# Memorandum	

To:	**Andrew Nowacki PE, Robert Vance PE, Gail Payne (City of Alameda)**
From:	**Dan Matthies PE CFM, Satish Kumar PE (Wood Rodgers)**
CC:	**Erin Smith (City of Alameda), Cheng Soo (Wood Rodgers), Danielle Mieler (City of Alameda)**
Date:	**5/06/2021**
Subject:	**City of Alameda – Northern Shoreline Adaptation Project – Basis of Design Memo** **FINAL**

1 INTRODUCTION

The City of Alameda is planning to apply for various grants for the Northern Shoreline Adaptation project (Project). The Project proposes to construct and/or enhance an existing seawall/levee that would protect properties and infrastructure in a 100-year coastal flood event, including the Webster and Posey Tubes, and would consider future means to protect the area against sea level rise. See **Figure 1** below.

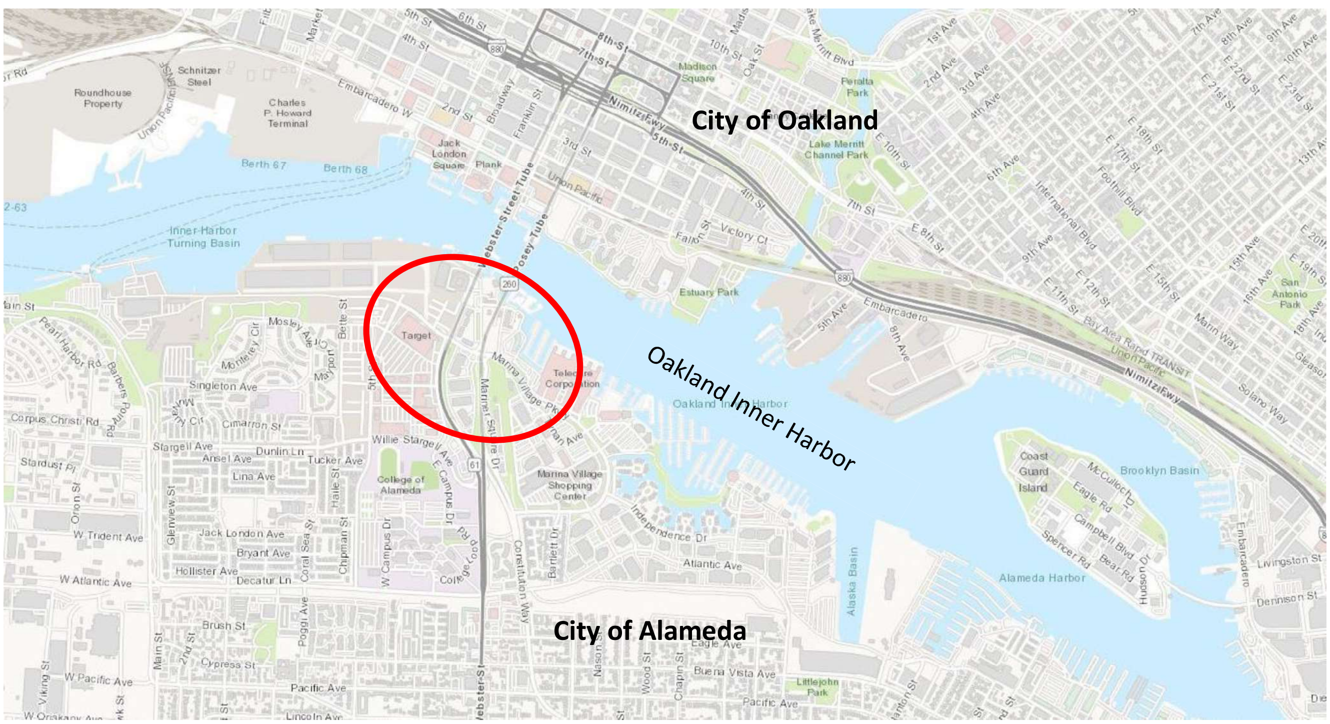


Figure 1: Project Location

The shoreline area has been mapped into the 100-year (1% Annual Exceedance Probability or 1% Chance Floodplain) floodplain based on the effective FEMA Flood Insurance Rate Map (FIRM) dated 2018. Wood Rodgers updated this map using 2019 LIDAR topography to better define the floodplain. The inland floodplain is due to a low-lying area near the Webster and Posey Tubes crossing the Oakland Inner Harbor, between Alameda Island and

Oakland. See **Figure 2** below. The low-lying area includes an existing non-engineered earthen berm constructed to provide some measure of flood protection from the Oakland Inner Harbor.

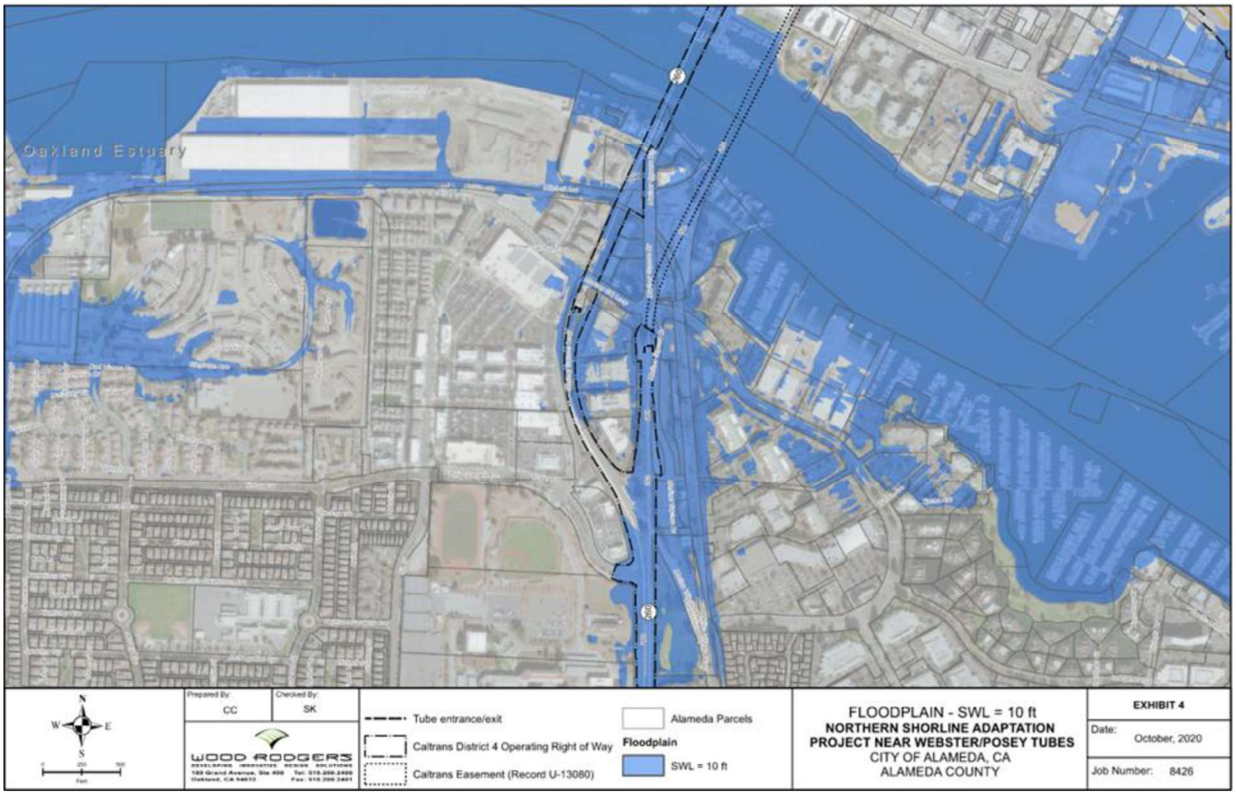


Figure 2: Existing 1% Tidal Flooding

The City of Alameda has contracted with Wood Rodgers to preliminarily design flood control improvements to remove the low-lying landside area from the 1% Chance Floodplain, for the purpose of pursuing grants.

2 PURPOSE

The purpose of this Preliminary Basis of Design document is to provide the following:

1. Determine the top elevation of the proposed flood control improvements necessary to meet FEMA requirements.
2. Define the extent of the proposed flood control improvements to achieve closure.
3. Evaluate levee and/or floodwall alternatives considering; constructability, cost, aesthetics, etc., to provide a recommendation.

3 REFERENCES

1. *Code of Federal Regulations, 44 CFR 65.10*
2. *FEMA FIRM Preliminary 06001C0254* (AECOM), 2014
3. *FEMA FIRM Effective 06001C0254G*, 2018
4. *Rising Seas in California, an Update on Sea-Level Rise Science*, April 2017
5. *San Francisco Bay Tidal Datums and Extreme Tides Study* (AECOM), February 2016.
6. *Adapting to Rising Tides Bay Area Sea Level Rise Analysis and Mapping Project* (AECOM), September 2017.
7. *Floodplain Mapping TSDN, Alameda County, California, A Central San Francisco Bay Coastal Flood Hazard Study* (AECOM), May, 2014

8. *Central San Francisco Bay Coastal Flood Hazard Study, Alameda County, California, Coastal Analysis Report* (AECOM), April 24, 2014
9. *Design of Coastal Revetments, Seawalls, and Bulkheads, Engineering Manual EM 1110-2-1614 (USACE)*, June 30, 1995

4 FLOOD PROTECTION TOP ELEVATION/EXTENT

The top elevation of the Project is a crucial factor to providing adequate shoreline protection by means of a levee and/or floodwall. The final top elevation will meet FEMA requirements for accreditation and design engineer certification.

To set top elevation, the criteria were first defined, then the most recent FEMA Flood Insurance Study (FIS) was reviewed as discussed below. All elevations in this Basis of Design are referenced to **NAVD88.**

4.1 Criteria

The criteria used to determine the top of flood protection will be from the text of 44 CFR 65.10 (Ref 1), shown below in italics:

For levees to be recognized by FEMA, evidence that adequate design and operation and maintenance systems are in place to provide reasonable assurance that protection from the base flood exists must be provided. The following requirements must be met:

(1) Freeboard

(iii) ***For coastal levees, the freeboard must be established at one foot above the height of the one percent wave or the maximum wave runup (whichever is greater) associated with the 100-year stillwater surge elevation at the site.***

(iv) Occasionally, exceptions to the minimum coastal levee freeboard requirement described in paragraph (b)(1)(iii) of this section, may be approved. Appropriate engineering analyses demonstrating adequate protection with a lesser freeboard must be submitted to support a request for such an exception. The material presented must evaluate the uncertainty in the estimated base flood loading conditions. Particular emphasis must be placed on the effects of wave attack and overtopping on the stability of the levee. ***Under no circumstances, however, will a freeboard of less than two feet above the 100-year stillwater surge elevation be accepted.***

4.2 Existing Conditions

4.2.1 FEMA Flood Insurance Rate Map (FIRM)

The National Flood Insurance Program (NFIP), managed by FEMA, aims to reduce the impact of flooding on private and public structures. It does so by providing affordable insurance to property owners, renters and businesses and by encouraging communities to adopt and enforce floodplain management regulations. FEMA develops Flood Insurance Studies (FIS) to define the risk of flooding in NFIP areas. The FIS include Flood Insurance Rate Maps (FIRMs) used by FEMA to set insurance rates.

Currently, the Effective FIRM is dated 2018 and is shown below.

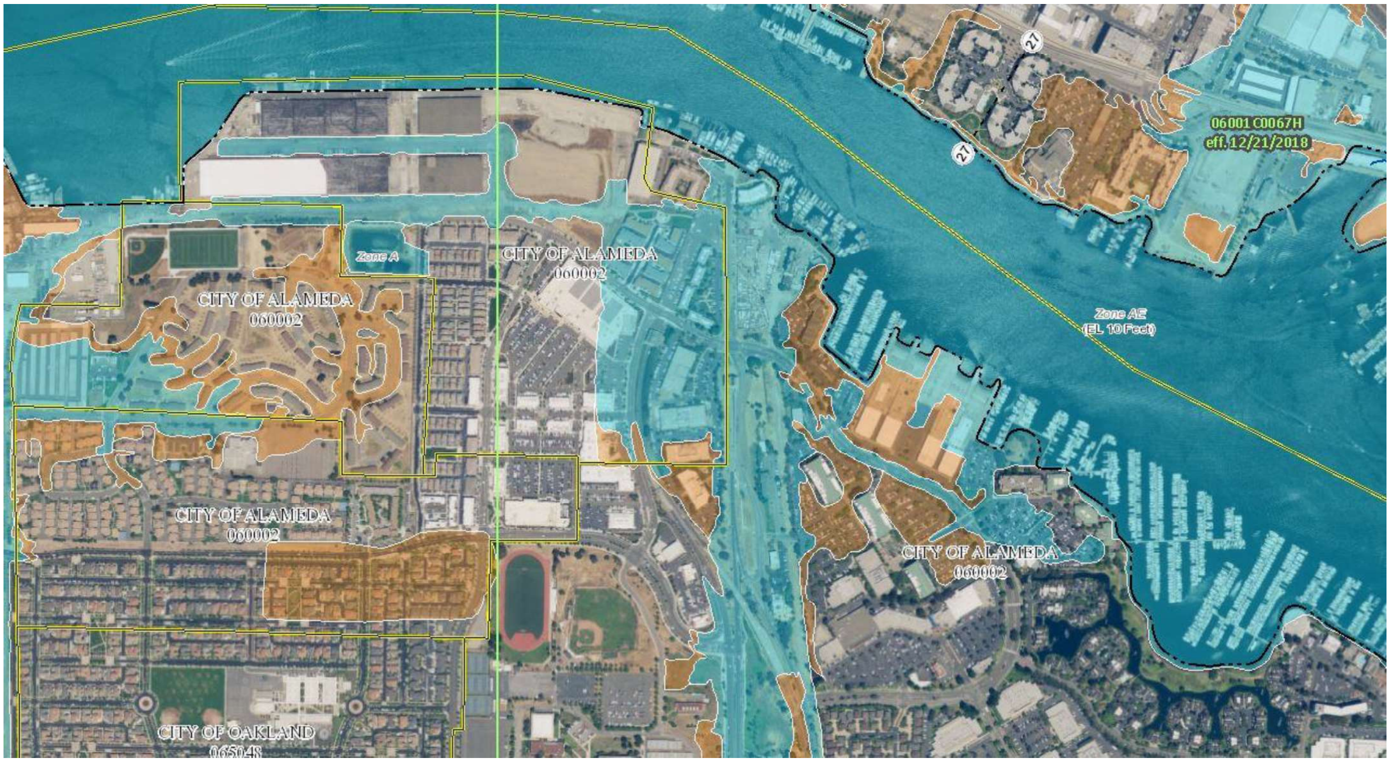


Figure 3: Existing 2018 FEMA FIRM

In the effective FIRM above, portions of the project site are within Zone AE (El 10) and portions of the project site are adjacent a Zone AE (El 10). Zone AE indicates where the 1% Chance Floodplain reaches inland due to the fact that ground adjacent to the Oakland Inner Harbor is lower than the 1% Stillwater Elevation.

The FEMA Detailed Analysis that was used to develop the FIRM maps for the coastline on Alameda Island was available for review. The FEMA Detailed Analysis accounts for storm surge, wave runnup, and overland propagation to define the maximum hazard water level. The Detailed Analysis will be used for the flood control design criteria of the Northern Shoreline Adaptation Project.

4.2.2 FEMA Detailed Analysis

Based on the Coastal Analysis Report, 2014 (Ref 8), "*Coastal flooding hazards were evaluated (with) 1D transect-based models. Wave setup, runup, overtopping, and overland wave propagation were analyzed for 78 transects along the northern Alameda County coastline (see Figure 4). Transects were placed at locations that are representative of a reach of shoreline, with consideration of the study area features that are important to the wave hazard processes that affect the area. In areas where wave runup might be significant, transects were oriented approximately perpendicular to local topographic and bathymetric contours and were placed with consideration to variations in shoreline and nearshore slopes, shoreline structures, structure or bluff crest elevations, shoreline orientation, and incident wave conditions.*"

The North Shoreline project site is located between transect 26 and transect 27 (see **Figure 4** below).

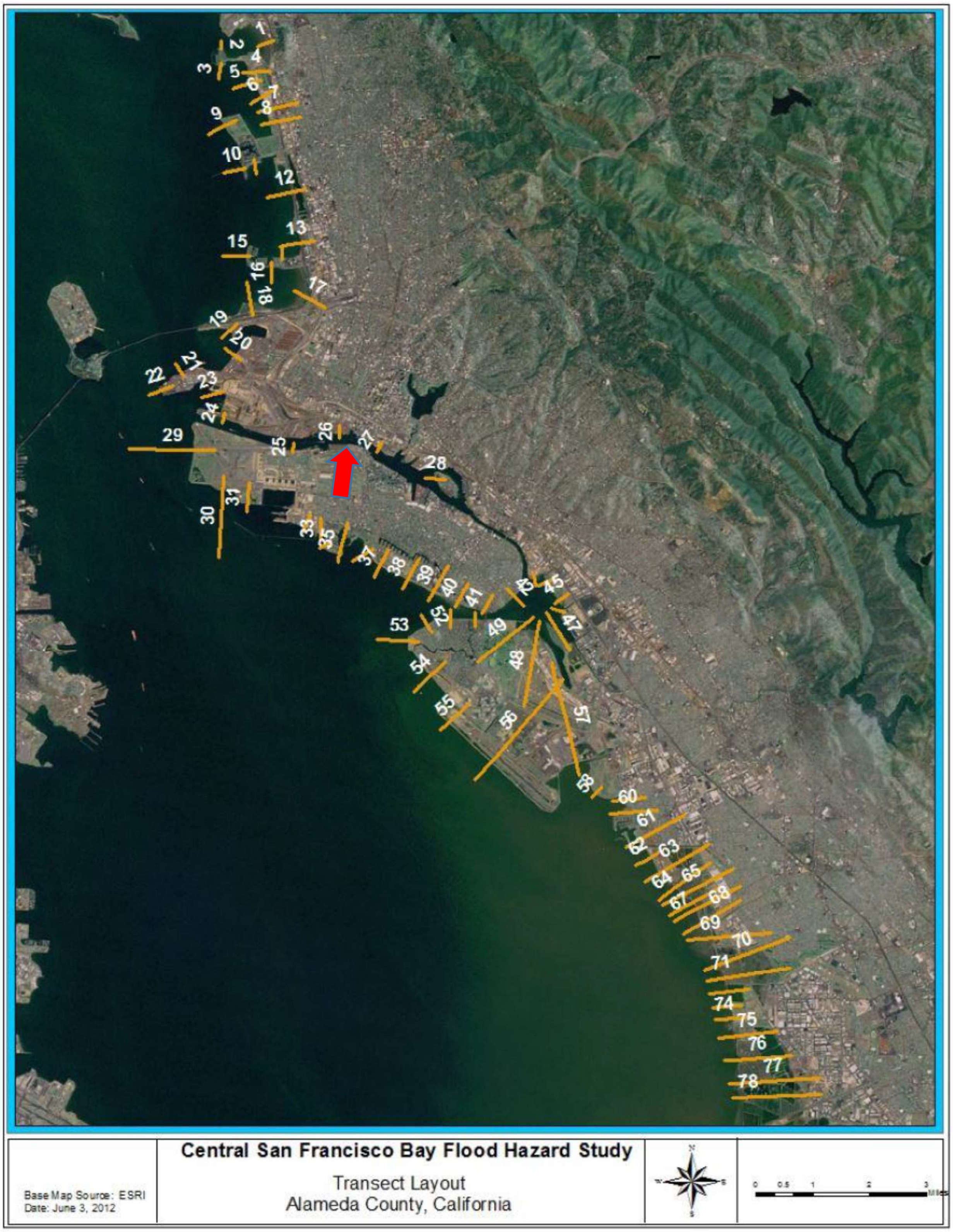


Figure 4: Transect Locations

From the same report, the 1% Stillwater Elevation (SWEL), 1% Wave Crest Elevation, and 1% Wave Runup Elevation is presented in **Table 1** below.

Table 1- Transects AECOM 2014

Transect Number	Structure Description	Runup Method	WHAFIS	1% SWEL (ft NAVD)	1% Wave Crest Elevation (ft NAVD)	1% Runup Elevation (ft NAVD)	Overtopping (Y/N)
25	Revetment	TAW	-	9.78	9.90	10.31	Y
26	Pier/Wharf	SPM	-	9.76	9.48	9.51	N
27	Revetment	TAW	-	9.73	9.62	9.75	N
28	Revetment	TAW	-	9.73	10.12	10.67	N
29	Revetment	TAW	-	9.78	11.56	11.39*	Y
30	Revetment	TAW	-	9.91	11.98	11.84	N
31	Revetment	TAW	-	9.90	11.78	11.77	Y
32	Revetment	TAW	-	9.90	11.59	11.42	N
33	Revetment	TAW	-	10.15	11.99	11.38	Y
34	NA	DIM/TAW	-	10.15	12.81	12.84*	Y
35	Revetment	TAW	YES	10.16	12.20	13.06	N
36	NA	TAW	-	10.20	12.39	12.95	N
37	NA	TAW	-	10.21	12.30	13.06	N
38	NA	DIM/TAW	-	10.23	12.53	10.94	Y
39	NA	DIM	-	10.22	12.15	10.53	Y
40	NA	DIM/TAW	-	10.22	11.41	12.00	N
41	Revetment	TAW	-	10.07	9.74	9.82	N
42	NA	TAW	-	10.03	9.85	9.64	N
43	Revetment	TAW	-	10.01	9.55	9.52	N
44	NA	DIM/TAW	-	10.01	9.93	9.84	Y
45	NA	-	YES	10.03	9.86	—	—
46	Revetment	TAW	-	10.03	9.99	9.80	N
47	NA	-	YES	10.04	10.00	—	—
48	Non-levee Embankment	-	YES	10.04	9.73	—	—
49	Non-levee Embankment	-	YES	10.04	9.80	—	—
50	NA	TAW	-	10.07	10.11	9.97	N

Using the table above to define the "*height of the one percent wave or the maximum wave runup (whichever is greater) associated with the 100-year stillwater surge elevation at the site*" (the criteria from 44 CFR 65.10):

- The highest 1% stillwater elevation: 9.76 ft (Transect 26)
- The highest 1% wave height elevation: 9.62 ft (Transect 27)
- The highest 1% wave runup elevation: 9.75 ft (Transect 27)

The wave height elevation and the wave runup elevation are based on statistically derived concurrent stillwater elevations that are less than the "highest 1% stillwater elevation". The two combinations of the statistically derived stillwater elevations plus the waves are both lower than the "highest 1% stillwater". Therefore, the "highest 1% stillwater" elevation governs over the two wave scenarios at this location.

Based on this information, the minimum top of levee or floodwall elevation should be either:

1) 9.48 ft wave crest elevation plus one foot of freeboard = 10.48 ft,
2) 9. 51 ft wave runup plus one ft freeboard = 10.51 ft, or
3) 9.76 ft plus two ft freeboard from the detailed analysis = 11.76 ft,

…whichever is higher. Elevation 11.76 ft (9.76 ft plus two ft of freeboard) governs, which is required as stated above in section 4.1.

The detailed analysis results in a top of protection elevation based on the stillwater. Based on the freeboard criteria in Section 4.1, the minimum top of levee or floodwall elevation should be 10 ft (9.76 ft rounded up) plus two ft of freeboard. Therefore, a top of levee/floodwall elevation of 12.0 ft will be used for existing conditions.

4.3 Future Conditions

As the sea level increases, the improvements required to address sea level rise (SLR) become more extensive and therefore more of a City-wide problem. At some point, this one project will need to be incorporated into a City-wide project for continuous shoreline protection or a larger sub-regional or regional project. Therefore, this grant application will not attempt to define improvements at that scale. It is our proposal to limit the sea level rise assumed to that which can be accommodated without a wholesale re-definition of this project. We will, however, acknowledge and accommodate future expansion and linking to these City-wide improvements.

4.3.1 Future Risk Analysis

To provide the City with a recommendation for a top of wall elevation (and a design still water elevation), a simplified relative risk and a simplified relative cost analysis was conducted.

4.3.1.1 Relative Risk

To estimate the relative risk of future sea level rise, five different 1% Stillwater elevations were projected inland from the Oakland Inner Harbor near the project site.

Wood Rodgers used the GIS and the LIDAR base map to identify the extent of improvements necessary for:

1. Existing conditions (100-year tide) = 10.0 ft (Exhibit 4) = <u>2,125 lf of improvements</u>
2. 0.5 ft of sea level rise (100-year tide) = 10.5 ft (Exhibit 5) = <u>2,275 lf of improvements</u>
3. 1.0 ft of sea level rise (100-year tide) = 11.0 ft (Exhibit 6) = <u>4,330 lf of improvements</u>
4. 2.0 ft of sea level rise (100-year tide) = 12.0 ft (Exhibit 7) = <u>4,930 lf of improvements</u>
5. 3.0 ft of sea level rise (100-year tide) = 13.0 ft (Exhibit 8) = <u>6,575 lf of improvements</u>

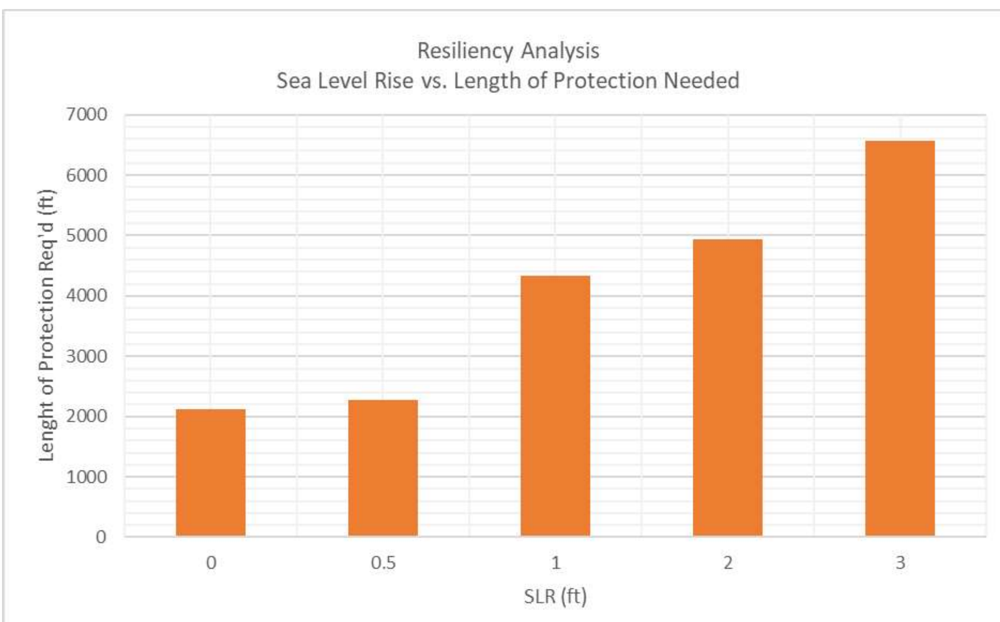


Figure 5: SLR vs Length Required

From the plot of SLR vs. length of protection required shown in **Figure 5**, you can see in that from existing conditions to a 2 ft of SLR, the length of protection (in this case a floodwall) required increases from existing conditions to about 1.0 ft, but then levels off at 2.0 ft of SLR. This is because the "high ground" that will anchor the floodwall gradually recedes to 1.0 ft, but then is high enough to provide protection for another 1.0 ft of SLR.

The figures show that the project can readily accommodate up to 2.0 ft of SLR.

From this analysis, and discussion with the City, a top of levee/floodwall elevation of 12.0 ft + 2 ft freeboard = 14.0 ft will be used.

From a review of **Table 2**, and with an assumed project construction date around 2026, a 2.0 ft SLR could be assumed to make the project viable for between 30 years (0.5% probability SLR meets or exceeds) to 67 years (50% probability SLR meets or exceeds). In **Table 2**, green cells represent SLR scenarios that the project is viable, grey cells represent SLR scenarios whose range is above and below the threshold and could vary in viability, and orange cells are beyond the project viability.

Table 2- Sea Level Rise Projections for San Francisco Bay for High Emissions Scenario

Project Planning Horizon	**Likely Range (ft)** (66% probability SLR is between)	**Median Project SLR (ft)** (50% probability meets or exceeds)	**1-in-20 Chance Project SLR (ft)** (5% probability meets or exceeds)	**1-in-200 Chance Project SLR (ft)** (0.5% probability sea level rise meets or exceeds)
2030	0.3 - 0.5	0.4	0.6	0.8
2040	0.5 - 0.8	0.6	1.0	1.3
2050	0.6 - 1.1	0.9	1.4	1.9
2060	0.8 - 1.5	1.1	1.8	2.6
2070	1.0 - 1.9	1.4	2.4	3.5
2080	1.2 - 2.4	1.7	3.0	4.5
2090	1.4 - 2.9	2.1	3.6	5.6
2100	1.6 - 3.4	2.5	4.4	6.9

Note: As shown in Cal-Adapt documents, the sea level rise projections shown are for the high emissions scenario referred to as Representative Concentration Pathway (RCP) 8.5. RCP 8.5, often referred to as a "business-as-usual" scenario, is consistent with a future where there are few global efforts to limit or reduce emissions. RCP 8.5 is included as an upper bound for California's sea-level response projections because thus far, our greenhouse gas emissions worldwide have continued to follow the business-as-usual trajectory.

Exhibit 4 - Existing Floodplain Remapped with Updated Topography (LiDAR 2019), 1% AEP Elevation = 10.0 Ft

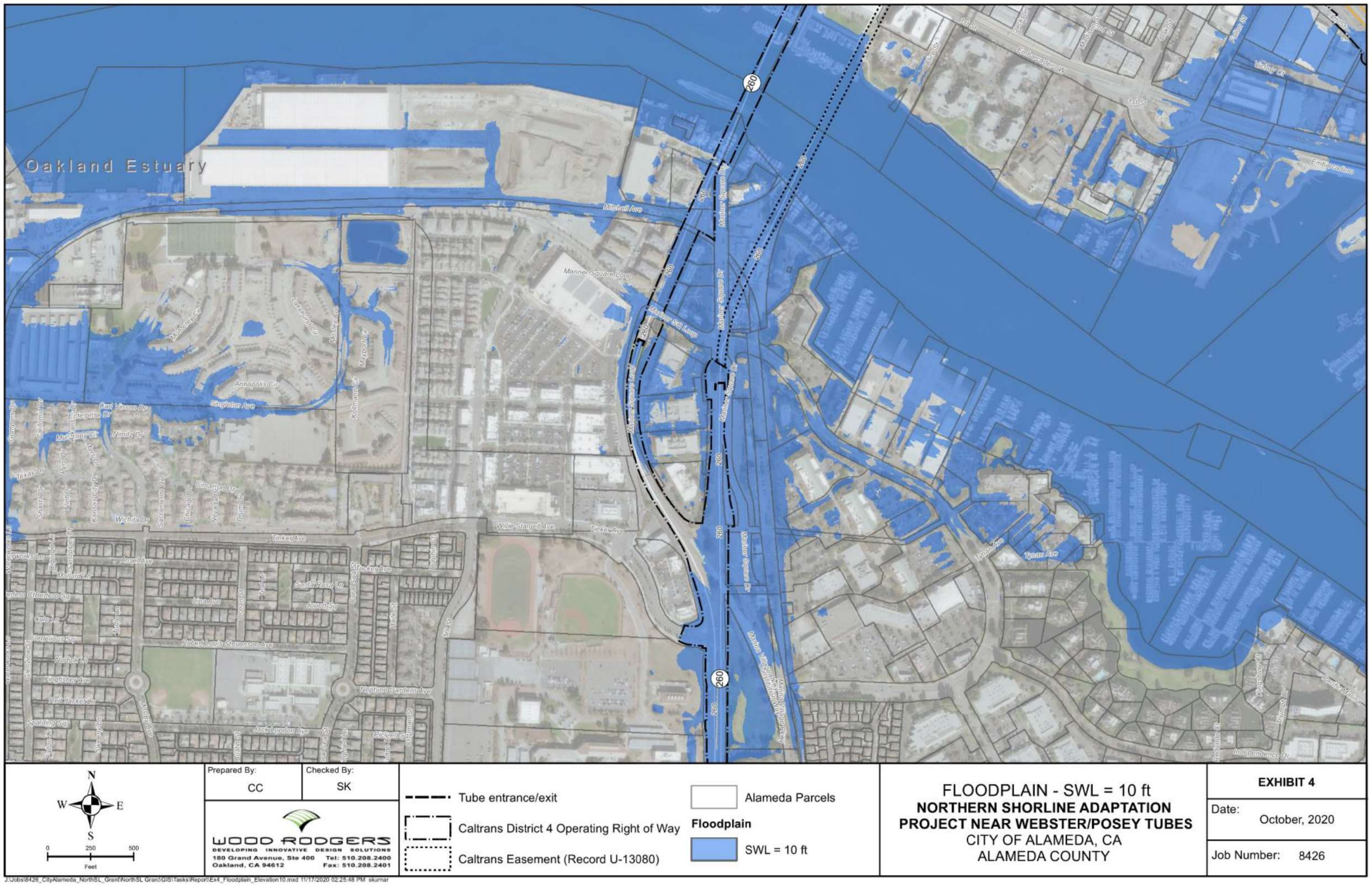


Exhibit 5 – Future Floodplain with Sea Level Rise = 0.5 feet, 1% AEP Elevation = 10.5 Ft

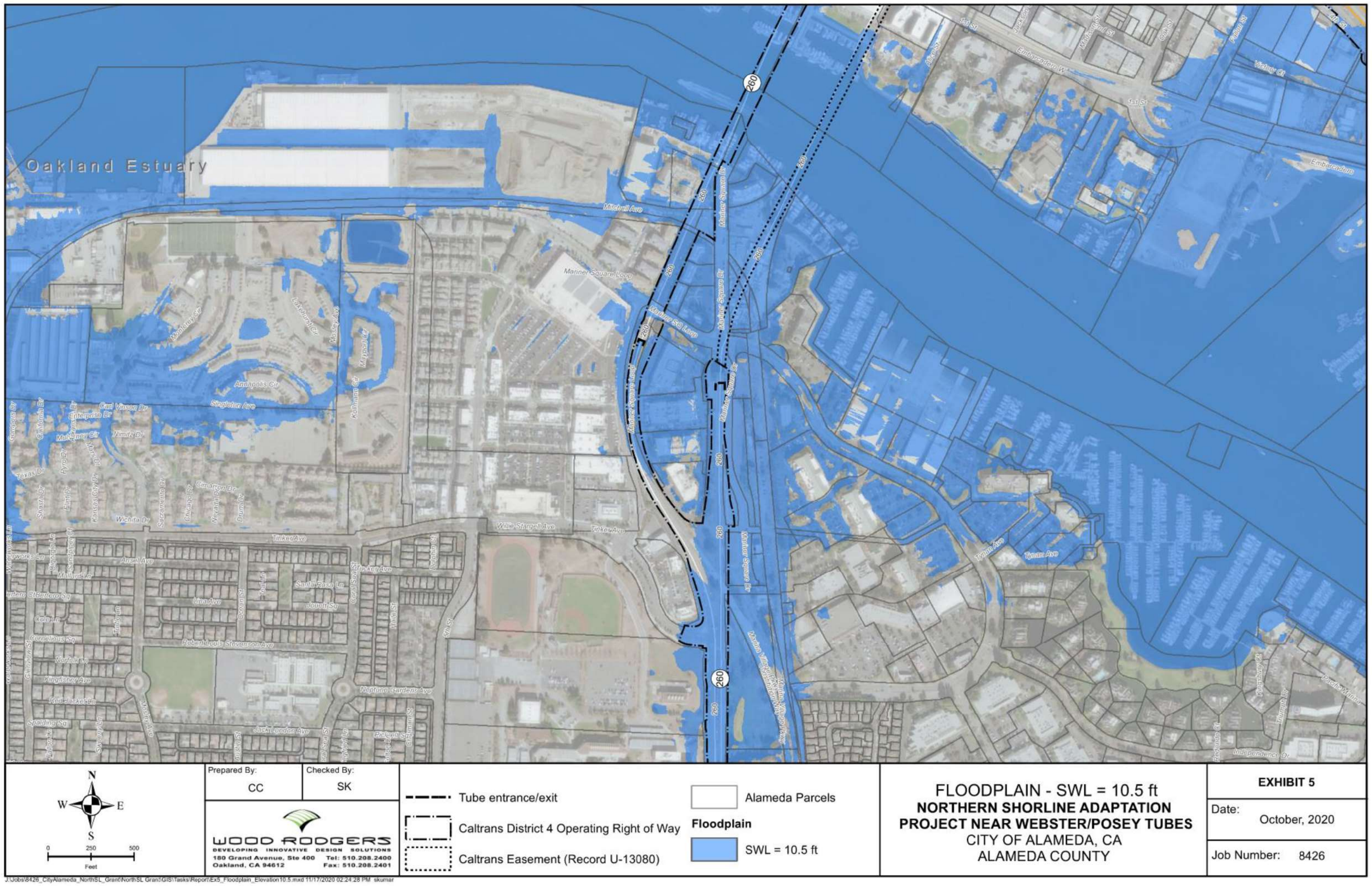


Exhibit 6 - Future Floodplain with Sea Level Rise = 1.0 feet, 1% AEP Elevation = 11.0 Ft

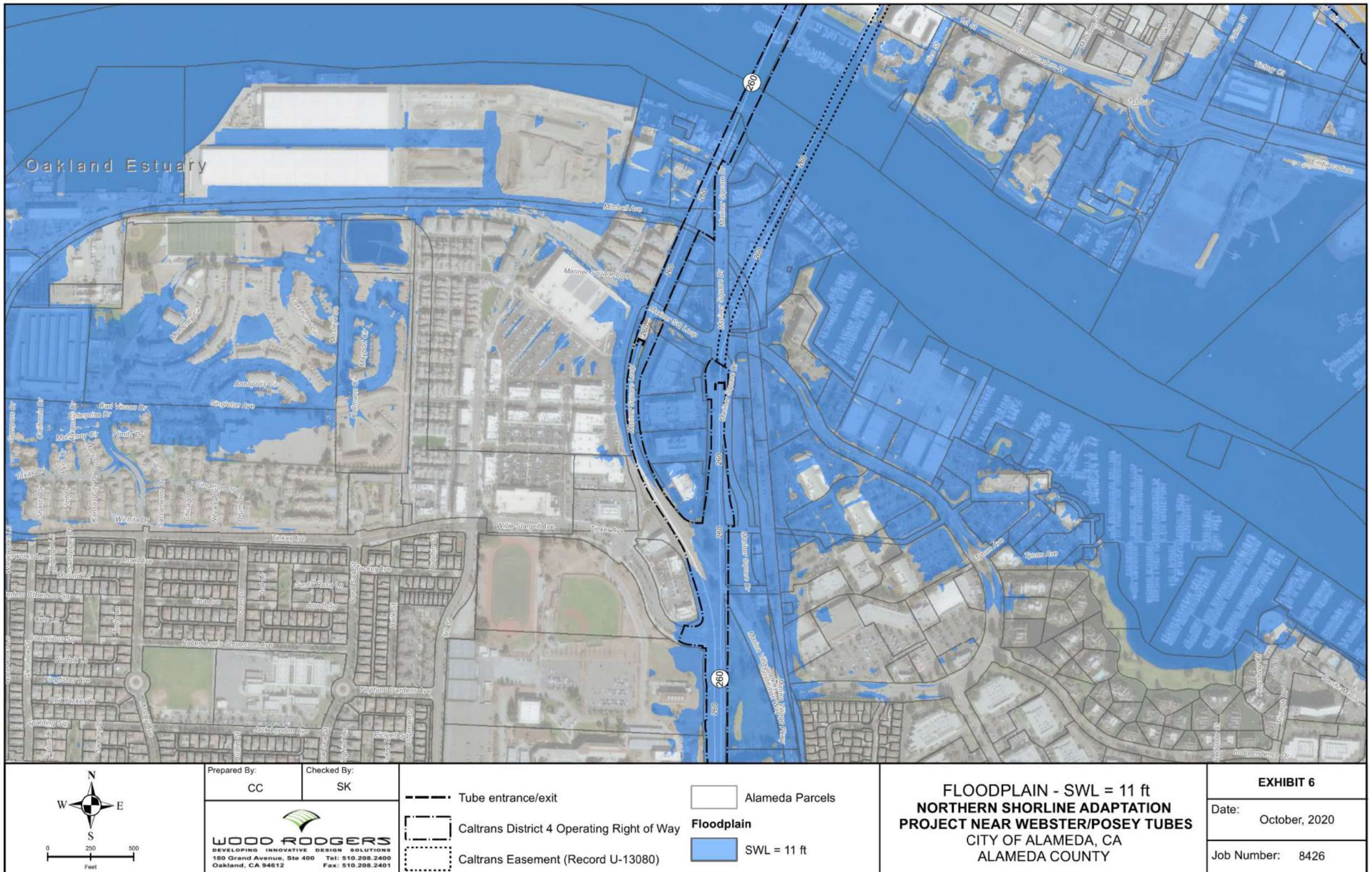


Exhibit 7- Future Floodplain with Sea Level Rise = 2.0 feet, 1% AEP Elevation = 12.0 Ft

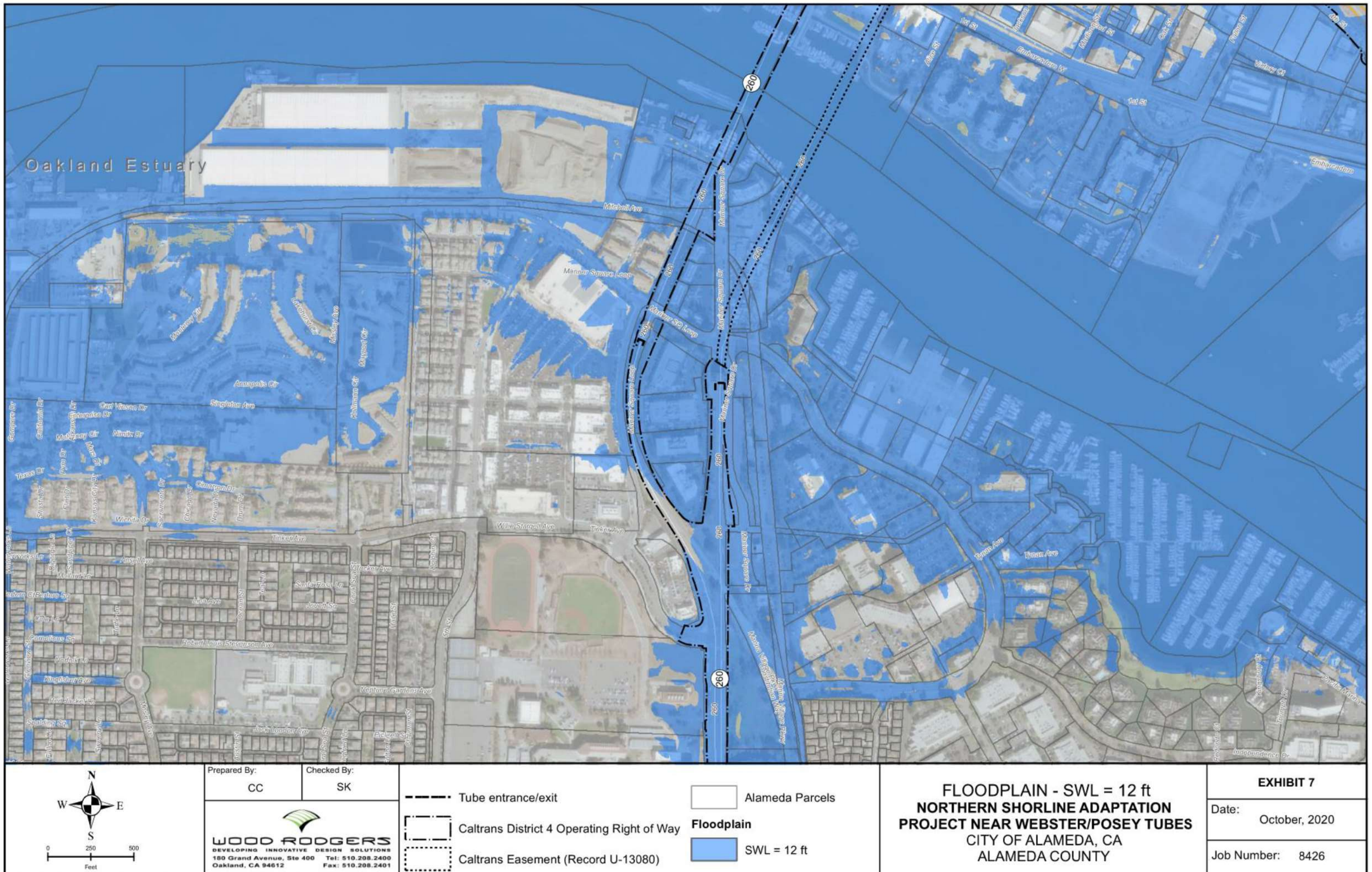
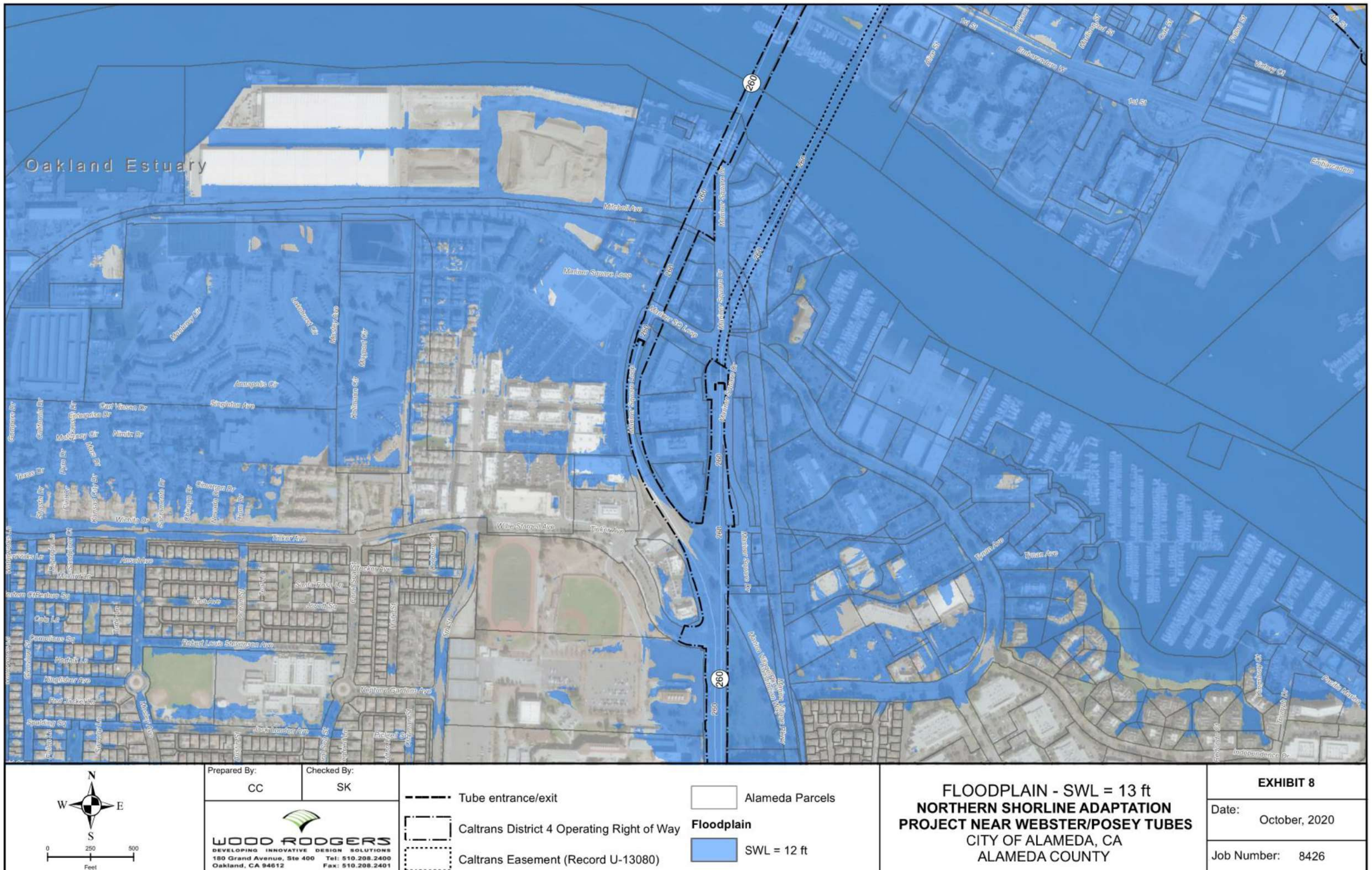
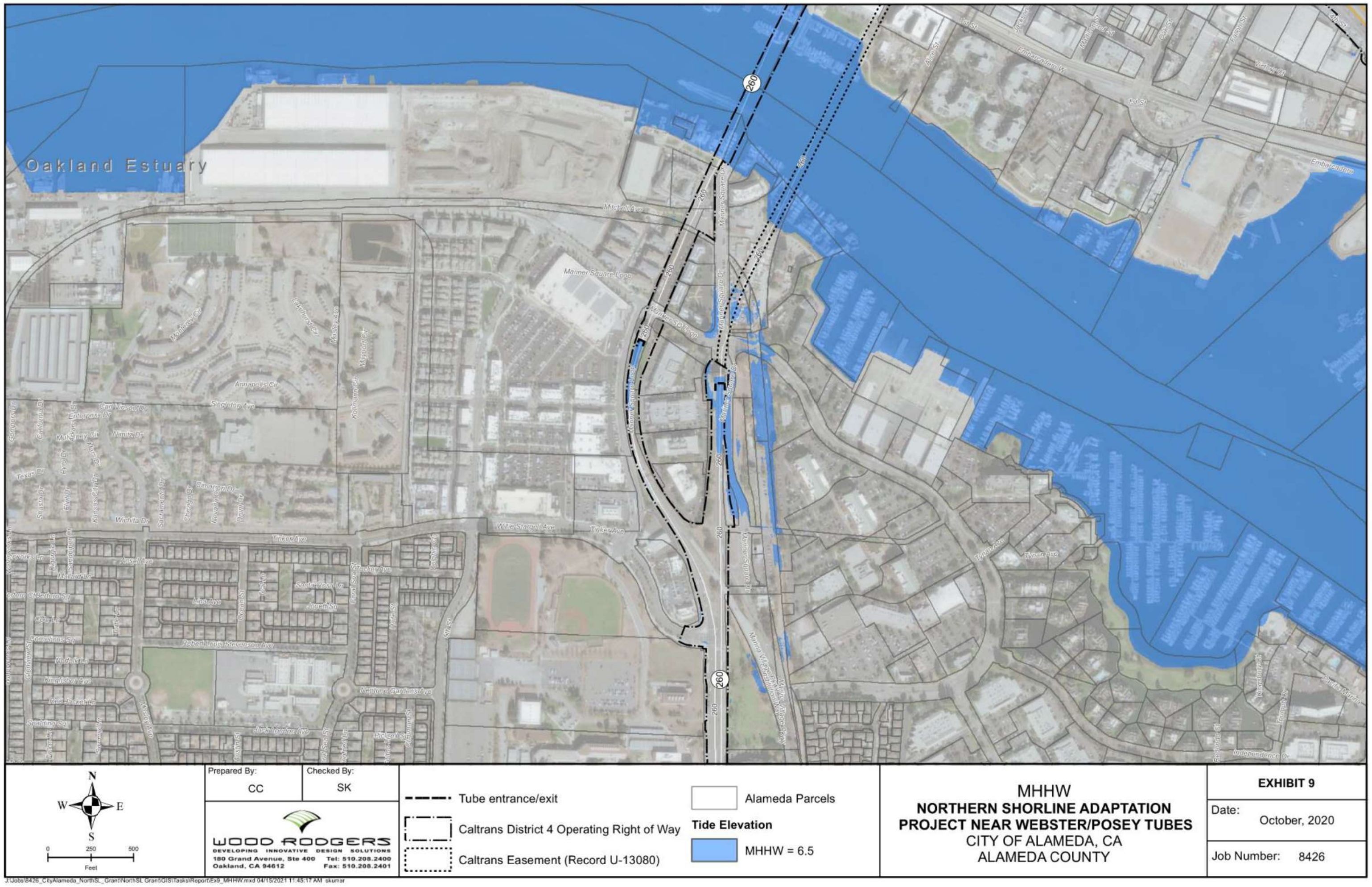


Exhibit 8 – Future Floodplain with Sea Level Rise = 3.0 feet, 1% AEP Elevation = 13.0 Ft



4.3.2 Other Elevation Considerations

The Oakland Inner Harbor Mean Higher High Water (MHHW) elevation is 6.5 Feet NAVD88 at the shoreline adjacent to the North Shoreline project site. This water level does not necessitate any shoreline improvements.



5 FLOOD PROTECTION ALTERNATIVES

Several flood protection alternatives were considered assessed and reduced to four of the most probable alternatives. The analysis considered site constraints (terrain, shoreline, existing utilities, etc.), property / easement bounds, aesthetics, access, constructability, feasibility, regulatory/permitting requirements, etc.

5.1 Project Alignments

Multiple project alignments were developed with consideration of project goals with emphasis on the following three (3) goals:

- Act as a barrier to the current 100-year coastal flood and future 100-year coastal flood incorporating sea level rise from entering local streets, portals, tubes and State Route 260 on the Alameda side
- Protect adjacent commercial and residential properties within the flood zone.
- Protect and enhance the San Francisco Bay Trail, waterfront access and other recreational and place-making opportunities and nature-based adaptation solutions.

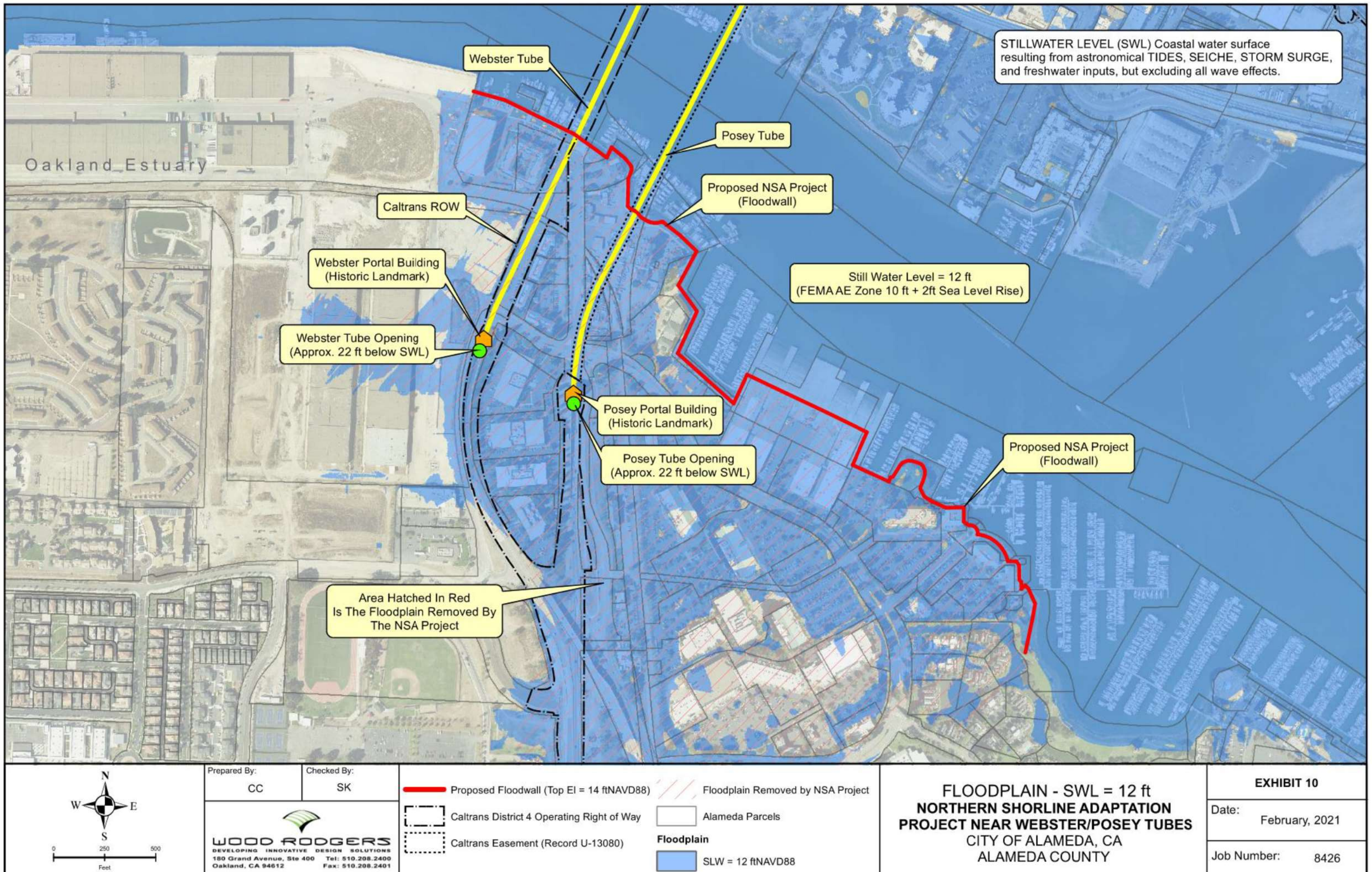
Project alignments that utilize existing high ground were first analyzed since they significantly reduce the extent and cost of the proposed protection feature. However, these alignments may require the City to obtain several easements, they may require managed retreat over time as sea levels rise, and they may result in temporary or complete loss of access to the existing Bay Trail.

Project alignments that are along the existing shoreline and are on the water side of the Bay Trail require a longer length of protection feature but can meet the three project goals above. These alignments do present the potential for additional permit requirements because of their nearness to the Oakland Inner Harbor, most of which can be avoided by strategic design of the protection feature. The presence of existing utilities servicing docks and boathouses along the shoreline alignment does present some construction challenges which can be addressed in the design process.

Since the shoreline project alignment can meet the three project goals unlike the other interior alignments, the shoreline project alignment was selected as the preferred project alignment.

See **Exhibit 10** for a map of the selected project alignment.

Figure 10 – Project Alignment



5.2 Typical Section Types

The selected project alignment has three general shoreline types, which include:

1) vertical shoreline walls
2) steep earthen embankments
3) shallow earthen embankments

The approximate station extents of these three shoreline types along the proposed project alignment are as follows: These stations are in reference to the provided plan set "*CityAlameda_NorthSL_Grant_Alt3_SWL_12'.pdf*".

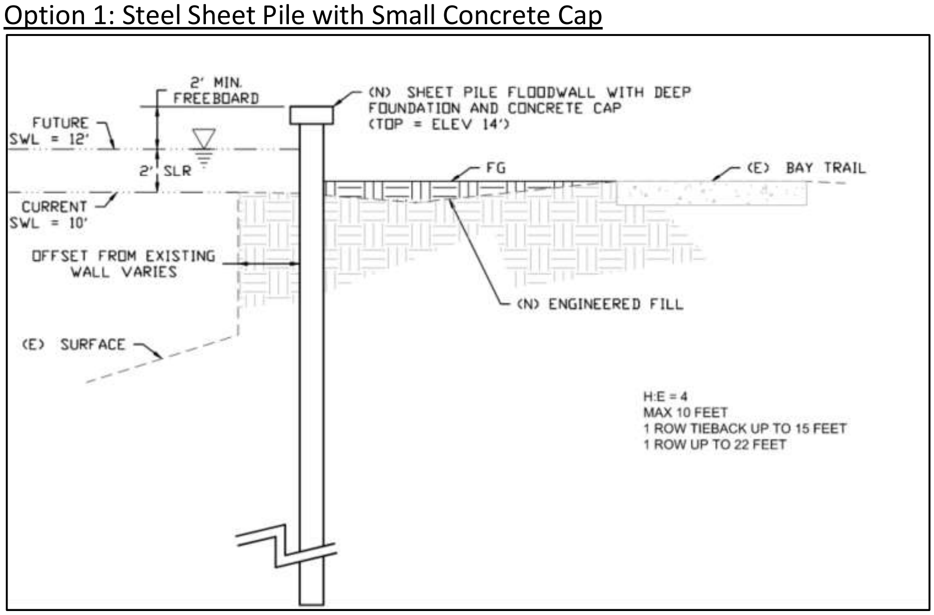
Vertical Shoreline Walls	Steep Earthen Embankments	Shallow Earthen Embankments
0+00 to 7+90	10+00 to 17+25	7+90 to 10+00
25+20 to 35+00	20+50 to 25+20	37+00 to 40+20
40+20 to 43+70	35+00 to 37+00	49+00 to 52+55
	43+70 to 49+00	

Preliminary typical wall section types were developed for the three types of shoreline listed above. These include variations of a Steel Sheet Pile Wall with a Concrete Cap (Typical Section 1), a Concrete Floodwall with a potential cutoff wall (Typical Section 2), an Earthen Berm/Levee (Typical Section 3) with a potential cutoff wall, and an Earthen Berm with a Concrete Floodwall and potential cutoff wall (Typical Section 4). The need for a cutoff wall will be evaluated in detail during the preliminary design phase of the project. Each of the section variations per shoreline type is shown below. Although these can be used for any shoreline type, they are depicted with the most relevant type. The improvements are shown as close as possible to the existing shoreline to avoid retreat and maintain use of the Bay Trail. The offset of the improvements varies along the project alignment.

The typical cross sections show the existing ground as a dashed line, with the Oakland Inner Harbor on the left and the landward side on the right in each:

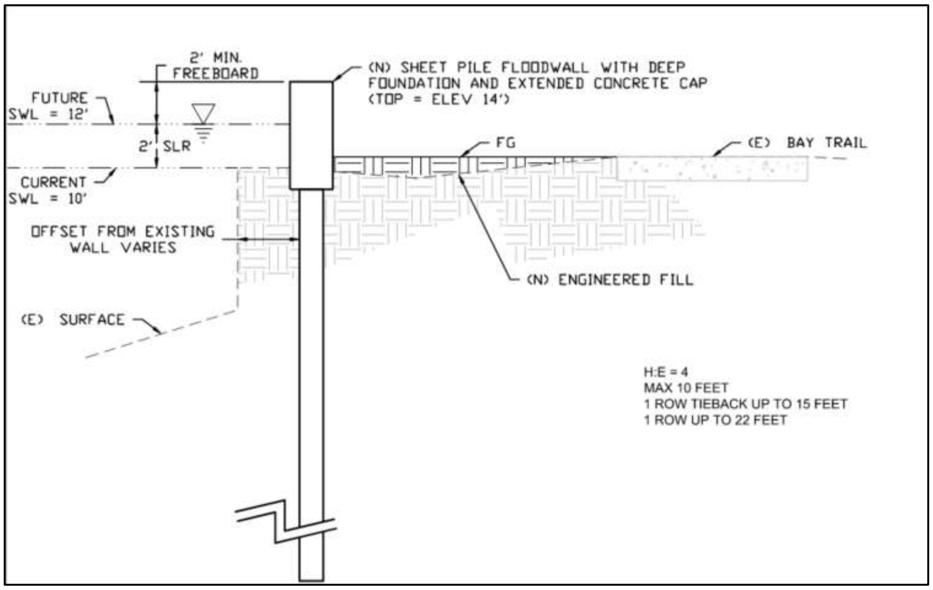
1. **Typical Section – Steel Sheet Piles (shown on a vertical shoreline)**

Option 1: Steel Sheet Pile with Small Concrete Cap



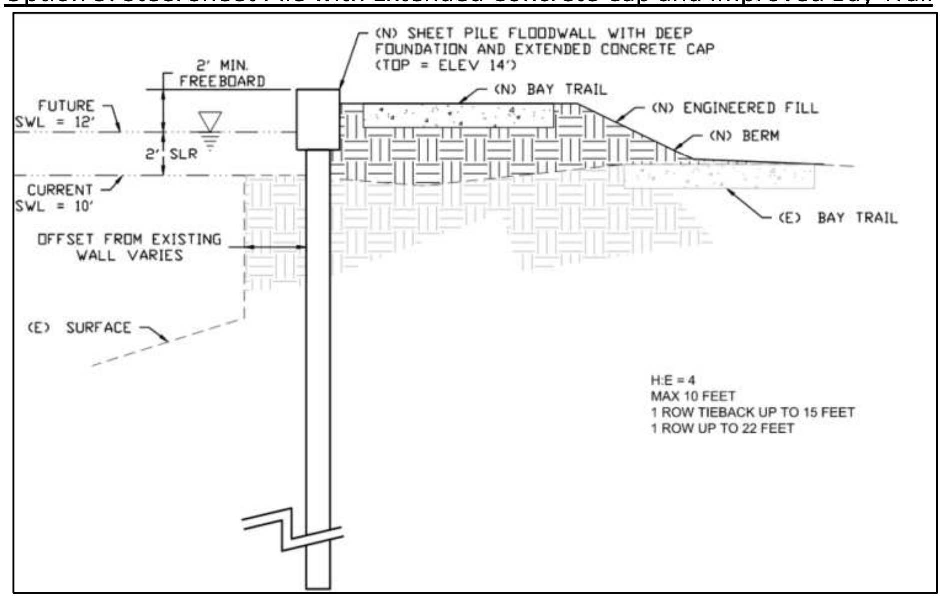
This typical section is highly adaptable. The steel sheet piles can be driven to a deep depth and have tie-back anchors installed to handle future loads from additional wall sections as sea level rises. The additional wall can be easily anchored to the concrete cap. This section will have exposed steel sheet pile visible from the Bay Trail. This may obstuct the trail views of the Oakland Inner Harbor and may not be as aethetically pleasing as other options.

Option 2: Steel Sheet Pile with Extended Concrete Cap



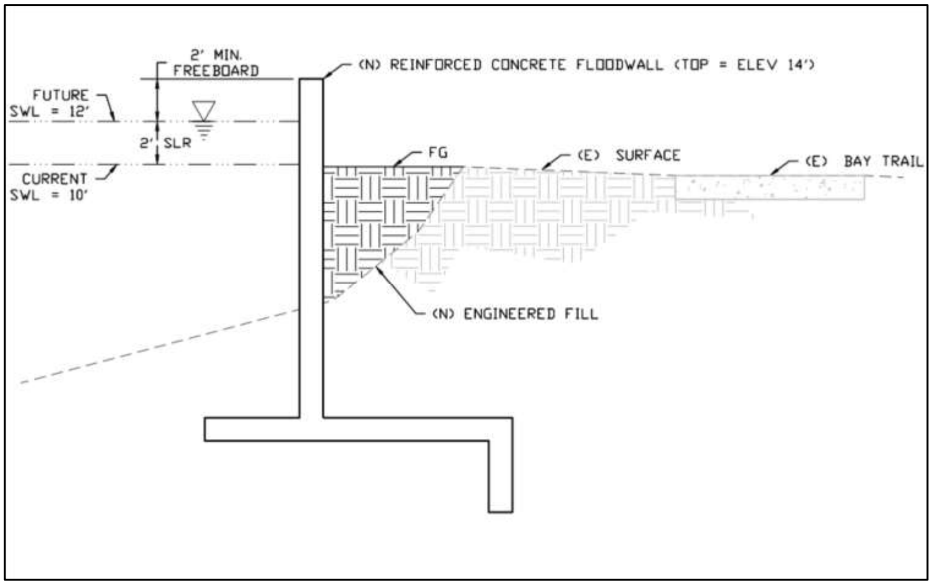
This typical section is similar to Option 1 except for the extended concrete cap, which can incorporate achitectural finishes to make the wall more aesthetically pleasing. This wall type may still obstuct the trail views of the Oakland Inner Harbor in certain locations.

Option 3: Steel Sheet Pile with Extended Concrete Cap and Improved Bay Trail



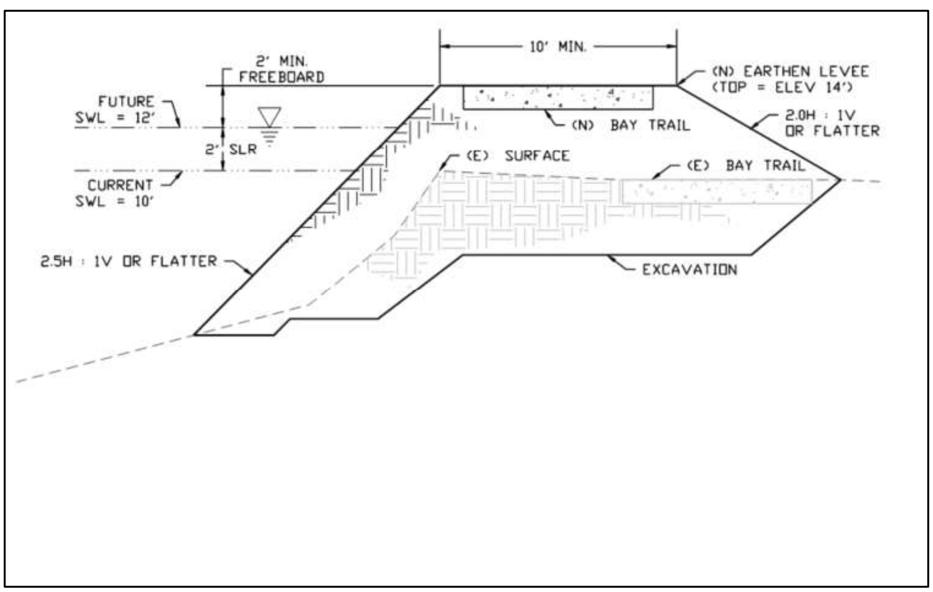
This typical section is similar to Option 2 except it includes an improved Bay Trail. The improved Bay Trail is raised such that the steel sheet pile wall no longer obstructs views from the trail.

2. Typical Section – Concrete Floodwall (shown on a steep shoreline)



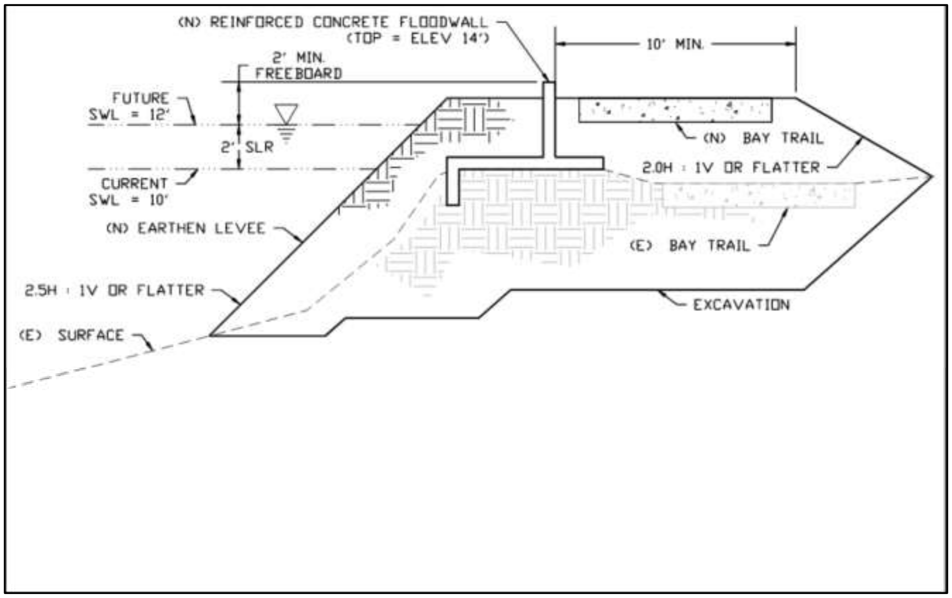
This typical section uses reinforced concrete that will require excavation and backfilling of engineered fill material. For steeper shorelines the wall may need to extend relatively deep or may require a pile foundation based on findings from subsurface investigations by a geotechnical engineer. The concrete wall can incorporate architectural finishes to make the wall more aesthetically pleasing.

3. Typical Section – Earthen Berm/Levee – (shown on a steep shoreline)



This typical section represents an earthen berm (levee) that will require excavation and placement of engineered levee fill material. The slopes of the berm should not be steeper than 2:1 for slope stability and this may result in a relatively wide footprint in some locations along the project alignment potentially involving filling withing the estuary. Also, because the alignment is underlain by Bay Mud, the berm will be nagatively impacted by liquefaction, lateral spreading, and consolidation settlement. The berm can have an improved Bay Trail on top to maintain the current views from the trail and incorporate nature based solutions such as habital restoration. The berm can be vegetated to be aesthetically pleasing.

4. **Typical Section – Earthen Berm with Floodwall Hybrid (shown on a steep shoreline)**



This typical section is similar to the berm section (#3) but will a concrete floodwall on top. This option also has an improved Bay Trail on top of the berm and incorporate nature based solutions such as habital restoration. The hybrid berm floodwall option has similar constraints as both the concrete floodwall and earthen berm typical but has a smaller footprint than the earthen berm.

5.3 Geotechnical and Structural Engineering Considerations

The four typical section types have specific geotechnical and structural engineering considerations that should be balanced to achieve a feasible, safe, and long-lasting shoreline protection feature.

Based on the available information, the site is underlain by artificial fill that is up to 25 feet thick and about 40 feet thick at the Webster Street Tube. Below the artificial fill, the Bay Mud is up to 15 feet thick. Older bay deposits (Old Bay Clay) are present below the Bay Mud to the depths previously explored by others. Subsurface information was not made available in the southern 300 feet of the alignment.

Because of these site conditions the berm typical sections (#3 and #4) would need to be overbuilt to mitigate seismically induced lateral spreading and liquefaction and may require (concrete) piles to support any type of concrete wall to allow bearing pressures. Other issues include slope stability of the Oakland Inner Harbor bank and consolidation settlement of the underlying Bay Mud. Lightweight fill would help to address consolidation settlement, however the decreased resistance to sliding and buoyancy would need to be considered.

From a geotechnical and structural perspective, a steel sheet pile wall with concrete cap is simplest to construct for the majority of the project alignment. Steel sheet pile walls are common for this application. The concrete cover cap on top of the steel piles can have architectural finishes and be a visual appealing feature. The piles can also be driven deep enough to accommodate higher loads from an additional wall anchored to the top of the concrete cover for future adaptation needs. The design of sheet pile walls will need to consider the presence of buried utilities or other improvements.

5.4 Alternatives Benefits and Challenges Matrix

Each alternative was discussed with the team and a preliminary selection matrix was created to compare the benefits, challenges, relative costs, and regulatory concerns of each which is presented in **Table 3**.

Table 3 - Preliminary Flood Control Alternatives Comparison Matrix

Alternative	Description	Benefits	Challenges	Relative Cost	Regulatory Concerns
1. Steel Sheet Pile Wall	Steel sheet piles driven or vibrated through existing ground	Small Footprint Highly Adaptable in Future	Driven piles may be obstructed by rock revetments and utilities	Moderate Low	OK if above MHHW
2. Concrete Floodwall	Reinforced Concrete wall with spread footing	Moderate Footprint	Sensitive to Consolidation Settlement	High	OK if above MHHW
3. Earthen Berm (Levee)	12-ft Top Width 2:1 Waterside Slope 3:1 Landside Slope	Matches Aesthetics No Obstructions to Bay Trail View Nature Based Solutions	Overbuild due to consolidation settlement Wide Footprint Levee Material Import	Moderate	OK if above MHHW
3. Earthen Berm w/ Floodwall Hybrid	Reinforced concrete wall on top of levee	Reduces Levee Material Import, slightly reduces footprint Nature Based Solutions	Settlement Wide Footprint	High	OK if above MHHW

Based on the preliminary matrix, each alternative was determined to be worth investigating further and preliminary unit cost estimates were developed to compare relative feasibility.

5.5 Alternatives Costs

Preliminary unit construction cost estimates (cost per linear foot of levee or floodwall) were developed for the four alternatives based on recent construction costs in the Bay Area per eBidboard. The construction cost estimates were based on the preliminary geotechnical recommendations (provided pre-geotechnical investigations/report) and available component unit costs as documented in the cost spreadsheet

Table 4- Preliminary Flood Control Alternatives Cost Estimate Summary

Alternative	Cost/LF	Length (Ft)	Cost*
1. Steel Sheet Pile Wall	$1,800	4,930	$8,874,000
2. Concrete Floodwall	$2,200	4,930	$10,846,000
3. Earthen Berm (Levee)	$1,500	4,930	$7,395,000
3. Earthen Berm w/ Floodwall Hybrid	$1,900	4,930	$9,367,000

** Cost are for construction only and exclude design, utility conflicts, permitting, and geotechnical analysis*

Since the lateral extent of the project will be the same regardless of the section type chosen, the unit costs provide a good indicator of the cost of each alternative relative to the others.

The cost for the planning, analysis and engineering design (PAED) is roughly 10-20% of the total cost in Table 4. This should be included in addition to the cost in Table 4 for budget planning.

5.6 Alternative Environmental Permitting

As each alternative was investigated, it became evident that environmental permitting and regulatory requirements could impact the overall project schedule and cost depending project limits. Therefore, Horizon Water and Environment (Horizon) was hired as a sub-consultant to investigate the construction limits and associated permits/agency requirements. Based on Horizon's research, if the project was designed to stay above the Mean Higher High Water (MHHW) on the shoreline side of the levee, it could be outside the jurisdiction of USACE, RWQCB, and CDFW. In addition, the relatively small size of the project area may not trigger a (RWQCB) NPDES/WDR permit.

Since the project will most likely be located within 100-ft of the Oakland Inner Harbor shoreline, it will be subject to Bay Conservation and Development Committee (BCDC) approval. Horizon will seek BCDC coverage under a region-wide permit. They will also prepare a letter for USACE providing information and justification of how the project is outside and avoids Corp jurisdiction. USACE encourages individuals to submit letters describing project boundaries/activities/avoidance when projects are in close proximity to jurisdictional areas.

See **Appendix B** for a Permitting Strategy Technical Memorandum.

5.7 Project Funding Opportunities

Several grants of programs are available to support the Northern Shoreline Adaptation Project. Several facets of the project are discussed such as transportation, housing, commerce and recreation. See **Appendix A** for a Funding Options Technical Memorandum.

5.8 Preliminary Caltrans Review

Caltrans Structural and Geotechnical Departments have reviewed the preliminary design plans and basis of design documents. The Structural review provided no comments or concerns for the proposed project. The Geotechnical review comments are provided below.

"The construction of the proposed seawalls within the zone of Webster and Posy tubes will add extra overburden on these tubes. The impact should be evaluated and measures should be taken to avoid the impact if needed."

Impacts to the tubes will be assessed during PAED, and any adverse impacts will be addressed and accommodated in the design phase of the project.

5.9 Recommendation

Based on the preliminary unit costs, the concrete floodwall (Section # 2) and the earthen berm with floodwall hybrid typical section (Section # 4) are the most expensive.

The steel sheet pile walls and earthen berm (levee) are the least expensive. After further discussing these two section types with the geotechnical engineer, it was found that the earthen berm (levee) alternative has a higher potential for lateral spreading and consolidation settlement due to the underlain Bay Mud. Furthermore, the earthen berm (levee) alternative may necessitate construction below MHHW which could trigger additional permitting requirements.

The section with the least risk and still mostly cost-effective is the Steel Sheet Pile Wall (Section 1). The option that meets most of the project objectives is Option 3 - Steel Sheet Pile with Extended Concrete Cap and Improved Bay Trail.

APPENDIX