US Army Corps of Engineers®

Appendix D

Economic Analysis

South Pacific Division, Continuing Authorities Program
San Francisco District

Continuing Authorities Program (CAP), Section 103

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South San Francisco Water Quality Control Plant (WQCP) Continuing Authorities Program (CAP) 103 Feasibility Study

1 Study Authority and Guidance

This economic analysis has been prepared to support the Lower Colma Creek Section 103, Continuing Authorities Program (CAP) Feasibility Study, which is being investigated under two authorities outlined in the Flood Control Act of 1936 and the Flood Control Act of 1948. The Flood Control Act of 1936 authorizes civil engineering projects and other flood control measures through the United States Army Corps of Engineers and other Federal Agencies. It is a general law or authority that is applied to all types of civil engineering projects including General Investigation Feasibility Studies and smaller CAP studies established in the Flood Control Act of 1948. Another provision established in this Act grants the Chief of Engineers the power to authorize minor flood control projects without having to first acquire Congressional approval.

2 Study Purpose

The Lower Colma Creek CAP 103 project is a coastal storm damage reduction project at a wastewater treatment plant in South San Francisco, California, adjacent to the San Francisco International Airport (SFO). The South San Francisco/San Bruno Water Quality Control Plant, and North Bayside System Unit Facilities (also referred to as South San Francisco Water Quality Control Plant or abbreviated as WQCP) services an area with over 165,000 full time residents, plus the daily population of SFO airport. The purpose of this report is to analyze coastal storm risk management opportunities at the WQCP. This study addresses the need for coastal storm risk management in the project area. There have been no improvements to reduce flood risk in the area surrounding the plant and although the WQCP hasn't been impacted from significant flooding from coastal sources, flood risk is expected to increase over time due to the location of the plant, which is in a low-lying coastal area, near the confluence of Lower Colma Creek with the San Francisco Bay.

3 Study Area Location

The study is examining flood risk at the WQCP located in the City of South San Francisco, CA (SSF) and provides services a larger area spanning several municipalities including SFO. South San Francisco is bordered by the cities of Brisbane to the north and San Bruno to the south. Figure 1 shows the location of the WQCP and Figure 2 displays the Sewer Service Area Map.

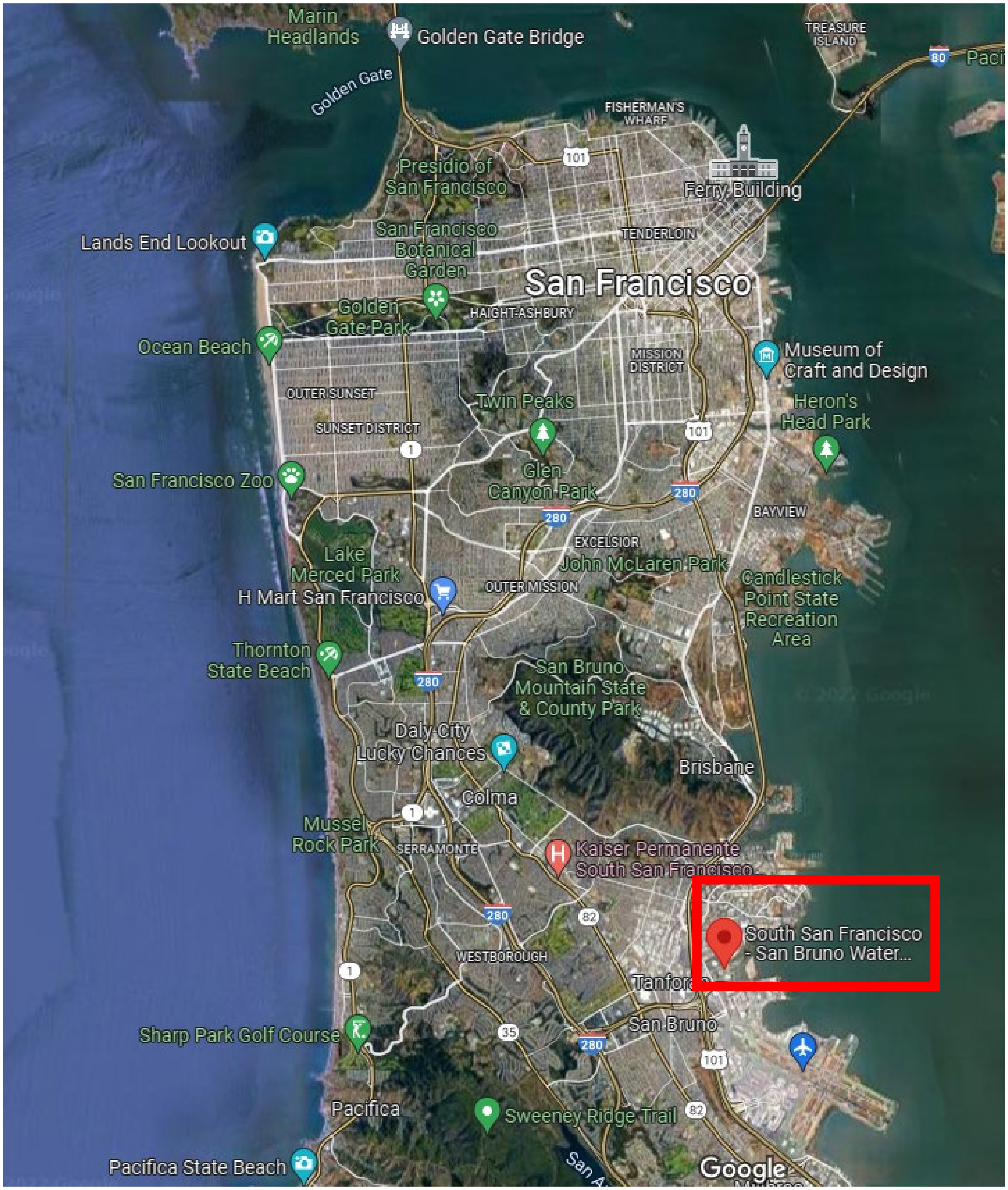


Figure 1: Study Area

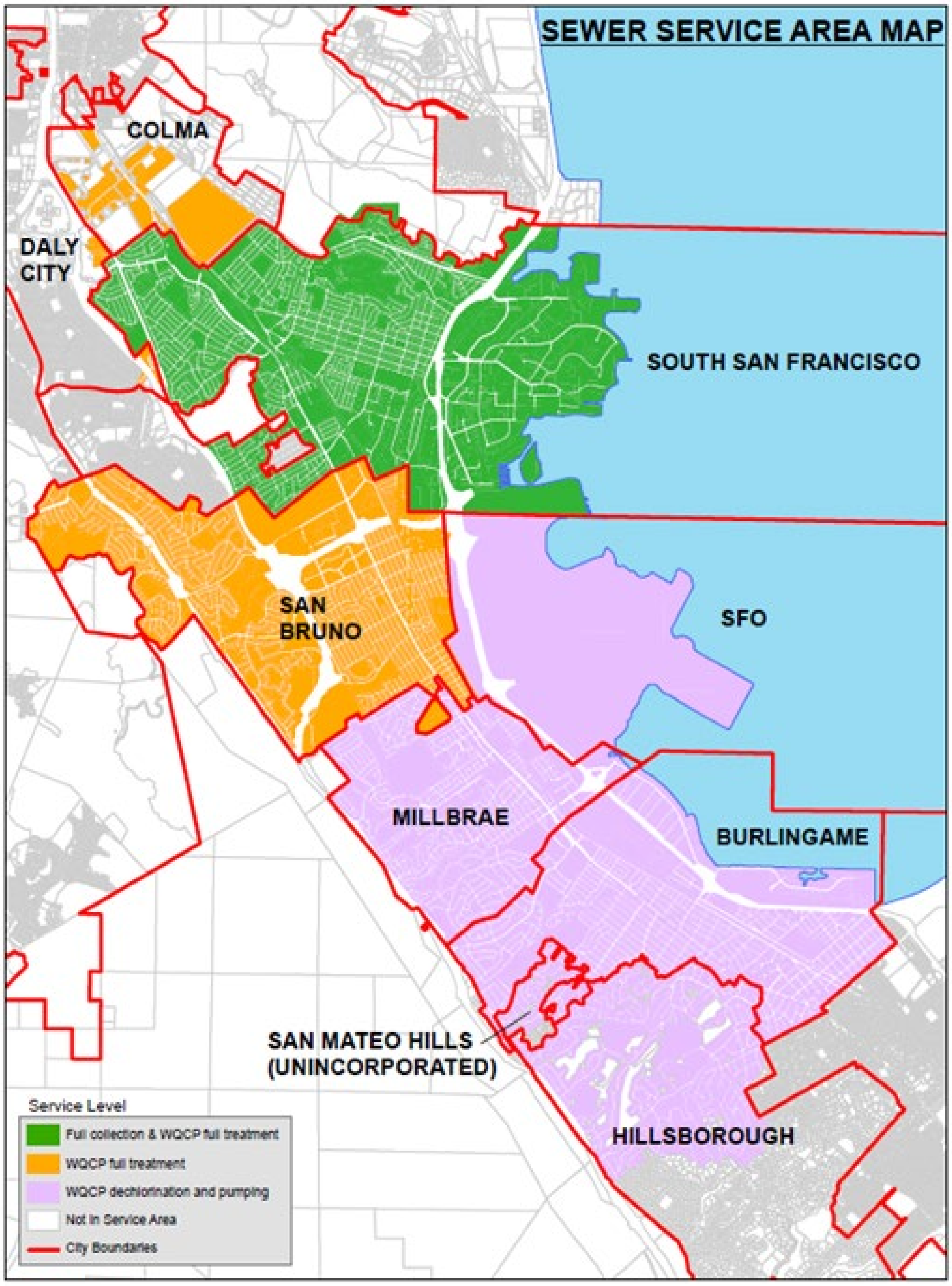


Figure 2: SSF WQCP Sewer Service Map

4 Study Sponsor

The non-Federal Sponsor (NFS) for the study is the City of South San Francisco.

5 Study Area Demographics and Project Area

The following provides an overview of the study area demographics, including population employment and labor force statistics, and race/ethnicity of the population residing in South San Francisco and San Bruno CA. These two municipalities are the most substantial users of the WQCP.

5.1 Population

The City of South San Francisco has a total population of 66,105 (April 2020) and San Bruno has a population of 43,908 (April 2020). Census data has shown that South San Francisco and San Bruno's population has grown about 3.8% and 6.4% respectively over the last decade.

5.2 Employment

Most employed citizens within South San Francisco and San Bruno work in private industry, followed by local, state and federal government sectors.

Table 1 shows the Labor Force Data for the cities of South San Francisco and San Bruno.

Table 1: Labor Force Data for South San Francisco and San Bruno

Area Name	Civilian Labor Force	Unemployment Rate
South San Francisco	38,714	2.5%
San Bruno	25,632	4%

Source: US Census, (2020 American Community Survey) Obtained 2022

5.3 Race & Ethnicity

Table 2 provides a summary of race and ethnicity for South San Francisco and San Bruno, California. In both cities, Asian/Hawaiian/Pacific Islander represents the largest ethnicity, with White (alone) representing the second largest ethnicity.

Table 2: Ethnicity Composition of South San Francisco and San Bruno

Area Name	White (alone)	African American	American Indian and Alaska Native	Asian/ Hawaiian/ Pacific Islander	Other
South San Francisco	14,584	1,311	732	28,427	12,215
San Bruno	14,822	771	458	15,304	6,479

Source: US Census (2020 American Community Survey)

6 Flood Risk Analysis Methodology

Flood risk analysis procedures are used to evaluate without-project flood damages in the study area. Guidance for conducting flood risk analysis is included in Corps Engineering Regulation 1105-2-101, *Risk-*

Based Analysis for Flood Damage Reduction Studies (3 January 2006) and Engineering Manual EM 1110-2-1619 *Engineering & Design – Risk Based Analysis for Flood Damage Reduction Studies (1 August 1996)*. The US Army Corps of Engineers Hydrologic Engineering Center has developed software specifically designed for conducting risk and uncertainty-based flood risk management studies. This software is referred to as the HEC-FDA Program (Version 1.4.3), which was certified by the Flood Risk Management Planning Center of Expertise. This program applies a Monte Carlo simulation process, whereby the expected value of damages is determined explicitly through iterative runs of the program where the program selects from a distribution of data collected from basic parameters. The simulation then conducts a numerical integration technique accounting for uncertainty in these parameters. Data requirements for the program include:

1. Configuration Information: This information is input directly into the program and includes streams, damage reaches, analysis years, and plan definition.

2. Hydrology and Hydraulic Engineering: Hydrologic and Hydraulic data include water surface profiles and exceedance probability functions. For this study, water surface profiles were developed using the HEC-RAS program. The profiles were entered into the HEC-FDA program. Uncertainty in exceedance probability functions and stage discharge functions are also input into the program. These engineering uncertainties will be described in more detail later in this section.

3. Economics: An economic database is typically prepared in Microsoft Excel according to specific guidelines outlined in the HEC-FDA manual and imported as a text (tab delimited file). Included in the Excel file are several structure attributes including the structure identifier number, structure category, stream location, ground and/or first floor elevation, and structure and content values. This data was collected through a survey completed by the WQCP facility management and GIS-based analyses. The data was entered into Excel spreadsheets and imported into the HEC-FDA program. Other parameters specified in the importable Excel file are the depth damage functions. Specific depth/damage functions for the contents of some of the WQCP structures were provided by facility management based upon a detailed assessment of equipment and contents at risk for a range of water surface elevations (WSEL).

6.1 Sea Level Rise (SLR) and HEC-FDA Analysis

The coastal engineer provided WSEL for each of eight annual exceedance probability (AEP) events for all three SLR scenarios: low, intermediate and high. These SLR scenarios were evaluated under both the without- and with-project conditions: low, intermediate, and high. In addition to WSEL at the base year of 2023 and at the end of the 50-year period of analysis in 2073, a midpoint year (2043) under all SLR scenarios was also provided. Including this midpoint year is a reasonable way to account for the fact that SLR is not expected to be linear over time. Without the inclusion of a midpoint, the HEC-FDA program will linearly interpolate the equivalent annual damages (EAD) between year one and year fifty of the period of analysis.

To carry out the flood damage analysis for this study, two HEC-FDA models were built for each SLR scenario: one model to estimate flood damages from the base year to 2043, and a second model to estimate damages from 2043 to 2073. Inputs to both HEC-FDA models will include base, mid-year and future year without- and with-project WSEL for all eight AEP events as well as probability exceedance functions, structure and content valuations, structure and content uncertainty parameters and depth damage curves for public structures and clean-up cost to structures in the study area.

The extreme tide elevations for each SLR scenario were compared to the elevation of key infrastructure within the WQCP area. These structures were chosen due to their importance and vulnerability to flooding and were divided into zones and numbered. Section 7.1.1 summarizes the locations and functions of each building. While ground elevations were available on the as-built plans for some of these structures, there were issues with the vertical datums on these plans, and other buildings were lacking elevation information. To remedy this, the U.S. Army Corps of Engineers, San Francisco District (USACE) sent out a survey team to acquire an accurate datum conversion as well as the building floor slab elevations for these structures in September 2021.

HEC-FDA combined WSEL and frequencies with the floodplain asset information, such as structures/contents and clean-up costs, to compute EAD, annual exceedance probability, and other performance statistics for both without- and with-project conditions. The final without- and with-project EAD estimate under each SLR scenario were calculated from the EAD outputs from each model. This was done via post-processing in a spreadsheet outside of the HEC-FDA model.

6.2 Sources of Uncertainty

The major sources of economic uncertainty include the following:

1. Value of property
2. Value of property contents
3. Flood stage at which damage begins
4. First floor elevations of structures
5. Responses to flood forecasts and warnings
6. Cleanup costs
7. Business losses
8. Depth-percent damage curves
9. Estimate of the stage associated with a given discharge
10. Estimate of damage for a given flood stage

Principal sources of error affecting the depth-damage relationship were examined in a risk and uncertainty framework. Those sources of error are 1) errors associated with the damageable property elevation, 2) errors associated with the values of structures in the floodplain inventory, 3) errors associated with values of structure contents in the floodplain inventory, and 4) errors associated with the damage functions used against the floodplain inventory.

There are numerous factors which affect the frequency distributions as well as the rating curves for the study area's hydraulic reaches. Those factors are discussed in detail in the Hydrology & Hydraulics Appendix.

Elevation of damageable property: In the floodplain, the flooding depths are relatively shallow, and the flood plains are relatively small and flat; therefore, even minimal adjustments to certain assumptions and/or variables (e.g., foundation height, depth of flooding, depth-percent damage functions, uncertainty inputs) may result in different economic results. For example, if the foundation height of the asset was 1.0ft instead of 0.5ft, the damages at Pump Station #4 would be $0 over the 50-year period of analysis. This would result in a Tentatively Selected Plan (TSP) EAD closer to $140,000 and a BCR of 0.25. Conversely, if the modeled depth of flooding at Pump Station #4 was increased by 0.5 ft, the BCR may double or triple the current estimates. Per EM 1110-2-1619, a standard deviation of 0.4 feet was used to account for the uncertainty associated with the elevation of damageable property. The 0.4 feet standard deviation was used for two reasons. Since the economic inventory was conducted by a visual on-site inspection, the first-floor elevations of structures were estimated rather than measured and would account for different variations in structure elevation.

Structure value: It was assumed that the estimated structure value, which was derived from property tax information and a field inventory, has a standard deviation of 15 percent of the structure value. This assumption is based on prior Albuquerque District studies, and prior experience of the Ft. Worth District, which developed that estimate from interviews with various County Assessor's offices.
The structure inventory values, and associated error distribution were then used to compute floodplain inventory that incorporates errors around structure value.

Content value: The error distribution associated with content value varied by structure type because different structure types (i.e., various types of electronics or machinery, etc.) contain different contents within them. Working with plant managers, the content to structure values were set at 35% for public structures and 30% for clean-up costs

Inundation Depth/Percent Damage: Depth damage functions compute the percent damage at a given depth for structures and contents. Since all the structures are non-residential (public structures and clean-up costs) and unique to the WQCP, representatives from both the WQCP and USACE worked together to develop the Depth Damage Curves and associated uncertainty parameters for each unique structure within the main plant and were based off factors such as insurance information and best professional judgement.

Clean-up Costs: In this analysis, it was assumed that the clean-up cost would be $10 per square foot. Based on research and prior USACE reports, the cost to clean-up sewage estimates ranged from $7-$14 per square foot. Various factors, such as duration of sewage in a structure and the depth of sewage within the structure accounted for this range in values. Since it was difficult to account for the duration and/or depth of sewage that could backup into structures, uncertainty for the values was entered into HEC-FDA. Figure 3 displays the uncertainty parameters entered into the model.

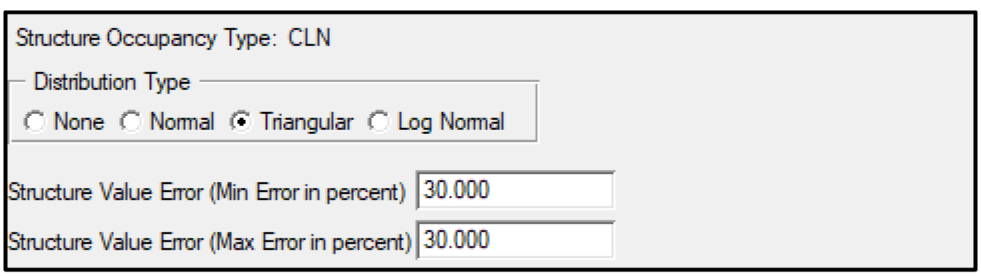


Figure 3: Clean-up Uncertainty Parameters

7 Without Project Condition

The without project condition includes both existing and future conditions expected to occur over a 50-year period of analysis starting at a base year of 2023. The without project condition is considered by USACE as the baseline condition expected to occur over a fifty-year period of analysis and serve as the basis for comparison when evaluating the potential benefits of project alternatives. Under this condition, it is assumed the WQCP will continue operations over the 50-year period current to today's (2023) operations.

Wastewater is transferred to the main facility by a network of 14 Pump Stations and two Storm Water Stations that covey raw sewage to the WQCP. The current average dry weather flow through the WQCP is nine million gallons per day (MGD) with peak wet weather flows of over 60 MGD. The permitted average dry weather flow capacity is 13 MGD (RWQCB, 2008). Wastewater treatment processes at the WQCP include screening and grit removal, primary clarification, secondary treatment by an activated sludge process, secondary clarification, disinfection, and dechlorination. Biosolids are concentrated using dissolved air flotation thickeners, anaerobically digested, and dewatered with belt filter presses. Biosolids are hauled from the WQCP site and deposited in a landfill in Livermore, California (RWQCB, 2008).

In addition to processing wastewater from the cities of South San Francisco and San Bruno, and the Town of Colma, the WQCP provides dechlorination treatment of the chlorinated effluent from the cities of Burlingame and Millbrae and San Francisco International Airport prior to discharging the treated wastewater into Lower San Francisco Bay.

It is assumed that in the without project condition, floodwaters could cause damage to WQCP structures, contents, and electrical equipment. Equipment essential to the operation of the WQCP—including pumps, blowers, and electrical panels—is susceptible to damage from floodwater. It is assumed that motors not rated to be submersible will fail when inundated by water. Electrical equipment will be disabled (by protective breakers & fuses) when conductors and terminals are shorted by water.

All wastewater from customers served by the WQCP would continue to flow by gravity toward the WQCP while it is offline. During this shutdown period, wastewater would begin to fill the collection system until it is unable to process the sewage. There are two possible openings through which sewage could spill out of the system while the WQCP is disabled: (1) it could spill out through a pipe near Colma Creek untreated (2) if the Pump Stations were to fail, sewage would back up into customers' homes or businesses and spilling out through floor, shower, or other drains.

Under existing conditions, if the WQCP is offline while the Pump Stations are still online, plant operators can store untreated influent in unused aeration basins at the facility until the WQCP was returned to service. If the Pump Stations were offline sewage backups in homes and businesses would damage bathrooms and adjacent areas on the first floor and require cleanup and replacement of some fixtures. The damage for this CAP study is assumed to impact 570 square feet per structure to represent bathrooms and adjacent interior areas. The cleanup cost per structure associated with sewage backup was estimated to be $10 per square foot and was based off previous USACE studies on sewage cleanup.

Untreated wastewater discharges could have adverse environmental impacts and may result in fines from regulatory agencies. Fines associated with untreated wastewater discharges—while potentially relevant to WQCP operators and rate payers—are not considered to be damages for the purposes of the economic analysis.

As previously mentioned in Section 6.1, to carry out the flood damage analysis for this study, two HEC-FDA models were built for each SLR scenario: one model to estimate flood damages from the base year to 2043, and a second model to estimate damages from 2043 to 2073. Inputs to both HEC-FDA models will include base/first year and future year without- and with-project WSEL for all eight AEP events. Additional model inputs include depth-damage curves for each of the structure types and contents. HEC-

FDA will calculate flood depths at each structure from the WSEL, which provide the water's stage, and structure elevations.

HEC-FDA combined flood depths and frequencies with the floodplain asset information to compute equivalent annual damages (EAD), annual exceedance probability, and other performance statistics both without- and with-project. The final without- and with-project equivalent annual damages EAD estimate under each SLR scenario were calculated from the outputs from each model under each SLR scenario. This was done via post-processing in a spreadsheet outside of the HEC-FDA model.

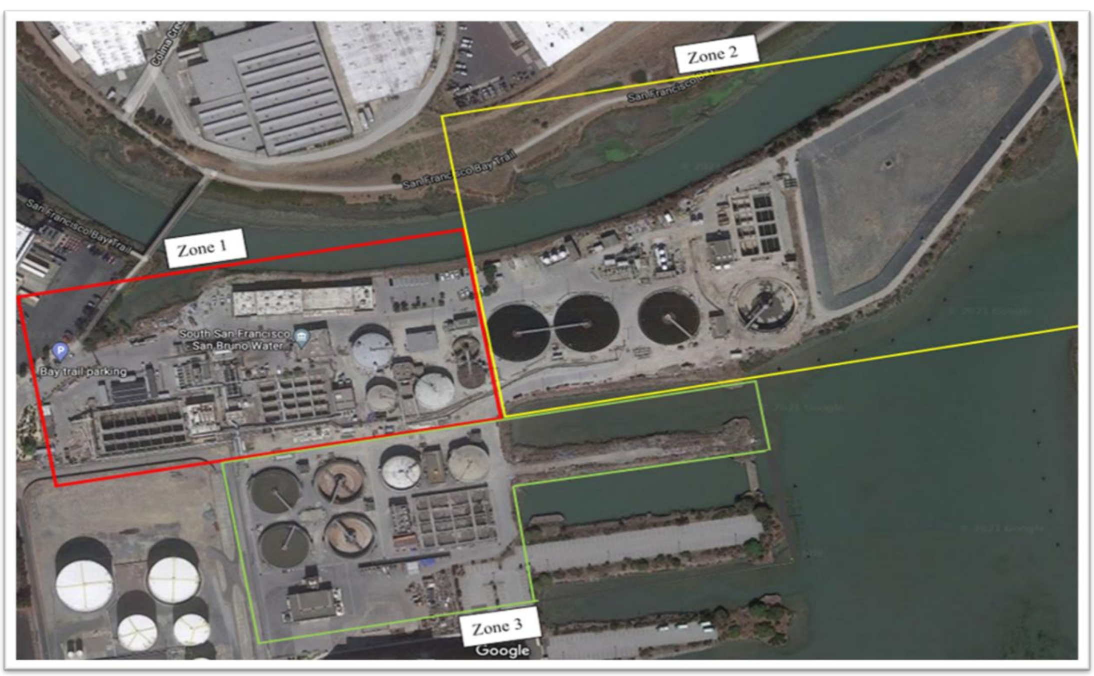
After estimating damages under the without project condition, a project alternative was developed to address the flooding problem at the plant. An evaluation of residual damages and damages reduced (benefits) was then conducted. Benefits for the alternative were then compared with costs to determine the net benefits and benefit/cost ratios.

7.1 Without Project Flood Damages

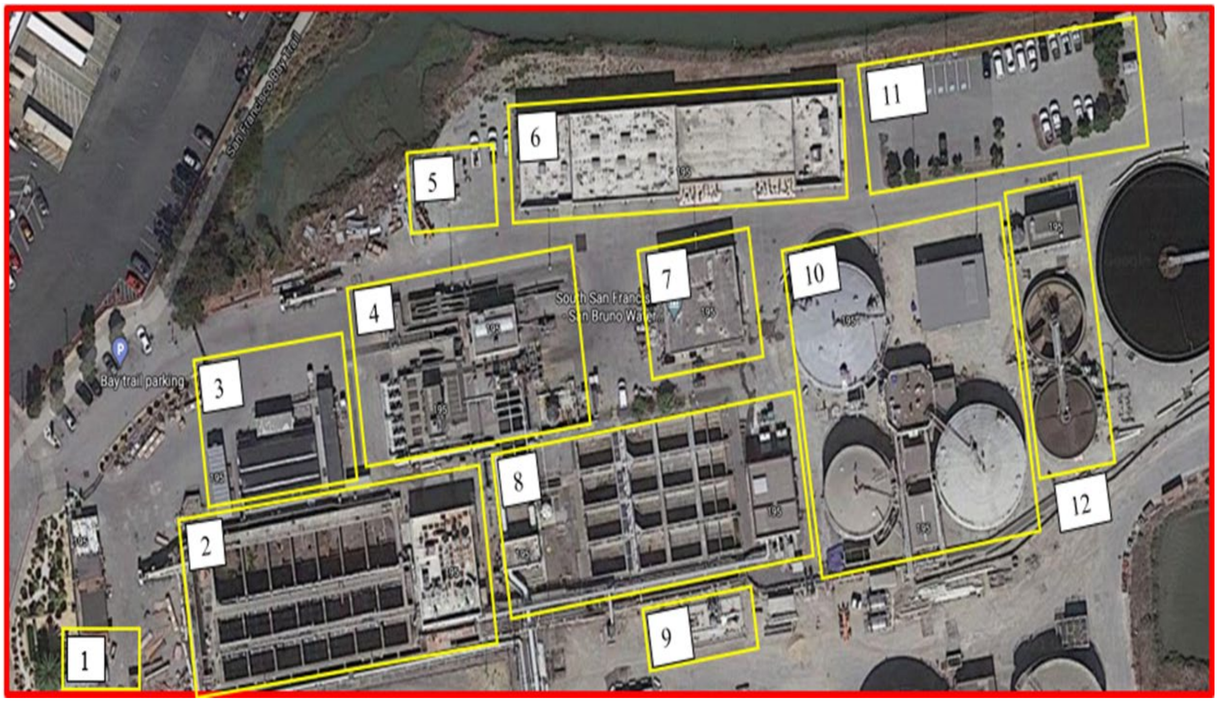
The sections below describe the methodology and results of the without project flood damage analysis. Subsequent sub-sections describe flood damages to: (1) structure, structure contents, machinery outside of structures; (2) the cost to clean-up structures connect to the WQCP.

7.1.1 Structure and Structure Contents – Descriptions & Values

A structural inventory for import into HEC-FDA was completed based on data gathered from the WQCP administration and through an onsite inspection of structures within the floodplain. Building locations were identified through an image obtained from Google Earth Pro of the WQCP. This data was supplemented with data collected from a survey developed by USACE, San Francisco District and delivered to the WQCP administration. The survey response provided information on foundation height, specific business activity for non-residential public buildings, condition, type of construction, and number of units. Structures within the WQCP parcel were categorized and grouped into three zones, as shown in Figure 4.



Zone 1



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San Francisco Bay Trail
Bay trail parking

Zone 2

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San Francisco Bay Trail

Zone 3

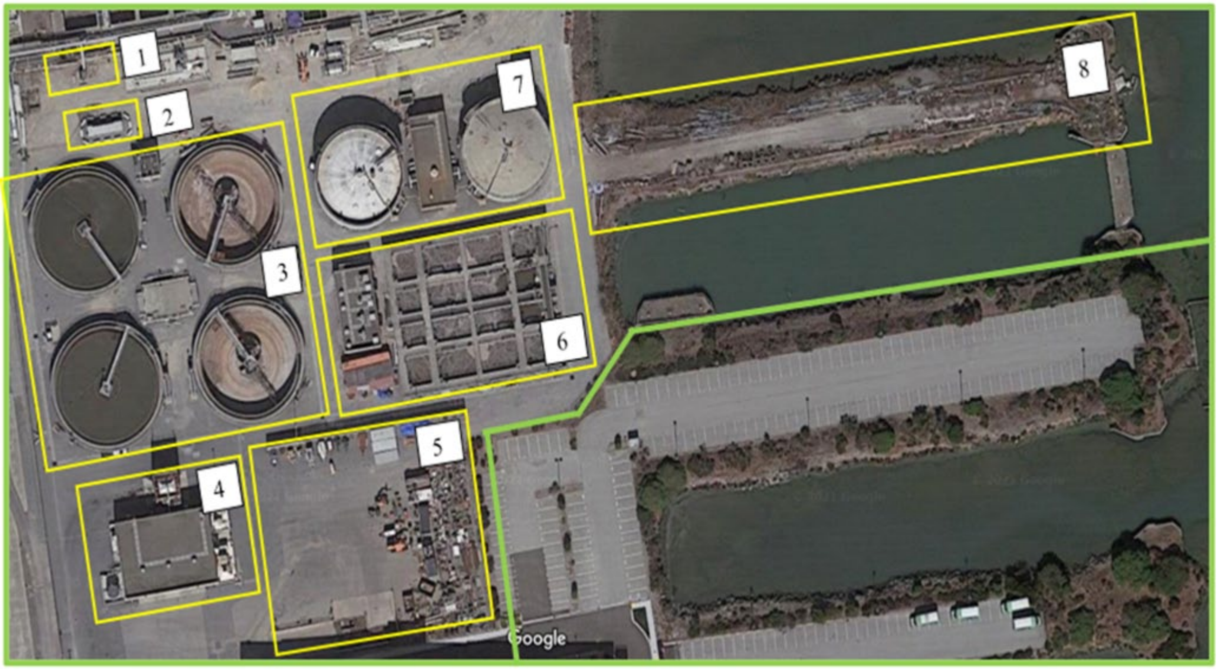

Figure 4: Maps of SSF WQCP Structures

All the structures were inventoried during the field survey (see Table 3). Structures in the data set were assigned a numerical identifier. Measurements of square footage for each structure was obtained through Google Earth Pro using the measuring tool and were classified by story, construction type and purpose. The buildings in red text were not included in the analysis.

Table 3: Description of SSF WQCP Facilities

Zone 1

Building	Name/ID	Square Feet/Perimeter Feet	Elevation	Construction	Purpose/Function
1	Natural Gas / Potable Water Feed	151 Perimeter Ft 1,421 Square Ft	4'	Steel	High Pressure Natural Gas (PG&E) and Potable Water (CAL Water)
2	Aeration Basins 5,6,7 / Blower Building 1 / Cogeneration Building	698 Perimeter Ft 25,079 Square Ft	1'	Concrete	Aerobic Activated Sludge Treatment / Associated Blowers / Cogen Engine / Associated Electrical MCC's & PLC's
3	MCC – B & 2 Transformers (Electrical Panels)	427 Perimeter Ft 10,627 Square Ft	.5'	Steel	Electrical Motor Control Center
4	Influent Pump Station / Headworks Facilities / Influent Chemical Facility	555 Perimeter Ft 18,166 Square Ft	1'	Concrete	Influent Pumps / Bar Screens / Grit Removal / Ferric/Polymer Chemicals / Associated Electrical MCC's & PLC's
5	Stormwater No. 4 Pump Station / Septage Receiving Station	289 Perimeter Ft 4,619 Square Ft	2'	Concrete	Plant Stormwater Station and Septage Receiving Station
6	Maintenance Shop / Offices / Laboratory	669 Perimeter Ft 17,401 Square Ft	.5'	Steel	Maintenance Shop / Offices / Laboratory for Water Analysis / Associated Electrical MCC's & PLC's
7	Administration Building	302 Perimeter Ft 5,588 Square Ft	.5'	Concrete	Offices / Operations Control Center / SCADA & City Network Servers
8	Old Sludge Building / Equalization Tanks 1,2,3,4 / Generator No. 1 Building / EMS MCC / Transformer K	703 Perimeter Ft 25,023 Square Ft	.5	Concrete	Pumps / Storage Tanks / Back - Up Utility Power Generator No. 1 / Associated Electrical MCC's & PLC's / EMS MCC / Transformer K Power Supply
9	Digester Gas Conditioning System (electrical panels)	190 Perimeter Ft 1,967 Square Ft	1'	Steel	Digester Gas Cleaning System / Associated Electrical MCC's
10	Digester 1,3 / Sludge Storage Tank / Digester Control Building / RTS Skid / Boiler No. 1 & 2 (electrical)	766 Perimeter Ft 36,498 Square Ft	.5'	Concrete	Anaerobic Digesters / Digester Thickening Equipment / Digester Mixing and Heating Equipment / Associated Electrical MCC's & PLC's
~~11~~	~~Employee Parking Lot – 12 Charging Stations~~	~~528 Perimeter Ft~~ ~~14,332 Square Ft~~	~~1~~	~~Concrete~~	~~Employee Parking Lot / Electrical Car Charging Stations~~
12	DAFT Building / Daft 1 & 2 / Stormwater 3 Pump Station (electrical Panel)	450 Perimeter Ft 10,512 Square Ft	.5'	Concrete	Waste Activated Sludge Thickening Equipment / Stormwater PS / Associated Electrical MCC's & PLC's

Zone 2

Building	Name/ID	Square Feet/Perimeter Feet	Elevation	Construction	Purpose/Function
1	Secondary Clarifiers No. 1 & 2 / RAS/WAS Facility No. 1	751 Perimeter Ft 31,614 Square Ft	(negative ft)	Concrete	Settling Tanks and Return and Waste pumps / Associated Electrical MCC's & PLC's
~~2~~	~~Mixed Liquor Channel / Flow Splitter No. 3~~	~~719 Perimeter Ft~~ ~~15,415 Square Ft~~	~~1~~	~~Concrete~~	~~Flow Conveyance & Diversion Structures~~
3	Final Effluent Pump Station	315 Perimeter Ft 5,381 Square Ft	.5	Concrete	Effluent Pump Station for SSF, SB, Burlingame, Millbrae & SFIA to SF Bay Outfall / Associated Electrical MCC's & PLC's
4	Sodium Bisulfite Dechlorination Facility	523 Perimeter Ft 10,875 Square Ft	.5	Concrete	Decholrination Facility for SSF, SB, Burlingame, Millbrae & SFIA to SF Bay Outfall / Pumps / Tanks / Associated Electrical MCC's & PLC's
5	Sodium Hypochlorite Disinfection Facility	261 Perimeter Ft 4,073 Square Ft	.5	Concrete	Disinfection Facility / Pumps / Tanks / Associated Electrical MCC's & PLC's
6	Secondary Clarifiers No. 3 & 4 / RAS/WAS Facility No. 2	885 Perimeter Ft 41,462 Square Ft	.5	Concrete	Settling Tanks and Return and Waste pumps / Associated Electrical MCC's & PLC's
7	Back - Up Utility Power Generator No. 2 / Transformer K-1 & K-3	269 Perimeter Ft 4,403 Square Ft	.5	Concrete	Back - Up Utility Power Generator No. 2 / Associated Electrical MCC's & PLC's / Transformer K-1 and K-3 Power Supply
8	Chlorine Contact Basins / 3Water Pumps / Near Shore Discharge Pipe / Stormwater No. 2 & 5 Pump Stations	800 Perimeter Ft 33,512 Square Ft	Get outfall elevation	Concrete	Disinfection Tanks / 3Water Pumps / Near Shore Discharge Pipe directly to Colma Creek / Storm Water PS's / Associated Electrical MCC's & PLC's
~~9~~	~~Effluent Storage Pond / Effluent Storage Pond Pumps, Associated Electrical MCC's~~	~~1,679 Perimeter Ft~~ ~~144,886 Square Ft~~	~~1~~	~~Liner/Concrete~~	~~Effluent Storage Pond / Effluent Storage Pond Pumps, Associated Electrical MCC's~~

Zone 3

Building	Name/ID	Square Feet/Perimeter Feet	Elevation	Construction	Purpose/Function
1	Transformer K-2	159 Perimeter Ft 1,428 Square Ft	.5	Steel	Power Supply to portion of facility.
2	12kV Plant Feed	160 Perimeter Ft 1,444 Square Ft	.5	Steel	12,000 Volts Power Supply from PG&E to K, K1, K2, K3 Transformers
3	Primary Clarifiers / Primary Sludge Facility / Stormwater Station No. 1	882 Perimeter Ft 48,363 Square Ft	Negative elevation	Concrete	Settling tanks for Sewage and Associate Pumps/ Associated Electrical MCC's & PLC's
4	Dewatering Facility	467 Perimeter Ft 13,259 Square Ft	.5	Concrete	Qty. 2 (2m) Belt Presses for Dewatering Digested Sludge from Digesters / Associated Electrical MCC's & PLC's
~~5~~	~~Vactor and Street Sweeping Pits and Plant Storage Area~~	~~700 Perimeter Ft~~ ~~30,522 Square Ft~~	~~1~~	~~Concrete~~	~~Vactor and Street Sweeping Dumping pits. Generator / pumps/ misc. Plant Storage~~
6	Aerations Basins No. 8 & 9 / Blower Building No. 2	645 Perimeter Ft 24,301 Square Ft	.5	Concrete	Aerobic Activated Sludge Treatment / Associated Blowers / Associated Electrical MCC's & PLC's
7	Digesters No 4 & 5 / Boiler No. 3	637 Perimeter Ft 22,792 Square Ft	.5	Concrete	Anaerobic Digesters / Digester Mixing and Heating Equipment / Associated Electrical MCC's & PLC's
~~8~~	~~Storage Land Finger~~	~~1,129 Perimeter Ft~~ ~~44,456 Square Ft~~	~~1~~	~~Dirt~~	~~Plant Storage for Misc. Equipment – No $ Value~~

The following tables summarizes the estimates of replacement costs for structures and contents at the WQCP, which were derived from the WQCP insurance estimates.

Table 4: Structure & Content Replacement Values

Zone 1

Building	Name/ID / Contents (Machinery, Equipment, Furniture, etc.)	Estimated Value Structure	Estimated Value Contents
1	Natural Gas / Potable Water Feed - High Pressure Natural Gas (PG&E) and Potable Water (CAL Water)	$100,000	$0
2	Aeration Basins 5,6,7 / Blower Building 1 / Cogeneration Building - Aerobic Activated Sludge Treatment / Associated Blowers / Cogen Engine / Associated Electrical MCC's & PLC's	$12,500,000	$5,000,000
3	MCC – B & 2 Transformers - Electrical Motor Control Center	$3,000,000	$1,000,000
4	Influent Pump Station / Headworks Facilities / Influent Chemical Facility - Influent Pumps / Bar Screens / Grit Removal / Ferric/Polymer Chemicals / Associated Electrical MCC's & PLC's	$6,100,000	$3,000,000
5	Stormwater No. 4 Pump Station / Septage Receiving Station - Plant Stormwater Station and Septage Receiving Station	$2,000,000	$1,000,000
6	Maintenance Shop / Offices / Laboratory - Maintenance Shop / Offices / Laboratory for Water Analysis / Associated Electrical MCC's & PLC's	$5,000,000	$1,500,000
7	Administration Building - Offices / Operations Control Center / SCADA & City Network Servers	$2,000,000	$500,000
8	Old Sludge Building / Equalization Tanks 1,2,3,4 / Generator No. 1 Building / EMS MCC / Transformer K - Pumps / Storage Tanks / Back - Up Utility Power Generator No. 1 / Associated Electrical MCC's & PLC's / EMS MCC / Transformer K Power Supply	$11,000,000	$6,000,000
9	Digester Gas Conditioning System - Digester Gas Cleaning System / Associated Electrical MCC's	$2,000,000	500,000
10	Anaerobic Digesters / Digester Thickening Equipment / Digester Mixing and Heating Equipment / Associated Electrical MCC's & PLC's	$14,000,000	$7,000,000
~~11~~	~~Employee Parking Lot – 12 Electrical Charging Stations~~	~~$0~~	~~$50,000~~
12	DAFT Building / Daft 1 & 2 / Stormwater 3 Pump Station - Waste Activated Sludge Thickening Equipment / Stormwater PS / Associated Electrical MCC's & PLC's	$3,000,000	$1,000,000

Zone 2

Building	Name/ID	Estimated Value Structure	Estimated Value Contents
1	Secondary Clarifiers No. 1 & 2 / RAS/WAS Facility No. 1 - Settling Tanks and Return and Waste pumps / Associated Electrical MCC's & PLC's	$6,000,000	$1,000,000
~~2~~	~~Mixed Liquor Channel / Flow Splitter No. 3 - Flow Conveyance & Diversion Structures~~	~~$2,000,000~~	~~$500,000~~
3	Final Effluent Pump Station - Effluent Pump Station for SSF, SB, Burlingame, Millbrae & SFIA to SF Bay Outfall / Associated Electrical MCC's & PLC's	$5,000,000	$1,000,000
4	Sodium Bisulfite Dechlorination Facility - Decholrination Facility for SSF, SB, Burlingame, Millbrae & SFIA to SF Bay Outfall / Pumps / Tanks / Associated Electrical MCC's & PLC's	$2,000,000	$500,000
5	Sodium Hypochlorite Disinfection Facility - Disinfection Facility / Pumps / Tanks / Associated Electrical MCC's & PLC's	$2,000,000	$500,000
6	Secondary Clarifiers No. 3 & 4 / RAS/WAS Facility No. 2 - Settling Tanks and Return and Waste pumps / Associated Electrical MCC's & PLC's	$7,000,000	$800,000
7	Back - Up Utility Power Generator No. 2 / Transformer K-1 & K-3 - Back - Up Utility Power Generator No. 2 / Associated Electrical MCC's & PLC's / Transformer K-1 and K-3 Power Supply	$4,000,000	$2,000,000
8	Chlorine Contact Basins / 3Water Pumps / Near Shore Discharge Pipe / Stormwater No. 2 & 5 Pump Stations - Disinfection Tanks / 3Water Pumps / Near Shore Discharge Pipe directly to Colma Creek / Storm Water PS's / Associated Electrical MCC's & PLC's	$6,000,000	$1,000,000
~~9~~	~~Effluent Storage Pond / Effluent Storage Pond Pumps - Associated Electrical MCC's~~	~~$2,500,000~~	~~$500,000~~

Zone 3

Building	Name/ID	Estimated Value Structure	Estimated Value Contents
1	Transformer K-2 - Power Supply to portion of facility.	$700,000	$50,000
2	12kV Plant Feed - 12,000 Volts Power Supply from PG&E to K, K1, K2, K3 Transformers	$3,000,000	$200,000
3	Primary Clarifiers / Primary Sludge Facility / Stormwater Station No. 1 - Settling tanks for Sewage and Associate Pumps/ Associated Electrical MCC's & PLC's	$9,000,000	$1,000,000
4	Dewatering Facility - Qty. 2 (2m) Belt Presses for Dewatering Digested Sludge from Digesters / Associated Electrical MCC's & PLC's	$4,500,000	$3,000,000
~~5~~	~~Vactor and Street Sweeping Pits and Plant Storage Area - Vactor and Street Sweeping Dumping pits. Generator / pumps/ misc. Plant Storage~~	~~$200,000~~	~~$150,000~~
6	Aerations Basins No. 8 & 9 / Blower Building No. 2 - Aerobic Activated Sludge Treatment / Associated Blowers / Associated Electrical MCC's & PLC's	$8,500,000	$4,000,000
7	Digesters No 4 & 5 / Boiler No. 3 - Anaerobic Digesters / Digester Mixing and Heating Equipment / Associated Electrical MCC's & PLC's	$7,500,000	$2,000,000
~~8~~	~~Storage Land Finger - Plant Storage for Misc. Equipment - No $ Value~~	~~$0~~	~~$0~~

The structure and content values shown on Table 4, as developed by WQCP representatives, represent depreciated replacement values. For structures and contents, estimates of depreciation were applied to the values shown on Table 5 based upon structure age and condition to derive depreciated structure replacement values. Depreciated structure replacement values are a function of the current replacement value of the structures their contents.

Table 5: Depreciation Percentages

CONDITION	Public	IND	COM
New	0	0	0
Excellent	2	3	3
Good	8	11	11
Fair	36	46	46
Poor	58	59	59

7.1.2 Household Cleanup Costs

From discussions with plant engineers, each pump station has several lateral connections that feed it, and the water is then pumped to the WQCP for treatment. If one or more pump stations were to fail, floodwaters (sewage) would leave debris, sediment, salts, and the danger of disease due to toxins throughout flooded structures.

Cleaning these structures is a necessary post-flood activity. Clean-up costs for the extraction of floodwaters, dry-out, and decontamination vary significantly, based upon various factors including depth of flooding. Based upon research and analysis conducted by both Sacramento and New Orleans Districts, a maximum value of $10 per square foot was assumed for such costs and was estimated to impact roughly 500 sq ft. However, if the pump stations were to remain online during a flooding event and the main WQCP were to go offline, sewage would still be pumped to the WQCP and discharged, untreated, into Colma Creek and the San Francisco Bay. For the purposes of this economic analysis, damages are only calculated for the scenario in which the Pump Stations fail in a flood event and clean-up is needed.

The H&H and Economic analysis determined that only Pump Station #4 was impacted by coastal flooding. Therefore, only lateral connections to Pump Station #4 were included in the analysis. It was estimated that a total of 30,170 connections were attributed to Pump Station #4 Damages were NOT computed if the pump stations remained online and the WQCP was offline. While the WQCP would incur fines if they released untreated sewage into the bay, this was not calculated as part of EAD.

7.1.3 Structure, Structure Contents (Public) and Clean-up Costs– Expected Annual Damages

Expected annual damages were computed by the HEC-FDA program based upon the engineering and economic inputs described in the previous sections. The expected annual damages, based off the Intermediate SLR Curve, (the curve was used as the basis of the TSP Selection), for the without project condition total approximately $1,959,857, which includes damages to structures, structure contents, and clean-up costs.

7.2 Expected Annual Damages

Figure 5 illustrates the conceptual analytical approach for USACE flood risk analyses. To find the damage for any given flood probability, first the discharge for a given annual exceedance probability event is given in the exceedance–probability-discharge panel (Panel 1). Next, the river channel stage associated with the discharge value is determined in the stage-discharge panel (Panel 2). When the stream banks are overtopped, water enters the floodplain, inundating properties and causing damages. By plotting the resulting stage-damage and exceedance probability-damage relationships developed in the iteration within a Monte Carlo simulation, the damage frequency curve is determined. Expected Annual Damages represent probability weighted average damages computed through by numerical integration of the damage-frequency curve. Expected annual damages represent the present value of flood damages that can be expected to occur in any given year, without prior knowledge of if any damaging flood event will occur. As a result, HEC- FDA simultaneously: (1) overestimates the flood damages that can be expected in many years, since many years will produce no damaging event; and (2) underestimates the flood damages that can be expected to result for many damaging flood events.

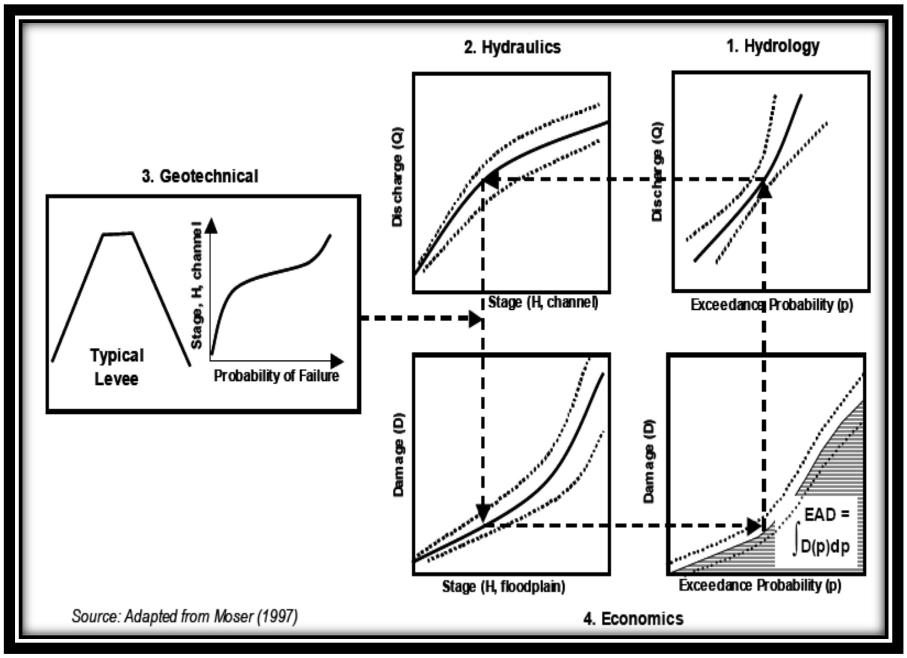

Figure 5: Determination of Expected Annual Damages

8 Considered Alternatives

During the planning charettes, 19 measures were identified for consideration in addressing the objectives of this study, which can be found in the main report. Both structural and non-structural measures were identified. Non-structural measures are permanent or contingent measures applied to a structure and/or its contents that prevent or provide resistance to damage from flooding. Non-structural measures differ from structural measures in that they focus on reducing the consequences of flooding instead of reducing the probability of flooding. Natural and nature-based features (NNBFs) were also considered for managing coastal flood risk. Finally, the team also brainstormed a recreation measure for improving recreation, as this is also an authorized purpose of the study. The Main Report discusses the alternatives and the rational of eliminating or carrying forward alternatives for final analysis

9 Evaluation of Final Array of Alternatives

This section evaluates the benefits and costs associated with the proposed flood risk management alternatives. Benefits associated each alternative are computed as the difference in expected annual damages between the with and without project conditions. The National Economic Development (NED) Plan is the plan which maximizes net benefits.

1) **No Action Plan**
2) **Alternative 1 – North Floodwall** plus ring floodwall at pump station 4, with flood warning system
3) **Alternative 2 – North and South Floodwall**s plus ring floodwall at pump station 4, with flood warning system

4) **Alternative 3 – Nonstructural only**. Floodproofing 23 buildings at the main WQCP and ring floodwall at pump station 4, with flood warning system, plus raising critical access in place and providing elevated emergency exits for plant operators.

9.1 Project Costs and Benefit to Cost Analysis and NED Plan

Project benefits and costs are expressed in average annual terms to facilitate comparison. In order for alternative costs to be compared to benefits, the proposed alternatives costs are amortized over the 50-year period of analysis using the current FY22 federal discount rate of 2.25%. Cost such as interest during construction, Real Estate Cost and Operation and Maintenance, Rehabilitation, Remediation and Repair (OMRR&R) costs were also added. Detailed and itemized costs for the alternative can be found in the Cost Engineering Appendix.

With benefit and cost calculations complete, two key economic indicators - the benefit cost ratio and net benefits - can be computed. These indicators measure the economic feasibility and efficiency of each alternative. For an alternative or increment thereof to be economically feasible, its benefits must exceed costs. The economically optimal plan is the one that maximizes net benefits – this plan is referred to as the NED Plan. Table 6 displays the project costs, benefits, net benefits and benefit/cost ratio of all analyzed alternatives.

Table 6: Average Annual Benefits and Costs for the Final Alternatives

With-Project Equivalent Annual Damages & Damages Reduced (April 2022 Price Level, Federal Discount Rate - 2.25%)				
	No Action	Alternative #1 (Intermediate SLR)	Alternative #2 (Intermediate SLR)	Alternative #3 (Intermediate SLR)
With-Project Avg Annual Flood Damage	$0	$248,794	$0	$15,184
Annual Damages Reduced	$0	$526,049	$774,843	$759,659
Project Costs				
Project Cost	$0	$7,463,000	$9,632,000	$149,125,000
PED	$0	$1,443,000	$1,820,000	$25,948,000
Construction Management	$0	$663,000	$837,000	$11,930
Real Estate Cost	$0	$1,411,000	$1,411,000	$0
Cultural Mitigation	$0	$150,000	$150,000	$0
Environmental Mitigation	$0	$650,000	$650,000	$0
Total Investment Costs	$0	$11,780,000	$14,500,000	$175,084,930
Average Annual Costs	$0	$394,846	$486,016	$5,868,560
Annual O&M Costs	$0	$67,000	$67,000	$0
Total Average Annual Costs	$0	$461,846	$553,016	$5,868,560
Results				
Annual Net Benefits	--	**$64,203**	**$221,826**	**-$5,108,901**
Benefit-to-Cost Ratio	--	**1.14**	**1.40**	**0.13**

As shown on the table above, both alternatives 1 and 2 are economically justified, with Alternative 2 having the highest net benefits. Alternative 2 is the NED Plan and therefore is selected as our Tentatively Selected Plan (TSP).

10 Update to TSP Post Agency Technical Review

Based on comments received from the Agency Technical Review, the following changes were made in the HEC-FDA model.

- Revised the water surface profiles in both the without and with-project condition (all SLR scenarios) and Alternative 1 and 3 (intermediate SLR scenario only) and Alternative 2 (all SLR scenarios). Originally HEC-FDA was configured find water depth at a certain structure within the study area by taking the water surface elevation at a particular structure and subtracting it by the elevation of that structure. That number was used to populate the water surface profiles in HEC-FDA. A switch was made to use elevations of the structures (in NAVD88) and use that elevation as the first-floor stage (1F_Stage) in HEC-FDA. Furthermore, the water surface elevations were converted to elevations (in NAVD88) for each SLR event instead of using depths.
- Uncertainty parameters were updated (or added) to depth damage curves for all damage categories (including redefining the Depth-Percent Damage functions for both structure and content values), adding uncertainty parameters to clean-up costs and reevaluating the Hydrology and Hydraulic inputs (under the probability exceedance function) in HEC-FDA
- Adjusted valuation of clean-up costs
- Updated to FY23 Federal discount rate of 2.5%

Tables 7 and 8 display the new results for the Average Annual Benefits and Costs for the Final Alternatives table and a new TSP Sensitivity to High/Low SLR table.

Table 7: Equivalent Annual Damages and Damages Reduced

Equivalent Annual Damages & Damages Reduced (April 2022 Price Level, FY 23 Federal Discount Rate - 2.5%)				
	No Action (Intermediate SLR)	Alternative #1 (Intermediate SLR)	Alternative #2 (Intermediate SLR)	Alternative #3 (Intermediate SLR)
Avg Annual Flood Damage	$1,959,857	$959,551	$0	Not analyzed as it is outside the CAP funding limit
Annual Damages Reduced	--	$1,000,306	$1,959,857	
Project Costs				
Project Cost	$0	$7,463,000	$10,214,000	$149,125,000
PED	$0	$1,443,000	$1,569,000	$25,948,000
Construction Management	$0	$663,000	$816,000	$11,930
IDC	$0	$7,686	$9,920	$153,581
Real Estate Cost	$0	$1,411,000	$1,411,000	$0
Cultural Mitigation	$0	$0	$0	$0
Environmental Mitigation	$0	$0	$0	$0
Total Investment Costs	$0	$10,987,686	$14,019,920	$175,238,511
Average Annual Costs	$0	$387,404	$494,315	$6,178,569
Annual O&M Costs	$0	$33,500	$67,000	$0
Total Average Annual Costs	$0	$420,904	$561,315	$6,178,569
Results				
Annual Net Benefits	--	$579,402	$1,398,542	-$6,178,569
Benefit-to-Cost Ratio	--	2.38	3.49	Below 1.0

Table 8: Sensitivity Analysis on the TSP

Equivalent Annual Damages & Damages Reduced (April 2022 Price Level, FY 23 Federal Discount Rate - 2.5%)				
Sensitivity Analysis on the Tentatively Selected Plan (TSP)				
	No Action (Low SLR)	Alternative #2 (Low SLR)	No Action (High SLR)	Alternative #2 (High SLR)
Avg. Annual Flood Damage	$1,270,512	$0	$12,706,880	$221,590
Annual Damages Reduced	--	$1,270,512	--	$12,485,289
Project Costs				
Project Cost	$0	$10,214,000	$0	$10,214,000
PED	$0	$1,569,000	$0	$1,569,000
Construction Management	$0	$816,000	$0	$816,000
IDC	$0	$9,920	$0	$9,920
Real Estate Cost	$0	$1,411,000	$0	$1,411,000
Cultural Mitigation	$0	$0	$0	$0
Environmental Mitigation	$0	$0	$0	$0
Total Investment Costs	$0	$14,019,920	$0	$14,019,920
Average Annual Costs	$0	$494,315	$0	$494,315
Annual O&M Costs	$0	$67,000	$0	$67,000
Total Average Annual Costs	$0	$561,315	$0	$561,315
Results				
Annual Net Benefits	--	$709,197	--	$11,923,974
Benefit-to-Cost Ratio	--	2.26	--	22.24

This new updated analysis demonstrates that Alternative 2 reduces all damages to the WQCP under the Low and Intermediate SLR curves and reduces the damage under the High SLR curve by greater than 95%. Although assumptions and uncertainty were either added or changed, this new analysis still confirms the prior analysis that Alternatives 1 and 2 are economically justified, with Alternative 2 identified as the TSP. Furthermore, the sensitivity analysis demonstrates that SLR has little effect on the TSP and would still be recommended as the plan to move forward into construction.

11 Comprehensive Benefits Plan

Alternative 2 is also the plan that meets the Comprehensive Benefits metric. The TSP plan meets all the criteria that make up the Comprehensive Benefits Plan. This analysis included:

- The "No Action" alternative
- A plan that maximizes net benefits across all benefit categories and is consistent with the study purpose described in Section 2 of this appendix (Alternative #2)
- A non-structural plan (Alternative #3)

- Evaluation of the Regional Economics and Other Social Effects (described in Section 14 of this appendix)

12 TSP Effect on Risk to Life Safety

Projected flood depths during coastal flood events at the WQCP and pump stations are shallow—roughly around 1.25 feet for a .01% annual exceedance probability event in 2073, using the USACE high SLR curve. Flood water velocities are not expected to significant enough to effect life safety. These factors indicate lower risk to life safety as the waters are relatively shallow and slow moving. However, life safety was still a key factor in evaluating the alternatives, and Alternative 2 reduces the risk to life safety because it eliminates the flood risk to the WQCP.

13 OSE, RED, and EQ Accounts

The NED account includes the estimate of economic damages from a flood event from a national perspective. The structure and content damages and clean up damages discussed previously are considered part of this account. However, the next three accounts will not be evaluated quantitatively as was done for the NED evaluation but will be evaluated qualitatively. These accounts are Regional Economic Development (RED), Other Social Effect (OSE) and Environmental Quality (EQ) impacts. The OSE account discusses the impact to several social well-being factors in the event of a flood. Some of these factors are health and safety, economic vitality, social connectedness, identity, social vulnerability and resilience, participation, and leisure and recreation. The RED account measures the impacts from flooding by the region and not the nation. Finally, the EQ account evaluates the impacts to the environmental quality of the impacted area. For all these accounts (OSE, RED, and EQ), an attempt is made to chronicle how these factors change during a flood event and how the change is reduced with the implementation of a project.

13.1 Other Social Effects (OSE)

The Other Social Effects (OSE) account displays plan effects on social aspects such as community impacts, health and safety, displacement, energy conservation and others. If the WQCP gets flooded a chain reaction of effects could occur. If a major flood occurs, the event will likely cause a disruption of service due to electrical failure of mechanical equipment at the plant rather than a broader power outage that impacts other facilities and homes. Once power goes down, the pumps in the influent will no longer move wastewater though the plant. For this study, the estimate of affected structures (or lateral connections) is approximately 60,300, however the number of affected lateral connections is closer to 30,000, since only a few of the Pump Stations are impacted from coastal flooding. If the flood is moderate to severe, individuals would need to relocate temporarily to a location with operable sewer services. In general, any significant flood event could be stressful and traumatic for residents impacted by the loss of service by the WQCP, and there could be impacts to health and human safety.

13.2 Regional Economic Development (RED)

The Regional Economic Development (RED) account displays changes in the distribution of regional economic activity (e.g., income and employment). This account is typically used to capture the regional impacts of a large capital infusion of project implementation dollars on income and employment throughout the study area through the use of income and employment multipliers. A large infrastructure project in the study area will have a positive impact on local income and employment.

13.3 Environmental Quality (EQ)

The Environmental Quality account displays non-monetary effects on ecological cultural and aesthetic resources including the positive and adverse effects of ecosystem restoration plans. The array of plans described in this appendix have flood risk management as their stated goals. EQ benefits or impacts are identified within the Environmental appendix to this report. However, water and wastewater treatment utilities are extremely important to people living in the areas they serve, but they are often at the highest risk of the effects of flooding. Flooding, as a sudden effect, is typically caused by storms and can cause these facilities (either intentionally or unintentionally) to release untreated water and sewage to the environment. Due to the weight of the floodwater, structural and electrical damage can cause wastewater within the system to become blocked and/or reverse flows. For example, during a flooding event the electrical systems of the WQCP are assumed to fail. Without electricity all processes requiring pumps would be shut down, including aeration and sludge pumping. This would cause an ultimate stoppage of flows and/or reverse the flow of wastewater due to pressure buildup. The reversal of wastewater flows would result in sewer system leakage, overflow near manholes and/or other access points along the line. The overflow from the manholes would then be captured by the stormwater system along the city transportation corridors before it reaches the river.

If untreated sewage is released into the environment during flooding, the most severe impact is usually to aquatic life. The negative effects of contaminated stormwater release on these environments are mainly due to the introduction of excess sediment and nutrients, and pollutants such as chemicals, heavy metals, and debris. These can degrade aquatic habitats, lower water quality, reduce overall natural biological production, and contaminate food resources for humans. Chemicals commonly associated with transportation to some degree include oils, solvents, fuels, heavy metals, and copper. Debris, sediments, and trash which carry additional pollutants can also be accumulated. Contaminants can often result in the death of many aquatic species or reduce an organism's life span and its ability to reproduce. Furthermore, these chemical contaminants can bio-accumulate in the food chain making the fish unfit for human consumption.

The sewage back up may impact homes or low-lying areas and become a breeding ground for bacteria such as *E. coli*. This contamination would likely discharge into the City's separate stormwater system being captured by storm drains, eventually indirectly impacting San Francisco Bay. This is in addition to potential untreated and unscheduled sewage releases from the WQCP itself. In some cases, these waterways may be utilized as a source of recreation and fishing. Contamination of water sources can cause diseases to spread, such as diarrhea and hepatitis A.

14 Performance Metrics and Summary

ER 1105-2-101, Risk Assessment for Flood Risk Management Studies, provides the requirement to describe project performance by annual exceedance probability (AEP), assurance (conditional non-exceedance probability), and long-term exceedance probability (LTEP). Project performance describing these attributes is computed within HEC-FDA and is based on a target stage. The performance for the TSP is shown in Table. 9

Table 9: Performance Metrics for the Study

Stream Name	Stream Description	Damage Reach Name	Damage Reach Description	Target Stage	Target Stage Annual Exceedance Probability		Long-Term Risk (years)			Conditional Non-Exceedance Probability by Events					
					Median	Expected	10	30	50	10%	4%	2%	1%	.4%	.2%
LC Creek	Lower Colma Cr	Reach 1	Entire study area	9.35	0.0001	0.0010	0.0104	0.0308	0.0508	0.9998	0.9998	0.9998	0.9997	0.9975	0.9950

The WQCP is a complex system of pump stations and treatment facilities that services much of South San Francisco and adjacent communities. It is a vital and essential component of infrastructure that is important to the community from a health and safety standpoint. It acts as a basic and important service to the local communities it serves. Based on the economic analysis, Alternative #2 serves as the NED plan because it maximizes net benefits and has the greatest positive impacts on social, environmental, and economic categories.