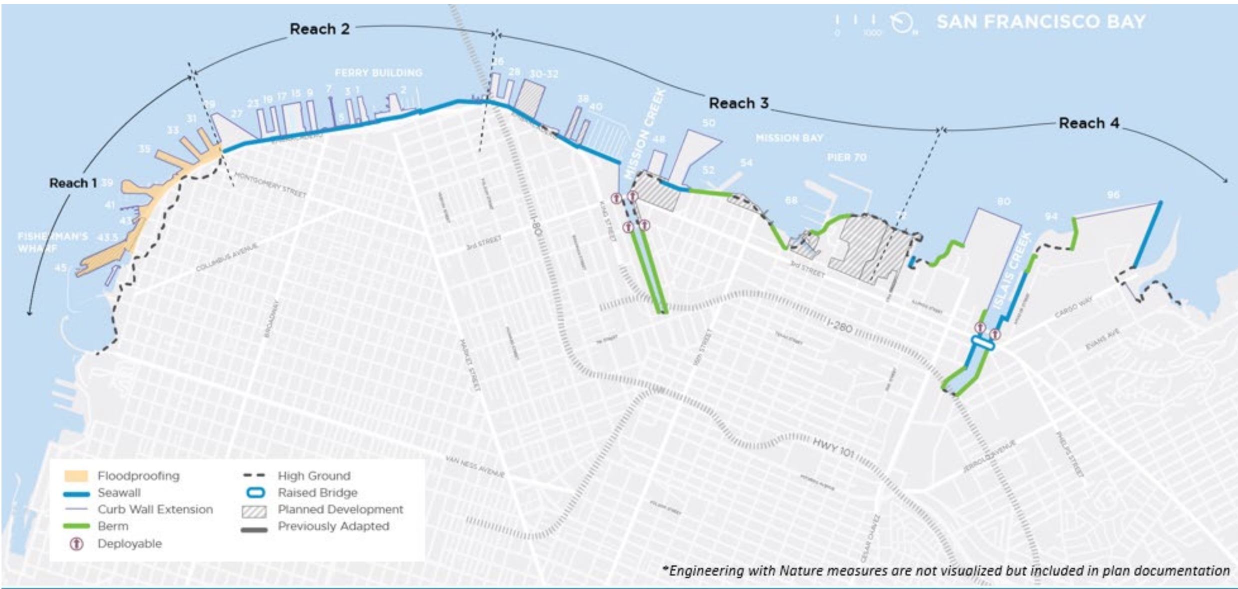


Figure 5-2: TSP Initial Actions

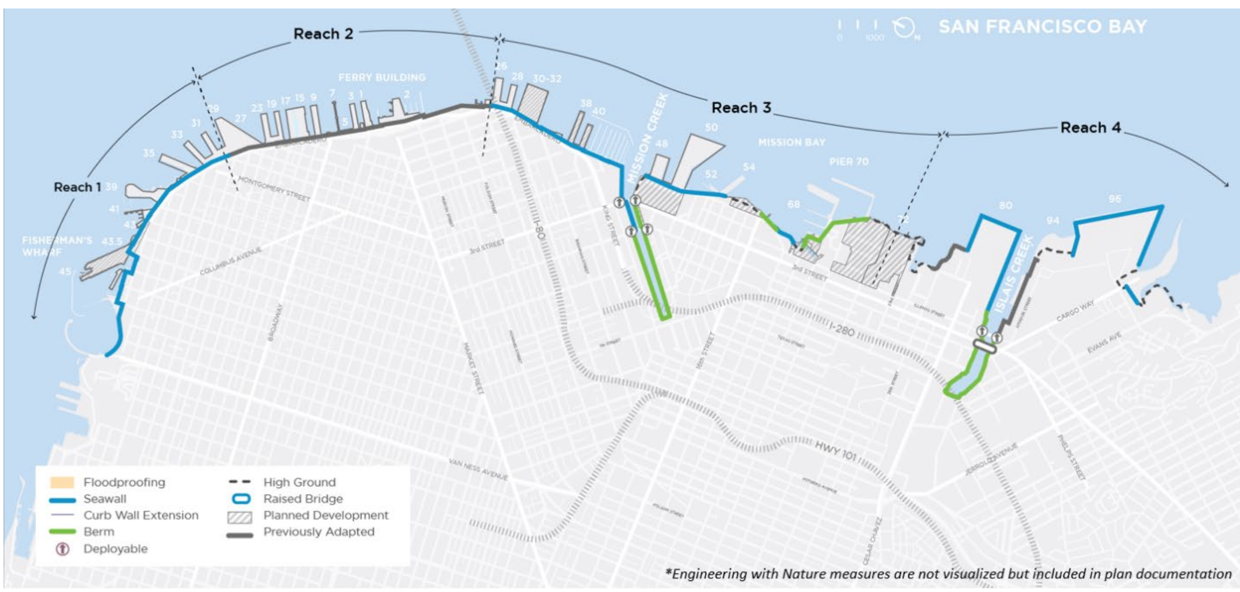


Figure 5-3: TSP Subsequent Actions

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

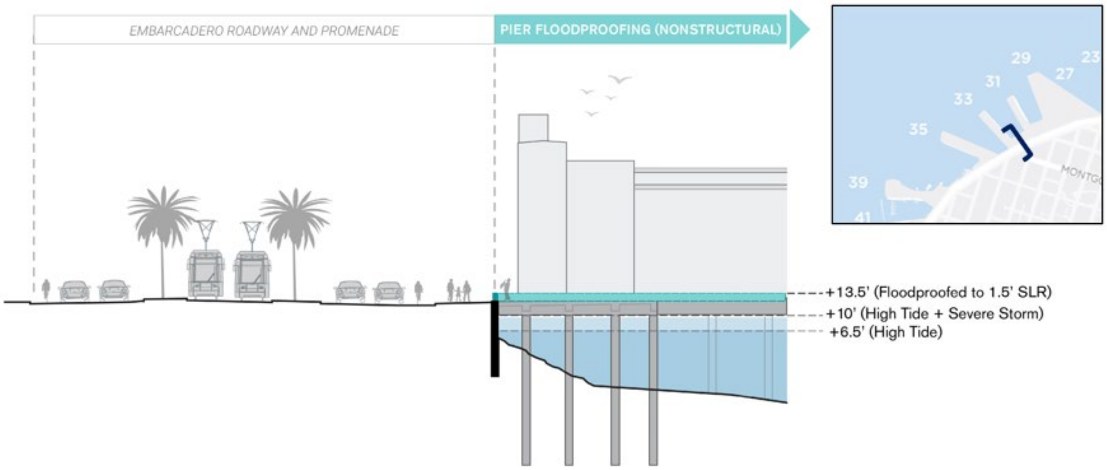
5.1.1. Embarcadero (Reaches 1 and 2)

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**).

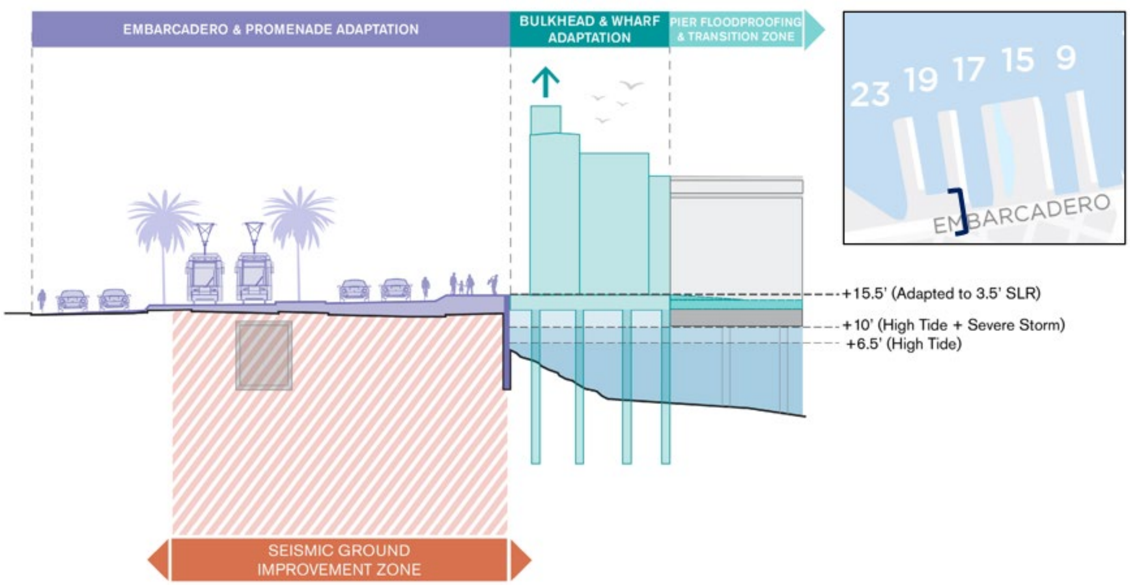
- From Pier 27-29 to the Bay Bridge, raise the shoreline along the Embarcadero by 3.5 to 7.5 feet to defend against 3.5 feet of SLR (finish elevation of 15.5 feet NAVD88) using raised and rebuilt bulkhead walls and wharves, approximately aligned with the location of the existing structures. Provide Embarcadero 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.



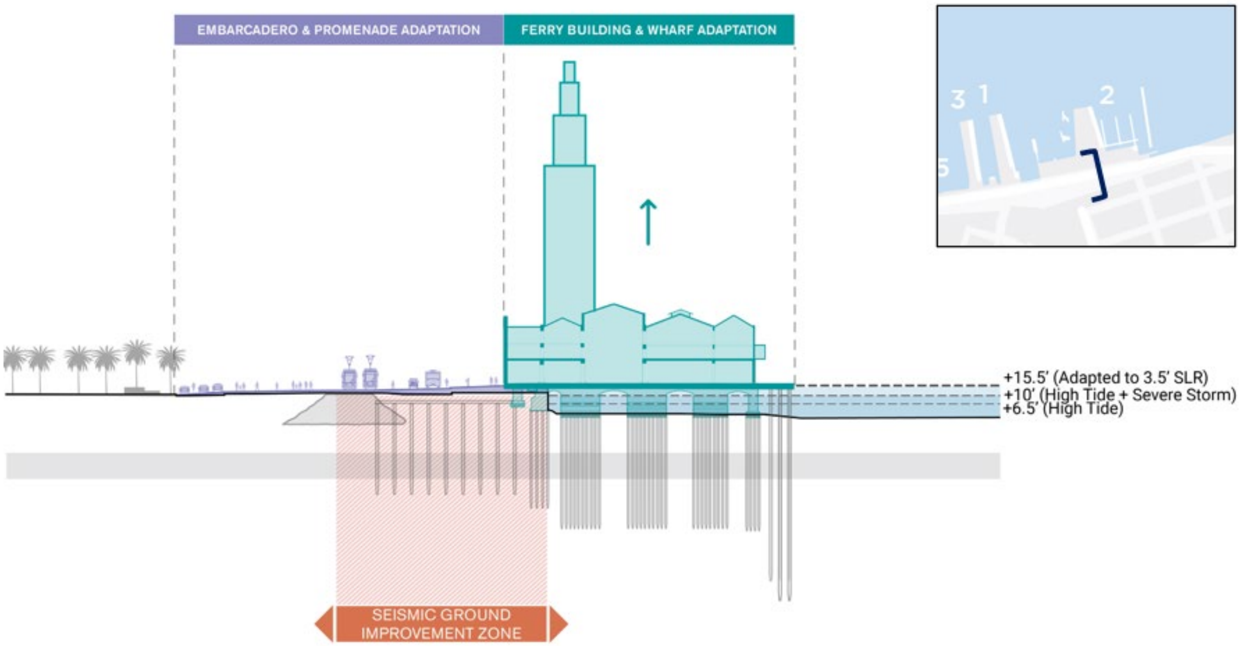
Gray and black represent existing conditions; teal represents TSP first actions

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



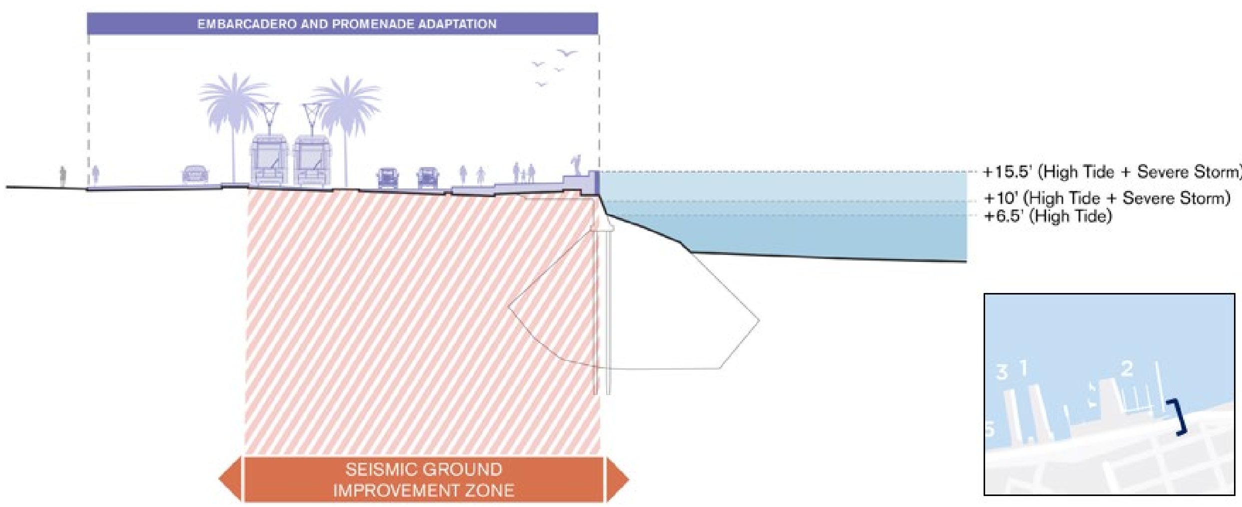
Gray and black represent existing conditions; orange, purple, and teal represent TSP first actions

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



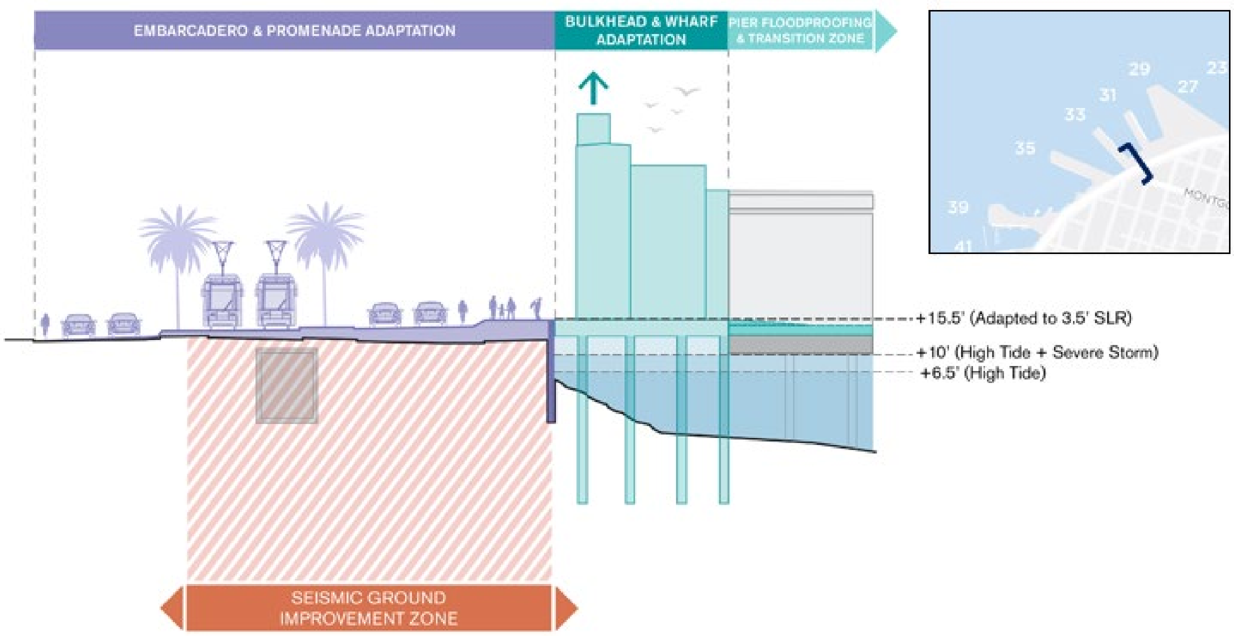
Gray and black represent existing conditions; orange and purple represent TSP first actions.

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)

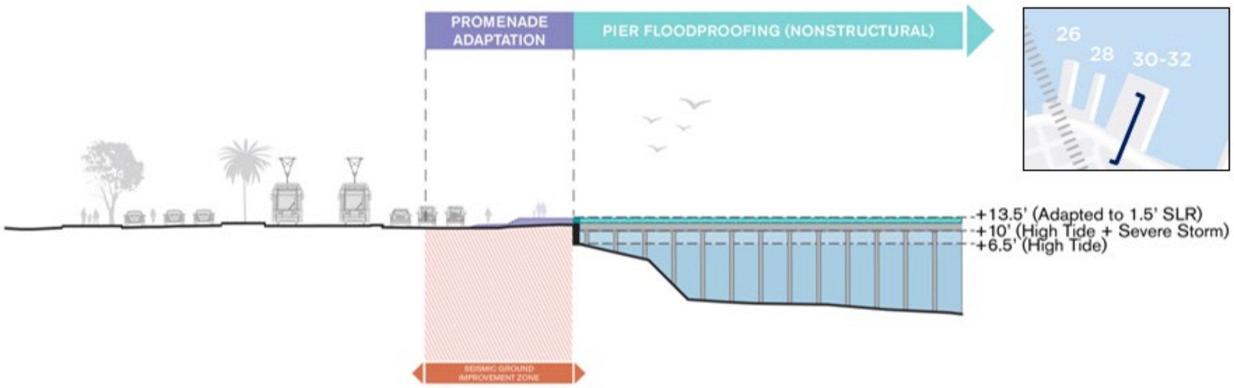
In the Mission Creek / Mission Bay geography, the TSP defends existing city and community assets in place by elevating the creek and Bay shorelines with naturalized or embankment shorelines, floodwalls, and raised and rebuilt bulkhead walls and wharves. The coastal defense will tie into existing and 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,

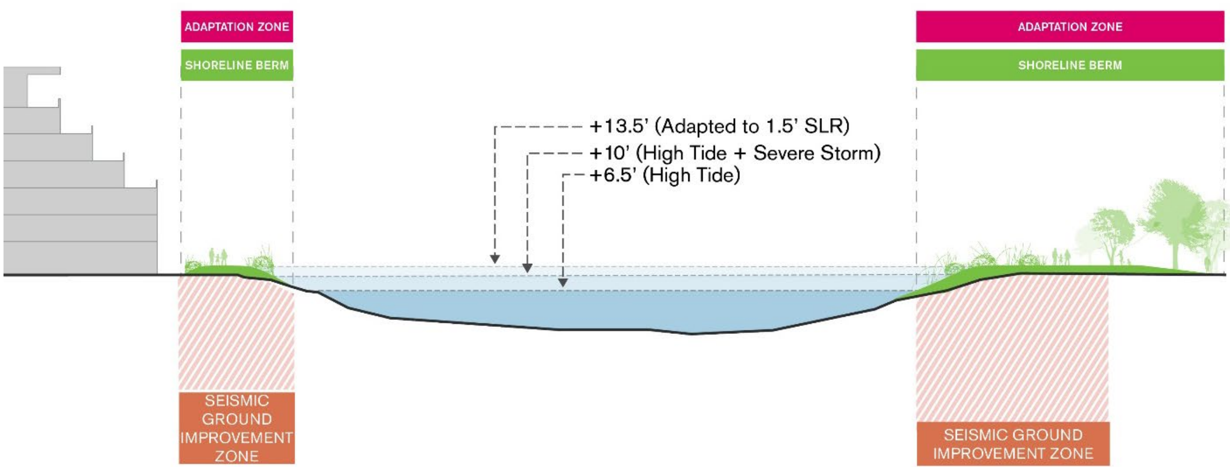
[8] Based on USACE intermediate and high RSLC.

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



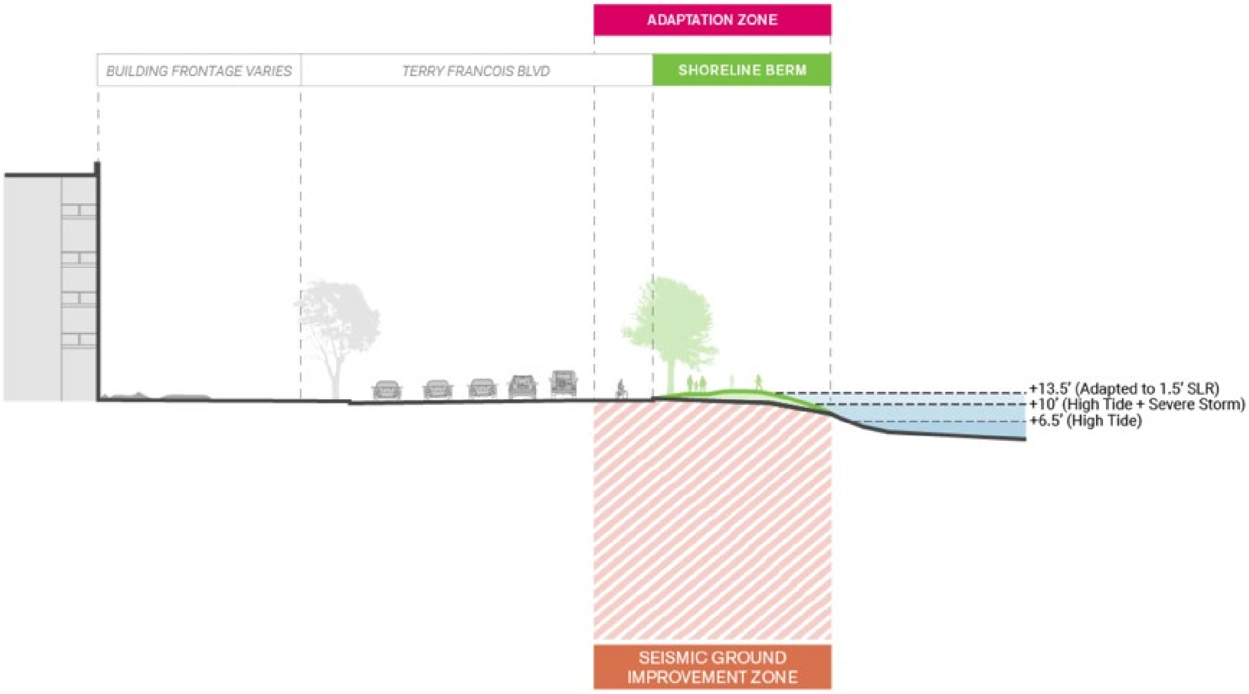
Gray and black represent existing conditions; orange, purple, and teal represent TSP first actions

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



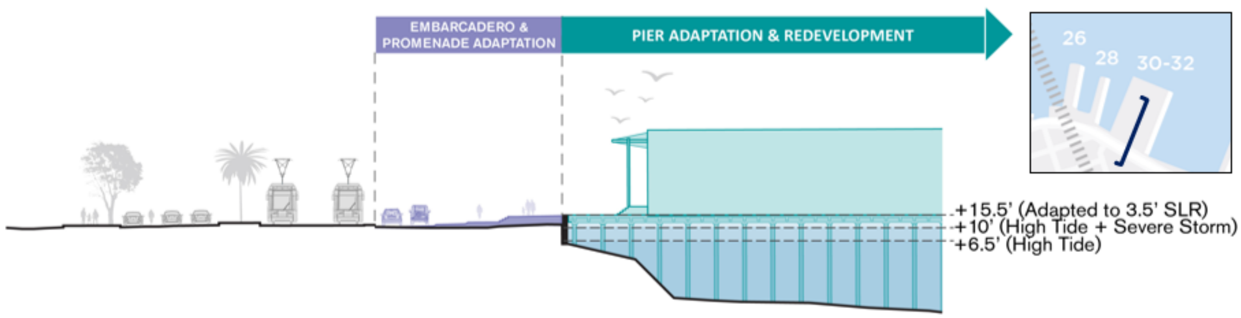
Gray and black represent existing conditions; orange, pink, and green represent TSP first actions

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

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

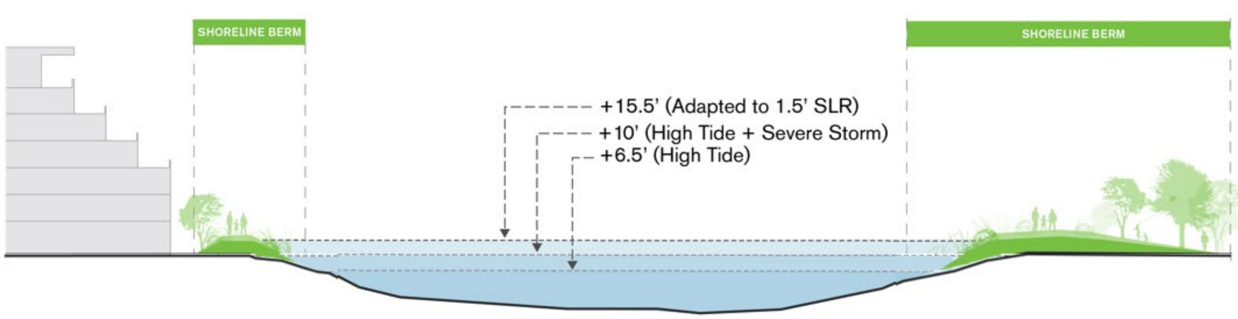
- Raise the Bay and creek shorelines an additional 2 feet to defend against 3.5 feet of SLR (15.5 feet NAVD88) using naturalized or embankment shorelines and seawalls, as well as raising and rebuilding bulkhead walls and wharves. Provide Bay Trail access atop and adjacent to the naturalized or embankment 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.



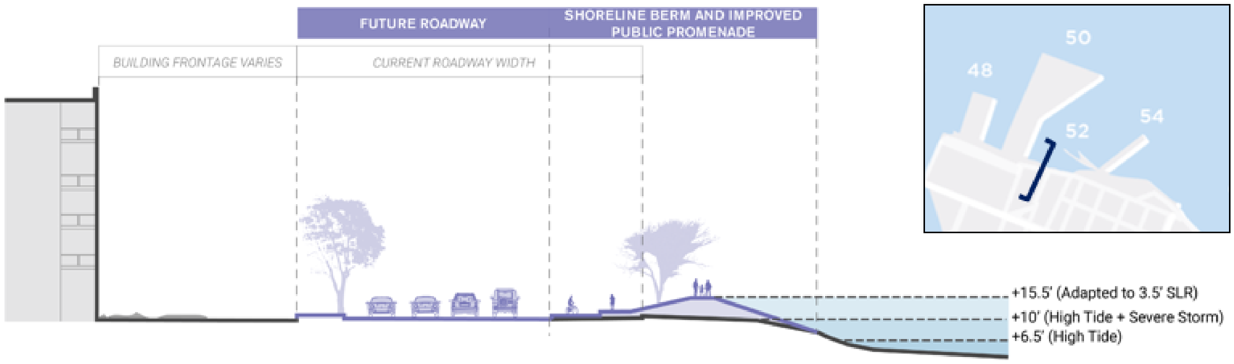
Gray and black represent post-first-action conditions; purple and teal represent TSP subsequent actions and example potential actions in coordination with development partners

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

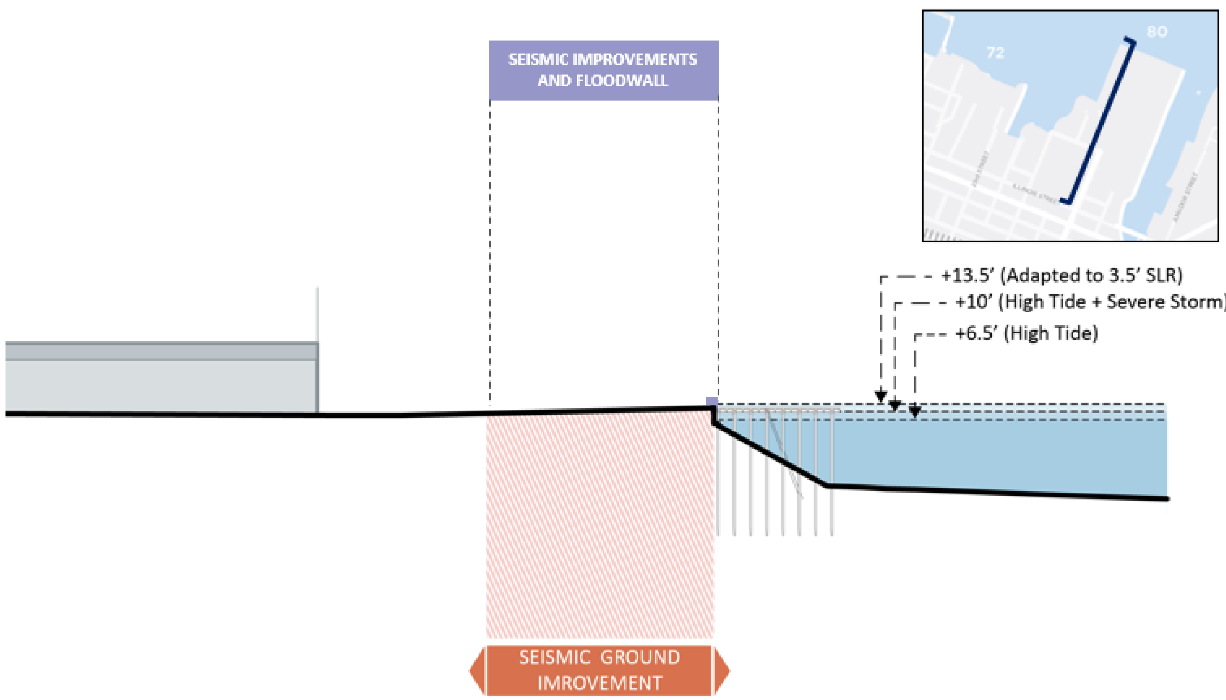
5.1.3. Islais Creek / Bayview (Reach 4)

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.

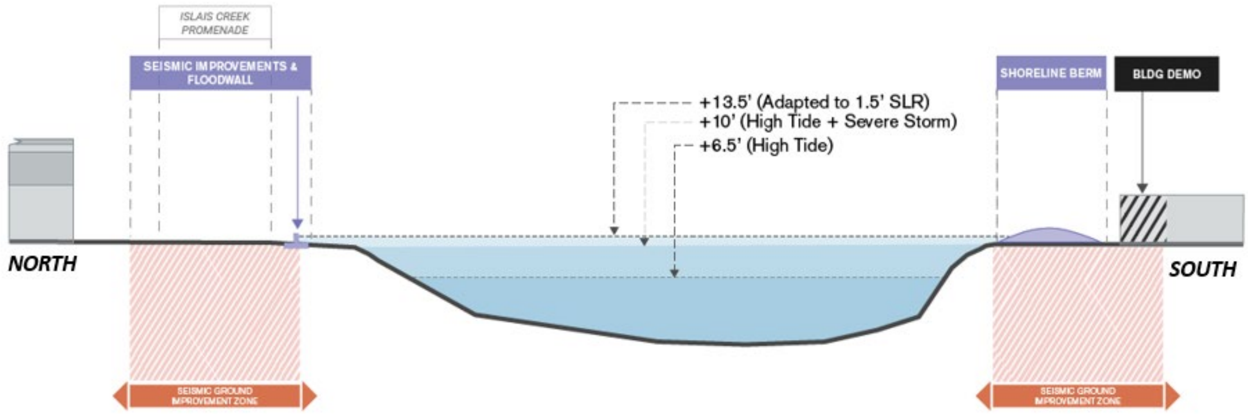
- 3rd Street Bridge will be rebuilt at a higher elevation[9] per the SF Public Works existing project, outside of the SFWCFS (FWOP Condition).
- Reconstruct Pier 90 and 92 wharves at 13.5' NAVD88 elevation and incorporate them into the coastal defense system.
- Consider removing portions of warehouses 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

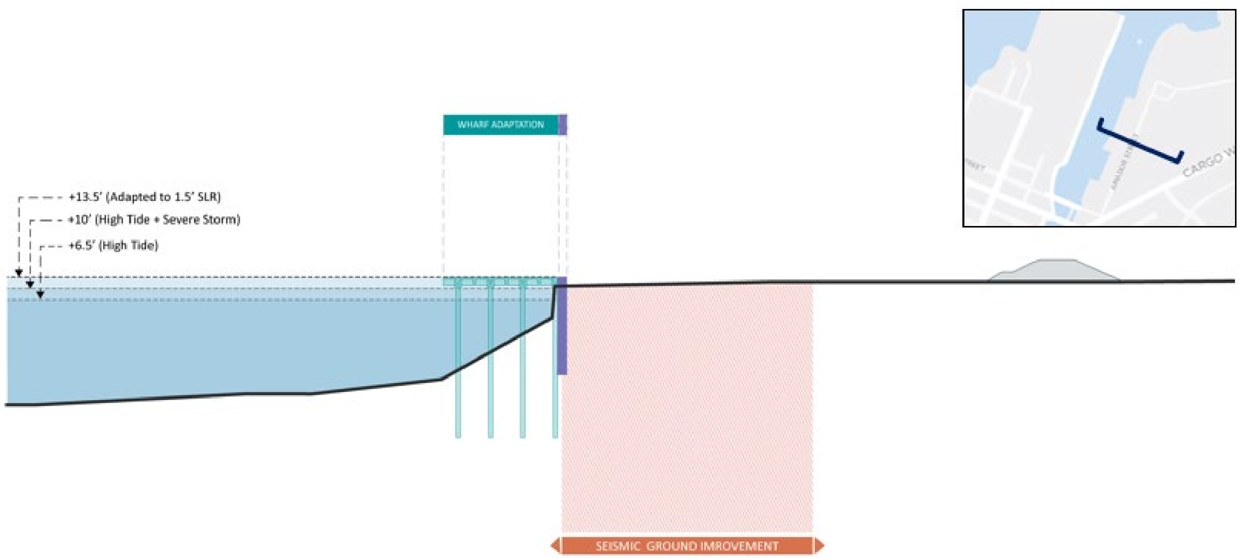
Figure 5-15: TSP First Actions: Potrero Point to Heron's Head Park (Reach 4), Pier 80

[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



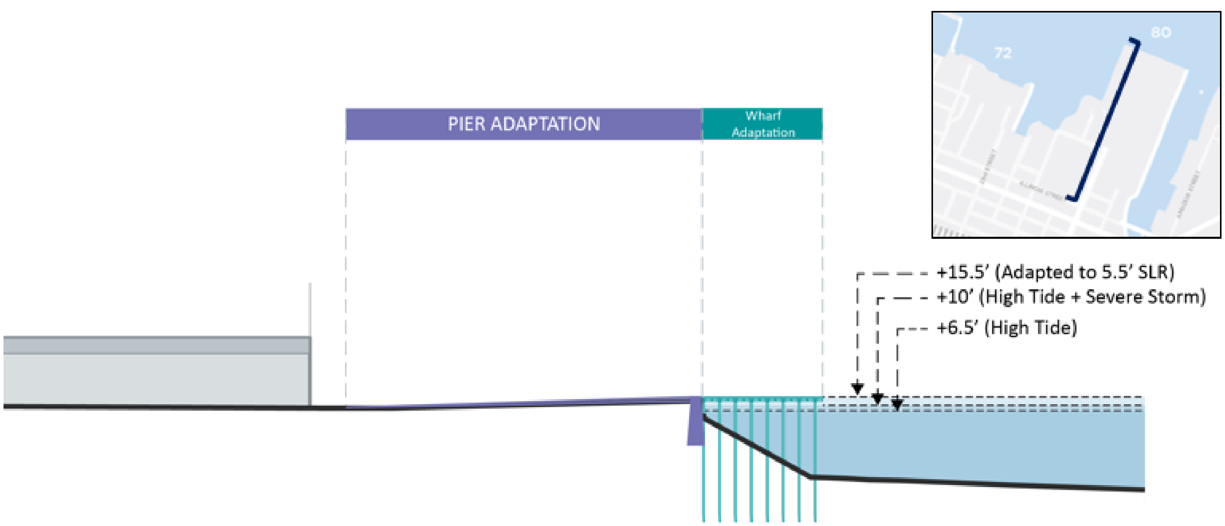
Gray and black represent existing conditions; orange, purple and teal represent TSP first actions

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**):

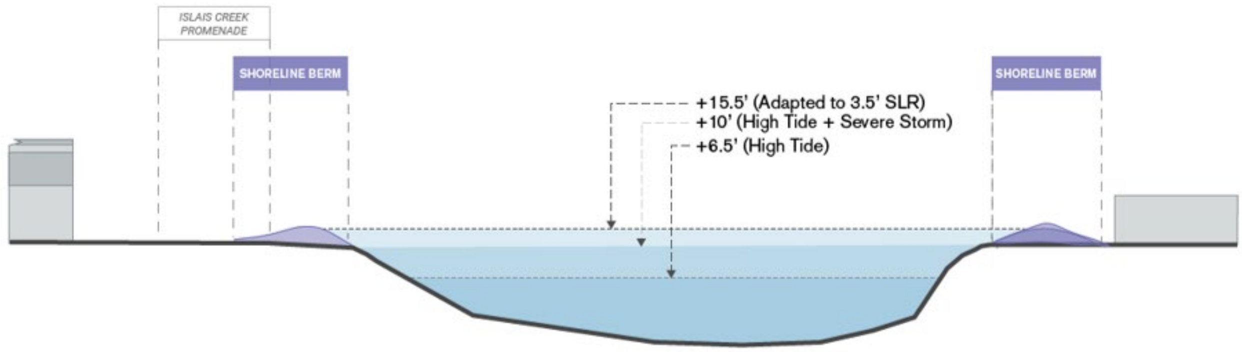
- Elevate the Bay and creek shorelines an additional 2 feet using a combination of naturalized or embankment shorelines, floodwalls, and raised bulkhead walls and wharves to defend against 3.5 feet of SLR (15.5 feet NAVD88).
- Perform ground improvement as required to mitigate lateral spreading and liquefaction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

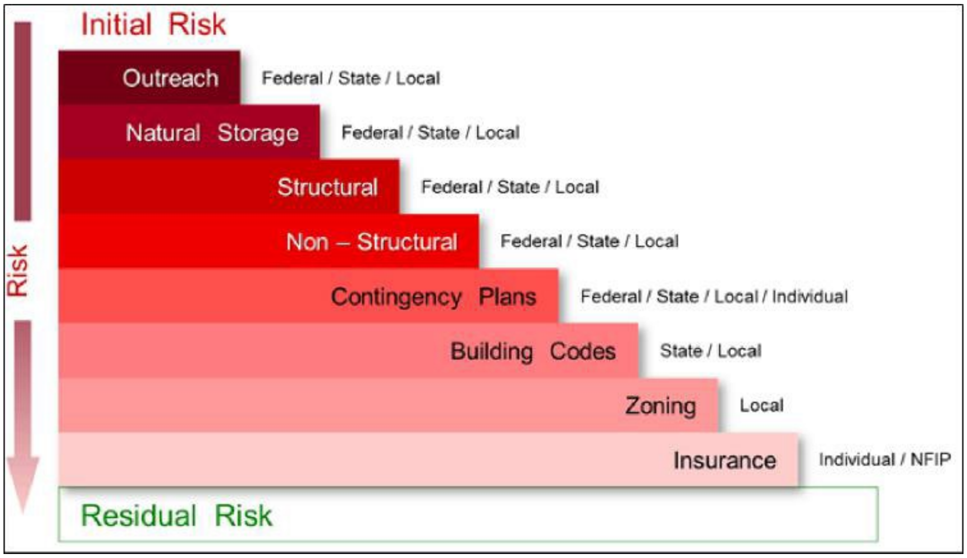


Figure 5-20: Shared Responsibility of Coastal Flood Risk Management

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.

Table 5-1: Tentatively Selected Plan Cost (2040 First Action)
(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 5-2: Project Annual Costs (2040 First Action)
(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, & Rehabilitation (OMRR&R)	$67,000,000
Monitoring and Adaptation Plan	TBD
Total Annual Cost	$525,000,000

Table 5-3: Tentatively Selected Plan Cost (2040 First and 2090 Second Actions)

(FY 24 Price Level)

	First Action	Second Action			Total Cost Range		
		Low RSLC	Intermediate RSLC	High RSLC			
Total First Cost	**$13,555,200,000**	**$0**	**$1,742,800,000**	**$11,625,500,000**	**$13,555,200,000**	**to**	**$25,180,700,000**
Lands & Damages**	$91,700,000	$0	$11,600,000	$81,383,000	$91,700,000	to	$173,083,000
Relocations	$1,278,400,000	$0	$718,000,000	$2,865,300,000	$1,278,400,000	to	$4,143,700,000
Fish & Wildlife Facilities	$23,900,000	$0	$11,600,000	$116,500,000	$23,900,000	to	$140,400,000
Breakwaters & Seawalls	$9,965,100,000	$0	$150,000,000	$5,239,900,000	$9,965,100,000	to	$15,205,000,000
Levees & Floodwalls	$96,100,000	$0	$28,200,000	$390,400,000	$96,100,000	to	$486,500,000
Pumping Plant	$281,300,000	$0	$565,300,000	$847,200,000	$281,300,000	to	$1,128,500,000
Bank Stabilization	$4,800,000	$0	$800,000	$0	$4,800,000	to	$4,800,000
Cultural Resource Preservation	TBD	$0	TBD	TBD	TBD	to	TBD
Mitigation	TBD	$0	TBD	TBD	TBD	to	TBD
Buildings, Grounds, & Utilities	$13,700,000	$0	$0	$0	$13,700,000	to	$13,700,000
Remaining Construction Items	$54,000,000	$0	$16,000,000	$351,400,000	$54,000,000	to	$405,400,000
Planning, Engineering, & Design	$1,139,900,000	$0	$157,500,000	$1,131,700,000	$1,139,900,000	to	$2,271,600,000
Construction Management	$606,200,000	$0	$83,800,000	$601,800,000	$606,200,000	to	$1,208,000,000

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

5.4. Economic Benefits

The PDT identified the three NED plans (one for each RSLC curve). From there, the PDT used information gathered for metrics in the RED, OSE, and EQ accounts to determine a Total Net Benefits Plan (TNBP). Concerns about disruptions in vulnerable communities stemming from flooding moved the PDT away from nonstructural solutions in the Southern Waterfront, while concerns over disruption in the Embarcadero, seismic life safety issues, and desire to protect berthing suggested a larger initial plan in Reach 2.

The TNBP was identified as the TSP, the costs and benefits for the first action and the second action under the Intermediate and High RSLC curve are shown in **Table 5-4** and **Table 5-5** for both the NED plan and the TNBP. Note that the costs used for the cost-benefit analysis do not include additional design and construction costs resulting from addressing seismic concerns, as specified in the Water Resources Development Act of 2020, Sec. 152(a). The costs also differ between the Intermediate and High RSLC curves because the second action depends on what rate of change is realized by 2090.

Table 5-4: TSP/TNBP and NED Plan for Intermediate RSLC

TSP/TNBP (FY2024, Intermediate RSLC)		**NED Plan (FY 2024, Intermediate RSLC)**	
FWOP AAD	180,583	FWOP AAD	180,583
FWP AAD	68,351	FWP AAD	86,512
Total Reduced AAD	112,232	**Total Reduced AAD**	94,072
Total Initial Construction (2040 and 2090, Discounted)	4,587,487	Total Initial Construction (2040 and 2090, Discounted)	469,804
Interest During Construction (IDC)	783,836	Interest During Construction (IDC)	29,749
Operation, maintenance, repair, replacement, and rehabilitation (OMRR&R)	22,624	Operation, maintenance, repair, replacement, and rehabilitation (OMRR&R)	1,926
Average Annual Cost (AAC)	180,832	**Average Annual Cost (AAC)**	16,640
Average Annual Net Benefits	-68,600	Average Annual Net Benefits	77,431
Benefit-Cost Ratio (BCR)	0.62	Benefit-Cost Ratio (BCR)	5.65
Residual Damages	37.85%	Residual Damages	47.91%

Table 5-5: TSP/TNBP and NED Plan for High RSLC

TSP/TNBP (FY2024, High RSLC)		NED Plan (FY2024, High RSLC)	
FWOP AAD	685,054	FWOP AAD	685,054
FWP AAD	51,651	FWP AAD	249,350
Total Reduced AAD	633,402	**Total Reduced AAD**	435,704
Total Initial Construction (2040 and 2090, Discounted)	7,010,544	Total Initial Construction (2040 and 2090, Discounted)	3,730,395
Interest During Construction (IDC)	1,337,598	Interest During Construction (IDC)	607,694
Operation, maintenance, repair, replacement, and rehabilitation (OMRR&R)	34,744	Operation, maintenance, repair, replacement, and rehabilitation (OMRR&R)	14,490
Average Annual Cost (AAC)	280,632	**Average Annual Cost (AAC)**	32,049
Average Annual Net Benefits	352,771	Average Annual Net Benefits	403,655
Benefit-Cost Ratio (BCR)	2.26	Benefit-Cost Ratio (BCR)	13.59
Residual Damages	7.54%	Residual Damages	36.40%

Though Average Annual Net Benefits are lower in the TSP than in the NED plan, the PDT asserts that the difference is more than made up for when considering the four accounts and the resiliency goals of the study. Additionally, the first action of the NED plans under each RSLC curve are scoped for that curve's rate of rise, but because the decision about the first action must be done without knowing the rate of rise, it is unlikely any plan will be scoped perfectly for unknown future conditions. Instead, it is preferable to select a plan that performs well in all future conditions to avoid a high risk of over- or under-investment.

5.5. Environmental and Social Benefits

Environmental and Social benefits were assessed for each RSLC within a Comprehensive Benefits Matrix that included Other Social Effects (OSE) and Environmental Quality (EQ) accounts to support evaluation of the alternatives against study objectives at the plan level and at the individual reach level.

One dominant theme in the TNBP choices of measures that differ from the NED scale within each is the need that the TNBP be effective in reducing risk across multiple possible RSLC scenarios over the period of analysis. The resulting Environmental and Social benefits informed the TNBP plan development by clarifying impacts to the community from exposure to coastal flood risk.

5.6. Risk and Uncertainty Analysis

There remains risk and uncertainty in project planning, engineering design, and environmental compliance at this phase of the Study. Risk and uncertainty will be managed as more information is known and analyses are refined throughout the Study, and into the PED phase and construction. This Section presents major areas of risk and uncertainty known at this time.

5.6.1. Implementation Risk

Ground improvements are required along the entire waterfront. Scheduling and sequencing this work will require several pieces of equipment, multiple subcontractors, or both, working in different locations simultaneously. If work from the water is necessary in Reach 2 near the Ferry Building, this becomes more challenging for the contractor and slows the production rates compared to working from the ground. When construction is taking place along the Embarcadero, specifically north and south of Rincon Park, coordinating traffic or finding alternate routes around the area will be necessary.

5.6.2. Residual Risk

The TSP reduces coastal flood risk across the period of analysis under multiple RSLC scenarios. Residual risk is evident by the damages that are estimated to continue in the FWP condition. Refinements to the TSP will seek to reduce residual risk and manage life safety concerns.

5.6.3. Risk to Life Safety

Life safety is the risk to individuals who may be affected by coastal storms and other events. Individual life risk is influenced by location, exposure, and vulnerability within a leveed area. An abbreviated Semi-Quantitative Risk Assessment (SQRA) for the San Francisco Waterfront is scheduled to be conducted in the first quarter of calendar year 2024. The SQRA will assess the proposed measures in the TNBP, the anticipated performance at each SLR projection and the likelihood of failure during various times ranging from normal, sunny day conditions to an earthquake event.

The level of flooding if the line of defense measures were to fail considering the modeled ranges of SLR potentially creates a life safety risk. The team will assess if at the intermediate or high SLR projections, the risk is transformed from a flooding risk to a life safety risk. This occurs when the line of defense measures become loaded more frequently and at higher elevations.

Emergency vehicles may not be able to reach residents in distress due to the flooding of roads and homes. In addition, there is an increased risk of fire in communities due to the potential compromising of electrical and natural gas systems.

5.6.4. Climate Change Adaptation

The TSP is the plan that reasonably maximizes total net benefits across all rates of RSLC largely because of the adaptation proposed at 2090 to increase the scale of measures if RSLC is increasing risk in the study area. The potential adaptive actions have been designed to correspond to possible RSLC rates over time, and have been modeled with the assumed implementation time of 2090, although the actual implementation time may vary based on engineering judgment and climate change assessments. A monitoring plan will be in place to guide risk assessment and adaptation of measures based on predetermined risk thresholds. The Monitoring and Adaptation Plan is described in *Appendix G: Monitoring and Adaptation Plan*, and will be developed further following public, agency and technical comments.

5.6.5. Economic Risk and Uncertainty

G2CRM modeling links the predictive capability of hydraulic and hydrologic modeling with project area infrastructure information, structure and content damage functions, and economic valuations to estimate the total damages under various proposed alternatives while accounting for risk and uncertainty. For more information about economic risk and uncertainty can be found in Appendix E.

G2CRM provides integrated hydrologic engineering and economic risk analysis during the formulation and evaluation of flood damage reduction plans in compliance with policy regulations ER 1105-2-100 *Planning Guidance Notebook* and ER 1105-2-101 *Risk Analysis for Flood Damage Reduction Studies* (WR 2000, 2019). Uncertainty in storm inputs, economic variables, and depth-percent damage functions are quantified and incorporated into evaluation of the Future Without Project (FWOP) condition and the performance of any proposed alternatives.

For SFMTA, based on the flooding sequence established, the cost to replace specific assets damaged by both flowing and standing water are calculated for key water elevations and plotted as stage-damage functions. The methodology to identify asset replacement costs for each agency include a range to account for uncertainty. These stage-damage functions and the total damageable value of each system are key inputs into the G2CRM flood model.

The replacement cost for the asset entry represents the maximum increased cost of transportation calculated: $46 million. A plus or minus 40% uncertainty was applied to the $46 million, giving a range from $28 million to $65 million for the minimum and maximum replacement cost estimates.

To develop the custom depth-damage curve for G2CRM use, the results for different water elevations were mapped to depth based on the critical elevation for the BART system, or 10.34 feet NAVD88. n additional plus and minus 15% uncertainty was applied to the mean depth-damage function given the high level of uncertainty around these estimations.

Custom-made depth-percent damage curves were derived for numerous unique physical and non-physical assets within the study area. In general, they represented the cost to repair or replace specific assets at key water elevations. Both the asset replacement costs, and the damages assigned by the depth-percent damage curves have high degrees of uncertainty, which are represented in the triangle distributions used within G2CRM.

Another economic uncertainty is how the study area will react to the High rate of sea level change. Estimates about when asset owners will take protective actions for their property and when they will be forced out of the floodplain due to high-frequency flooding could not be empirically modeled due to a lack of data. Instead, multivariate testing was done within G2CRM, showing how different assumptions about the parameters impacted the results. More information on this can be found in Appendix E.

5.6.6. 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. A clean site is defined as no hazardous substances above unrestricted use or unlimited exposure levels remain onsite per applicable federal, state, and/or local regulations.

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.

Short or long duration storms, particularly in the winter months could potentially cause delays. As seen this past year, atmospheric rivers can develop and lead to extended periods of rainfall and flooding. This is not a new phenomenon to the region and other construction projects have successfully dealt with this issue but not without delays.

5.7. Lands, Easements, Rights-of-Way, and Relocations, and Disposal Areas

The Non-Federal Sponsor will be responsible for acquiring and furnishing all land, easements, rights-of-way, relocations (i.e., P.L 91-646 relocations and utility/facility relocations), and disposal areas (LERRD) for the project areas, as required for the construction, operation, and maintenance of the proposed project. A Real Estate Plan was developed to present the Real Estate requirements for the Recommended Plan. The standard estates were reviewed and were found to be acceptable for the project. Other relevant information on the Non-Federal Sponsor's ownership of land, existing federal projects, potential relocations under the Uniform Relocation Assistance and Real Property Acquisition Policies Act (P.L. 91646, as amended), facility/utility relocations, a schedule for Real Estate acquisition activities, and other issues as required can be found in *Appendix F: Real Estate Plan*. Currently, it has not been determined that the Non-Federal Sponsor owns all the property required in the footprint of project area. Acquisition of parcels was estimated for real estate costs for those areas not owned by the Non-Federal Sponsor. From the feasibility level of design, much of the area in the footprint would require a levee easement. In estimating Real Estate costs, the land values were utilized for estimating the value to acquire a levee easement. For the few areas that buildings were to be removed, acquisition of the entire parcel was estimated. Should the Non-Federal Sponsor provided additional documentation of their ownership, the Real Estate costs will be adjusted to reflect those changes. To date, no leases have been provided for those businesses within the footprint of the project that will be impacted. Due to this, we have made assumptions as to the number of businesses would receive Relocation Assistance Benefits values. Currently, a Real Estate assessment is included in the Real Estate Plan that discusses the types of utilities/facilities identified and the impact to the project.

5.8. TSP Implementation

The implementation process would carry a plan that is recommended through the PED phase of a project, including development of plans and specifications, and construction. Funding by the Federal Government to support these activities would have to meet traditional civil works budgeting criteria.

5.8.1. 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 $14,661,800,000.

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 5-6** and **Table 5-7** respectively.

Table 5-6: 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 5-7: Total Project Cost (Fully Funded) Apportionment

(FY 24 Price levels, fully funded to FY 26)

Total Project Cost (Fully Funded)	**$14,661,800,000**
Federal Share (65%)	$9,530,170,000
Non-Federal Share (35%)	$5,131,630,000

5.8.2. Non-Federal Sponsor Responsibilities

A Project Partnership Agreement (PPA) package will be prepared, coordinated, and executed after the approval of the final IFR/EIS. The PPA serves as the agreement for the next phase of the project after the study phase. Under a PPA, either USACE or the NFS can lead design and construction for one or more separable elements of the TSP.

As the NFS, POSF must comply with all applicable Federal laws and policies and other requirements, including but not limited to:

a. Provide 35 percent of construction costs, as further specified below:

1. Provide, during design, 35 percent of design costs in accordance with the terms of a design agreement entered into prior to commencement of design work for the project;

2. Provide all lands, easements, rights-of-way, and placement areas and perform all relocations determined by the Federal government to be required for the project;

3. Provide, during construction, any additional contribution necessary to make its total contribution equal to at least 35 percent of construction costs;

b. Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) that might reduce the level of coastal flood risk reduction the project affords, hinder operation and maintenance of the project, or interfere with the project's proper function;

c. Inform affected interests, at least yearly, of the extent of risk reduction afforded by the project; participate in and comply with applicable Federal floodplain management and flood insurance programs; prepare a floodplain management plan for the project to be implemented not later than one year after completion of construction of the project; and publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in adopting regulations, or taking other actions, to prevent unwise future development and to ensure compatibility with the project;

d. Operate, maintain, repair, rehabilitate, and replace the project or functional portion thereof at no cost to the Federal government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal laws and regulations and any specific directions prescribed by the Federal government;

e. Give the Federal government a right to enter, at reasonable times and in a reasonable manner, upon property that the NFS owns or controls for access to the project to inspect the project, and, if necessary, to undertake work necessary to the proper functioning of the project for its authorized purpose;

f. Hold and save the Federal government free from all damages arising from design, construction, operation, maintenance, repair, rehabilitation, and replacement of the project, except for damages due to the fault or negligence of the Federal government or its contractors;

g. Perform, or ensure performance of, any investigations for hazardous, toxic, and radioactive wastes (HTRW) that are determined necessary to identify the existence and extent of any HTRW regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. 9601-9675, and any other applicable law, that may exist in, on, or under real property interests that the Federal government determines to be necessary for construction, operation and maintenance of the project;

h. Agree, as between the Federal government and the NFS, to be solely responsible for the performance and costs of cleanup and response of any HTRW regulated under applicable law that are located in, on, or under real property interests required for construction, operation, and maintenance of the project, including the costs of any studies and investigations necessary to determine an appropriate response to the contamination, without reimbursement or credit by the Federal government;

i. Agree, as between the Federal government and the NFS, that the NFS shall be considered the owner and operator of the project for the purpose of CERCLA liability or other applicable law, and to the maximum extent practicable shall carry out its responsibilities in a manner that will not cause HTRW liability to arise under applicable law; and

j. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended, (42 U.S.C. 4630 and 4655) and the Uniform Regulations contained in 49 C.F.R Part 24, in acquiring real property interests necessary for construction, operation, and maintenance of the project including those necessary for relocations, and placement area improvements; and inform all affected persons of applicable benefits, policies, and procedures in connection with said act.

5.8.3. Real Estate Requirements

The NFS will be responsible for acquiring and furnishing all land, easements, rights-of-way, relocations (i.e., P.L 91-646 relocations and utility/facility relocations), and disposal areas (LERRD) for the project areas, as required for the construction, operation, and maintenance of the proposed project. A Real Estate Plan was developed to present the Real Estate requirements for the Recommended Plan. The standard estates were reviewed and were found to be acceptable for the project. Other relevant information on the NFS's ownership of land, existing federal projects, potential relocations under the Uniform Relocation Assistance and Real Property Acquisition Policies Act (P.L. 91-646, as amended), facility/utility relocations, a schedule for real estate acquisition activities, and other issues as required can be found in *Appendix F: Real Estate Plan*. Should it be determined that additional lands are required during the design phase, the NFS would be required to purchase these lands using the appropriate standard estate.

Table 5-8 summarizes the real estate requirements for the TSP.

Table 5-8: Real Estate Requirements for the TSP

	Required Interest	Required Acres	# Parcels		# Owners	
			Private	Public	Private	Public
1st Action	**Fee Interest**	3.18	2	0	2	0
	Flood Protection Levee Easement	2.97	5	4	4	1

	Temporary Work Easement	0	0	0	0	0
2nd Action	**Fee Interest**	2.33	1	0	1	0
	Flood Protection Levee Easement	0.36	1	3	1	2
	Temporary Work Easement	3.75	0	3	0	1

5.8.4. 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. Different increments of the project may be completed as funding allows during this timeframe. 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. Furthermore, construction sequencing will also be dependent on completion of supplemental environmental studies, in accordance with the NEPA approach described more fully in Chapter 1. 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

5.8.5. 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. Predefined trigger conditions or elevations will confirm when the adaptive action will be implemented. 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. The MAP framework includes, but is not limited to:

- Identify thresholds of RSLC that would trigger the need for additional protection
- Evaluate the level of protection required to address the SLR risk based on those thresholds, considering other factors such as life of asset, other planned projects, and disruption from the construction period
- Describe coordination and involvement of resource agencies, USACE, Port, City, and State to manage the risks over time
- Develop the governance and executive structure that could be used to manage uncertainty in a collaborate effort based on trigger points identified for risk assessment and management
- Identify an approach for construction and costs based on thresholds of projected SLR, including appropriate lead times for planning and construction and margin of safety before intervention is needed
- Recommend approaches for Congressional authorization and future PED strategies that will enable USACE and the Port to more efficiently implement Second Actions given the uncertainty regarding future rates of RSLC
- Clarify appropriate scale and alignment of features to be constructed in time to reduce vulnerability to flooding in the study area

5.9. Operations, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R)

Operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) includes actions to sustain the constructed project and to maintain the stated level of benefits at the completion of construction and into the future. The NFS is responsible for OMRR&R costs and actions. Generally, the NFS is required to repair, rehabilitate, or provide replacement of components to maintain the original project benefits. A detailed OMRR&R manual will be developed during the PED phase to outline the expected OMRR&R requirements for each project component. Preliminary OMRR&R estimates are estimated as a percentage of the project cost and are subject to refinement as design proceeds.

The total estimated annual OMRR&R cost is $67,000,000. OMRR&R requirements would also include but are not limited to, annual exercising of gates and closure structures, grass mowing of levee and floodwall right of way, painting of metal surfaces, pump station operations and maintenance, and general maintenance of drainage structures.

5.10. Compensatory Mitigation

Mitigation needs are currently estimated to be fairly low for the TSP, pending further consultation with the RAWG and consulting parties in the Section 106 process. The TSP proposes nine acres of bay fill associated with construction of the Independent Measures as a first action that would require compensatory mitigation for the loss of nine acres, or 4,500,000 discounted-service-acre-year [DSAY], of subtidal habitat and once acre of pier removal as part of the TNBP resulting in a gain of 499,000 DSAY in subtidal habitat. After the total project features are accounted for, the total net mitigation need of 4,000,001 discounted-service-acre-year (DSAY) is required to compensate for TNBP and Independent Measure losses. The compensatory mitigation provides a few options to compensate for the loss and includes various combinations of pier removal and pile removal. Pier removal is compensated on an acre of injury for an acre of restoration (1:1) basis while pile removal is compensated on a 1:2 basis. The mitigation plan recommends the most cost-effective plan based on the information available, but primarily serves as a conceptual plan that would be modified and finalized during PED. For feasibility, the NNBFs associated with the independent measures were not taken into consideration when trying to document the total project benefits and costs from a habitat impact standpoint to demonstrate a worse-case scenario if for some reason they are not included in future designs. During PED, the need for compensatory mitigation will need to be reassessed and if the NNBFs are included, the compensatory mitigation documented in feasibility may not be required.

Avoidance and minimization measures (AMMs), as well as best management practices (BMPs), would be used during construction and in the final designs to avoid, permanent adverse impacts that would require additional compensatory mitigation. Details about AMMs and BMPs intended to be applied to each resource can be found in *Appendix D: Environmental and Cultural Resources*.

Preliminary analysis suggests the TSP is measuring below de minimis for the Clean Air Act and would not require compensatory mitigation for air quality. The PDT will continue to work with resource agencies to determine the most applicable models for use and level of mitigation needed to offset impacts.

5.11. USACE Environmental Operating Principles

The USACE Environmental Operating Principles (EOP) (ER 200-1-5) were developed to ensure USACE missions include integrated sustainable environmental practices, corporate responsibility, and accountability. These Environmental Operating Principles are:

- Foster sustainability as a way of life throughout the organization;
- Proactively consider environmental consequences of all USACE activities and act accordingly;
- Create mutually supporting economic and environmentally sustainable solutions;
- Continue to meet our corporate responsibility and accountability under the law for activities undertaken by USACE, which may impact human and natural environments;
- Consider the environment in employing a risk management and systems approach throughout the life cycles of projects and programs;
- Leverage scientific, economic, and social knowledge to understand the environmental context and effects of USACE actions in a collaborative manner; and,
- Employ an open, transparent process that respects views of individuals and groups interested in USACE activities.

The TSP meets the USACE Environmental Operating Principles as documented within this IFR/EIS through the USACE planning process and NEPA requirements for Federal agencies to assess the reasonably foreseeable environmental effects of federally funded projects. USACE and POSF have proactively considered environmental consequences (and benefits) of the alternative plans and will continue to do so for the Final FR/EIS. Scientific, economic, and social knowledge was leveraged in the preparation of this report, through special expertise of preparers, subject matter experts, public engagement, and resource agency coordination, and with the support of the USACE Engineering Research and Development Center (ERDC) to conduct a comprehensive analysis and/or modeling support for the San Francisco ecosystems, hydrodynamics, social effects, and environmental justice. Refer to Appendix H*: Public Involvement* for additional information on stakeholder engagement and public and agency coordination.

5.12. National Flood Insurance Program Compliance

Communities participating in a coastal flood risk management project with USACE are required to participate in FEMA's National Flood Insurance Program (NFIP) and to comply with the land use requirements of the program. Communities in the Study participate in and are in compliance with the NFIP. Because the plan would help manage coastal flood risk, it will inherently support the communities' compliance with the NFIP. As a Participating Agency, FEMA has been briefed about the plan. USACE will notify FEMA Region II once the project is authorized for construction by the U.S Congress. FEMA could choose to update flood maps and flood profiles to depict post-project conditions, which may affect flood insurance rates for homeowners and business owners who would benefit from the project. It is important to note that flood insurance rates are not set by USACE nor the State of California.

5.13. Views of the Non-Federal Sponsor

The POSF 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.

The TSP analyzes where USACE and San Francisco should build coastal flood defenses and implement an adaptation strategy to address SLR coupled with strong seismic foundations designed to weather foreseeable earthquakes. Based on the work of the PDT to date, the USACE and CCSF team is positioned to better plan and develop the specific waterfront improvements that will both reduce risks and meet our vision for a safe, equitable, inclusive waterfront for all.

The TSP is an innovative recommendation for a USACE urban mega-study. Instead of a plan focused solely on costs and national economic benefits, the PDT developed and assessed a comprehensive list of metrics that includes RED, EQ, and OSE.

These metrics – coupled with public feedback to date – have shaped how the TSP prioritizes life safety and emergency response, enhances, and sustains social, economic, and ecological opportunities, addresses disproportionate impacts to vulnerable populations, and ensures public access to the waterfront and historic places for all.

POSF was particularly pleased that USACE allowed POSF and its 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.

Based on internal engagement with CCSF agencies and what they understand from prior public engagement, POSF recommends joint collaboration to evaluate the following plan adjustments and refinements as the TSP undergoes further refinement. Some of this work will occur during the remainder of the study. Other work will occur during the preconstruction engineering and design (PED) phase. Some of the following will include work that the City elects to pursue concurrent with but alongside work with USACE.

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, San Francisco uses a “dig once” principle, where possible. 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 historic resources where the structures have ground floor elevations that are above 13.5 feet NAVD88 or structures intersect the shoreline,

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, and the extent to which coastal flood defenses and inland drainage systems can help mitigate the influence of SLR on groundwater elevations.

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. This will have impacts on the scope and cost associated with inland drainage. The City team 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.

Value Engineering: The Port engineering team believes that there may be opportunities to reduce costs by refining shoreline stability measures and assumptions, examining other ground improvement approaches and strategically scoping the quantity and extent of work that drives cost.

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.

6. Environmental Compliance*

The draft IFR-EIS has been prepared to satisfy the requirements of all applicable environmental laws and regulations, where possible, and has been prepared using the Council on Environmental Quality (CEQ) NEPA regulations (40 CFR Part 1500–1508) and the USACE's regulation ER 200-2-2 – Environmental Quality: Policy and Procedures for Implementing NEPA, 33 CFR Part 230. In implementing the Recommended Plan, any compliance that could not be completed during the feasibility phase will be secured during the PED phase and the USACE would continue to follow the provisions of all applicable laws, regulations, and policies related to the proposed actions.

Based on agency feedback, demonstration of full compliance of the first action measures during feasibility is likely for the following laws and executive orders (EOs): NEPA, Fish and Wildlife Coordination Act (FWCA), Endangered Species Act (ESA), Clean Water Act (CWA) Section 404, National Historic Preservation Act (NHPA), E.O. 12898 (Environmental Justice), E.O. 11988 (Floodplain Management), and E.O. 11990 (Protection of Wetlands). Full compliance may not be possible for the Magnuson-Stevens Fishery Conservation and Management Act (MSA) and CWA Section 401. There are a few measures in the project that may preclude full compliance if the agencies determine there is not sufficient level of design detail for them to make a determination. Since the TNBP is a system, the agencies will not likely make a determination on only parts of the project because their policies require considering the whole project and would not allow a multi-part review. Full compliance cannot be achieved and must be addressed during PED for the following laws: Marine Mammal Protection Act (MMPA), Clean Air Act (CAA), and Coastal Zone Management Act (CZMA) due to lack of detailed design required to complete the analysis.

6.1. Compliance Status

Compliance with the following laws, regulations, and Executive Orders (**Table 6-1** and **Table 6-2**), as applicable, is required for environmental acceptability of the project alternatives, which includes but is not limited to the following:

Table 6-1: Regulatory Compliance Status

Title of Law	U.S. Code	Compliance Status
Abandoned Shipwreck Act of 1987	43 United States Code (U.S.C.) 2101	In Progress
American Indian Religious Freedom Act of 1978	Public Law No. 95-341, 42 U.S.C. 1996	In Progress
Anadromous Fish Conservation Act of 1974	16 U.S.C. 757 a et seq.	Not Applicable
Archaeological and Historic Preservation Act of 1974	Public Law 93-291 and 16 U.S.C.469-469c	In Progress

Title of Law	U.S. Code	Compliance Status
Archaeological Resources Protection Act of 1979	16 U.S.C. 470aa–470mm	In Progress
Bald and Golden Eagle Protection Act of 1962, as amended	16 U.S.C. 668	Compliant. Appendix D-1, Section 5.11
Clean Air Act of 1972, as amended	42 U.S.C. 7401 et seq.	Delayed until PED; Appendix D-1 Section 5.3. Conceptual General Conformity Determination included in Appendix D-2-1.
Clean Water Act of 1972, as amended	33 U.S.C. 1251 et seq.	Appendix D-1, Section 5.2 Section 401 -- Delayed until PED. Coordination with the Water Board is ongoing. It is anticipated that preliminary draft compliance documentation will be available in the final IFR-EIS; however, the Water Quality Certification will be received during PED. Section 404 – Ongoing, draft 404(b)(1) included in Appendix D-4-1
Coastal Barrier Resources Act of 1982	Public Law 114-314	Not Applicable
Coastal Zone Management Act of 1972, as amended	16 U.S.C. 1451 et seq.	Delayed until PED. Appendix D-1 Section 5.10. Coordination is ongoing with BCDC. It is anticipated that preliminary draft compliance documentation will be available in the final IFR-EIS; however, the Consistency Determination will be received during PED.
Comprehensive Environmental Response, Compensation and Liability act of 1980	42 U.S.C. 9601	Compliant. The NFS would be responsible for any and all cleanup or treatment of CERCLA sites prior to work beginning. Appendix D-1-6.
Endangered Species Act of 1973	16 U.S.C. 1531	In Progress; Appendix D-1 Section 5.5. Section 7 Consultation will be initiated after draft report release. The consultation record, including an anticipated Biological Opinion from NMFS and concurrence letter from USFWS will be included in the final IFR-EIS.
Fish and Wildlife Coordination Act of 1958, as amended	16 U.S.C. 661	In Progress. D-1 Section 5.7. A Coordination Act Report will be included in the Final IFR-EIS.
Land and Water Conservation Act	16 U.S.C. 460	Not Applicable
Magnuson-Stevens Fishery Conservation and Management Act – Essential Fish Habitat Amendment	16 U.S.C. 1801	In Progress; Appendix D-1 Section 5.9. Consultation with NMFS is ongoing and will be formally initiated with the draft report release. The consultation record including

Title of Law	U.S. Code	Compliance Status
		the EFH Conservation recommendations will be included in the final IFR-EIS.
Marine Mammal Protection Act of 1972, as amended	16 U.S.C. 1361	Delayed until PED. Appendix D-1 Section 5.8
Marine Protection, Research, and Sanctuaries Act of 1972	33 U.S.C. 1401	Not Applicable
Migratory Bird Treaty Act of 1918, as amended	16 U.S.C. 703	Compliant, Appendix D-1 Section 5.6
National Environmental Policy Act of 1969, as amended	42 U.S.C. 4321 et seq.	In Progress. NOI published 27 Jul 23; 60-day comment period for EIS will occur. Appendix D-1 Section 5.1
National Historic Preservation Act of 1966, as amended	54 U.S.C. Section 300101	In Progress. Appendix D-1 Section 5.4. Programmatic Agreement (PA) will be executed and is included for review and comment in Appendix D-3.
Native American Graves Protection and Repatriation Act of 1990	25 U.S.C. 3001	In Progress
Resource Conservation and Recovery Act of 1976	42 U.S.C. 6901 et seq.	In Progress. Appendix D-1-6.
Rivers and Harbors Act of 1899	33 U.S.C. 401 et seq.	Compliant. Appendix D-1 section 5.12
Hazardous Wildlife Attractants on or Near Airports	FAA AC 150/5200-33C and the Memorandum of Agreement (MOA) with FAA	Compliant. Appendix D-1 section 5.13

Table 6-2: Executive Order Compliance Status

Title of Executive Order	Executive Order Number	Compliance Status
Environmental Justice – Federal Actions to Address Environmental Justice and Minority and Low-income Populations	12898	In Progress, Appendix D-1 section 5.17 and Appendix D-1-3.
Environmental Justice 40	14008	In Progress
Floodplain Management	11988	Compliant, Appendix D-1 Section 5.14
Invasive Species	13112	Compliant, Appendix D-1 section 5.16

Marine Protected Areas	13158	Compliant. No measures proposed in Golden Gate National Recreation Area. No other MPAs are present in or near the study area.
Protection and Enhancement of the Cultural Environment	11593	Compliant. All measures have avoided or minimized impacts to cultural resources and will be mitigated where necessary to compensate for unavoidable adverse impacts. See Appendix D-1 Section 4.18 and Appendix D-3
Protection of Wetlands	11990	Compliant, Appendix D-1 Section 4.14 and 5.15
Protection of Children from Environmental Health and Safety Risks	13045	Compliant, Appendix D-1 section 5.18
Responsibilities of Federal Agencies to Protect Migratory Birds	13186	Compliant, Appendix D-1, Appendix D-1 Section 5.6

6.2. Conceptual Mitigation Plan

A conceptual mitigation plan (Appendix K) has been included to show unavoidable impacts from bayfill.

7. Public Coordination and Views

Coordination with stakeholders has been a critical component of the SFWCFS. Since 2018, USACE and POSF have held numerous workshops and meetings with Cooperating/Participating Agencies and other Federal, State, and local stakeholders to share information on the Study scope, purpose, and formulation of alternatives, as well as to exchange ideas and information on natural and marine resources within the Study Area. Refer to *Chapter 1: Introduction* and *Appendix H: Public Involvement* for additional information.

7.1. NEPA Scoping Process

The Study began in 2018 under the USACE San Francisco District, South Pacific Division and was transferred to the Tulsa District out of the Southwestern Division in 2021. The USACE San Francisco District and Port issued a Notice of Early Scoping in the Federal Register August 20, 2020. At that time, it was unclear if significant effects would be realized and the need for an EIS was not formally announced.

Virtual public scoping meetings were held on September 16 and 17, 2020 coinciding with the Notice of Early Scoping. During early scoping, several significant environmental and social issues were raised including but not limited to minimizing bay fill; effects of high rates of SLR on any alternative considered; disruptions to businesses, transportation corridors and walk paths; environmental justice impacts on historically disadvantaged communities; impacts to water quality, contaminated sites, historic resources; and the potential cost and time to implement any of the strategies. In general, there was wide support for use of nature-based measures in lieu of gray infrastructure, preserving and increasing public access to the waterfront, and incorporating adaptation components to address uncertainties in SLR.

7.2. Agency Coordination

The PDT has been coordinating with federal, state, and local governmental agencies throughout the plan formulation process to identify potential concerns, ways to avoid, minimize, and mitigate for adverse impacts, and where NNBFs or other beneficial features could be incorporated into the planning and designs. Coordination with these agencies has included attendance at meetings hosted by USACE and other agencies including two environmental agency teams that were formed – the RAWG and the ENWG, described in *Chapter 1: Introduction*. The PDT will continue to engage with agencies throughout the planning process, to further refine the designs and impact analysis and in support of environmental compliance activities described in *Chapter 6: Environmental Compliance*.

NEPA regulations and processes define three types of formal roles for agencies. A Lead Agency is the federal agency preparing or having taken primary responsibility for preparing a NEPA document. A Cooperating Agency is any federal agency other than a lead agency which has jurisdiction by law or special expertise with respect to any environmental impact involved in a proposal (or a reasonable alternative) for legislation or other major federal action significantly affecting the quality of the human environment. A Participating Agency is a federal or state agency that has an interest in the proposal. Cooperating and Participating Agencies must provide comments within their special expertise or jurisdiction and use the NEPA process to address any environmental issues of concern to its agency. A total of 12 invitations (5 federal agencies, 7 state agencies) were sent. Two formal acceptance letters were received from cooperating agencies and two declines were received from state agencies (California State Historic Preservation Office and Bay Area Quality Management District). Any agency who did not formally respond are assumed to have accepted the invitation to be a cooperating or participating agency. The following is a list of formal agency roles for this Study:

- **Lead Agency:** 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

7.3. Tribal Consultation

Although there are no federally recognized Tribes within San Francisco County, California, the USACE worked with the POSF, the City of San Francisco, and the USACE San Francisco District's Tribal Liaison and utilized the database of the State of California's Native American Heritage Commission to identify Native American Tribes with an interest in the project area. The USACE has initiated consultation with the Amah Mutsun Tribal Band of Mission San Juan Bautista, Amah-Mutsun Tribal Band, Association of Ramaytush Ohlone, Costanoan-Rumsen Carmel Tribe, Indian Canyon Mutsun Band of Costanoan, Muwekma Ohlone Indian Tribe of the San Francisco Bay Area, The Ohlone Indian Tribe, Rumšen Am:a Tur:ataj Ohlone, and the Wuksache Indian Tribe/Eshom Valley Band. The USACE continues to coordinate with these groups with regard to NEPA and NHPA compliance.

7.4. Areas of Controversy

Four general areas of controversy were raised during the Early Scoping and Scoping Periods, public meetings, and engagements, and during agency coordination completed since the start of the study. They include:

- Equity and social justice
- Uncertainties in future climate conditions leading to potential over- or under-estimation of RSLC
- Potential impacts to water quality and the marine environment

- Cost of the project to address the problems

Other concerns were raised during the scoping and coordination periods, including but not limited to historic resources should be preserved, disruption to businesses and tourism should be avoided, increase the open space and recreational opportunities, and preserving the waterfront’s connection to the Bay. However, all these concerns were validated by many, as opposed to the areas of controversy which had distinctly two-sides to each concern (e.g., there is disagreement in the rate of RSLC, some believe that the rates used are more aggressive than other studies in the area have assumed, while others believe it is not aggressive enough).

8. Recommendations

The recommendations contained herein reflect the information available at this time and current departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of highest review levels within the Executive Branch. Consequently, the recommendations may be modified by the Chief of Engineers before they are transmitted to the Congress as proposals for authorization and implementing funding. However, prior to transmittal to Congress, the partner, the State, interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

PENDING FOR FINAL FEASIBILITY REPORT

Date

Timothy P. Hudson
Colonel, U.S. Army
Commanding

9. List of Report Preparers*

The following USACE and POSF staff and consultants contributed to the preparation of this report.

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