EFWS Seawater Supply

Pre-Feasibility Study

San Francisco Public Utilities Commission

Project number: 60641951

4 June 2021

Quality information

Prepared by	Checked by	Approved by
J. Orlins, PE, PhD, PMP	C. Smith, PE	J. Orlins, PE, PhD, PMP

Revision History

Revision	Revision date	Details	Name	Position
0	4 December 20	Initial DRAFT	J. Orlins	Task Lead
1	16 December 20	Incorporated preliminary feedback	J. Orlins	Task Lead
2	24 April 21	Incorporated additional feedback, added Appendix H with comments & resolution of comments	J. Orlins	Task Lead
3	4 June 21	Final; removed Appendix H	J. Orlins	Task Lead

Prepared for:

San Francisco Public Utilities Commission

Prepared by:

AECOM
1111 Third Avenue
Suite 1600
Seattle, WA 98101
aecom.com

Table of Contents

Appendices

Figures

Tables

Acronyms and Abbreviations

AWSS	Auxiliary Water Supply System
BAAQMD	Bay Area Air Quality Management Districts
BART	Bay Area Rapid Transit
BCDC	Bay Conservation and Development Commission
bgs	below ground surface
CalAm	California American Water Company
Caltrans	California Department of Transportation
CCC	California Coastal Commission
CCSF	City and County of San Francisco
CDD	City Distribution Division
CDFW	California Department of Fish and Wildlife
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
CS-199	AWSS Engineering Services Contract CS-199
CSLC	California State Lands Commission
CWA	Clean Water Act
DFPS	dedicated fire protection system
DIP	ductile iron pipe
EA	environmental assessment
EFH	essential fish habitat
EFWS	emergency firefighting water system
EIR	environmental impact report
EIS	environmental impact statement
EQ	earthquake
ESA	Endangered Species Act
ESCP	erosion sediment control plan
ESER	earthquake safety and emergency response
FEMA	Federal Emergency Management Agency
ft.	Feet or foot
FIRM	flood insurance rate maps
fps	feet per second
FRA	fire response area
GGNRA	Golden Gate National Recreation Area
gpm	gallons per minute
HDPE	high-density polyethylene
ID	inside diameter

in.	inches or inch
LCP	Local Coastal Program
MG	Million gallons
MPWSP	Monterey Peninsula Water Supply Project
MW	megawatt
MWSS	municipal water supply system
N/A	not applicable
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act of 1966
NMFS	National Marine Fisheries Service
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
PEFWS	potable emergency firefighting water system
psi	pounds per square inch
PWSS	potable water supply system
RWQCB	Regional Water Quality Control Board
SF	San Francisco
SFFD	San Francisco Fire Department
SFPUC	San Francisco Public Utilities Commission
SHPO	State Historic Preservation Officer
SSMP	sewer system management plan
SWPPP	storm water pollution prevention plan
SWPS	seawater pump station
SWRCB	State Water Resources Control Board
TBD	to be determined
USACE	US Army Corps of Engineers
USCG	US Coast Guard
USFWS	US Fish and Wildlife Service
USGS	United States Geological Survey
WDR	waste discharge requirement
WSP	Welded steel pipe

Executive Summary

The San Francisco Public Utilities Commission (SFPUC) is actively improving and planning expansions to its existing infrastructure for the Emergency Firefighting Water System (EFWS). At present, the existing EFWS does not provide coverage over the entire city of San Francisco. SFPUC is evaluating several measures to expand the system to enhance firefighting capabilities in areas of the city that are not served by the present EFWS and to improve overall supply reliability.

The primary purpose of this pre-feasibility study is to identify the factors that will need to be considered for development of additional seawater supply sources for the EFWS. The goal of the study is not to develop recommendations for siting one or more new seawater pump stations or answer all the questions regarding feasibility; the goal is to document items that will need to be considered in future evaluations. The scope of the study includes regulatory and engineering aspects, as well as rough estimates of costs for different types of potential seawater pumping stations (SWPS) to aid in further planning.

Flow Requirements Evaluated

It is anticipated that regional water mains will be avaliable within 24 hours of a major seismic event, but local supply sources will be required in the immediate aftermath. Although the existing, currently planned and potential supplemental supply sources for the City can meet post-earthquake fire demands, water storage within the city will be severely impacted. For example, under some modeled scenarios, the Twin Peaks Reservoir (currently the primary EFWS storage facility) may not be able to supply flow beyond 6 hours. Within three days, most of the potable reservoirs may reach a low level where they are no longer available for fire fighting. Only Lake Merced, with its nearly 2 billion gallons of capacity, can maintain a significant storage over the 5-day period.

Cisterns and fireboats will likely be required in the initial hours after an earthquake. Secondary water sources can meet not only firefighting demands, but also reduce the impact on the potable reservoirs. Supplemental sources include other potable reservoirs such as Merced Manor, Stanford Heights, and College Hill Reservoirs as well as nonpotable sources such as Lake Merced or new seawater intake supplies.

Based upon currently projected demands, the maximum amount of supply deficit is approximately 40,000 gallons per minute (gpm). For the purposes of this pre-feasibility study, new seawater intake supplies with flows from 3,000 gpm to 50,000 gpm are considered.

Regulatory Considerations

Primary shoreline regulatory agencies (those typically having a final say in the overall approval process) vary depending on the location of off-shore and near-shore intake structures, pipelines, and other infrastructure.

The California Coastal Commission (CCC) and National Park Service (NPS) will be the primary shoreline regulatory agencies on the ocean side of the city west of the Golden Gate Bridge. On the bay side, the Bay Conservation and Development Commission (BCDC) is the primary shoreline decision making body.

Other regulatory jurisdictions or entities include the California State Lands Commission (CSLC), State Water Resources Control Board (SWRCB), Regional Water Quality Control Board (RWQCB), US Army Corps of Engineers (USACE), National Marine Fisheries Service (NMFS), the California Department of Fish and Wildlife (CDFW), US Coast Guard (USCG), Port of San Francisco and the Presidio Trust.

The potential challenge or degree of difficulty in obtaining permits from the primary shoreline regulatory agencies is generally moderate to high. The CCC and SWRCB are likely to have the most stringent requirements; BCDC is expected to have a less onerous and more streamlined review and approval process in comparison.

One of the greatest permitting challenges for implementing additional seawater sources to the EFWS will be approval of a new seawater withdrawal from either the Pacific Ocean or San Francisco Bay. The California Ocean Plan requires subsurface seawater intakes (assuming they are feasible), rather than open water intakes. If subsurface intakes are not feasible, open water intakes must be screened to reduce entrainment of marine life. This typically requires screens with openings less than 1.0 mm, to prevent entrainment of small aquatic organisms. To minimize impingement of marine life on open water intake screens, the through-screen velocity must generally be less than 0.5 feet per second. Similar (though perhaps slightly less stringent) open water intake criteria exist for waters on the bay side of the City under the BCDC Bay Plan, in which subsurface intake systems in silty muds are deemed infeasible. With any screening system for open water intakes, consideration must be made for screen cleaning and inhibition of growth of marine organisms.

It should be noted that the existing Pump Stations 1 and 2, fireboats, and suction connections for the EFWS do not meet these current requirements. Since the use of seawater intakes to supplement the EFWS will not be a regular, ongoing withdrawal of seawater from either the ocean or the bay, the regulatory agencies may be amenable to relaxation of their normal requirements.

Regions of City Considered for Seawater Intakes

Based upon the geogrpahy of San Francisco and the division of primary regulatory jurisdicitons, evaluation of potential seawater intakes for expansion of the EFWS was considered in five sub-regions of the City. These shoreline subregions include the Southern Dunes, Rocky Area South, Rocky Area North, North Bayfront, and East Bayfront.

Engineering Factors Considered

For each of the five sub-regions, the distance from the shoreline to the closest tie-in point of the existing EFWS and the elevation differences between these locations were used to determine required pipeline lengths, diameters and pump discharge pressures for flows ranging from 3,000 gpm to 50,000 gpm. For the present study, seawater intakes for these areas were considered for supplementing the existing EFWS, and not connecting to the Potable EFWS (PEFWS) on the west side of the city.

The sizes of piping to connect new seawater intakes to the existing EFWS for flows in this range (20 to 50 inches) are generally larger than the pipes in the existing EFWS at the closest connection points (typically 12 to 20 inches), especially at the western extents of the existing EFWS. This may cause issues with providing additional flows at suitable pressures to an expanded system, and may require “up-sizing” (increasing the diameter) of existing EFWS piping in certain areas or making tee connections to the existing piping (to provide two discharge paths). That level of analysis is beyond the scope of this pre-feasibility study.

Both open water intakes and slant wells (a type of subsurface intake) were included in this pre-feasibility study. In general, either type of intake is viable from an engineering perspective (though perhaps not a permitting one) in the three subregions on the ocean side of the City. Due to the sediment formations and geology of San Francisco Bay, an open water intake is considered the only viable intake type for the two subregions on the bay side of City.

The number of pumps required to supply seawater to the EFWS is a function of the overall flows required and type of intake. For a flow of 20,000 gpm, three conventional pumps rated at 10,000 gpm each (2 duty, 1 standby), fed by an open water intake would be suitable. For the same flow, 8 submersible pumps mounted in slant wells rated at 3,000 gpm each (7 duty, 1 standby) would likely be required. For smaller or larger flows, the number and capacity of pumps changes accordingly.

Costs

Order-of-magnitude cost estimates for new intake seawater supplies for each of the five subregions were developed for pump station flows ranging from 3,000 to 50,000 gpm. Initial design, permitting, and construction costs are generally lowest for pump stations fed by open water intakes on the bay side of the City, and greatest for open water intakes on the ocean side of the city. Initial costs for slant well intakes on the ocean side are generally in the middle range.

For a total flow of 3,000 gpm (representing a small pump station), the present value initial cost for an open water intake would cost approximately $25M on the bay side; a slant well intake would cost approximately $40M on the ocean side; and an open water intake on the ocean side would cost approximately $68M. For a total flow of 40,000 gpm (representing a large pump station), the present value initial cost for an open water intake would cost approximately $93M on the bay side; a slant well intake would cost approximately $145M on the ocean side; and an open water intake on the ocean side would cost over $180M.

When lifecycle costs are considered (assuming a 15-year replacement cycle for major components), open water intakes on the bay side will still be the least expensive; costs for either slant wells or open water intakes on the ocean side are on average at least twice that of an open water intake on the bay. For a total flow of 3,000 gpm, lifecycle cost (including initial costs, annual operations & maintenance, and periodic renewal) for an open water intake on the bay side would cost approximately $36M; a slant well intake would cost approximately $55M on the ocean side; and an open water intake on the ocean side would cost approximately $78M. For a total flow of 40,000 gpm, lifecycle costs for an open water intake on the bay side would cost approximately $116M; a slant well intake would cost approximately $286M on the ocean side; and an open water intake on the ocean side would cost at least $200M.

Next Steps

Advancing the concept of additional seawater intake supplies to the City's EFWS will require further engineering and analysis, including assessment of flow requirements, refinement of engineering aspects, environmental / permitting requirements, and operational & maintenance considerations.

SFPUC is currently conducting a long-range planning study for the EFWS, taking into consideration currently planned and potential future modifications to the overall EFWS system. That study will provide further definition of the required supplemental flows, both in terms of quantity and geographic region where flows are required.

From a regulatory and permitting perspective, it will be important to identify the relevant lead agencies early once a preferred course of action has been identified. Understanding and early coordination of environmental compliance and permit acquisition efforts will ease the overall compliance process.

Chapter 1: Introduction

The San Francisco Public Utilities Commission (SFPUC) is actively improving and planning expansions to its existing infrastructure for the Emergency Firefighting Water System (EFWS). The existing EFWS does not provide coverage over the entire city of San Francisco (SF). SFPUC is evaluating several measures to expand the system to enhance firefighting capabilities in areas of the city that are not served by the present EFWS and to improve supply reliability.

1.1 Background

The EFWS provides water solely for fire suppression; it is a high-pressure, earthquake-resilient system that is separate from the regular Municipal Water Supply System (MWSS). The EFWS is used by the San Francisco Fire Department (SFFD) to protect against the loss of life and property from fire following an earthquake and is also used to suppress non-earthquake multiple-alarm fires.

The EFWS is currently supplied with water from multiple sources including existing water supply tanks and reservoirs and two seawater pump stations located on the northeast side of the city. Additional water for firefighting can be provided by three fireboats (which can pump water from San Francisco Bay into the EFWS system), 52 suction manifolds along the waterfront, and water storage cisterns located in various parts of the City.

In 2019, the City and County of San Francisco Civil Grand Jury issued a report on the City's firefighting system[1], which made several recommendations regarding improvements to the EFWS system. Specifically, recommendation No. 6 of the report states:

> *R6. The SFPUC, the SFFD and the SF Department of the Environment should study adding salt-water pump stations to improve the redundancy of water sources, especially on the west side. Findings and recommendations from this study should be presented to the Board of Supervisors by no later than June 30, 2021.*

1.2 Purpose and Scope

The purpose of this study is to identify the factors that will need to be considered for development of additional seawater supply sources for the EFWS. The goal of the study is not to develop recommendations for siting one or more new seawater pump stations or answer all the questions regarding feasibility; the goal is to document items that will need to be considered in future evaluations. The scope of the study includes regulatory and engineering aspects, as well as estimation of order-of-magnitude costs for various seawater intake concepts.

1.3 Organization of Report

This pre-feasibility study is divided into 10 main chapters:

- Chapters 1 and 2 provide an introduction and background of the existing EFWS and currently planned improvements.

[1] City and County of San Francisco 2018-2019 Civil Grand Jury, 2019. *Act Now Before It is Too Late: Aggressively Expand and Enhance our High-Pressure Emergency Firefighting Water System.*

- Chapter 3 summarizes the existing water supply sources and the potential flow requirements from new sources.
- Chapter 4 provides an overview and details of the regulatory aspects related to development of new seawater supplies for the EFWS, including the environmental permitting process and relevant regulatory jurisdictions and requirements.
- Chapter 5 discusses potential locations for new seawater pumping facilities for expansion of the EFWS.
- Chapter 6 documents the engineering aspects, geologic, geotechnical, and coastal hazards that must be considered for pumping stations located on either the Pacific Ocean and San Francisco Bay sides of the City, along with operations and maintenance and security considerations.
- Chapter 7 describes the different types of seawater intakes that could be used to provide seawater for expansion of the EFWS.
- Chapter 8 discusses the need for coordination and integration with other development and redevelopment activities within the city.
- Chapter 9 provides an estimate of construction and operations costs for the types of pumping systems envisioned.
- Finally, Chapter 10 summarizes the items that will need to be addressed in the next stages of project development.

Chapter 2: Background Information

This chapter provides background information regarding existing and prospective EFWS facilities, key prior studies, other potential infrastructure that could potentially support an expanded EFWS and summarizes similar infrastructure established by other municipalities globally.

2.1 EFWS Facilities

The EFWS presently consists of the following components:

- Auxiliary water supply system (AWSS): A high-pressure standalone fire protection water supply system which was constructed following the fires and devastation of the 1906 San Francisco earthquake.
- Cisterns: Below-grade water storage tanks for water supply for fire suppression
- Storage reservoirs and tanks consisting of Twin Peaks Reservoir, Ashbury Tank, and Jones Street Tank
- Portable water supply system (PWSS): 5-inch portable hose units which extend the range of SFFD assets
- Two seawater pump stations: Draw water from the bay and inject it at high pressure into the EFWS (AWSS)
- Suction connections: Waterfront bay suction points for bay water supply for fire suppression
- Fireboat manifolds: Points of connection for bay water supply for fire suppression from fireboats
- Fulton Street emergency hydrants: Low pressure emergency hydrants using Stow Lake in Golden Gate Park as source of water

Figure 2-1 shows the components of the EFWS, apart from the PWSS.

The City Distribution Division (CDD) of SFPUC is responsible for the operation and maintenance of the EFWS. During firefighting events, CDD coordinates with the San Francisco Fire Department (SFFD) to enable the proper operation of the system to respond to the dynamic needs of the fire.

The Earthquake Safety and Emergency Response (ESER) bonds approved by voters in 2010, 2014 and 2020 provided SFPUC with funds to plan, design, and construct projects to expand and enhance the reliability of the EFWS in San Francisco. Figure 2-1 also shows the improvements completed or funded through the 2010 and 2014 ESER Bonds.

The two existing seawater pump stations (PS1 and PS2) can each provide up to approximately 10,800 gpm of seawater from San Francisco Bay to the high-pressure EFWS at 300 psi. Because they convey seawater, which is corrosive to metallic piping such as that used in the EFWS, these pump stations are intended for use only after a major seismic event when additional water for fire suppression is expected to be needed.

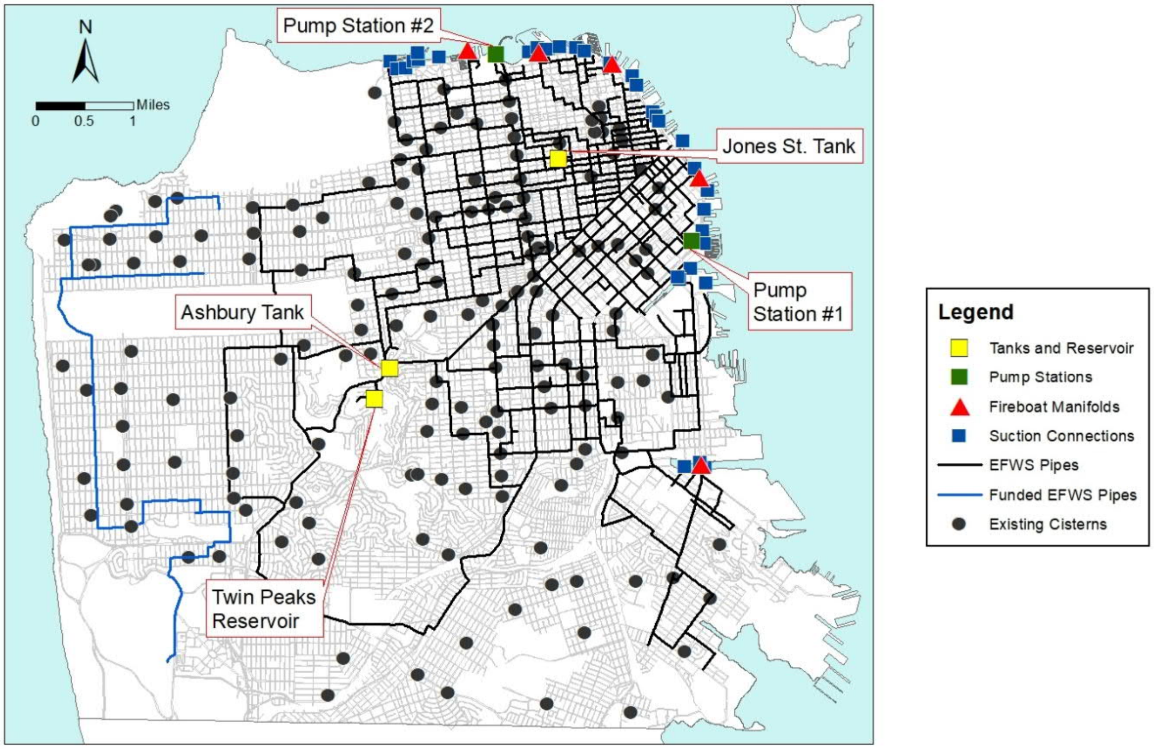


Figure 2-1: EFWS Systems

2.2 PEFWS System

The proposed potable emergency firefighting water system (PEFWS) would supply water by pipeline to the Sunset and Richmond Districts of the city, fed from Lake Merced.

The PEFWS Pipeline Alternatives Analysis Report (AECOM, 2020b) identified the need for new pump stations at Lake Merced and the Sunset Reservoir in order to achieve adequate pressure along the proposed PEFWS pipeline for emergency firefighting, and an acceptable level of system pumping redundancy in case either pump station is out of service. The recommended alternative would provide 30,000 gallons per minute (gpm) of supply with a minimum pressure of 150 pounds per square inch (psi) at all fire hydrants to deliver water to the eight included fire response areas (FRAs).

The PEFWS Pipeline Conceptual Engineering Report (AECOM, 2020c) further refines the PEFWS work performed to date and includes a more detailed assessment of the items related to the pipeline, such as hydrants, valves, and appurtenances.

The Lake Merced Pump Station is currently being planned and designed by the SFPUC and will supply the PEFWS during emergencies from Lake Merced Reservoir in addition to regional potable transmission mains. The Sunset Reservoir Pump Station will be planned and designed in the future and is expected to be constructed when funded. It will provide potable water from Sunset Reservoir and connections from regional potable transmission mains.

Other water supply sources to the PEFWS will be considered separately. The PEFWS Sunset Pump Station Summary Technical Memorandum (AECOM, 2019) contains a compilation of the materials/presentations used to develop the preliminary selection of the pump station site, the development of various mechanical pump alternatives (*e.g.* vertical turbine pumps, horizontal split case pumps), potential building and site concepts, potential connections to Sunset Reservoir and other existing water sources, and a planning-level estimate of probable costs.

The PEFWS will include approximately 47,500 feet of 24-inch earthquake-resistant ductile iron pipe, approximately 15,800 feet of 36-inch welded steel pipe, and approximately 9,500 feet of 42-inch welded steel pipe. The planned facilities associated with PEFWS are shown in Figure 2-2.

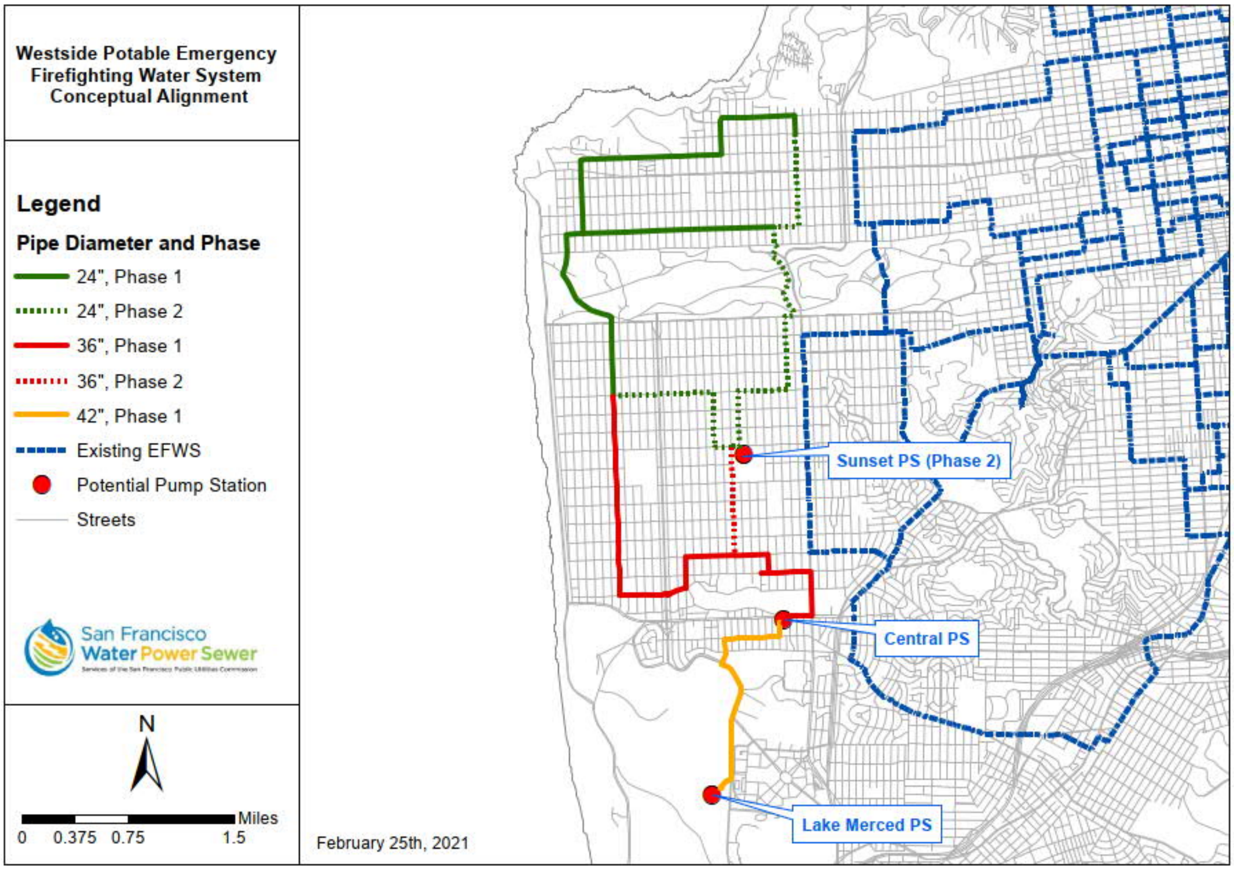


Figure 2-2: Map of PEFWS

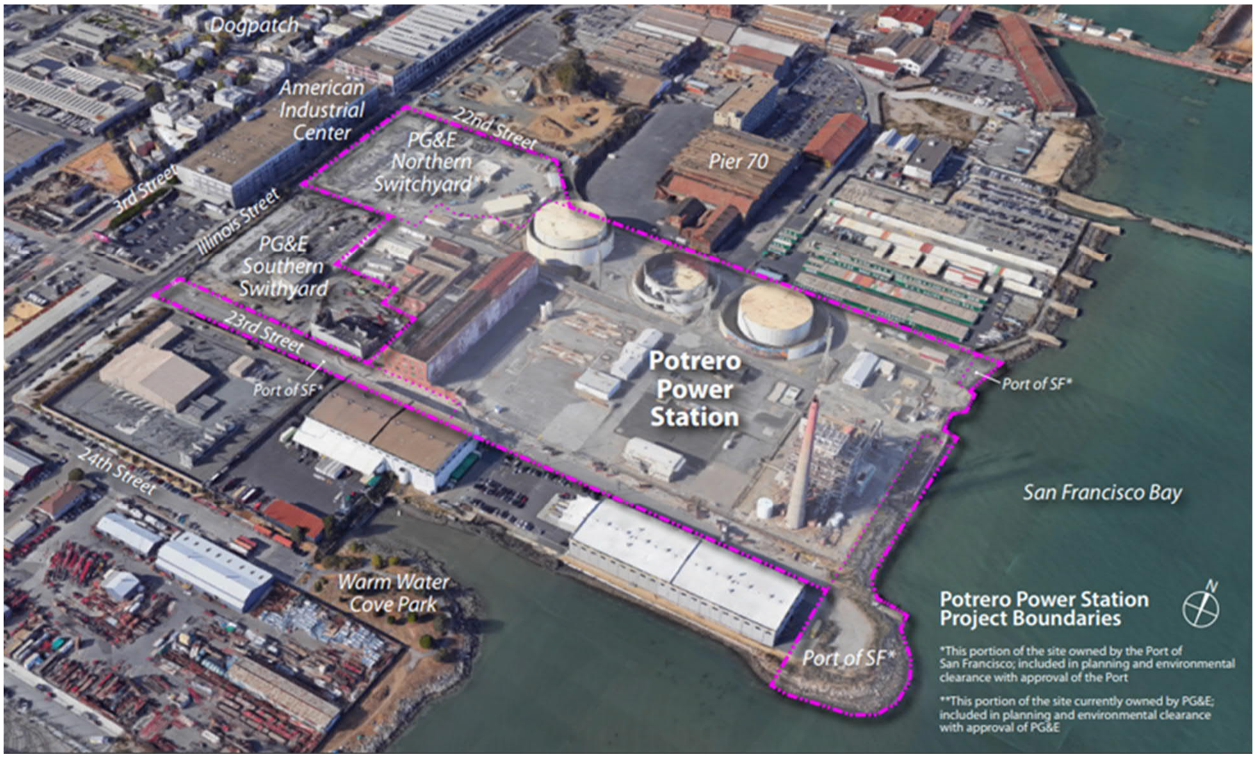
2.3 Other Potential Infrastructure

In addition to development of new land-based facilities, it may be possible to adapt or repurpose existing seawater intake infrastructure or use other pump station technologies to support the EFWS.

2.3.1 Repurposing of Retired Potrero Power Station Intake

The Potrero Power Station is a 28+ acre site located in the Central Waterfront District east of the Dogpatch and American Industrial Center and directly fronting San Francisco Bay. For over 150 years (before being decommissioned as a power plant in 2011 by then-owner Mirant Potrero LLC), the site was host to a range of industrial uses from barrel-making and sugar refining to power generation. The site was purchased by Associate Capital/California Barrel Company in 2016, and in 2017 Associate Capital began an extensive planning process to redevelop the property.

In 2020, the City's Planning Commission and Board of Supervisors approved the Development Agreement for Associate Capital to redevelop the area. The proposed project will be a majority residential, mixed-use, and mixed-income neighborhood. It will provide up to approximately 2,600 new housing units, 1.8 million square feet of commercial/retail/hotel space, 7 acres of open space, and off-street parking for approximately 2,700 vehicles. The site is shown in Figure 2-3.



Source: https://sfgov.org/sfplanningarchive/potrero-power-station)

Figure 2-3: Potrero Power Station

The decommissioned power station used a surface water intake structure to draw in a maximum of approximately 226 MGD (157,000 gpm) of seawater from the Bay to cool the condensers in the power generation process. The intake is located near the northeast corner of the site, approximately 250 feet north of the existing outfall structure, which was used to discharge spent cooling water back to the Bay.

Under the new redevelopment plan, a stormwater outfall for discharging runoff from the project site would be installed in the vicinity of the existing intake structure. The current condition of the intake structure, screens, and tunnel are unknown, but as they are original to the plant (mid-1960s), it is assumed that they would need rehabilitation and improvement in order to be to be repurposed for a new seawater pump station in this area.

2.3.2 Floating Pump Stations

In lieu of constructing a fixed, land-based seawater pump station, another possible option is to construct a floating or barge-mounted pump station. Such a pump station would have the capability and added benefit to be relocated to specific locations along a shoreline to areas of the greatest need. Due to the calmer, more protected waters of San Francisco Bay, this type of pump station would be better suited for the eastern side of the city, rather than the Pacific Ocean coastline.

This technology has been around for many decades and is used worldwide in numerous applications and industries. Floating pump stations can be as simple as exposed vertical turbine pumps mounted on a platform floating on pontoons, to a large, fully enclosed facility floating on a barge with separate rooms for the pump equipment, electrical equipment, storage, and even conference rooms or offices, if desired. Pump station capacities can be scaled to cover the range of intake rates under consideration. Photographs of typical floating pump stations are shown in Figure 2-4.

A floating pump station could be self-contained, with diesel- or electric-driven pumps in a single facility. Such an installation could minimize siltation issues such as those experienced it the intakes of the existing Pump Station 1 and Pump Station 2.

Source: CHAMCO *Source: HMS Group*

Figure 2-4: Examples of Floating Pump Stations

To support floating pump stations, permanent walkways extending out from the shoreline with discharge piping mounted underneath would need to be installed at the various selected "docking" locations for the pump station. The discharge piping exiting the pump station would be connected to this permanent discharge piping with flexible connectors to pump seawater into the existing EFWS network in the area.

Another option is to design a discharge system that can connect directly to the existing fireboat manifolds strategically situated along the bay shoreline. These manifolds allow seawater to be pumped into the existing EFWS network to charge the system and are used by the fireboats for this purpose. There are five such manifolds, the locations of which are shown in Figure 2-1. A photograph of one of these existing manifolds is shown in Figure 2-5. Facilities would also need to be provided to anchor the pump station from horizontal movement while moored at its various locations.

Figure 2-5: Typical Fireboat Manifold Inlet

2.3.3 Other Infrastructure and Concepts

There are several other potential water sources to supplement the existing EFWS, as described briefly below. These concepts have not been included in the scope of this pre-feasibility study.

2.3.3.1 Upgrading Existing Seawater Pump Stations

It may be possible to upgrade or retrofit the existing PS1 and PS2 to provide additional capacity to supplement the EFWS. This concept has been previously explored for PS2 (AECOM/AGS, 2013c). For the present study, it is assumed that the existing PS1 and PS2 will remain in their current configurations, and supplemental flows to the EFWS will be provided by new pump stations.

2.3.3.2 Reverse Use of Existing Wastewater Treatment Outfalls

San Francisco has several existing wastewater outfall pipelines, which discharge treated wastewater effluent to either San Francisco Bay or the Pacific Ocean. It may be possible to use these existing outfalls in a “reverse mode” on an emergency basis as intakes to provide seawater to the EFWS. There are numerous technical and regulatory issues associated with this concept; these issues are beyond the scope of the current study.

2.3.3.3 Pumping Seawater to Lake Merced

In lieu of seawater pump stations providing flow directly into the existing EFWS, a seawater pump station could provide supplemental flow to Lake Merced, which would then feed the PEFWS. This concept poses many challenges; the introduction of seawater to Lake Merced would impact both water quality in the lake as well as introduction of seawater into the potable PEFWS system.

2.4 Similar Systems in Other Geographies

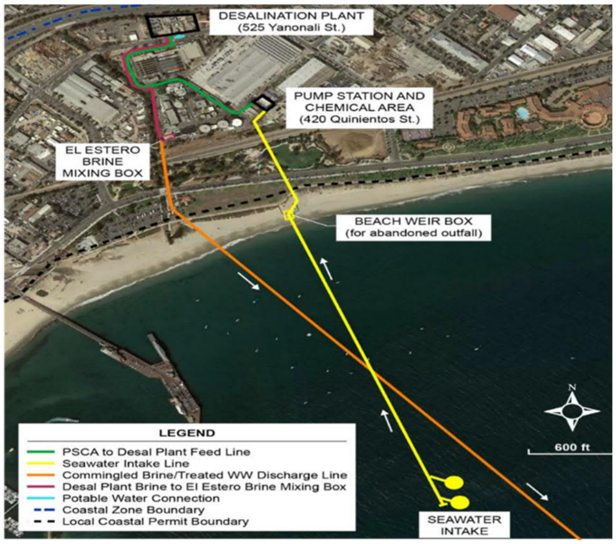
In California, several recent and proposed projects incorporate seawater intakes for desalination plants. Other major municipalities around the world have seawater intake systems for various purposes ranging from firefighting (like the EFWS) to toilet flushing. Key organizations with existing or proposed seawater-supplied systems are described below.

2.4.1 Carlsbad Desalination Plant, Carlsbad, CA

The Claude “Bud” Lewis Carlsbad Desalination Plant is the largest seawater desalination plant in the United States and has been in operation since 2015. Located in San Diego County adjacent to the Encina Power Station, the plant delivers nearly 50 million gallons per day (approximately 35,000 gpm) of desalinated water to San Diego County. Owned and operated by Poseidon Water, the plant currently uses the existing seawater intake for the Encina Power Station, which draws once-through cooling water from Agua Hedionda Lagoon via an open water intake. Intake water is screened, used for cooling processes at the Encina Power Station, and a portion of the heated return water is directed to the desalination plant. Poseidon is currently designing and permitting a new state-of-the-art intake system to be constructed when the Encina Power Station is fully decommissioned and demolished.

2.4.2 City of Santa Barbara, CA

The City of Santa Barbara, California has an operating desalination plant with an open water intake. The City’s Charles E. Meyer Desalination Plant draws in approximately 16,000 gpm of seawater and produces 3 million gallons of drinking water per day through reverse osmosis. The intake is not truly “open” to the ocean but has screens with an opening size of one millimeter to prevent entrainment or impingement of marine life, as required by the California Ocean Plan.



(a) Seawater Intake Pipeline

(b) Seawater Intake Screen

https://www.waterboards.ca.gov/santaana//water_issues/programs/Wastewater/Poseidon/2019/Santa_Barbara_Tour_of_Charles_E_Meyer_Desal_Project_Presentation_to_Santa_Ana_Regional_Board.pdf

Figure 2-6: City of Santa Barbara Desalination Plant Intake and Screen

2.4.3 Monterey County, CA

California American Water Company (CalAm) is in the development process of the Monterey Peninsula Water Supply Project (MPWSP) to augment existing drinking water supplies. The MPWSP will include seawater desalination, along with aquifer storage and recovery and groundwater replenishment through wastewater reclamation. The currently proposed desalination component of the overall program will consist of seven subsurface slant intake wells (five active and two standby), a desalination plant, and related facilities.

A pilot slant well was installed and operated between April 2015 and December 2017 to verify viability of the intake concept and collect geologic and hydrologic data. The facilities included the test slant well, a submersible 2,500 gpm, 300 hp submersible well pump, a wellhead vault, electrical facilities and controls, temporary flow measurement and sampling equipment, monitoring wells, and a temporary pipeline connection to the adjacent MRWPCA ocean outfall pipeline for discharges of the test water. The test slant well was drilled at 19 degrees below horizontal, was 685 feet long, and screened for 450 linear feet.

The test well was operated successfully for over two years. CalAm is currently in the environmental review and permitting process with the California Coastal Commission.

2.4.4 South Coast Water District, Long Beach, CA

The South Coast Water District has proposed an ocean desalination project in southern Orange County, California. If developed, the Doheny Ocean Desalination plant would draw water from the Pacific Ocean at Doheny State Beach via slant wells angled under the seafloor, as shown schematically in Figure 2-7. Raw seawater would then be treated at a new reverse osmosis (RO) treatment plant. The use of slant wells was selected (rather than a traditional open seawater intake) as this type of intake prevents marine life from being drawn into the pumps. Several test wells were dug, and a pilot program was operated for several years, with wells producing approximately 2,100 gpm of flow.

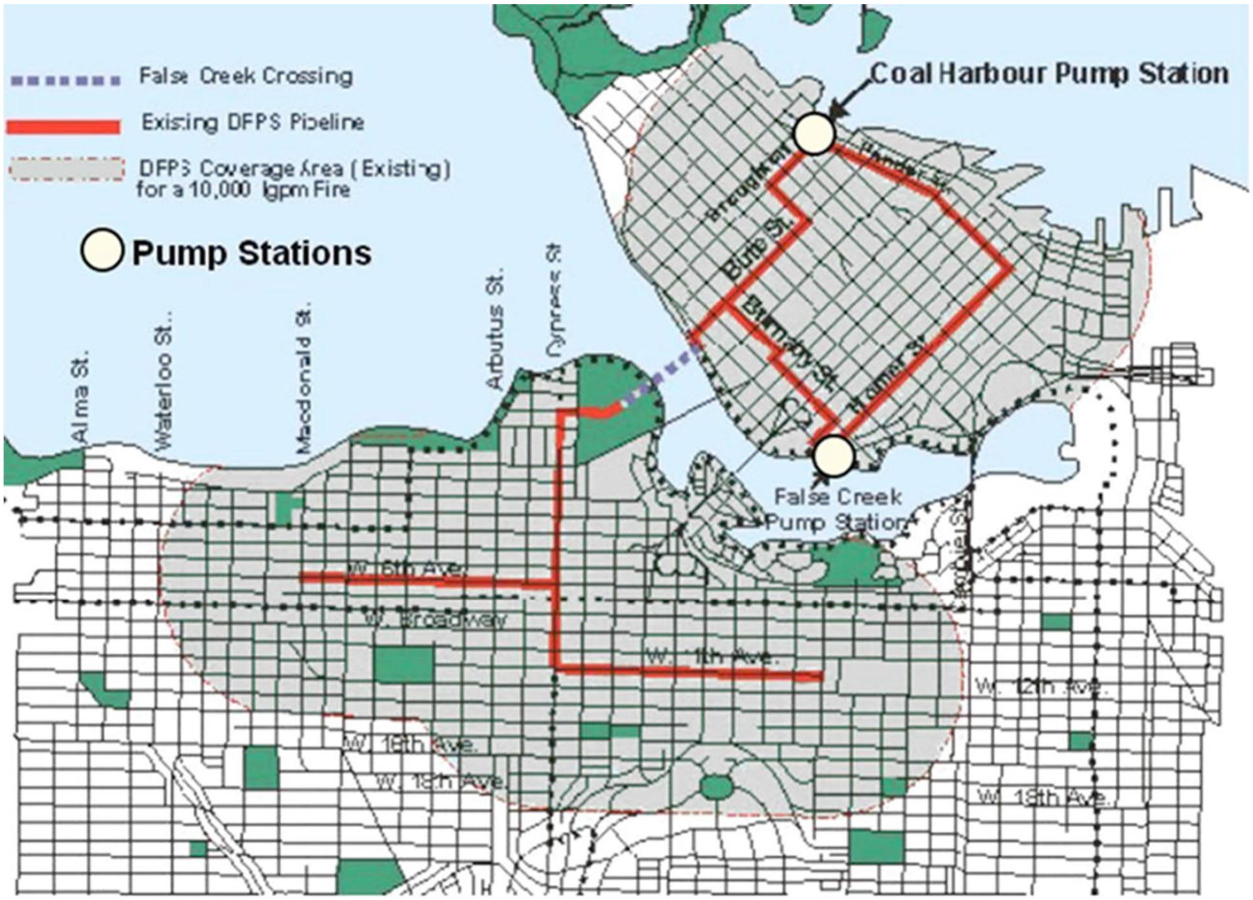
Source: Project Fact Sheet, https://www.scwd.org/civica/filebank/blobdload.asp?BlobID=8168

Figure 2-7: Proposed Doheny Desalination Plant Slant Well Intakes

2.4.5 Vancouver, BC

The dedicated fire protection system (DFPS) in Vancouver, BC, completed in 2003, was constructed as an enhanced secondary fire suppression system for the downtown core, Kitsilano, and Fairview Slopes neighborhoods. This system was modeled after San Francisco's AWSS, and is designed to operate parallel to, and in support of, the regular water main system, which feeds the standard red fire hydrants across the city. In the event of a major earthquake, the DFPS would act as a standalone system, pressurized to 300 psi, and able to withstand the shock of an earthquake measuring approximately 8.3 on the Richter scale.

The DFPS comprises a network of 6.2 miles of 24-inch welded steel underground pipes and forms a wide loop through most of the downtown core, as shown in Figure 2-8. Seven underground valve chambers are located at various critical junctions on the line, each having the capability of sealing off segments of the DFPS in the event of a breach, keeping the remainder of the system operational.



Source: The 1906 San Francisco Earthquake and Fire—Enduring Lessons for Fire Protection and Water Supply, Charles Scawthorn

Figure 2-8: City of Vancouver, BC Dedicated Fire Protection System

Twin pumping stations, located at False Creek and Coal Harbor, are equipped with two Fairbanks Morse vertical turbine pumps. Each pump draws water from a 150,000-gallon storage tank, which is located underneath each pumping station. At full flow, each station can pump 10,000 gpm of water through the DFPS network. Each pumping station is also fully equipped to draw in seawater from the Burrard inlet and False Creek if the wet wells become depleted, or the regular municipally water supply is cut off.

The stations are able to withstand the force of a powerful earthquake and also comes fully equipped with internal power generators and are stocked with enough diesel fuel, equipment and provisions for a crew of six highly trained engineers and operators to last a week in isolation.

2.4.6 Hong Kong, China

Since the late 1950s, Hong Kong has used seawater extensively for toilet flushing. The seawater flushing system is an effective way to conserve fresh water as Hong Kong has never been self-sufficient in fresh water supply. About 80 percent of the population is now provided with seawater for toilet flushing. The water is pumped from 42 treatment plants on the coast through a network of pipes carrying water to businesses and residences solely for toilet flushing. Using seawater for this purpose reduces the city’s freshwater consumption by 20 percent.

The risk of corrosion of the pipes is reduced through use of cement lined iron pipes for the main distribution network and polyethylene (HDPE) pipes for in-building services. Duplex stainless steel is used for the pumps. These measures have increased the average life expectancy of pipes in the network before renewal may be necessary.

At one of the treatment plants in Wan Chai, four large pumps withdraw water from the sea, as shown in the photograph in Figure 2-9. The water passes through mesh gates that filter out aquatic organisms, floating plastics, and other debris. The seawater is then then treated through electro-chlorination, where an electric current is passed through the seawater, triggering a reaction that produces hypochlorite. This process not only disinfects the water but also reduces odor.

Figure 2-9: Pumps at Wan Chai Seawater Treatment Facility Supply Toilet Flushing Water

Chapter 3: Supply and Demand Evaluation

This chapter reviews the available existing water supply sources for the EFWS, as well as the potential flow requirements needed from new seawater supplies to the EFWS system.

3.1 Existing Supply Sources

To fight fires after an earthquake, water must be supplied at a sufficient flow rate and pressure and for an adequate duration to meet estimated post-earthquake fire demand. Water flow and pressure is provided by infrastructure such as pipelines, pump stations and storage facilities by way of their elevation. The volume of storage facilities, such as reservoirs and large bodies of water (such as San Francisco Bay), also govern the duration for which firefighting supplies can be maintained.

Cisterns and fireboats will likely be required in the initial hours after an earthquake but take time to mobilize to an active status. The existing seawater Pump Station 1 can be started remotely, but requires personnel to initiate, and Pump Station 2 at present has no remote capability.

The Emergency Firefighting Water System Supply Analysis Technical Memorandum (AECOM, 2020a) analyzed and examined the storage volume available for fighting fires on a city-wide basis at the present time.

3.2 Seawater Pump Station Demands

Although the existing and currently planned PEFWS supply sources can likely meet the immediate post-earthquake fire demands throughout much of San Francisco, water storage within the city will be severely impacted. For example, under some modeled scenarios, the Twin Peaks Reservoir (currently the primary EFWS storage facility) may not be able to supply flow beyond 6 hours. Within three days, most of the potable reservoirs may reach a low level where they are no longer available for fire fighting. Only Lake Merced, with its nearly 2 billion gallons of capacity, can maintain a significant storage over the 5-day period (AECOM, 2020a).

Supplemental water sources can meet not only firefighting demands, but also reduce the impact on the potable reservoirs. Supplemental sources include other potable reservoirs such as Merced Manor, Stanford Heights, and College Hill Reservoirs as well as nonpotable sources such as Lake Merced or new seawater pump stations.

The maximum amount of supply deficit at present is estimated to be on the order of 40,000 gpm, but future growth in the City may increase demands. A separate analysis is currently being conducted to evaluate overall EFWS needs for the future (AECOM, 2021).

Different configurations of the new seawater pump stations are discussed herein, ranging from 3,000 gpm to 50,000 gpm. This range of flows was selected to provide a broad view of potential additions of seawater to the EFWS.

Chapter 4: Regulatory Considerations

This chapter reviews the various regulatory jurisdictions and authorizations that may be required for development of new seawater supplies to the EFWS system.

4.1 Overview

Proposed actions to enhance and expand existing firefighting water supply with an EFWS will require the installation, testing, operation, and maintenance of new facilities and infrastructure. Preferred and alternative actions developed and proposed to meet the purpose and need for enhancing the firefighting water supply will require review and input from the public, state and federally mandated environmental review, and various permits, authorizations and leases from regulatory agencies and other key stakeholders.

One avenue for public review of project alternatives would occur during the environmental review processes established under the California Environmental Quality Act (CEQA) and, for any direct federal involvement or funding, under the National Environmental Policy Act (NEPA). With certification of a final CEQA document and a decision document signed by a federal acting agency under NEPA, there remains a considerable permit acquisition phase prior to project implementation.

At the present pre-feasibility assessment stage, this chapter describes the need for CEQA and NEPA documentation, public involvement as part of the acting agency decision-making process, and, moreover, the range of regulatory jurisdictions and processes that may be necessary under various conditions.

While a range of project implementation strategies envisaged are in an early stage of development, any one method for expanding and enhancing the existing EFWS would have an impact upon several managed man-made and natural resources within and adjacent to the city of San Francisco. New or expanded seawater extraction infrastructure, associated pumping stations and a distribution pipeline system will involve a plethora of federal, state, regional and local regulatory jurisdictions and stakeholders. These entities will be keenly interested in the process used by the SFPUC to identify preferred action and alternative actions prior to issuing permits affecting managed resources.

Below is an overview of anticipated environmental review and regulatory permits and leases that should be considered when establishing preferred and alternative actions. This analysis should be further developed as a set of identified alternatives so that specific actions can be considered from a regulatory perspective.

4.2 Project Design Development and Alternatives Analysis

It is critical to understand the regulatory framework and policies that impinge upon a proposed project early in the development of the hierarchy of alternatives. Design considerations may be substantially influenced by a regulatory agency's policies that govern the type and location of facilities and infrastructure that may be required to meet a project's purpose and need. When consulted early and thoroughly considered, such an understanding with these entities can lead to synergies and co-benefits with overall agency efforts and public policy goals, particularly at the local level. Such inclusion of environmental regulatory considerations early in the project development and site-selection process is instrumental in streamlining the impending environmental review processes under NEPA and CEQA, as well as subsequent permit acquisition efforts.

4.3 NEPA/CEQA Process

Federally funded actions or those requiring a federal permit will typically trigger the need for NEPA review and documentation by a lead federal agency per Council on Environmental Quality regulations at 40 Code of Federal Regulations (CFR) Parts 1500–1508. Should new access to seawater from the Pacific Ocean be proposed, intake infrastructure within waters of the U.S. adjacent to the city of San Francisco would require permits from the U.S. Army Corps of Engineers (USACE), National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (USFWS), and potentially the National Park Service (NPS) or the U.S. Coast Guard (USCG), if the footprint crosses NPS land or triggers a change in markings on navigational charts, respectively. For near- and on-shore actions within federally managed lands such as broad areas of the Golden Gate National Recreation Area (GGNRA), the NPS would be the likely lead federal agency requiring review under NEPA. The NPS GGNRA is present along most of the coastal areas on the Pacific Ocean side of the city. NPS NEPA policy is found at https://www.nps.gov/subjects/nepa/policy.htm.

Other federal agencies may be affected, but at a lower degree of potential impact (*i.e.,* crossing a federal interstate highway or federally owned land parcel). Depending on the level of potential impacts to federally managed resources, the NEPA process may require the preparation of an environmental impact statement (EIS), an environmental assessment (EA) or, for simple actions commonly occurring and authorized by the federal agency, a categorical exclusion may be warranted (*i.e.*, a simple pipeline crossing a previously disturbed area). In general, an EIS may take 3 to 5 years to complete, an EA about 2 years, and a categorical exclusion in much less time, if allowed.

Similarly, for a City-proposed EFWS project of this scope and magnitude, a CEQA analysis and associated public review would be required before finalizing a decision to proceed per Public Resources Code 21000–21189 and the CEQA Guidelines at California Code of Regulations, Title 14, Division 6, Chapter 3, Sections 15000–15387), available from http://leginfo.ca.gov/ and http://ccr.oal.ca.gov/. The anticipated scope of the EFWS project points to the likely need for an environmental impact report (EIR) under CEQA. The range of environmental topics analyzed under CEQA and the criteria used to determine impact significance differs from that under NEPA, but the preparation time is on par with an EIS. In some cases, these parallel evaluations can be more efficiently prepared under a joint CEQA/NEPA document. This is particularly advantageous when each lead agency is clear about and well aligned with each other's environmental review priorities and schedule.

4.4 Potentially Affected Regulatory Agencies and Jurisdictions

During and following the NEPA/CEQA process, a host of permits and authorizations will be required from regulatory agencies. The likely affected agencies, depending on the affected state waters, shoreline, and upland areas affected, are described below. They involve federal, state, regional and local resource management and planning agencies responsible for the use of air, water and terrestrial resources, urban planning areas and transportation corridors. Numerous regulatory agencies have overlapping or related responsibilities, particularly in areas near the convergence of ocean and estuarine waters of San Francisco. Certain responsibilities are clearly separated by whether they involve ocean or bay resources, such as the California Coastal Commission (CCC) along the ocean and the Bay Conservation and Development Commission (BCDC) along the bay.

the review of ocean and bay shoreline opportunities for potential expansion of the EFWS, and associated regulatory responsibilities, have been segmented into five subregions based on geologic, regulatory and land use influences (see Figure 4-1 and Figure 4-2). These subregions include:

- Ocean Southern Dunes: Longshore sandy beaches south of Sutro Heights (Balboa Street) and southward to the city limits.
- Ocean Rocky Area South: Beaches and headlands south of the Presidio to the south end of Sutro Heights.
- Ocean Rocky Area North: Headlands fronting the Presidio west of the Golden Gate Bridge.
- SF Bay Area North Bayfront: The bay shoreline from the Golden Gate Bridge to the Bay Bridge.
- SF Bay Area East Bayfront: The bay shoreline from the Bay Bridge south to the city limits.

Table 4-1: Primary Shoreline Regulatory Jurisdictions

<table>
<tr><th>Study Subregion</th><th>Intake</th><th>Pump Station</th><th>Pipelines</th><th>Discharge</th><th>Flushing</th></tr>
<tr><td>Ocean/Rocky Area North</td><td rowspan="3">California Coastal Commission

and

National Park Service</td><td colspan="2">Presidio Trust</td><td colspan="2" rowspan="3">California Coastal Commission</td></tr>
<tr><td>Ocean/Rocky Area South</td><td colspan="2" rowspan="2">National Park Service

City of San Francisco
(Local Coastal Program)</td></tr>
<tr><td>Ocean/Southern Dunes</td></tr>
<tr><td>SF Bay/North Bayfront</td><td colspan="5" rowspan="2">San Francisco Bay Conservation and Development Commission</td></tr>
<tr><td>SF Bay/East Bayfront</td></tr>
</table>

From a regulatory compliance perspective, each of the project components are defined as follows:

- Intake System: Subsurface intake wells or infiltration galleries or screened open-water intake pipeline systems that are positioned below the mean high water (MHW) elevation.
- Pump Station: Typically consist of fossil fuel-powered water pumping systems housed in a shelter or enclosure and located upland of the MHW and within proximity to its water source.
- Pipelines: These represent pipelines needed for a variety of uses, including conveyance between the source water and a pump station with high-pressure circulation within the city, and pipelines dedicated to the discharge of seawater to open water or sewer systems following testing and/or freshwater flushing.
- Discharge: The point of release of seawater from a discharge pipeline other point source into a water body or other receiving area.
- Flushing: The point of release of freshwater that has been used for flushing pipelines and pump stations following testing with seawater into a water body or receiving area.

4.4.1 Potentially Affected Primary Shoreline Regulatory Jurisdictions

To more readily depict and describe potentially affected regulatory agencies with jurisdiction for areas where project components would occur along or near the shoreline within each subregion, a set of primary shoreline regulatory jurisdictions have been identified in Table 4-1. Primary shoreline jurisdictions are agencies that typically have final regulatory approval authority and frequently require all other permits to have been obtained prior to receiving their approval. These primary shoreline jurisdictions are shown geographically on the map provided in Figure 4-1.

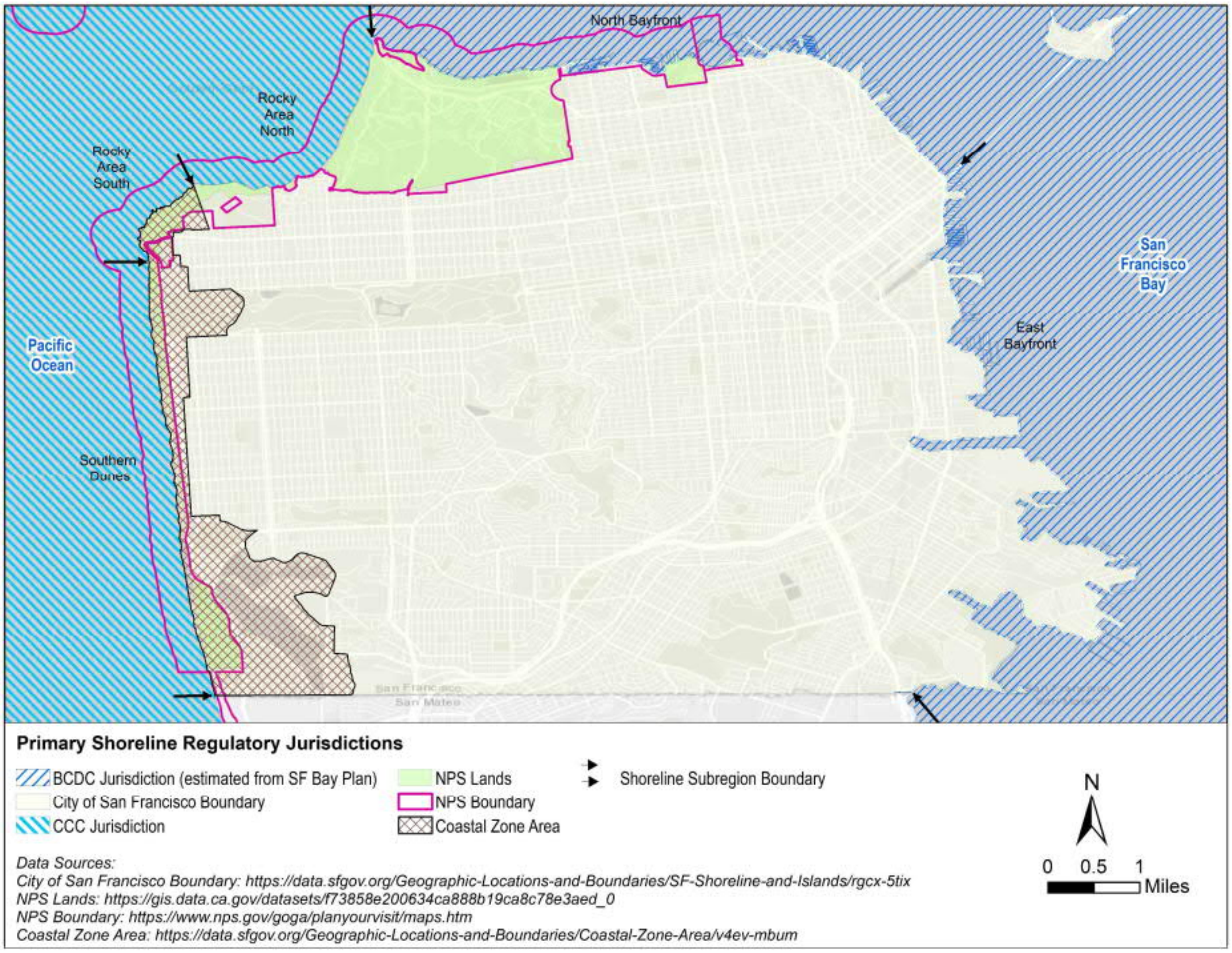


Figure 4-1: Primary Shoreline Jurisdictions

4.4.2 Potentially Affected Secondary Shoreline Regulatory Jurisdictions

Other affected regulatory agencies occur at or near the shoreline within each subregion. Secondary Shoreline Regulatory Jurisdictions are those that have responsibility for resources and lands (submerged and upland) for which a permit, authorization or lease would be required. These agencies are identified by subregion in Table 4-2 and are shown geographically on the map provided in Figure 4-2.

Table 4-2: Secondary Shoreline Regulatory Jurisdictions

<table>
<tr><th>Study Subregion</th><th>Intake</th><th>Pump Station</th><th>Pipelines</th><th>Discharge</th><th>Flushing</th></tr>
<tr><td>Ocean/Rocky Area North</td><td rowspan="5">State Lands Commission
Regional Water Quality Control Board
U.S. Army Corps of Engineers
California Dept of Fish and Wildlife
National Marine Fisheries Service
U.S. Coast Guard</td><td>--</td><td>--</td><td colspan="2" rowspan="5">State Lands Commission
Regional Water Quality Control Board
U.S. Army Corps of Engineers
U.S. Coast Guard</td></tr>
<tr><td>Ocean/Rocky Area South</td><td>--</td><td>--</td></tr>
<tr><td>Ocean/Southern Dunes</td><td>--</td><td>--</td></tr>
<tr><td>SF Bay/North Bayfront</td><td colspan="2" rowspan="2">Port of San Francisco</td></tr>
<tr><td>SF Bay/East Bayfront</td></tr>
</table>

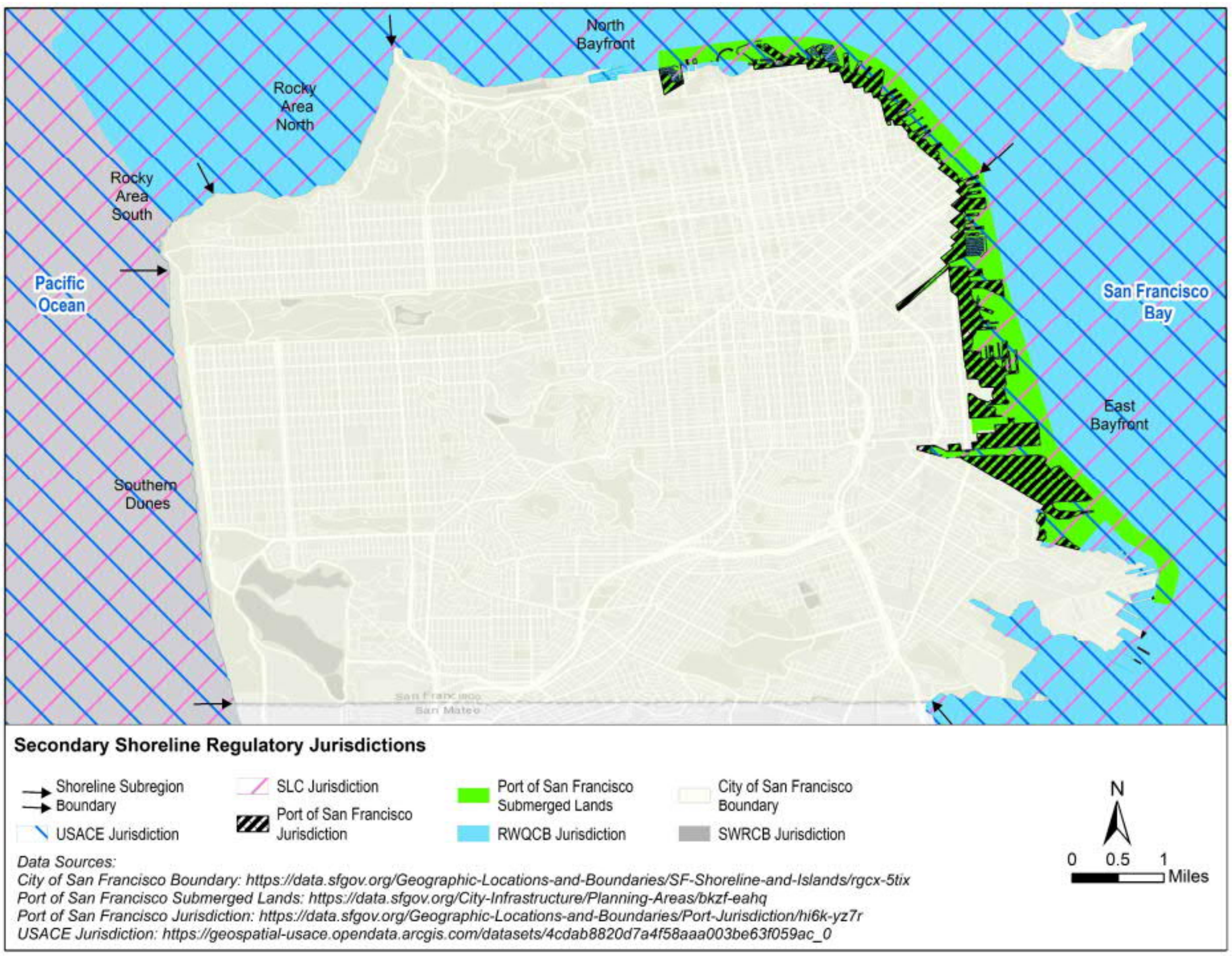


Figure 4-2: Secondary Shoreline Regulatory Jurisdictions

4.4.3 Other Potentially Affected City Interior Regulatory Jurisdictions

In addition to the agencies and jurisdictions discussed above, other regulatory agency jurisdictions that may occur upland of the shoreline and within the city interior are identified below. This may not be an exhaustive or exclusive list; however, the typical regulatory jurisdictions potentially affected within the city interior are tentatively identified in Table 4-3.

Table 4-3: Other Potentially Affected City Interior Regulatory Jurisdictions

<table>
<tr><th>Study Subregion</th><th>Intake</th><th>Pump Station</th><th>Pipelines</th><th>Discharge</th><th>Flushing</th></tr>
<tr><td>Ocean/Rocky Area North</td><td rowspan="5">Not Applicable</td><td colspan="2" rowspan="5">Presidio Trust (Rocky Area North)
National Parks Service (ocean subregions)
City Planning Department (planning areas)
California Department of Transportation
Regional Transit Agencies
California Department of Fish and Wildlife
U. S. Fish and Wildlife Service
U.S. Army Corps of Engineers
Region 2 Water Quality Control Board
California State Parks (East Bayfront)</td><td colspan="2" rowspan="5">Not Applicable</td></tr>
<tr><td>Ocean/Rocky Area South</td></tr>
<tr><td>Ocean/Southern Dunes</td></tr>
<tr><td>SF Bay/North Bayfront</td></tr>
<tr><td>SF Bay/East Bayfront</td></tr>
</table>

Regulatory jurisdictions that extend from the near-shore area into the interior of the city include various city departments, including planning and transportation agencies, city parks, and various historic districts. Permits or exemptions from permits may be required from these various local departments, in addition to federal, state, and regional entities mentioned above. Also present are rights-of-way for regional, state, and federal highway, train, transit, and rail corridors. Perpendicular and longitudinal encroachment crossings of these rights-of-way require a detailed application expressing the need, purpose, function, design and maintenance of utility infrastructure or other proposed elements for which an encroachment permit is requested. A high-level representation of San Francisco planning zones is depicted in Appendix A. More fine-scale data for each individual area is available and should be reviewed as alternative sites are considered.

4.5 Regulatory Jurisdiction Details

This section provides greater insight into each of the potentially affected regulatory entities that may be involved with implementing the EFWS, depending on the siting alternatives ultimately considered. A general assessment for this level of analysis has been provided regarding the overall level of time, expense and challenging requirements that would likely be encountered with each entity. These levels of difficulty are generally defined as follows:

- **High**: Requires substantial time and expense to coordinate with regulatory staff and decision-makers, preparing advance special studies and engineering documentation for review, and encounters substantial public scrutiny and appeals processes that may extend the time required for approval. Review and approval time are typically 24 to 36 months even under ideal conditions.
- **Moderate**: Requires modest amounts of time and expense to coordinate with regulatory staff and decision-makers, with the need for highly predictable advance special studies and engineering documentation and has a well-defined application review structure and timeline. Review and approval time are typically 12 to 24 months.

- **Low**: Requires minimal amounts of time and expense to coordinate with regulatory staff relative to other entities, with very limited to no preparation of advance special studies required, and their approval process is largely independent of decisions by other regulatory entities. Review and approval time are typically less than 12 months.

Note that several of these entities are procedurally or statutorily intertwined with another reviewing entity's decision, requiring one approval in order to obtain final authorization under a more consequential approval (*e.g.*, a Water Quality Certification from the RWQCB in order to obtain final authorization of a USACE Individual Permit under the Clean Water Act).

4.5.1 Federal Jurisdictions

4.5.1.1 National Park Service

The NPS, within the US Department of Interior, has jurisdiction of portions of the coastline under the 1972 Golden Gate National Recreation Enabling Act (H.R. 16444) and under Title 16 U.S. Code Subchapter LXXXVI, GGNRA. The GGNRA is defined as the lands within the defined federal boundaries, waters, and submerged lands extending 1/4 mile offshore from the coastal enclaves (Figure 4-1). The Enabling Act defines the area to "provide for recreation and educational opportunities consistent with sound principles of land use planning and management. In carrying out the provisions of this subchapter, the secretary shall preserve the recreation area, as far as possible, in its natural setting, and protect it from development and uses which would destroy the scenic beauty and natural character of the area" (H.R.16444).

From our experience, the NPS would be a lead federal agency under NEPA for any substantive infrastructure within its jurisdiction, both immediately offshore and onshore. An encroachment permit and construction permit would be required from NPS for work within GGNRA. GGNRA, collectively, is also considered a National Historic Landmark and habitat for federal and state listed species protected under NEPA, CEQA, and other subsequent natural resource regulations. In addition, the following Memoranda of Understanding exist between the NPS and others that may become relevant to the EFWS depending on siting alternatives ultimately under consideration.

Memoranda of Understanding

- *Fort Mason and the Presidio were formerly owned by the US Army. NPS has an MOU with the US Army (1972) that outlines joint usage of Fort Mason as a sub-installation of the Presidio (nps.gov). A portion of the Presidio is managed by The Presidio Trust, described below.*
- *Areas of the GGNRA including Fort Funston, Ocean Beach, and Lands End were formerly owned by the City and County of San Francisco (CCSF). A MOU between CCSF and NPS (1975) requires the General Superintendent of the GGNRA to formally notify and consult City Planning on all proposed construction plans (sfdog.gov). The MOU includes a provision for public access that states transferred CCSF-owned park lands were to be reserved by the NPS "to hold only for so long as said real property is reserved and used for recreation and park purposes."*
- *The City's Fire Department has an MOU with the NPS that states the Department responds to areas they own within GGNRA (sf-fire.org)*

The NPS has a well-established NEPA implementation process that would tend to streamline project review under that federal policy; however, leases or encroachment permits may take considerable time under federal transfer procedures. The coordination and approval efforts with NEPA are characterized as moderate.

4.5.1.2 The Presidio Trust

The Presidio of San Francisco is managed by two federal agencies in partnership; 300 acres along the coast are managed by the National Park Service (see below), while the rest of the Presidio (1,191 acres) is managed by the Presidio Trust. Both federal agencies work in close collaboration with the Golden Gate National Parks Conservancy, a nonprofit organization that provides indispensable philanthropic and programmatic support.

The Presidio Trust is an unusual federal agency founded under the Presidio Trust Act and charged with operating the park without taxpayer support. Funds earned through leasing homes and workspaces and operating hotels, a golf course, and venues are used for park management and upkeep.

The Trust and its partners have converted the former military post into an inviting national park site wet within an urban area. The Presidio is home to a large community of residents and tenants, and offers recreation, hospitality, and educational opportunities to people throughout the Bay Area and beyond.

Under the provisions of the Presidio Trust Act, six members of the Presidio Trust Board are appointed by the President of the United States. The seventh member, currently Todd Willens, is the U.S. Secretary of the Interior or his/her designee. The Board acts only as a body, taking actions by vote. All the actions of the Trust Board are reported publicly by publishing the minutes of each meeting. As a public safety project, the coordination effort and timing are expected to be moderate.

4.5.1.3 US Army Corps of Engineers

Under Section 404 of the federal Clean Water Act (1972, amended in 1987) (CWA), Section 10 of the Rivers and Harbors Act (1899), and the Navigable Waters Protection Rule (2020), the USACE issues Standard Permits and General Permits. Standard Permits include Individual Permits and Letters of Permission. General Permits include Nationwide Permits and Regional Permits. Each permit requires a different NEPA process, agency coordination, public notification, and preparation of information depending on the project’s overall impacts and level of complexity.

All work in or touching navigable waters, wetlands, streams, lakes, ponds, and other jurisdictional Waters of the US require consultation with USACE. Prior to submitting a permit application, applicants are encouraged to prepare and submit a Jurisdictional Determination Report. This report provides descriptions and mapping to identify the limits of a project site, in additional to the limits of jurisdictional waters of the US. Notification to National Marine Fisheries Service and/or USFWS for endangered species consultation and to the State Historic Preservation Office (SHPO) for cultural and historic resource considerations are made by the Corps as part of the Section 404 application process.

Early collaboration with the USACE prior to submittal of permit applications under Section 404 of the CWA has been a valuable means of integrating key elements into the design and required alternatives analysis for minimizing overall fill and associated impacts to natural resources. USACE permit review guidance is provided in Appendix B. The USACE review is well regimented yet dependent upon approvals from NMFS, USFWS, SHPO and RWQCB and is thereby expected to have a moderate level of difficulty for this type of initiative.

4.5.1.4 National Marine Fisheries Service

NMFS, within the National Oceanic and Atmospheric Administration, has jurisdiction of most marine biological resources, including species habitat under Section 7 of the Endangered Species Act (ESA) and under the Magnuson Steven Fisheries Conservation and Management Act (MSA). Consultation with the NMFS under Section 7 of the ESA would be required for proposed actions within ocean or bay waters adjacent to the city of San Francisco and in affected freshwater streams supporting anadromous fish and other protected species.

Under the ESA, certain species also have designated Critical Habitat, defined as areas of habitat believed to be essential to the species' conservation (see Appendix A). Actions in designated Critical Habitat must not destroy or adversely modify that habitat. Similarly, under the ESA, some protected fish species also have established Essential Fish Habitat (EFH), defined as includes reefs, kelp forests, bays, wetlands, rivers, and ocean that are necessary for fish reproduction, growth, feeding, and shelter. EFH requires identification and guidelines for fisheries management for the conservation of species with Regional Fishery Management Councils (Councils) and the Secretary of Commerce in fishery management plans. The regulations require consultations on actions that may adversely affect EFH.

Areas of mapped eelgrass in the bay are additionally protected under NMFS's California Eelgrass Mitigation Policy (2014) and the State's "Strategic Plan to Protect California's Coast and Ocean 2020 – 2025" (see Appendix A). Eel grass ecosystems are recognized as critical habitat for many marine species and are threatened from urban development and pollution. Section 3.1.4 of the state's document directs the California Ocean Protection Council (advisory council to the California Coastal Commission) to "work with partners to preserve the existing, known 15,000 acres of seagrass beds and create an additional 1,000 acres by 2025 by supporting projects that protect existing and potential eelgrass habitats as identified in habitat suitability mapping, consistent with the California Eelgrass Mitigation Policy."

The Federal Marine Mammal Protection Act of 1972 (MMPA) protects all marine mammals, despite the species status under the ESA. The MMPA requires work in marine waters to apply for an Incidental Harassment Authorization (IHA) from the NMFS Office of Protected Resources (NMFSOPR). A select few species protected under the MMPA that may occur in San Francisco waters are under USFWS jurisdiction; however, permit applications would still be processed through NMFSOPR. A third federal agency, the Marine Mammal Commission, reviews and make recommendations on the policies and actions of the Service and NMFS related to their implementation of the MMPA.

Consultation with NMFS will be required to determine a complete list of protected species and habitat that have potential to occur as alternative sites are identified. Evaluating the potential to affect EFH and marine mammals prior to final siting and/or design of take and discharge elements have been shown to streamline NMFS review time under Section 7 of the ESA and promote issuance of a letter of no adverse effect to the extent possible. When carefully sited within marine environments, this project would be expected to encounter a moderate level of difficulty in obtaining NMFS authorization.

4.5.1.5 U.S. Fish and Wildlife Service

The U.S. Fish and Wildlife Service (USFWS) shares jurisdiction and Section 7 ESA consultation with the NMFS. USFWS jurisdiction covers all terrestrial and freshwater aquatic species, as well as terrestrial critical habitat (see Appendix A). One of the few marine mammal species under the jurisdiction of USFWS, pursuant to the MMPA, that may occur in San Francisco waters is the Southern sea otter *(Enhydra lutris)*.

USFWS also reviews and comments on National Wildlife Refuges (NWR) and State Habitat Conservation Plans (HCP) to minimize impacts on fish and wildlife species and their habitats. There are no NWR or HCPs in CCSF; however, it is likely that many wildlife species that occur within CCSF are shared populations from nearby NWR throughout San Francisco Bay and on the Farallon Islands offshore of Ocean Beach, as well as from nearby Habitat Conservation Plans in San Mateo County and the East Bay.

Similarly, consultation with USFWS will be required to determine a complete list of protected species and habitat that have potential to occur as alternative sites are identified. Early coordination with the USFWS's purview under Section 7 of the ESA to review efforts to avoid or minimized potential effects to federally protected species and document these conditions in a Biological Assessment has streamlined USFWS review time and their issuance of a favorable Biological Opinion. The type and amount of potentially affected species under USFWS review would tend to be relatively easy to avoid or mitigate in an urban setting. The relative level of difficulty in completing coordination with the USFWS is considered low.

4.5.1.6 U.S. Coast Guard

US Coast Guard authority for structures installed in or over navigable waters is provided in Code of Federal Regulations Title 33, Navigation and Navigable Waters. Chapter I – Coast Guard, Department of Homeland Security, Subchapter C, Aids to Navigation, Part 64, Marking of Structures, Sunken Vessels and other Obstructions, Subpart C—Structures, § 64.21, Marking and notification requirement. In general, it states that before establishing a submerged or overhead structure in or over waters of the US, the owner or operator shall apply for a Coast Guard review to determine if the proposed structure poses a hazard to navigation and to obtain authorization to install and mark the structure. The appropriate USCG District Commander will determine whether there is a hazard to maritime navigation and, if appropriate, the obstruction marking requirements.

4.5.2 State Jurisdictions

4.5.2.1 California Coastal Commission (CCC)

The California Coastal Commission (CCC), in partnership with coastal cities and counties regulates the use of land and water in the designated coastal zone, and is responsible for implementing coastal zone planning and management under both the State of California Coastal Act of 1976 and under the Federal Coastal Zone Management Act of 1972 (Title 16 US Code 1451). The CCC coastal zone is generally defined as extending seaward to the state's outer limit of jurisdiction, including all offshore islands, and extending inland generally 1,000 yards from the mean high tide line (databasin.org) (Figure 4-1).

Development activities generally require a Coastal Development Permit from either the California Coastal Commission or from the City of San Francisco under its CCC-approved Local Coastal Plan (LCP) (see further discussion of the City's LCP below). Upon review and acceptance of a completed CDP application and CCC staff review, a public hearing is required if a proposed project is within the CCC's appealable subarea of a LCP (see Figure 4-1) or if the Zoning Administrator determines that the project has a significant impact on the Coastal Zone (coastal.ca.gov).

The coastal zone regulated by the CCC does not include the area of jurisdiction attained by the San Francisco BCDC. The BCDC was created prior to the CCC and established pursuant to Title 7.2 (commencing with Section 66600) of the Government Code. However, the CCC can comment on a project within BCDC jurisdiction if the project may impact resources that fall within either BCDC, CCC jurisdiction (Section 30330 CA Coastal Act). For proposed actions within its jurisdiction, in this case within Pacific Ocean subregions, the CCC will typically be the final approval obtained from a state regulatory agency.

It is advantageous to engage senior CCC staff regarding the identification of seawater intake site alternatives, including coordination with technical consultants with an understanding of intake engineering and screening technologies, environmentally sensitive habitat areas, and discharge dispersal and construction techniques. That said, the CCC's opinion and final decision can be difficult to predict, as external factors can emerge late in the review process that may result in further studies, mitigation efforts or renewed public outreach. The level of difficulty for coordination and review time prior to approval of a Coastal Development Permit is considered high.

4.5.2.2 San Francisco Bay Conservation and Development Commission

The San Francisco Bay Conservation and Development Commission (BCDC) regulates all fill and coastline development in the San Francisco Bay basin under the California State McAteer-Petris Act (1965). In August 1969, the McAteer-Petris Act was amended to make BCDC a permanent agency and to incorporate the policies of the San Francisco Bay Plan (Bay Plan) into state law. BCDC Jurisdiction includes all bay waters east of the Golden Gate Bridge including creeks, rivers, sloughs, tributaries, marshes, mudflats, salt ponds, and other wetlands. BCDC's jurisdiction extends to the mean high tide line in areas that do not contain tidal marsh and up to five feet above mean sea level in areas of tidal marsh, as well as upland to 100 feet from the shoreline (Figure 4-1).

Land use practices that have the potential to impact water quality, to change the shoreline (including public access), and the protection of coastal resources are handled by BCDC or CCC, depending on geographic region of the SF Peninsula. Any project that touches San Francisco Bay or touches any point along the bay shoreline requires a BCDC permit. BCDC's jurisdiction does not overlap with the CCC; however, as mentioned above the agencies may comment on projects that may impact resources that fall within the other's jurisdiction (see CCC description above).

BCDC's regulatory document, the Bay Plan states that regulatory authority for water quality remains with the RWQCB, EPA, and USACE; however, the Bay Plan implements measures to support and promote the Basin Plan to maintain sufficiently high water quality levels for beneficial water use in the bay, including recreation and healthy aquatic habitats. Pages 84 through 86 of the Bay Plan discuss policy for water intake, circulation, and drainage as it pertains to managed Wetlands, salt ponds, and desalination.

BCDC also published the document titled Desalination and the San Francisco Bay. Chapter 2 discusses seawater intake systems for the bay. It states that open, surface intake systems may be on the bay bottom or suspended from a structure built over the water (*i.e.,* a pier). Subsurface intakes systems do not work well due to a lack of granular material underlying the bay or on its shoreline, consequently these systems are not part of intakes for facilities such as desalination plans or other purposes.

The BCDC has demonstrated a keen understanding of appropriate seawater intake methods and technologies that support project goals and protect submerged bay bottom resources. Their review of prior desalination plant and other intake proposals have led to a relatively successful path forward and a more predictable level of scrutiny. Depending on the size and location of infrastructure within the bay, the level of difficulty for coordination and review time prior to a final BCDC authorization is considered moderate to high.

4.5.2.3 State Water Resources Control Board

The State Water Resources Control Board (SWRCB) has jurisdiction and responsibility under the federal Porter-Cologne Act, federal CWA, and California Water Code Section 13170 for water quality control in all Waters of the United States. The SWRCB is divided into geographic regions of the state, and each regional Water Board takes jurisdiction of the state. Regional waters of the San Francisco Bay Basin, including tributaries, drainages, and some coastal waters are part of Region 2 (RWQCB). The RWQCB works cooperatively with both CCC and BCDC to establish and implement water quality objectives.

CCC and SWRCB Ocean Standards

The SWRCB has established Ocean standards to protect the beneficial uses of California's marine waters, primarily through the establishment of water quality objectives and implementing provisions in statewide water quality control plans and polices. Ocean standards plans and policies include the Water Quality Control Plan for Ocean Waters of California (Ocean Plan), the Water Quality Control Plan for

Control of Temperature in the Coastal and Interstate Waters and Enclosed Bays and Estuaries of California (California Thermal Plan), and the Water Quality Control Policy on the Use of Coastal and Estuarine Waters for Power Plant Cooling (Once-Through Cooling Policy).

The Ocean Plan is one of five statewide water quality control plans established by the SWRCB to preserve and enhance California’s territorial ocean waters for the use and enjoyment of the public. This is achieved by controlling the discharge of waste into the ocean and seawater intake. Discharge of waste can include stormwater runoff, municipally treated sewage outflow, and other discharges by industry under regional and state board permits. The Ocean Plan, adopted by the SWRCB on July 6, 1972, has been amended five times since it was last reviewed in 2011. The amendments are as follows:

- Model Monitoring, Vessel Discharges, and Non-Substantive Amendment (2012): Guidance for monitoring ocean waters, aligned provisions with state and federal laws and regulations for commercial vessel discharges, and applied various formatting and grammatical changes.
- State Water Quality Protection Areas and Marine Protected Areas Amendment (2012): Established new criteria for designating State Water Quality Protection Areas.
- Trash Amendment (2015): Provisions to control trash entering California’s ocean waters.
- Desalination Amendment (2015): Requirements to protect ocean waters during the construction and operation of seawater desalination facilities.
- Bacteria Amendment (2019): Revised statewide bacteria water quality objectives and implementation options to protect recreational users from the effects of pathogens (bacteria).

One key element of the Ocean Plan is stated under California Water Code Section 13142.5(b), which requires an Ocean Plan Determination for a range of seawater uses, including municipal intake (and discharge during testing) systems, and reads in part, as follows:

> *For each new or expanded coastal powerplant or other industrial installation using seawater for cooling, heating, or industrial processing, the best available site, design, technology, and mitigation measures feasible shall be used to minimize the intake and mortality of all forms of marine life.*

The Coastal Act supports the jurisdiction of the SWRCB relative to maintaining water quality for biological productivity and the protection of human and habitat health. The Act states that any development will be consistent with SWRCB Plans, including public service intake and outfall systems, per Article 2, Section 30705 and Article 4, Section 30233 (4): Incidental public service purposes, including, but not limited to, burying cables and pipes or inspection of piers and maintenance of existing intake and outfall lines. The most recent 2019 SWRCB staff review and proposed changes to the Ocean Plan proposed are presented at https://www.waterboards.ca.gov/water_issues/programs/ocean/docs/opr2019_dsfrpt.pdf

While land use practices that have the potential to impact water quality, the actions that change the shoreline (including public access), and the protection of coastal resources are handled by BCDC or CCC, depending on geographic region of the SF Peninsula. The actions and decisions on water supply, water rights, waste discharge requirements, and other specific water quality control actions are handled by the RWQCB. Overall, the level of difficulty for coordination and review time prior to approval from either the SWRCB or its RWQCB is considered high to moderate.

4.5.2.4 California State Lands Commission

The State Lands Commission ("Commission") has jurisdiction and management control over those public trust lands of the State received by the State upon its admission to the United States in 1850 ("sovereign lands"). For construction and operation of structures in waters of the state of California, a State Lands

Commission (SLC) lease application would be required in accordance with guidelines found at https://www.slc.ca.gov/wp-content/uploads/2018/07/Lease_App_Guidelines_2011.pdf. Generally, these sovereign lands include all ungranted tidelands and submerged lands, beds of navigable rivers, streams, lakes, bays, estuaries, inlets, and straits (Figure 4-2).

Exceptions for specific waterfront lots along the bayside of San Francisco exist pursuant to the San Francisco Beach and Water Lots Act (Chapter 41, Chapter 44, and Chapter 75, Statutes of 1851). The Act granted certain tidal and submerged lands in the city of San Francisco for private use and occupation for a term of ninety-nine years. Sales were carried out pursuant to the waterfront development plan known as the “Beach and Water Lots” and much of what is now downtown San Francisco passed into private ownership in this fashion. In 1863, the state Board of Harbor Commissioners took possession of all the waterfront of San Francisco, extending to six hundred feet into the waters of the bay (Legislature Chapter 306, Statutes of 1863).

In 1968, City and County of San Francisco, through the San Francisco Port Commission, was granted the land that had previously been under the jurisdiction of the San Francisco Port Authority, including all of the sovereign tide and submerged lands (slc.ca.gov).The Commission and the Port Commission (discussed further under Section 3.6.4 Local Jurisdictions) manages sovereign lands for the benefit of all the people of the State, subject to the Public Trust for water-related commerce, navigation, fisheries, recreation, open space and other recognized Public Trust uses. In addition, the State manages lands received after Statehood including Swamp and Overflowed lands and School lands. The Commission's Land Management Division in Sacramento administers the leasing of these lands, sand and gravel extraction from these lands, and dredging or disposal of dredged material on these lands. The Commission also manages the development of all mineral resources contained on such lands.

Upon receipt of an application or an inquiry about use of State lands, the Commission's Title Unit reviews its files and information submitted by the applicant to determine the extent of the State's property interest in the proposed project site. In some cases, the complex nature of the title to the lands may result in the applicant having to submit a title report (preliminary report of title or title policy) as part of the application process.

The lands managed by the Commission vary widely in character and utility. The Commission maintains multiple-use management practices to assure that the greatest possible public benefit is derived from these lands. The Commission will consider numerous factors in determining whether or not a proposed use of the State's land is appropriate including, but not limited to, the potential impacts on and the consistency with the Public Trust under which the Commission holds the State's sovereign lands, protection of natural resources and other environmental values, and preservation or enhancement of the public's access to State lands.

Other factors that the Commission will also consider are the size, location, intended use, and described need for the project/structure/facility, its relationship to the surrounding environment and if the size of the project/structure/facility is appropriate for the location and type of use or operation proposed. The Commission may approve, condition, or deny any application, based upon the above referenced factors or other issues raised during the application review process.

As with other affected jurisdictions within the state of California, the issuance of any lease, permit or other entitlement for use of State lands by the Commission requires review for compliance with the California Environmental Quality Act and no proposed project will be approved by a Responsible Agency under CEQA until its requirements been met.

The Commission has launched a new online system that allows the public to access, submit, and track lease and permit applications. It’s called the “Online System for Customer Applications and Records

(OSCAR)," and it went live in July 2019. It provides the Commission with new automation capabilities that enable it to accept and process applications and jurisdictional inquiries electronically.

While nominally a public lands leasing organization, their lease permit process requires substantial adherence to Ocean Plan, Bay Plan, and other stringent standards prior to granting leases for submerged state lands. The level of difficulty for coordination to obtain a California State Lands Commission (CSLC) lease within state submerged lands (ocean, bay, streams) is considered moderate.

4.5.2.5 California Department of Fish & Wildlife

California Department of Fish and Wildlife (CDFW) Region 3 includes the San Francisco Bay and Delta. CDFW takes on many authorities for other state and federal agencies under the California Fish and Game Code. For example, CDFW implements Incidental Take Permits for protected species under the federal ESA as well as additional species protected under the California ESA. CDFW has jurisdiction to implement and enforce fisheries regulations and to monitor EFH, pursuant to the federal MSA, as well as enforcing the federal Migratory Bird Treaty Act, which prohibits the take of any migratory bird. Under the Marine Life Protection Act, CDFW has the authority to control activities, recreation, education, and protections in state marine protected areas (marine reserves, marine conservation areas, and marine parks). There are several state marine protected areas in San Francisco Bay, but none that occur along the CCSF shoreline or nearby waters.

In addition to required consultation for endangered species as part of the USACE-issued 404 Permit and as part of the BCDC Permit, CDFW issues 1602 Lake and Streambed Alternation Permits pursuant to Fish and Game Code section 1602. A 1602 permit is required prior to beginning any activity that may use material from, divert, change, or obstruct the natural flow of any river, stream, or lake. CDFW also has a memorandum of understanding with the Water Board (1966). Under the terms of this MOU, the CDFW, formerly the Department of Fish and Game (DFG), agrees to notify the Water Board of any suspected violations of the Water Board's requirements for ocean disposal.

CDFW also has jurisdiction for land use and special access in the city's only state park, Candlestick Point State Recreation Area (see Appendix A). Developed in 1977, the park is in the East Bayfront subregion of the EFWS project study nearby Bayview/Hunters Point neighborhoods on landfill originally planned to be a naval shipyard after World War II. It is the state's first urban state recreation area. Public access includes trails, picnicking areas, bird watching, and an entry point for windsurfing on the bay. Pursuant to Fish and Game Code Sections 4305 and 4306, all wildlife and plant life is protected within the state park regardless of ESA listed status. All geological and anthropological features within the park boundaries also receive special status protection pursuant to Fish and Game Code Sections 4307 and 4308.Coordination with the CDFW to obtain Incidental Take Permits can be slow, even when providing full details and solid biological analysis. Largely due to limited review staff, completion of this process can take a year or more even under the best of conditions. Consequently, the level of difficulty for coordination and review time prior to approvals from the CDFW is considered moderate to low.

4.5.2.6 California Department of Transportation

An encroachment permit would be required when crossing into a California Department of Transportation (Caltrans) right-of-way. Their right-of-way within the city of San Francisco is depicted in Appendix A. An "encroachment" is defined in Section 660 of the California Streets and Highways Code. An encroachment permit is a contract between the Department and an encroachment permit holder, (permittee), that describes the terms and conditions under which you are granted permissive authority to enter onto State right-of-way to perform the activity. An encroachment permit grants permission to the permittee or their agent (a contractor) to perform the activity within the State's right-of-way, and assignment to another party is prohibited. An encroachment permit is not a property right, such as an easement, nor does it confer a property right. It cannot be transferred with the sale of real personal property.

Section 671.5 (a) of the California Streets and Highways Code requires that the Department either approves or denies an Encroachment Permit Application submittal within 60 calendar days, upon determination that the submittal is complete. The section grants the Department the authority in what constitutes a completed Encroachment Permit Application submittal. It also stipulates that an Encroachment Permit Application submittal is complete when all other statutory requirements, including CEQA, have been complied with. The actual time needed to review and approve your application will depend on the completeness of your submittal, scope, and complexity of the proposed work. A flowchart depicting the Caltrans encroachment permit process is provided in Appendix B.

Chapter 600, Utility Permits, from the Caltrans Encroachment Permits Manual states that it is Caltrans' policy is to allow utilities within conventional highway right-of-way subject to reasonable conditions and to exclude them from within access-controlled right-of-way to the extent practicable with few exceptions. Requests for utility encroachments that are not allowed by Caltrans policy or utility access within access-controlled right-of-way require an approved encroachment policy exception. The primary purpose of these policies is to protect both the public and highway workers from the hazards of a damaged, exposed, cut, or penetrated utility. The secondary purpose is to protect the public's investment in the highway system. Procedures for determining and collecting permit fees for utility facility encroachments owned by utility companies differ from those encroachments owned by private companies or developers. Usually, utility companies providing utility facility service to the public are billed for application and inspection fees whereas other companies pay fees at the time of application.

Chapter 602.5B details Longitudinal Utility Encroachments allowed for utilities running within and parallel to a Caltrans conventional highway right-of-way when required for publicly owned utility facilities dedicated to public use when approved by the Caltrans District (District 4). Requests for longitudinal encroachments by privately owned companies for their own use are not allowed.

The "Standard Encroachment Permit Application" (form TR-0100), instructions, plan set requirements, "EP Application Checklist" (form TR-0402) and other related forms can be found at http://www.dot.ca.gov/trafficops/ep/apps.html. Additional supporting documentation may be required depending on the scope of work such as: construction plans, location map, traffic control plans, letter of authorization, environmental documentation, storm water permit(s), certification of compliance with Americans with Disabilities Act, surety bonds, liability insurance, *etc.* Caltrans provides a flowchart guidance document, provided in Appendix B.

The Department's "Plans Preparation Manual" establishes uniform standards and procedures to be used when preparing right-of-way maps, preliminary exhibits, and the development of project plans. It is available at http://www.dot.ca.gov/design/cadd/manuals/ppm.html. All plans must comply with provisions of the California Business and Professions Code.

Given the number and type of likely encroachments, including the potential to seek longitudinal encroachments within a right-of-way, the review of engineering documents and completion of their approval process at Caltrans District 4 (Oakland) can take a year or more to complete. The relative level of difficulty for coordination and review time prior to approval from transportation agencies is considered low.

4.5.2.7 California Office of Historic Preservation

The California Office of Historic Preservation (OHP) administers federally and state mandated historic preservation programs to further the identification, evaluation, registration, and protection of California's irreplaceable resources. The State Historic Preservation Officer (SHPO) is responsible for the operation and management of the OHP, as well as long range preservation planning. The Governor appoints the SHPO, in consultation with the State Historical Resources Commission and the Director of the Department of Parks and Recreation. OHP's responsibilities include:

- Identifying, evaluating, and registering historic properties
- Ensuring compliance with federal and state regulatory obligations
- Encouraging the adoption of economic incentives programs designed to benefit property owners
- Encouraging economic revitalization by promoting a historic preservation ethic through preservation education and public awareness and, most significantly, by demonstrating leadership and stewardship for historic preservation in California

Architectural Review and Incentives

OHP administers the Federal Historic Preservation Tax Incentives Program and provides architectural review and technical assistance to other government agencies and the public in the following areas:

- Interpretation and application of the Secretary of the Interior's Standards and Guidelines for the Treatment of Historic Properties
- General assistance with and interpretation of the California Historical Building Code and provisions for qualified historic properties under the Americans with Disabilities Act
- Developing and implementing design guidelines
- Preservation incentives available for historic properties
- Sustainability and adaptive reuse of historic properties

OHP works with California's city and county governments to aid them in integrating historic preservation into the broader context of overall community planning and development activities by adopting a comprehensive approach to preservation planning which combines identification, evaluation, and registration of historical resources with strong local planning powers, economic incentives, and informed public participation.

Section 106 National Historic Preservation Act

For projects implemented or funded by a federal agency, coordination with the SHPO under Section 106 of the National Historic Preservation Act of 1966 (NHPA) would be required in addition to completion of the NEPA process for both archaeology and historic properties. Under Section 106 of the NHPA, actions with a federal nexus are required to consider the effects on historic properties, defined to include buildings, other structures, sites, objects, or districts. These include listings or eligible listings (determined in consultation with the SHPO) on the National Register of Historic Places, or in the city’s historic districts and conservation districts. San Francisco has 11 designated historic districts and six conservation districts and has recognized approximately 30 districts included in the California Register of Historical Resources, the National Register of Historic Places, or named as National Historic Landmark districts (see Appendix A). The NHPA also protects cultural items and archeologic sites significant to local Native American groups.

As part of a more detailed site alternatives analysis, review of the OHP’s California Historical Resources Information System (CHRIS) would be beneficial. It includes a statewide Historical Resources Inventory

(HRI) database maintained by OHP and the records maintained and managed by an independent regional Information center at Sonoma State University.

With proper analysis by qualified professionals, an, in certain cases the implementation of resource avoidance, coordination with the SHPO is a lengthy but manageable process. The relative level of difficulty for coordination and review time prior to authorization from the SHPO is considered moderate. A flowchart of the review process, along with the city's Planning Department's historic resource determination guide is provided in Appendix B.

4.5.3 Regional Jurisdictions

4.5.3.1 Region 2 - Regional Water Quality Control Board

Created by in 1967, the SWRCB implements Section 401, Certification Rule, under the federal Clean Water Act (CWA). Modified under the Porter-Cologne Water Quality Control Act (1970), the SWRCB coordinates with and supports Regional Water Boards to set statewide policy, and reviews petitions that contest Regional Board actions (waterboards.ca.gov). Regional boundaries are based on unique differences in climate, topography, geology, and hydrology for regional watersheds. Regional 2 RWQCB sets regional standards for San Francisco Bay under the Water Quality Control Plan (Basin Plan) for the San Francisco Bay region. The Basin Plan is the master policy document that contains descriptions of the legal, technical, and programmatic bases of water quality regulation (waterboards.ca.gov).

The RWQCB's work cooperatively with the CCC and BCDC to establish and implement water quality objectives. See Section 3.6.2 for a summary of SWRCB cooperative ocean standards with the CCC.

BCDC and Region 2 RWQCB

Under the RWQCB Basin Plan, agreements potentially applicable to the EFWS initiative and affecting waters of San Francisco Bay include:

- Resolution No. 87-154: A memorandum of understanding between the SWRCB, Regional Water Board and BCDC that requires a project applicant to obtain all discretionary approvals from the Water Board before filing its BCDC permit application.
- MOU: No. 87-154: Applicants must acquire other state/regional approvals before applying for a BCDC permit
- Resolution No. 737: RWQCB cooperates with BCDC to ensure protection of bay waters and shoreline under the Bay Plan. Resolution 737 with BCDC requires wastes resulting from project permitted by BCDC to be connected to existing sewer lines, and to disapprove or temporarily withhold approval of any project that would cause added waste loading on a community sewerage system that is not meeting Board waste discharge requirements. In addition, the regulation of discharges for temperature to coastal waters, bays and estuaries is outlined in the Water Quality Control Plan for the Control of Temperature in the Coastal and Interstate Waters and Enclosed Bays and Estuaries of California, known as the State's Thermal Plan (see Section 3.6.2).
- Resolution No. 70-19: Wastes resulting from BCDC-permitted projects are to be connected to existing sewer lines; and temporary or permanent disapproval of a project that would cause added waste loading on a community sewerage system that does not meet Board waste discharge requirements.

USACE and Region 2 RWQCB

Region 2 RWQCB issues Section 401 of the Clean Water Act water quality certifications and National Pollutant Discharge Elimination System (NPDES) permits. An NPDES permit addresses water pollution by regulating point sources that discharge pollutants to jurisdictional Waters of the US (epa.gov). Section 401 requires that any applicant for a USACE-issued Section 404 CWA permit also obtain a Water Quality Certification from the State. Section 401 permits cover any discharge and/or fill materials, as well as water quality standard compliance (in.gov). Under the federal 1972 CWA NPDES permit program, the EPA authorizes state, tribal, and territorial governments such as the RWQCB, enabling them to perform many of the permitting, administrative, and enforcement aspects of the NPDES program (EPA retains oversight responsibilities).

Related Local Water Quality Programs

- Existing NPDES permits issued to the CCSF for the operations of the Southeast and Oceanside Water Pollution Control Plants, the City is required to implement a Pretreatment Program. This Program is required to comply with the regulations incorporated in the Clean Water Act (33 USC Section 1251) and the General Pretreatment Regulations (Title 40 CFR Part 403) (sfwater.gov).
- The California State Construction General Permit requires the development of a Storm Water Pollution Prevention Plan (SWPPP) and/or Erosion Sediment Control Plan (ESCP), depending on site conditions. These permit applications are submitted to SFPUC and to Public Works through the City's Construction Site Runoff Control Program.
- Under CEQA and CWA provisions, the SWRCB also adopted a General Waste Discharge Requirement (WDR) in 2006 for all publicly owned sanitary sewer systems in California with more than 1 mile of sewer pipe. The goal of the WDR is to provide a consistent statewide approach for reducing system overflows. The WDR requires that SFPUC prevent untreated wastewater from entering storm drains, creeks, or other watersheds by developing a Sewer System Management Plan (SSMP). If an overflow occurs, the SSMP contains mandatory report requirements. Additional regulations governing these discharges are contained in the City's sewer use ordinance - Article 4.1, Chapter X, Part II of the San Francisco Municipal Code. Additional wastewater pollutant limitations are contained in the City's Public Works Order No. 158170 (see sfwater.gov).
- Stormwater is conveyed separately and discharged directly into the bay, the ocean, or Lake Merced without receiving treatment, a system collectively referred to as the Municipal Separate Storm Sewer System (MS4). Construction projects in MS4 areas must comply with Statewide General Permit requirements (SWRCB Order 2009-0009-DWQ) in addition to the City's Construction Site Runoff Control Ordinance (see Public Works Code 260-13).

The level of engineering and other technical analysis required to determine potential water quality effects during construction and to adhere to the guidance for intake and discharge in the Ocean Plan, among other land-based effects, require early examination and collaboration with Water Board staff to provide results using accepted methods and parameters. A RWQCB authorization under the Ocean Plan is required prior to approval of a Coastal Development Permit from the CCC. The level of difficulty for coordination and review time for approvals from the RWQCB is considered moderate.

4.5.3.2 Bay Area Air Quality Management District

The Bay Area Air Quality Management District's (BAAQMD) Regulation 2 Rule 1 describes the permit requirements for sources of air pollution. In general, any equipment or operation that emits pollutants into the atmosphere requires a Permit to Operate from the District unless it is excluded from District

Regulations per Regulation 1 or exempted from District permit requirements by a specific section of Regulation 2 Rule 1. Any air pollution control equipment, associated with a source that requires a District permit, is also required to have a Permit to Operate from the District. Facilities may use the Permit Exemption Guidance to aid in determining whether a source is required to have a permit or is exempt from permit requirements.

A flow diagram of the BAAQWMD's permitting process is provided for illustrative purposes in Appendix B. If an application is not complete, the APCO shall notify the applicant in writing and indicate what additional data or fees are required to complete the application. Typically, the District must review and determine whether an application is complete within 15 working days of receipt of the application

Stationary diesel engines are internal combustion engines used in generators, pumps, and material handling equipment (such as tub grinders). The primary pollutants from internal combustion engines are oxides of nitrogen (NOx), hydrocarbon and other organic compounds (POCs), carbon monoxide (CO), sulfur dioxide (SO2), and particulate (PM10). In calculating these emissions, emission factor data from CARB, EPA, and/or the manufacturer are used to estimate emissions for NOx, CO, POC, and PM10.

For emergency standby diesel engines, the owner or operator shall operate only to mitigate emergency conditions, for emission testing to demonstrate compliance with a district, state, or federal emission limit, or for reliability-related activities (maintenance and other testing) but excluding emission testing. Operating while mitigating emergency conditions or while emission testing to show compliance with district, state or federal emission limits is not limited.

A permit application cannot be approved unless a modeling analysis demonstrates that the proposed source emissions will not interfere with the attainment or maintenance of a National Ambient Air Quality Standard (NAAQS), and, if applicable, will not cause an exceedance of a prevention of significant increment. For District purposes, NAAQS is defined to include both California and national standards. Guidance from the District's Engineering Division is available for the applicant's use to give the permit applicant specific assumptions, requirements, conventions, and procedures for the preparation of a modeling analysis. Because this guidance cannot cover every aspect of the analysis needed for a proposed source without becoming unwieldy, the applicant should submit a modeling plan (protocol) with their application before beginning the analysis, per the Permit Handbook found at https://www.baaqmd.gov/~/media/files/engineering/permit-handbook/baaqmd-permit-handbook.pdf.

Once it has been determined that a permit is required for a particular source or operation, a facility obtains the required permit by submitting a permit application package to the District's Engineering Division. The Engineering Division of the District issues and renews air quality permits for equipment that emits or controls the emission of air pollution from large and small facilities. If a facility is unsure about whether a permit is required, it is advisable to submit a permit application package for the operation; and the District will make the final determination.

A flow diagram of the BAAQWMD's permitting process is provided for illustrative purposes in Appendix B. Typically, the District must review and determine whether an application is complete within 15 working days of receipt of the application. With the use of standard equipment emissions specifications for internal combustion engines, the relative level of difficulty in obtaining a BAAQMD permit to construct or permit to operation is considered low.

4.5.3.3 Bay Area Rapid Transit and Caltrain

Bay Area Rapid Transit

If work is to be done on Bay Area Rapid Transit (BART) property, or if it is determined that inspection or monitoring will be needed for your project, a permit will be required. Their right-of-way within the city of San Francisco is depicted in Appendix A. The BART Real Estate and Property Development Department coordinates permits and plan review for any construction on, or adjacent to, a BART right-of-way. For subsurface crossings, refer to the General Guidelines for Design and Construction Over or Adjacent to BART's Subway Structures.

An application for construction permit must be completed along with the appropriate fee, including an as-built deposit and four sets of plans showing the proposed construction. After receipt of a completed and executed application, a work order is opened to support Department time charged to the project. The following types of BART standard permits should be anticipated for a proposed water pipeline crossing: Utility Permit (general utility work within existing easements by utility companies or self-insured entities), Permit to Enter (construction of temporary improvements on District property), and/or Permit to Enter (.pdf) (construction of permanent improvements on District property).

BART staff uses the application information to prepare the appropriate permit. BART staff will assign a permit number and add conditions specific to your permit based on plan review, including insurance certificates and endorsements. All permit issued by BART are subject to the General Terms and Conditions Relating to Utility Permits. A request to purchase an easement is treated just like a permit and is also subject to the Fee Schedule.

Caltrain

Caltrain's Peninsula Corridor Right-of-Way is a property owned by the Peninsula Corridor Joint Powers Board, which sets policies regarding requests for property conveyance and related access agreements. Their right-of-way within the city of San Francisco is depicted in Appendix A. Typical types of access agreements issued by Caltrain and a description of their standard form of agreement for each type of agreement to enter their right-of-way include:

- **Encroachment Permit**: Used to allow third parties access to Caltrain-owned property for a specific purpose when a lease is not appropriate. An encroachment permit would be appropriate to allow non-continuous occupancy. This short-form permit is not appropriate for construction activities, not even surveying or potholing.
- **Right-of-Entry Permit Agreement**: Required to allow third-party access to Caltrain property for a specified period to accomplish a specified activity, which generally involves construction.
- **License Agreement**: Issued to allow a permanent or semi-permanent facility to be constructed on Caltrain property. The license agreement allows the facility to be initially constructed and then remain in place. Depending on the situation, typically a Right-of-Entry Permit Agreement is required every subsequent time the licensee wished to access the facility for construction and/or maintenance.

Agreements are issued through the Caltrain Real Estate and Property Management Department and requires insurance coverage of $2 million per occurrence and $2 million aggregate General Liability insurance coverage. The permittee is typically charged a processing fee to cover Caltrain's cost in reviewing the request and issuing a permit, as well as an annual fee for use of the property. Overall, the relative level of difficulty to obtain a Caltrain encroachment permit is low; however, when a longitudinal right-of-way crossing (lengthwise within the right-of-way) is involved the level of difficulty can be greater.

4.5.4 Local Jurisdictions

4.5.4.1 City of San Francisco Local Coastal Plan (LCP)

The San Francisco Coastal Zone extends from the Point Lobos recreational area in the north to the Fort Funston cliff area in the south (refer to Figure 4-1). The Local Coastal Program (LCP) is a policy and regulatory document required by the 1976 California Coastal Act that establishes land use, development, natural resource protection, coastal access, and public access. San Francisco's Local Coastal Program was originally certified in 1986 and amended in 2018. The policies of the LCP were incorporated into the Western Shoreline Area Plan, the element of the General Plan that establishes land use, development, and environmental policies for the designated area. Projects that require a Coastal Zone Permit from the Planning Department shall be reviewed for consistency with the city’s Western Shoreline Plan, within the San Francisco General Plan (sfgov.org).

Actions requiring a Coastal Zone Permit include, but are not limited to: new construction, demolition, or alterations of structures, divisions of land, activities that change the intensity of use of land or public access to coastal waters, rip-rap repair, dredging, repair or maintenance to structures located in an environmentally sensitive habitat area, and alterations of land forms including removal or placement of vegetation, on a beach, wetland or sand dune, or within 100 feet of the edge of a coastal bluff, or stream or in areas of natural vegetation (SF Planning Code Section 330). Provided the project adheres to the goals and objectives within the city’s LCP, including public involvement, the level of difficulty is estimated to be low. Note that portions of the area under the LCP is appealable to the CCC, meaning any decision by the City can be appealed to the CCC by a person or entity willing to pay a large fee.

4.5.4.2 Port of San Francisco

The Port of San Francisco manages the waterfront as the gateway to a world-class city, and advances environmentally and financially sustainable maritime, recreational and economic opportunities to serve the City, Bay Area, and California (refer to Figure 4-2). The Port is governed by a five-member Board of Commissioners, each of whom is appointed by the Mayor and subject to confirmation by the City's Board of Supervisors. Each commissioner is appointed to a four-year term. The Port Commission is responsible for the seven and one-half miles of San Francisco Waterfront adjacent to San Francisco Bay, which the Port develops, markets, leases, administers, manages, and maintains. Its jurisdiction stretches along the waterfront from Hyde Street Pier on the north to India Basin on the south.

The Port of San Francisco Waterfront Plan (2015) sets forth land use and development policies adopted by the San Francisco Port Commission by subareas for all properties within the Port's jurisdiction. It focuses on maritime areas, open spaces and public access, and residential and commercial uses. Leases or encroachment permits are issued based on policies within a subarea. The Waterfront Plan is available at https://sfport.com/waterfront-land-use-plan-chapters.

The Waterfront Plan provides the foundation for Port efforts to integrate public and private investment to improve the waterfront for broad public use and enjoyment. It includes a comprehensive public access and open space plan along the waterfront, integrated with the Port's varied maritime industries, and opportunities for new public-private partnership projects. The Waterfront Plan includes a Waterfront Design & Access Element which provides direction on how projects should be designed to respect and enhance the waterfront's historic character, create architectural delights, and attract people to enjoy a wide range of activities.

Port Resilience Projects

The Port has been planning for sea level rise for years. In recognition of the Port's critical role in creating a resilient waterfront, the Port Commission requires that every project consider current and future flooding. Every new project means a stronger waterfront. This innovative approach is leading to sea level rise adaptation and project implementation along the waterfront, including the following projects:

- Downtown San Francisco Ferry Terminal Expansion Project
- Fire Station 35
- Mission Bay Ferry Landing
- Mission Rock
- Pier 70

The USACE and the Port have partnered to study flood risk along San Francisco's bayside shoreline. The USACE/Port Flood Study area begins just north of the Port's jurisdiction at Aquatic Park and ends just south of Heron's Head Park at the Port's southern boundary.

The Port leads the Embarcadero Seawall Program, a citywide effort to strengthen the 3-mile Embarcadero Seawall from earthquake, flooding, and sea level rise risks. The Program is currently in the planning stage, following an extensive vulnerability study. Critical life safety projects are estimated for completion by 2026. The Program will take decades to complete and is estimated to cost up to $5 billion.

To enable waterfront revitalization, the Port works closely with the San Francisco Planning Commission and its Board of Supervisors, the San Francisco BCDC, and the California State Lands Commission to align the various land use plans and policies held by each entity. Port projects must comply not only with the Waterfront Plan, as well as respond to the objectives of these regulatory agencies. This is important to minimize confusion between agencies and streamline the entitlement process for individual projects.

There are a host of Port codes for buildings and piers accessed at https://sfport.com/codes-guidelines-regulations. No single code or specific guidance is identified regarding utility crossings and waterfront access. Port properties on piers and within 100 feet of the shoreline are subject to BCDC permit requirements (https://sfport.com/sharedspaces). With proper technical review and siting of infrastructure conducted in concert with the Port staff, the level of difficulty for obtaining a Port lease or encroachment permit is moderate.

4.6 Areas of Known Contamination

In San Francisco, local government takes the lead for land use decisions related to hazardous waste facilities and for emergency response programs. State government oversees the management of hazardous waste including all transport activities. The federal government has taken the lead in regulating and in some cases funding the cleanup of past contamination which all levels of government now seek to prevent (SF General Plan).

The County of San Francisco is required to include a Hazardous Waste Management Plan as part of the General Plan under The Tanner Act of 1986. Hazardous waste mandates were developed by the Office of San Francisco's Chief Administrative Officer in conjunction with a citizens advisory group. The plan was approved by the Board of Supervisors in 1992 and by the State EPA in 1995. San Francisco Health Code Article 22A, "Maher Ordinance" requires San Francisco Department of Public Health oversight for the characterization and mitigation of hazardous substances in soil and groundwater in designated areas zoned for industrial uses, sites with industrial uses or underground storage tanks, sites with historic bay fill, sites in close proximity to freeways or underground storage tanks (see Appendix A). Actions within an area disturbing a minimum of 50 cubic yards require prior contact with the Department of Public Health as part of the Planning Department's building permit process.

As with all planning areas within the city, more fine-scale analysis should be obtained during the consideration of alternative sites. Depending on the locations selected for EFWS infrastructure, oversight by the City Department of Public Health, the level of difficulty in concurring with a preferred alternative is expected to be low.

4.7 Summary of Key Regulatory Considerations

Understanding and early coordination of environmental compliance and permit acquisition efforts will result in a more efficient project planning and public outreach efforts. Environmental compliance includes the preparation of NEPA and CEQA documentation so that affected NEPA lead federal agencies and the City of San Francisco, as a lead CEQA agency can document their decision-making process under the federal and state policies. Concurrent and subsequent efforts associated with permit acquisition and various encroachment and lease approvals from public agencies would also be required. Likely affected federal, state, and local/regional agencies involved with reviewing and authorizing portions of the project are summarized in Table 4-4.

Primary shoreline regulatory agencies (those typically having a final say in the overall approval process) vary depending on the location of off-shore and near-shore intake structures, pipelines, and, potentially, pump station infrastructure. In general, these agencies would include the CCC and NPS on the ocean side of the city west of the Golden Gate Bridge (though some NPS jurisdiction on the bay side occurs just east of the bridge, too). The Presidio Trust would also be a primary decision-maker where it has responsibilities in upland areas immediately west of the bridge, and the City of San Francisco would be a primary decision-maker for upland areas within its Local Coastal Program further south. On the bay side, BCDC is the primary shoreline decision making body. In general, BCDC is expected to have a less onerous and more streamlined review and approval process compared to the CCC. The potential challenge or degree of difficulty in obtaining permits from these primary shoreline regulatory agencies is generally moderate to high.

Secondary shoreline regulatory agencies (those that also issue permits, that are typically obtained prior to final authorizations from primary shoreline regulatory agencies), include the USACE, CDFW, RWQCB, CSLC, the City of San Francisco and the Port of San Francisco for in-water and nearshore upland infrastructure. The potential challenge or degree of difficulty in obtaining permits from these agencies is generally low to moderate, except for the RWQCB, which is high due to compliance with the Ocean Plan and Bay Plan water quality standards. On the bay side, substantial interaction with the Port of San Francisco may also be required where they have jurisdiction.

Other upland regulatory jurisdictions that extend from the near-shore area into the interior of the city include various city public works, planning, parks and transportation departments, state parks and historic resource agencies, state and regional transportation and air quality, agencies and various other local stakeholders.

It should be noted that the existing Pump Stations 1 and 2, fireboats, and suction connections for the EFWS do not meet these current requirements. Since the use of seawater intakes to supplement the EFWS will not be a regular, ongoing withdrawal of seawater from either the ocean or the bay, the regulatory agencies may be amenable to relaxation of their normal requirements.

Depending on the preferred course of action, NEPA and CEQA efforts may take 18 to 24 months, and subsequent permitting would take up to 24 months.

Table 4-4: Summary of Prospective EFWS Regulatory Permits and Authorizations

Regulatory Agency	Permit/Agreement Name	Applicable Project Component(s)	Potential Level of Difficulty/Comments
Federal			
USFWS	Section 7 ESA Biological Opinion	Work in terrestrial species habitat	Low in urban environment.
NMFS	NMFS Section 7 ESA Biological Opinion or no adverse effect letter	Work in marine species habitats	Moderate in marine environment.
USACE	Section 10 Rivers & Harbors Act	Work within waters of the U.S. /wetlands	Low given footprint in marine environment
	Section 404 CWA Permit		Low given limited wetlands potentially affected
NPS	Easements	Infrastructure within Park Lands	Moderate
Presidio Trust	Easements	Infrastructure within Trust Lands	Moderate
USCG	Authorization	Structures in navigable waters	Low
State/Regional			
SHPO	Section 106 Consultation	All	Moderate in urban environment
CDFW	CESA Section 2081 Incidental Take Permit	Infrastructure in key habitat	Low in urban environment
	Section 1602 Lake and Streambed Alteration Agreement	Infrastructure in lakes & streambeds	Moderate to Low given footprint in lakes and streams.
SWRCB	Sec 13142.5(b) Ocean Plan Determination	Work within Pacific Ocean	High given Ocean Plan guidance for seawater intake
Caltrans	Encroachment Permits	Pipeline in Route 1	Low
State Parks	Right of Entry	Pipeline crossing State Parks	Low
RWQCB	Section 401 CWA Water Quality Certification (WQC)	Work requiring USACE permit	Moderate given potential discharge volume
	NPDES Construction General Permit	All new construction	Low
CCC	Coastal Development Permit	Work within Coastal Zone	High given Coastal Act or Local Coastal Program policies
BCDC	Development Authorization	Work in bay submerged lands/shorelines	Moderate to High depending on the extent and location
CSLC	State Lands Lease	Work within State (Submerged) Lands	Moderate depending on resource impacts
Regional/Local Approvals			
SF City/County	Coastal Development Permit	Work within City	Low
Port of SF	Lease or Encroachment Permit	Pipeline in Port Jurisdiction	Moderate
BAAQMD	Permits to Construct and Operate	Pump Station(s)	Low
Caltrain/BART	Encroachment Permit	Pipelines	Low

Chapter 5: Seawater Supply Location Considerations

This chapter describes the various geographies that were identified and evaluated to provide a structured assessment of seawater supply opportunities and challenges as part of an expanded EFWS system. The ocean and bay shoreline regions surrounding the city of San Francisco have been divided into five subregions. These shoreline subregions include the Southern Dunes, Rocky Area South, Rocky Area North, North Bayfront, and East Bayfront, as shown in Figure 5-1. Each of these subregions and their general suitability for a new seawater supply facility are described below.

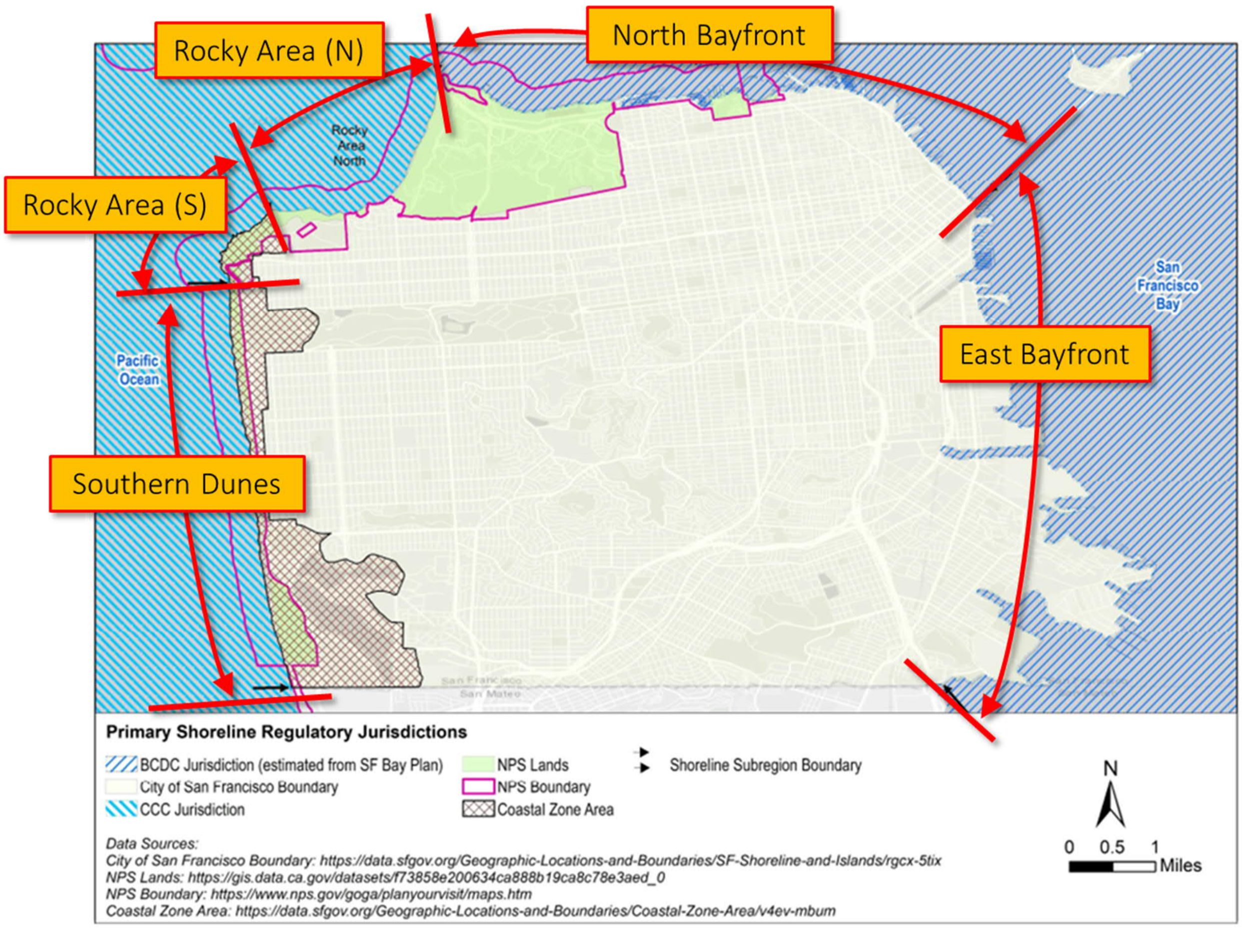


Figure 5-1: San Francisco Subregions Considered for Seawater Supplies to EFWS

5.1 Pacific Ocean Region

The Pacific Ocean region includes the Pacific coastline from the southern city limits near Fort Funston to the Golden Gate Bridge and is the region where the CCC has primary jurisdiction. It is divided into three subregions as described below.

5.1.1 Southern Dunes Subregion

The Southern Dunes subregion includes the area from the city limits near Fort Funston north approximately 4.7 miles to Balboa Street, two blocks north of Golden Gate Park. Figure 5-2 shows the portion of this subregion considered for a new seawater supply facility (circled in purple).

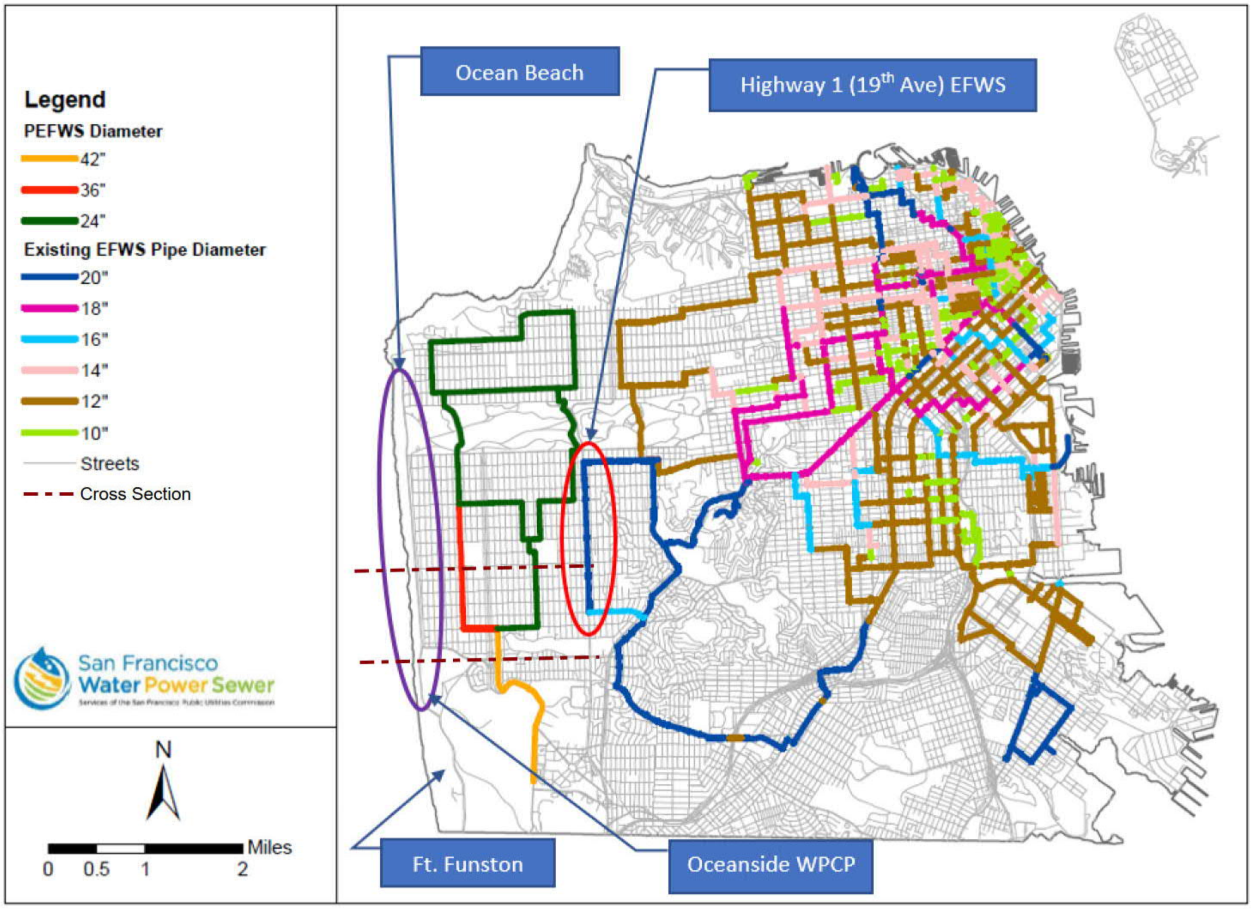


Figure 5-2: Potential Seawater Supply Locations – Southern Dunes Subregion

Near Fort Funston on the southern end, the topography is characterized by sandy cliffs rising sharply from the beach to a bluff upon which remnants of the former fort still sit. The cliffs range in height from approximately 75 to 200 feet above the beach level from north to south. North of Fort Funston, from roughly SFPUC's Oceanside Water Pollution Control Plant (WPCP) to Balboa Street is Ocean Beach, a relatively wide and flat sandy beach with occasional low-lying dunes between it and the Great Highway that runs along its eastern edge. Topographic cross-sections from the ocean inland at two typical locations along Ocean Beach are shown in Figure 5-3 and Figure 5-4. The locations of these cross-sections within the subregion are shown in Figure 5-2.

Figure 5-3: Typical Cross Section – Sloat Boulevard

Figure 5-4: Typical Cross Section – Quintara Street/Sunset Reservoir Area

The Ocean Beach section would be a suitable location for a new seawater supply facility. A preferred location for a seawater pump station should be considered as close as possible to the beach but east of the Great Highway, outside of the jurisdictional limits of the CCC, NPS, and the City's Coastal Zone. Regardless of the pump station location, however, its intake from the ocean would cross land regulated by these agencies, so they will still be involved in the permitting process. Either type of intake (open water or slant wells) is considered feasible within this subregion, although regulatory preferences and/or requirements may lean more towards one type than the other. Both intakes types are discussed in more detail in Chapter 7.

Location will ultimately determine the type of intake that is most feasible from an engineering perspective. On Ocean Beach, slant wells may be the preferred choice up to a certain discharge capacity, but beyond that capacity the sheer number of wells required to produce a desired flow rate may make them impractical and/or cost prohibitive when compared to a single intake tunnel with an onshore pump station.

For example, preliminary estimates of slant well production using publicly available hydrogeologic data for the Pacific coastline in San Francisco indicate that up to 17 slant wells could be required to produce a total flow rate of 50,000 gpm. Cost, access, land requirements, environmental impacts, and permitting may prove challenging for a large number of wells. Flow withdrawals of this magnitude could also have an impact on local groundwater levels on the west side of the city, which could create performance issues for existing municipal water supply wells.

Additional analysis and groundwater modeling using more site-specific data are necessary to develop a more accurate estimate of well production. This analysis generally would be performed during the planning phase and could change the number of wells required at a given site. Regulatory influences may also play a large part in the type of intake selected.

Hydrogeologic characterization of the Pacific Ocean coastline is addressed in Section 7.2.4.

For a seawater supply facility located near Ocean Beach between Sloat Boulevard on the south and Lincoln Way on the north, it is approximately 1.7 miles to the nearest existing EFWS piping in 19th Avenue. Figure 5-2 shows the existing EFWS and planned PEFWS networks within the city and their proximity to this subregion. The EFWS piping is only 20-inch diameter in this area, so it may need to be upsized to accommodate the additional inflow for some distance beyond the connection point. This would need to be evaluated using iterative hydraulic modeling.

5.1.2 Rocky Area South Subregion

The Rocky Area South subregion includes the area from Balboa Street at the north end of Ocean Beach to Point Lobos. Figure 5-5 shows the portion of this subregion considered for a new seawater supply facility (circled in purple).

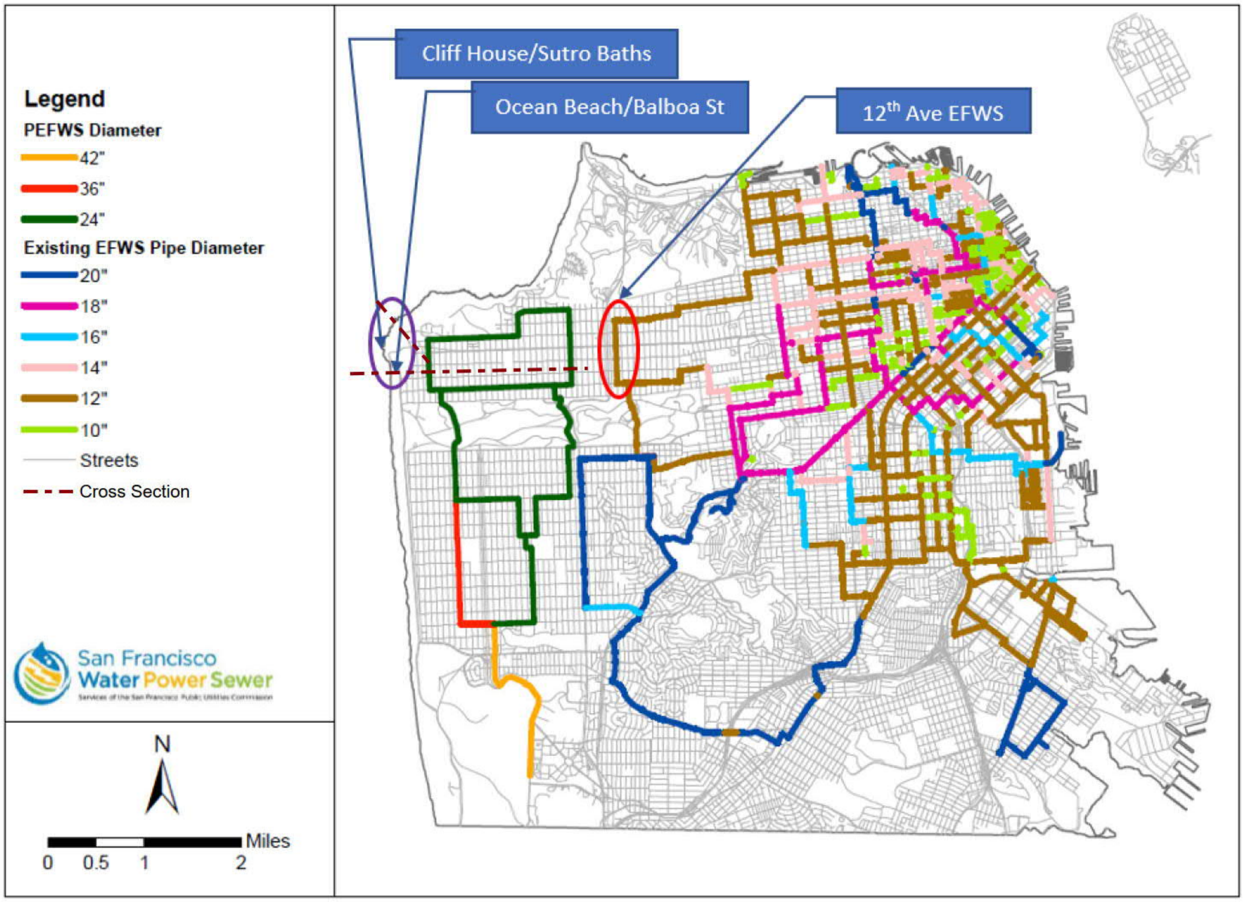


Figure 5-5: Potential Seawater Supply Locations – Rocky Area South Subregion

The topography is primarily characterized by steep, rocky cliffs rising sharply from a narrow, rocky beach to a bluff ranging from approximately 100 to 240 feet above the beach level depending on location. The very southern end of this subregion at Balboa Street may be a potential location for a new seawater supply facility as it still has relatively easy access to Ocean Beach. Siting a pump station anywhere north of this area would be a greater challenge; due to the narrow width of the beach, a pump station would need to be placed on the bluff above the cliffs. Construction access to the beach would also be difficult.

The subsurface geology of the cliffs and bluffs is predominately bedrock, which would limit opportunities for subsurface intakes such as slant wells. An open-water intake tunnel may be possible; the intake tunnel would need to be bored underneath the beach and cliffs and a submerged intake pipe extended horizontally out (or vertically up) into the ocean above the seafloor with screens on the end. A vertical access shaft would also need to be installed at the pump station building on the surface of the bluff. A pump station in this area would sit on federal land managed by the NPS as part of the GGNRA.

Topographic cross-sections from the ocean inland have been developed for two hypothetical locations within this subregion. These are shown in Figure 5-6 and Figure 5-7. The locations of these cross-sections within the subregion are shown in Figure 5-5.

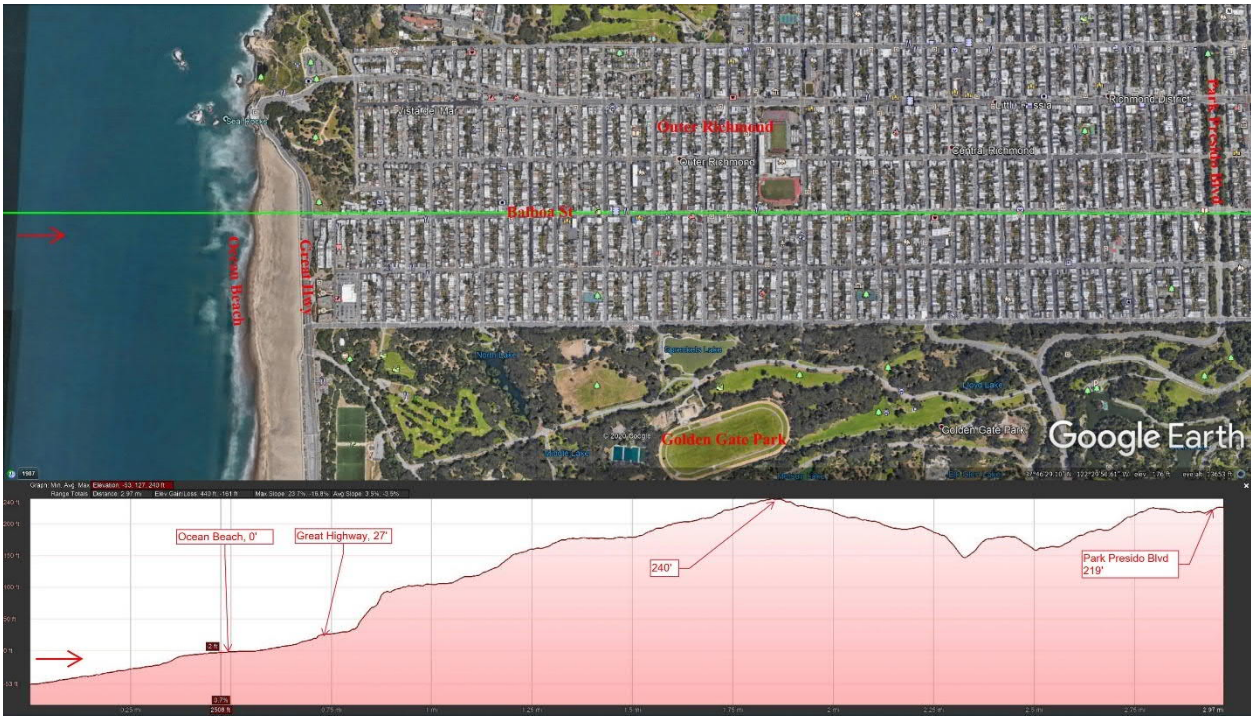


Figure 5-6: Typical Cross Section – Balboa Street

Figure 5-7: Typical Cross Section – Lands End Area

From Balboa Street near Ocean Beach, the distance to the existing EFWS piping in 12th Avenue is approximately 2.2 miles along existing roads. Figure 5-5 shows the existing EFWS and planned PEFWS networks within the city and their proximity to this subregion.

As with the Southern Dunes area, a preferred location for a seawater pump station should be considered as close as possible to the beach but east of the Great Highway, outside of the jurisdictional limits of the CCC, NPS, and the City's Coastal Zone. The existing EFWS piping is only 12-inches in diameter in this vicinity, so it may need to be upsized to accommodate the additional inflow. Assessment of required pipe sizes would need to be evaluated using iterative hydraulic modeling.

Both subsurface and open water intakes are considered feasible at this location. It may not be feasible or desirable to use slant wells if the desired total discharge capacity is over 30,000 gpm. Based on preliminary hydrogeologic desktop analysis of the area, it is estimated that up to 10 slant wells may be required to produce a total flow rate of this magnitude at Ocean Beach; even more wells would be required for larger capacities.

5.1.3 Rocky Area North Subregion

The Rocky Area North subregion includes the area from Point Lobos to the Golden Gate Bridge. Figure 5-8 shows the portion of this subregion considered for a new seawater supply facility (circled in purple).

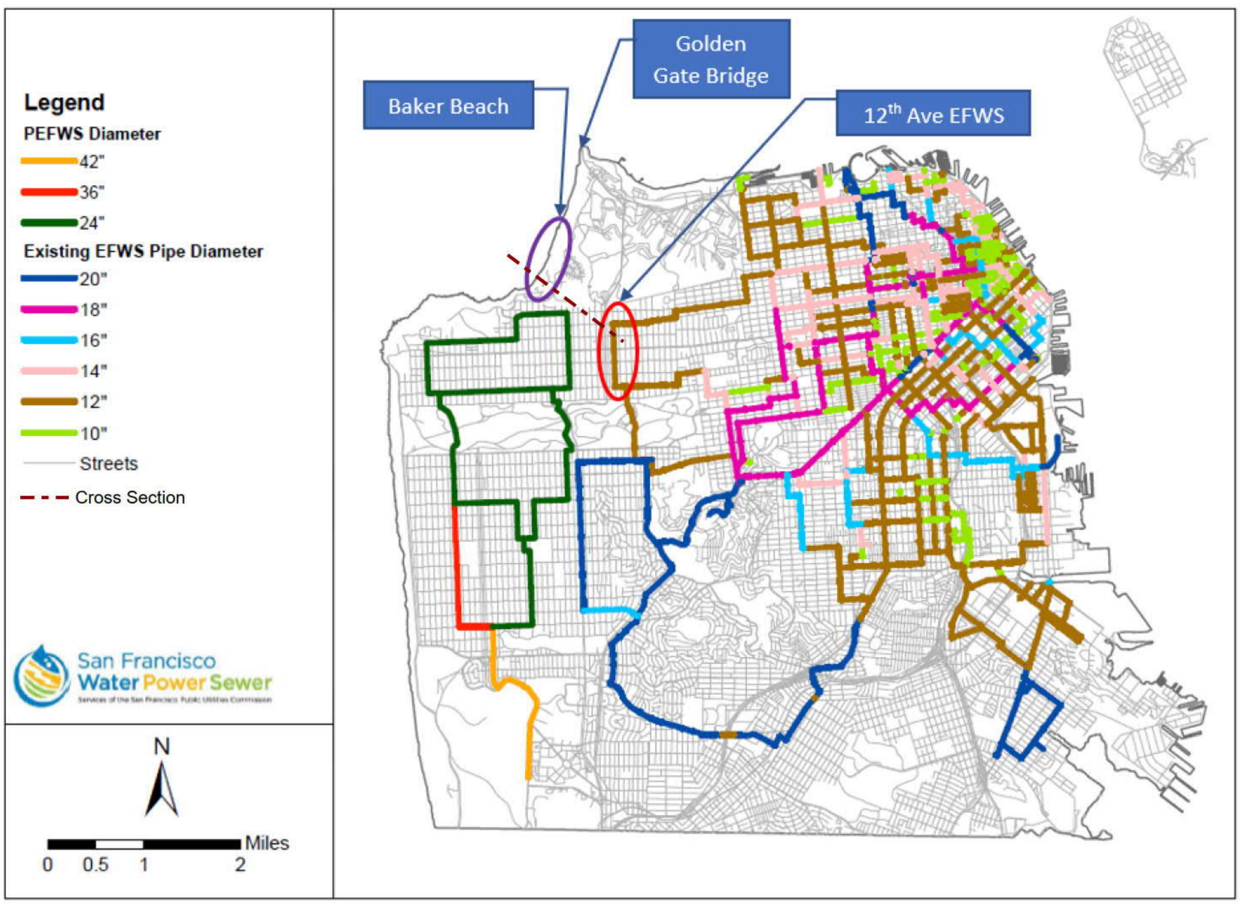


Figure 5-8: Potential Seawater Supply Locations – Rocky Area North Subregion

Like the Rocky Area South subregion, much of the topography is characterized by steep, rocky cliffs rising sharply from a narrow, rocky beach to a bluff ranging from approximately 100 to 250 feet above the beach level depending on location. However, approximately one-quarter of this subregion also includes Baker Beach, a wide, gently sloping sandy beach at the foot of milder hillside slopes that rise approximately 100 to 150 feet from the beach to the bluff above. A topographic cross-section from the ocean inland at Baker Beach is shown in Figure 5-9.

Figure 5-9: Typical Cross Section – Baker Beach Area

Baker Beach may be a feasible location for a new seawater supply facility. From this area, the nearest connection point to the existing EFWS network in 12th Avenue is approximately 1.5 miles along existing roads. Figure 5-8 shows the existing EFWS and planned PEFWS networks within the city and their proximity to this subregion. The EFWS piping is only 12-inches in diameter at this location, so it may need to be upsized to accommodate the additional inflow from the facility.

Both slant wells and an open-water intake tunnel are considered feasible at Baker Beach. Outside of the Baker Beach area the subsurface geology is like that in the Rocky Area South subregion, predominately bedrock. As such, only an open-water intake tunnel would be considered feasible, installed in the same manner and under the same conditions as one in the Rocky Area North subregion. A seawater pump station built at Baker Beach or in the bluff area of this subregion would also sit on federal land managed by the NPS or Presidio Trust as part of the GGNRA.

5.2 San Francisco Bay Region

The San Francisco Bay region includes the San Francisco Bay shoreline from the Golden Gate Bridge to the southern city limits near Candlestick Point as shown in Figure 5-1, and is the region where BCDC has primary regulatory jurisdiction. It is divided into two subregions as described below.

5.2.1 North Bayfront Subregion

The North Bayfront subregion includes the area from the Golden Gate Bridge to the Bay Bridge. Figure 5-10 shows the portion of this subregion considered for a new seawater supply facility (circled in purple).

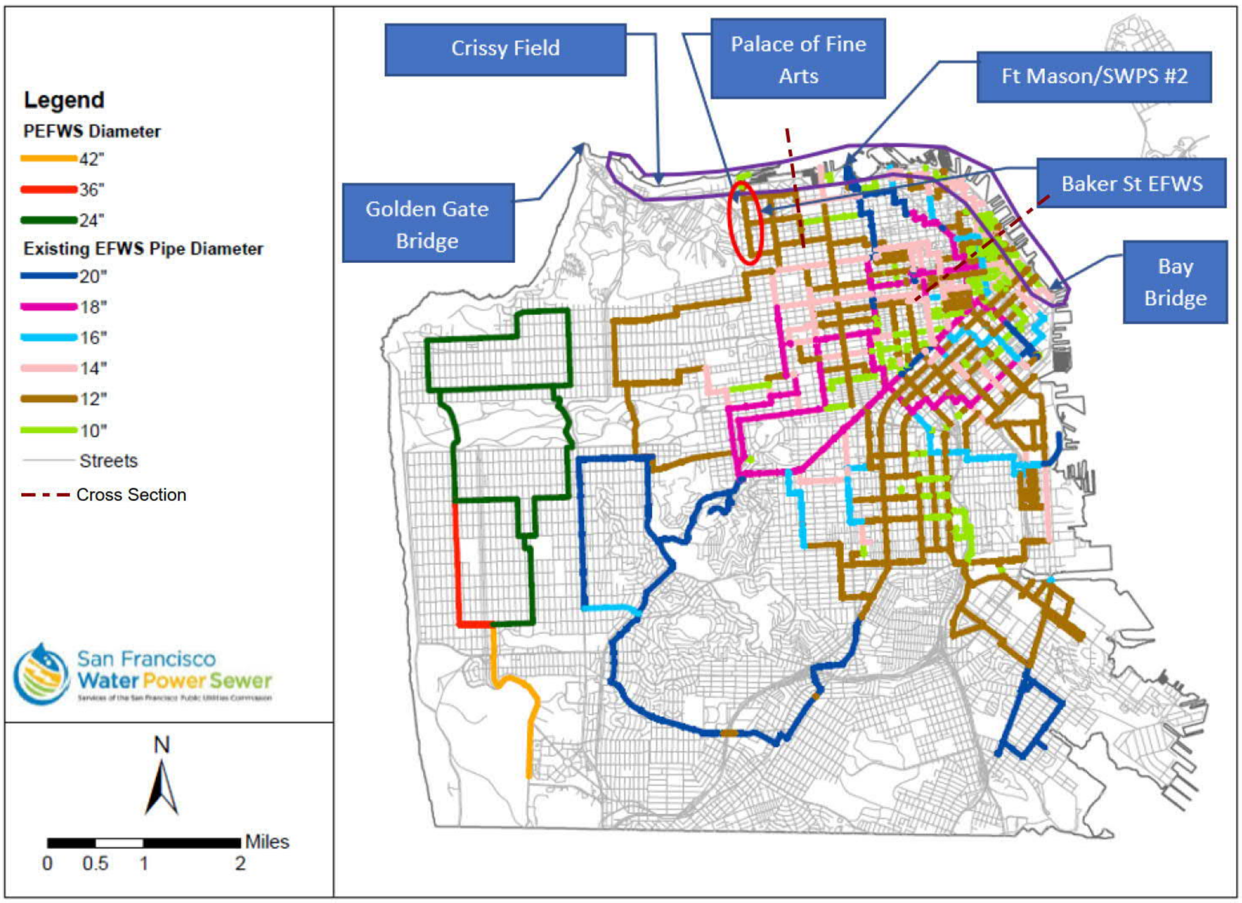


Figure 5-10: Potential Seawater Supply Locations – North Bayfront Subregion

The topography is characterized by having moderately steep, rocky cliffs rising from a narrow, rocky beach from the Golden Gate Bridge east to Crissy Field; relatively wide, flat beaches and open ground along Crissy Field to the San Francisco Marina; open ground with armored, rocky shoreline through the marina to Fort Mason; then predominately urban waterfront along the remainder of the subregion through Aquatic Park, Fisherman's Wharf, and along The Embarcadero to the Bay Bridge, with multiple piers extending out into the bay.

Existing Seawater Pump Station No. 2 is located within this subregion near the northeast corner of Fort Mason at the north end of Van Ness Avenue, adjacent to Aquatic Park. Topographic cross-sections from the bay inland have been developed for two typical locations within this subregion, as shown in Figure 5-11 and Figure 5-12.

Almost anywhere within this subregion from Crissy Field eastward could be a potential location for a new seawater supply facility. Figure 5-10 shows the existing EFWS and planned PEFWS networks within the city and their proximity to this subregion.

A preferred location for a new seawater pump station should be considered as close as possible to the shoreline but outside of the 100-foot upland jurisdictional limits of the BCDC, the primary regulatory agency for actions within San Francisco Bay. Regardless of the pump station location, its intake from the bay would cross land regulated by the BCDC, so that entity will still be involved in the permitting process. In addition, a seawater supply facility located in the area from Crissy Field west to the Golden Gate Bridge would sit on federal land managed by the NPS or Presidio Trust as part of the GGNRA, so these two Federal agencies would be involved in this area.

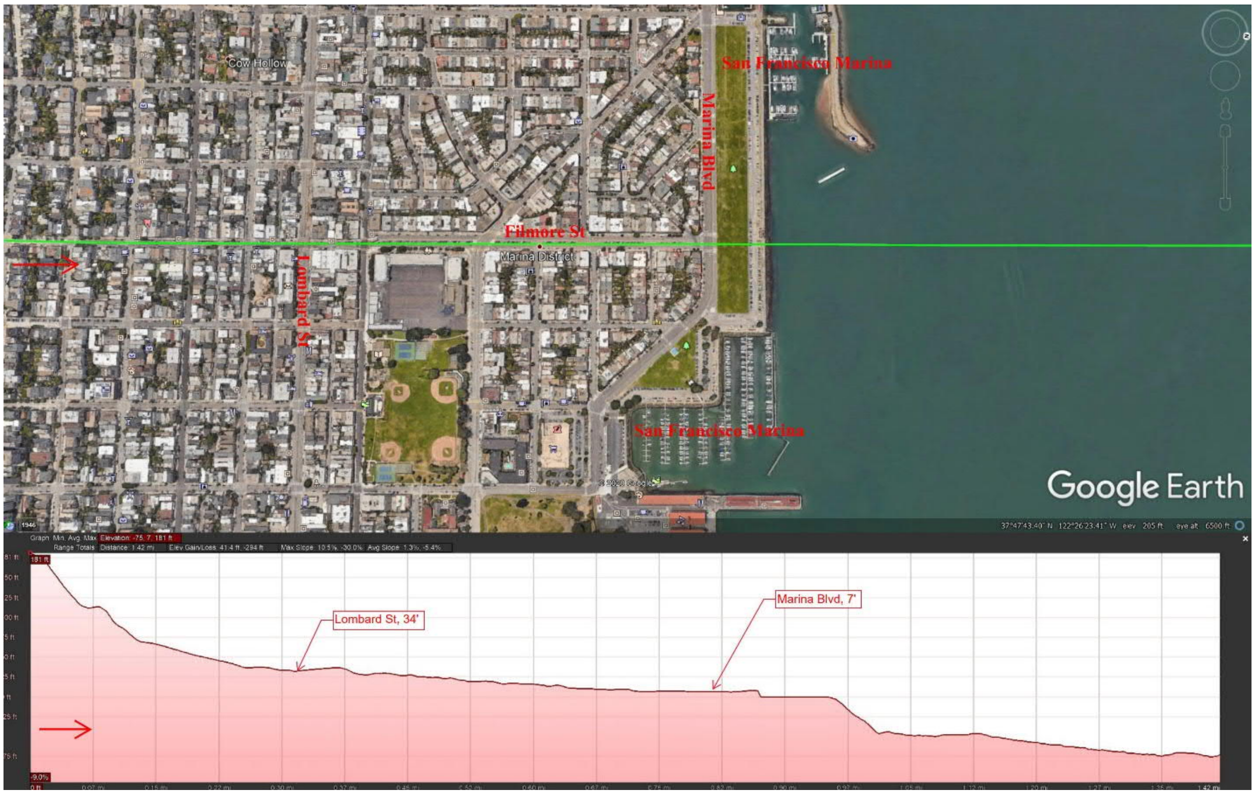


Figure 5-11: Typical Cross Section – Filmore Street

Figure 5-12: Typical Cross Section – Pier 9 Area

For a seawater supply facility located at Crissy Field, the nearest existing EFWS piping is in Baker Street near the Palace of Fine Arts, approximately 500 feet to 1.3 miles away along existing roads, depending on the site. This existing EFWS piping in this area is only 12-inch diameter. For the remainder of this subregion, the distance from the shoreline to the existing EFWS network is only a few hundred feet or less. The majority of the existing EFWS piping in this area is 10 or 14 inches in diameter, as shown in Figure 5-10.

As with the existing EFWS piping on the west side of the city, all EFWS piping in the vicinity of the connection point(s) may need to be upsized for some distance to accommodate the inflow from a new seawater supply facility.

Only an open-water intake is considered feasible along the bay, in either subregion. This is due primarily to the silty bottom of the bay which could severely limit the production of a slant well due to poor permeability. The BCDC also finds subsurface intake systems to be infeasible and prefers open-water intakes, so permitting a slant well in this area would be a significant challenge if pursued. Locating enough vacant land to construct multiple slant well arrays could also present a serious challenge.

5.2.2 East Bayfront Subregion

The East Bayfront subregion includes the area from the Bay Bridge south to the city limits near Candlestick Point. Figure 5-13 shows the portion of this subregion considered for a new seawater supply facility (circled in purple).

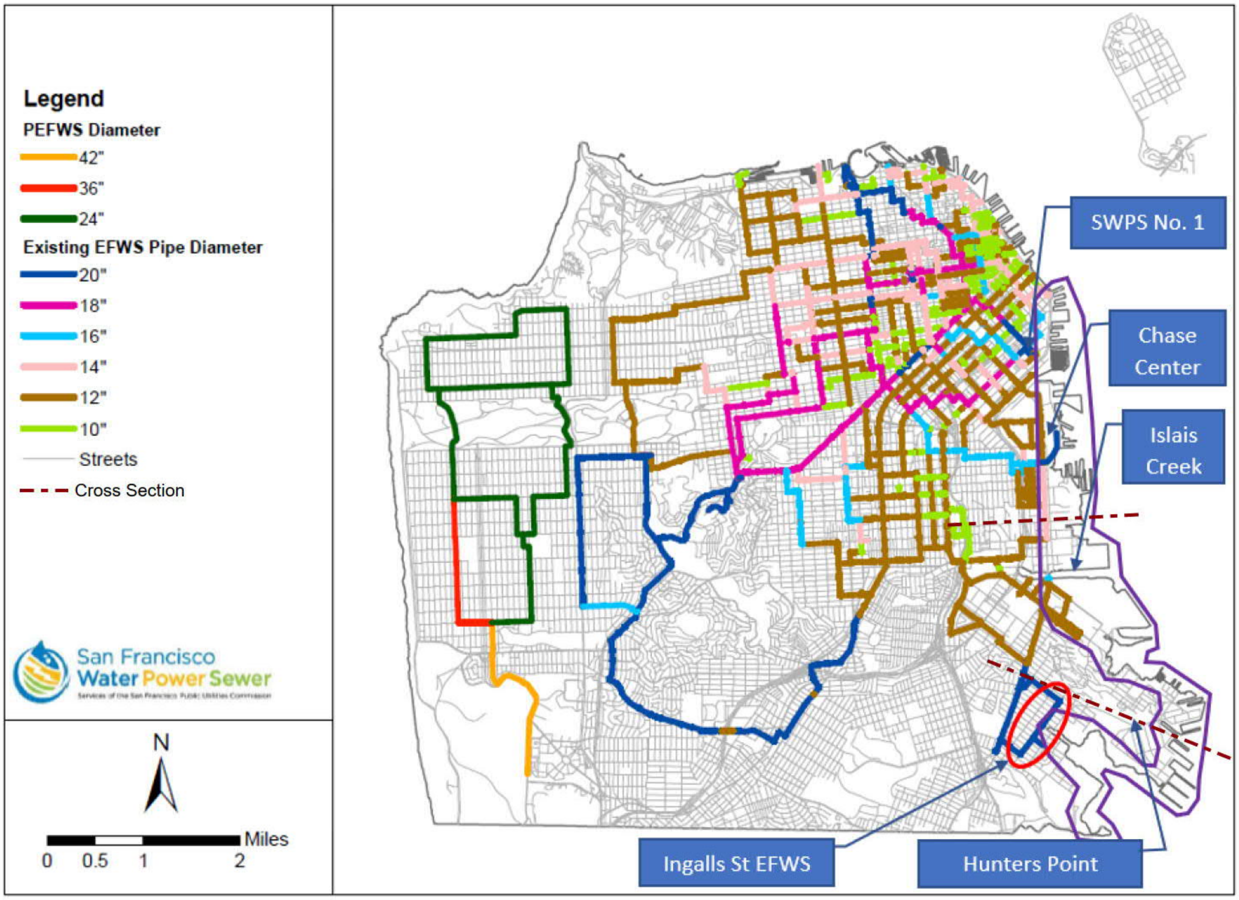


Figure 5-13: Potential Seawater Supply Locations – East Bayfront Subregion

The topography is like the North Bayfront subregion and is characterized as predominately urban and former heavy industrial waterfront. Most of the shoreline, especially on the southern end near Hunters Point and Candlestick Point, has been expanded outward into the bay over time from its original boundaries using fill material placed on top of bay mud.

Existing Seawater Pump Station No. 1 is located within this subregion underneath the SFFD Headquarters Building on the southwest corner of Townsend Street and 2nd Street. Topographic cross-sections from the bay inland have been developed for two typical locations within this subregion, as shown in Figure 5-14 and Figure 5-15.

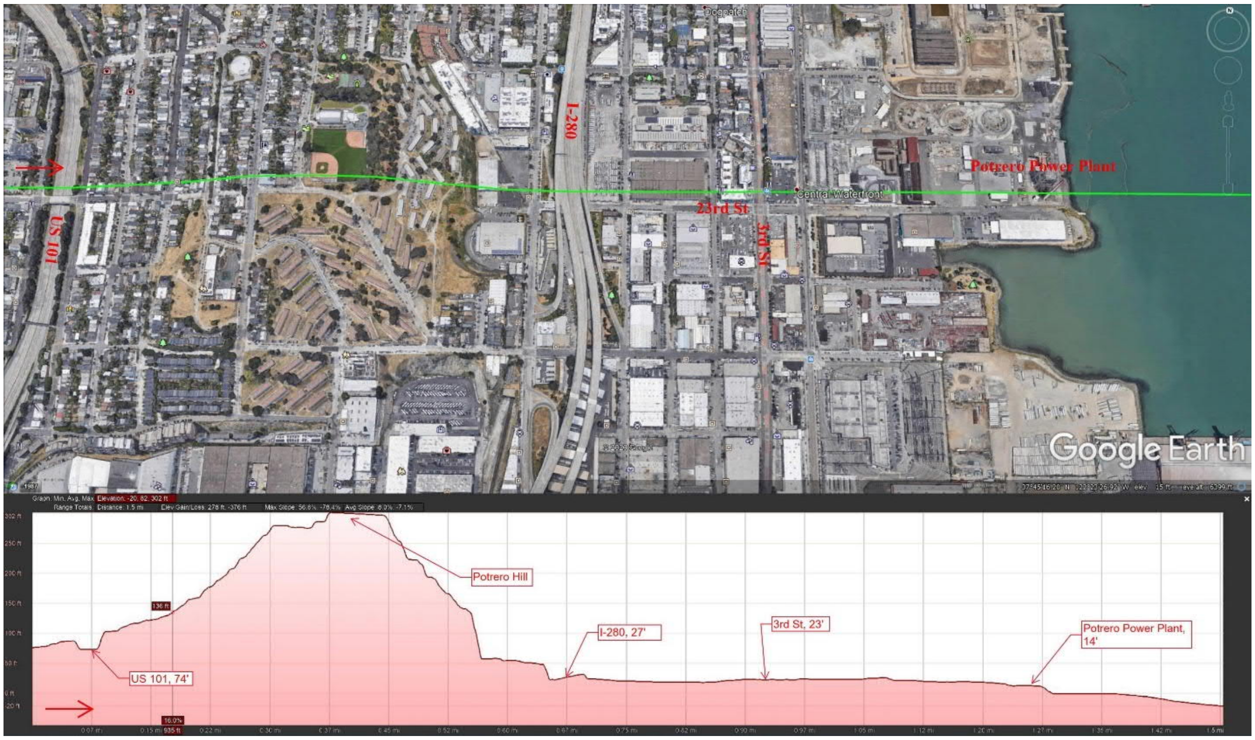


Figure 5-14: Typical Cross Section – 23rd Street/Potrero Power Station Area

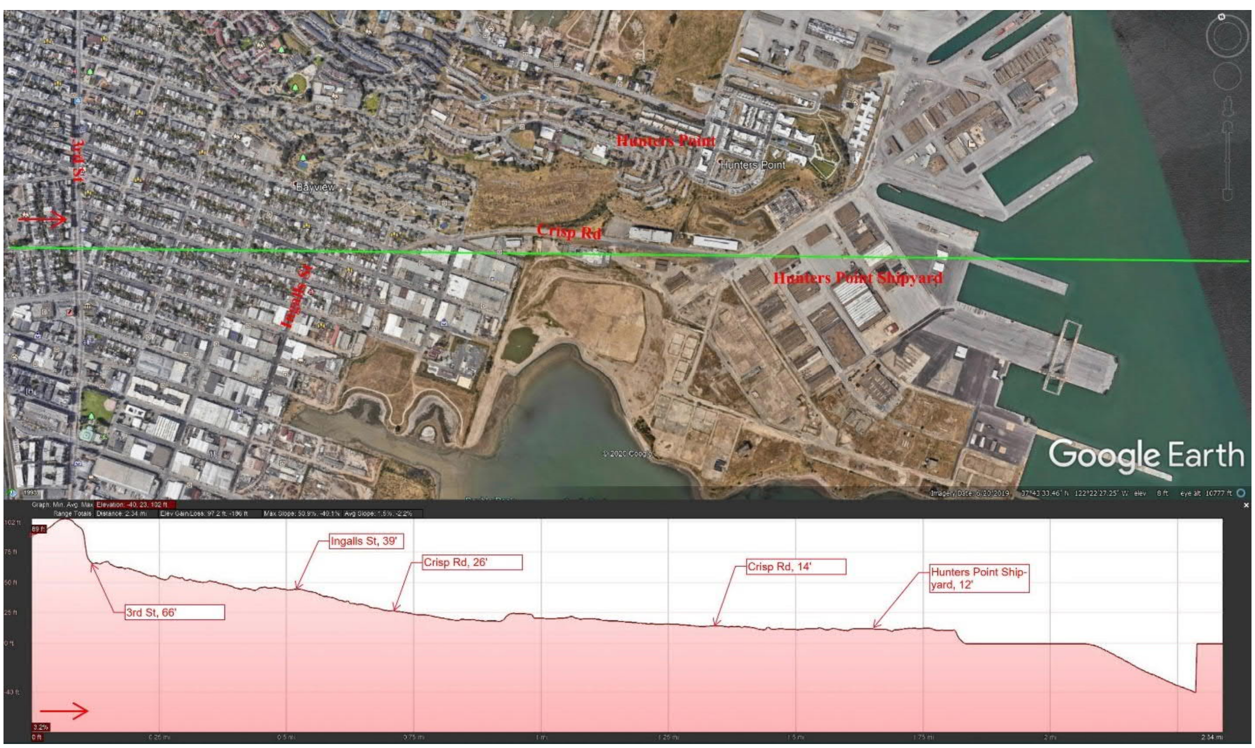


Figure 5-15: Typical Cross Section – Hunters Point Area

Almost anywhere within this subregion could be a potential location for a new seawater pump station. Figure 5-13 shows the existing EFWS and planned PEFWS networks within the city and their proximity to this subregion. It may not be quite as challenging to find available land to construct a new pump station in this subregion compared to the North Bayfront subregion. A preferred location should again be considered as close as possible to the shoreline but outside of the jurisdictional limits of the BCDC. Regardless of the pump station location, its intake from the bay would cross land regulated by the BCDC, so that entity will still be involved in the permitting process.

Much future redevelopment is planned for the Hunters Point and Candlestick Point areas, so it may make sense to locate at least one pump station in this vicinity to provide an additional firefighting water supply to service this growth.

The distance from the shoreline to the nearest existing EFWS piping varies greatly depending on location. In the area from the Bay Bridge south to Islais Creek, existing EFWS piping ranges from approximately 500 feet to 2,000 feet from the shoreline, with the distance generally increasing as one moves farther south. Most of the existing EFWS piping in this area is either 12 or 14 inches in diameter, with a few sections of 16- and 20-inch pipe near PS 1 and the Chase Center.

South of Islais Creek in the Hunters Point and Candlestick Point areas, the nearest existing EFWS piping varies from approximately 500 feet to 1.5 miles from the shoreline depending on location. This pipe is either 12 or 20 inches in diameter. The existing 20-inch EFWS pipe in Ingalls Street would be a likely connection point in this area due to its larger size and capacity.

The existing EFWS piping may need to be upsized near the connection point(s) and for some distance beyond to accommodate the additional inflow from a new seawater supply source. As with the other subregions, this would need to be evaluated by performing iterative hydraulic modeling on the EFWS network.

Chapter 6: Pump Station Concepts

This chapter presents existing engineering and operational aspects of the EFWS and prospective engineering design opportunities and challenges for a new pump station(s) in any of the five subregions analyzed.

6.1 Overview

New seawater pump stations, regardless of whether located at the Pacific Ocean or San Francisco Bay shoreline, would be anticipated to only tie into the existing high pressure EFWS network to provide additional water supply after a major seismic event.

Although it is supplied with potable water, the existing EFWS is considered a non-potable system. After use with seawater supplied by new (or the existing) pump stations, it is anticipated that the EFWS lines would need to be thoroughly flushed with potable water (or recycled water, if available) to expel the corrosive seawater from the pipe network.

It is anticipated that any new seawater pump stations will not connect to the future PEFWS network, which will contain potable water. The PEFWS will be designed with enough capacity to meet the projected post-large earthquake firefighting water demands and targeted supply reliability goals within the eight FRAs it will support on the west side of the city.

One or two large regional seawater pump stations could be constructed to meet the required demands, or multiple smaller pump stations could be built at strategic locations, as shown in Figure 6-1. An advantage of having multiple small pump stations would be the inherent redundancy of having distributed facilities.

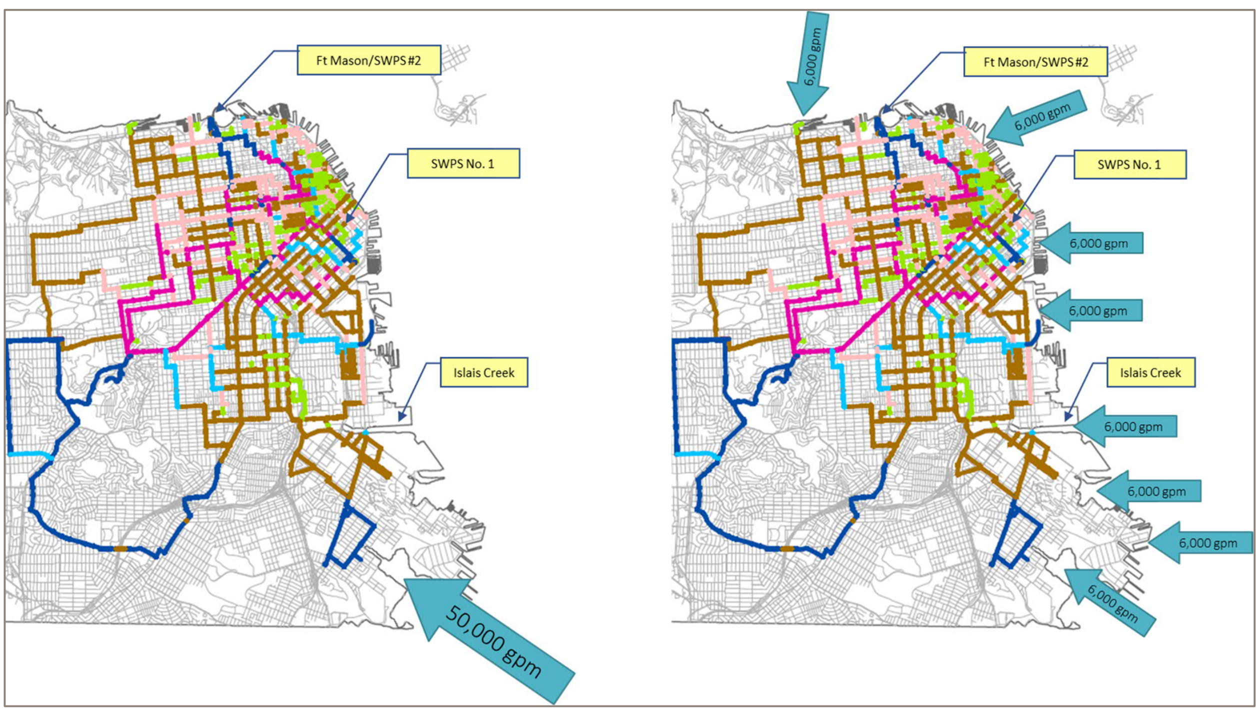


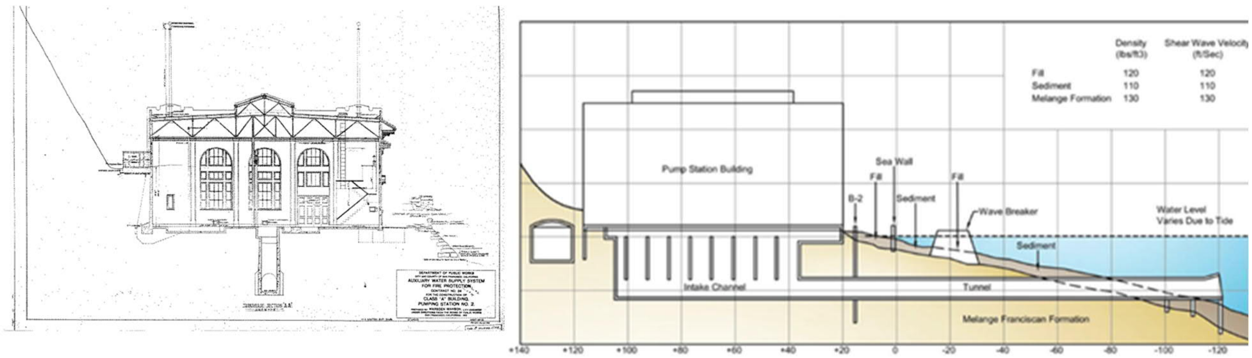
Figure 6-1: Single Large Pump Station vs. Multiple Smaller Pump Stations

Multiple smaller facilities would reduce the impact on the existing EFWS network by requiring less local "upsizing" of existing pipe due to smaller inflows; provide more flexibility by allowing the placement of pump stations close to FRAs with higher projected demands; and spread out the seawater inflows over a wider portion of the EFWS network.

Multiple pump stations are expected to cost more in total than one large pump station to provide the same total flow rates, and each would likely need to be permitted separately, possibly increasing the overall environmental and permitting level of effort (and cost) significantly.

6.2 General Configurations

New seawater pump stations could have general layouts and configurations like the existing PS1 and PS2 (which makes sense for large flow capacities), as shown in Figure 6-2, but could also have smaller configurations, similar to those used for the SFPUC Groundwater Supply Project, as shown in Figure 6-3.



Source: SFPUC Record Drawing *Source: AECOM/AGS (2013b)*

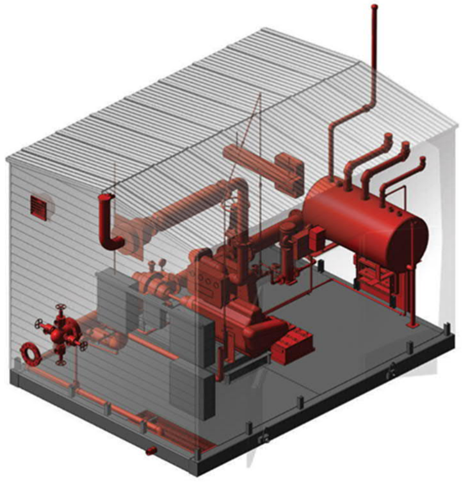
Figure 6-2: Existing Stormwater Pump Station 2

Source: http://www.sfwater.org/sfgroundwater

Figure 6-3: Existing Groundwater Supply Pump Station Buildings

Another option for new seawater pump stations could be the use of prefabricated or "package" pump systems, which can fit in the footprint of a semi-truck trailer. These can be configured for either open-air or enclosed applications, as shown in Figure 6-4.

Source: www.pattersonpumps.com



Source: www.armstrongintegrated.com

Figure 6-4: Examples of Package Pump Systems

6.3 Design Parameters

Preliminary design considerations have been developed for new seawater pump stations located within the five subregions of shoreline defined for this Study. These design considerations are listed in Table 6-1 and discussed in the sections below.

Information is included for pump station capacities ranging from 3,000 to 50,000 gpm. Appendix D shows conceptual layouts of seawater pump stations of these capacities.

For this study, it is assumed that one standby pump will be provided for redundancy for pump station capacities of 10,000 gpm and above. For 3,000 and 6,000 gpm capacity pump stations, it is assumed that no standby pumps will be provided.

For pump station capacities ranging from 20,000 gpm to 50,000 gpm, it is assumed that each individual pump has a capacity of 10,000 gpm, so the total capacity of the station can be increased by simply adding additional pumps (*i.e.*, a 40,000-gpm pump station has four primary duty pumps and one standby pump). For a 10,000 gpm capacity pump station, two 5,000 gpm pumps are assumed to be provided, while for 3,000 and 6,000 gpm capacity pump stations, only a single pump is assumed to be provided.

For this study, all pumps are assumed to be equipped with diesel engines as their primary driver. A small emergency generator would be provided to run the necessary electrical, communications, and security equipment at the pump station in event of a power outage following a large earthquake. Alternatively, the pumps could be equipped with electric motors with a larger diesel-powered generator to maintain operability during a power outage.

In addition to the information presented in Table 6-1, a summary of the existing geotechnical and geologic/seismic conditions and related hazards that could potentially be encountered at seawater pump stations within each subregion are presented in the sections below. A brief discussion of the potential future impacts of ongoing sea level rise near the shorelines is also included.

Table 6-1: Seawater Pump Station Preliminary Design Considerations

		Pump Station Design Considerations by Subregion					Existing Seawater Pump Stations	
	Subregion	Ocean/Southern Dunes	Ocean/Rocky Area South	Ocean/Rocky Area North	SF Bay/North Bayfront	SF Bay/East Bayfront	SWPS No. 1	SWPS No. 2
	General Parameters							
	Normal EFWS Connection Pressure (pounds per square inch, psi)[11]	200	143	143	160	160	160	160
	Max. EFWS Connection Pressure (psi)[12]	200	234	268	328	328	328	328
	Min. Distance from Shore to High Pressure EFWS (mi)[3]	1.70	2.20	1.50	0.05	0.15 to 1.50	0.02	0.15
	Diameter of High Pressure EFWS Piping @ Closest Tie-In Inches (in.)	20	12	12	10 to 14	12 to 20	20	20
	Water Quality	Ocean	Ocean	Ocean	Bay	Bay	Bay	Bay
	Connection to Potable EFWS	Possible[1]	Possible[1]	Possible[1]	No	No	No	No
	Potential Intake Types	Slant Well(s)/Open Water	Slant Well(s)/Open Water	Slant Well(s)/Open Water	Open Water[6]	Open Water[6]	Open Water	Open Water
	Frequency of Use[2,4]	After EQ only	After EQ only	After EQ only	After EQ only[4]	After EQ only[4]	After EQ only[4]	After EQ only[4]
	Flush EFWS Piping After Use	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Discharge Requirements vs. Capacity							
3,000 gpm	Discharge Pressure (psi)[5]	345 (or 344)	432 (or 404)	445 (or 464)	375 (or 374)	381 to 418	N/A	N/A
3,000 gpm	Discharge Pipe Inside Diameter (ID) (in.)[9,10]	18 (or 2X14)	14 (or 2X12)	14 (or 2X10)	12 (or 2X10)	12/14	N/A	N/A
3,000 gpm	Flow Velocity (fps)	3.73 (or 3.09)	6.17 (or 4.2)	6.17 (or 6.05)	8.4 (or 6.05)	8.4/6.17	N/A	N/A
3,000 gpm	Total Hydraulic Power (megawatts, MW)[13]	0.45	0.56	0.57	0.48	0.49 to 0.54	N/A	N/A
3,000 gpm	Hydraulic Power per Pump (MW)[14]	0.45	0.56	0.57	0.48	0.49 to 0.54	N/A	N/A
3,000 gpm	Hydraulic Power at EFWS Connection (MW)[15]	0.26	0.30	0.35	0.42	0.42	N/A	N/A
6,00	Discharge Pressure (psi)[5]	344 (or 345)	436 (or 432)	447 (or 445)	373 (or 373)	381 to 421	N/A	N/A

		Pump Station Design Considerations by Subregion					Existing Seawater Pump Stations	
	Subregion	Ocean/Southern Dunes	Ocean/Rocky Area South	Ocean/Rocky Area North	SF Bay/North Bayfront	SF Bay/East Bayfront	SWPS No. 1	SWPS No. 2
	Discharge Pipe ID (in.)[9,10]	24 (or 2X18)	18 (or 2X14)	18 (or 2X14)	18 (or 2X14)	16/18	N/A	N/A
	Flow Velocity (fps)	4.2 (or 3.73)	7.47 (or 6.17)	7.47 (or 6.17)	7.47 (or 6.17)	9.45/7.47	N/A	N/A
	Total Hydraulic Power (MW)[13]	0.89	1.12	1.15	0.96	0.98 to 1.08	N/A	N/A
	Hydraulic Power per Pump (MW)[14]	0.89	1.12	1.15	0.96	0.98 to 1.08	N/A	N/A
	Hydraulic Power at EFWS Connection (MW)[15]	0.52	0.60	0.69	0.85	0.85	N/A	N/A
10,000 gpm[8]	Discharge Pressure (psi)[5,7]	342 (or 340)	410 (or 416)	474 (or 461)	374 (or 374)	380 to 403	291	293
	Discharge Pipe ID (in.)[9,10]	30 (or 2x24)	24 (or 2x18)	20 (or 2x16)	20 (or 2x16)	20/24	2x20	2x20
	Flow Velocity (fps)	4.48 (or 3.50)	7.00 (or 6.22)	10.08 (or 7.88)	10.08 (or 7.88)	10.08/7.00	5.45	5.45
	Total Hydraulic Power (MW)[13]	1.47	1.76	2.04	1.61	1.63 to 1.73	1.35	1.36
	Hydraulic Power per Pump (MW)[14]	0.74	0.88	1.02	0.80	0.82 to 0.86	0.34	0.34
	Hydraulic Power at EFWS Connection (MW)[15]	0.86	1.01	1.15	1.41	1.41	0.74	0.74
20,000 gpm	Discharge Pressure (psi)[5]	348 (or 342)	420 (or 410)	436 (or 474)	373 (or 375)	374 to 387 (or 375 to 403)	N/A	N/A
	Discharge Pipe ID (in.)[9,10]	36 (or 2x30)	30 (or 2x24)	30 (or 2x20)	30 (or 2x20)	36 (or 2x24)	N/A	N/A
	Flow Velocity (fps)	6.22 (or 4.48)	8.96 (or 7.00)	8.96 (or 10.08)	8.96 (or 10.08)	6.22 (or 7.00)	N/A	N/A
	Total Hydraulic Power (MW)[13]	2.99	3.61	3.75	3.21	3.21 to 3.33	N/A	N/A
	Hydraulic Power per Pump (MW)[14]	1.50	1.80	1.87	1.60	1.60 to 1.66	N/A	N/A
	Hydraulic Power at EFWS Connection (MW)[15]	1.72	2.01	2.30	2.82	2.82	N/A	N/A
30,000 gpm	Discharge Pressure (psi)[5]	348 (or 355)	413 (or 397)	432 (or 465)	373 (or 374)	375 to 405 (or 379 to 438)	N/A	N/A
	Discharge Pipe ID (in.)[9,10]	42 (or 2x30)	36 (or 2x30)	36 (or 2x24)	36 (or 2x24)	36 (or 2x24)	N/A	N/A
	Flow Velocity (fps)	6.86 (or 6.72)	9.34 (or 6.72)	9.34 (or 10.50)	9.34 (or 10.50)	9.34 (or 10.50)	N/A	N/A

	Subregion	Pump Station Design Considerations by Subregion					Existing Seawater Pump Stations	
		Ocean/Southern Dunes	Ocean/Rocky Area South	Ocean/Rocky Area North	SF Bay/North Bayfront	SF Bay/East Bayfront	SWPS No. 1	SWPS No. 2
	Total Hydraulic Power (MW)[13]	4.48	5.32	5.56	4.81	4.83 to 5.22	N/A	N/A
	Hydraulic Power per Pump (MW)[14]	1.49	1.77	1.85	1.60	1.61 to 1.74	N/A	N/A
	Hydraulic Power at EFWS Connection (MW)[15]	2.58	3.02	3.45	4.23	4.23	N/A	N/A
40,000 gpm	Discharge Pressure (psi)[5]	346 (or 348)	403 (or 420)	425 (or 437)	373 (or 373)	375 to 398 (or 376 to 410)	N/A	N/A
	Discharge Pipe ID (in.)[9,10]	48 (or 2x36)	42 (or 2x30)	42 (or 2x30)	42 (or 2x30)	42 (or 2x30)	N/A	N/A
	Flow Velocity (fps)	7.00 (or 6.22)	9.15 (or 8.96)	9.15 (or 8.96)	9.15 (or 8.96)	9.15 (or 8.96)	N/A	N/A
	Total Hydraulic Power (MW)[13]	5.94	6.93	7.30	6.40	6.44 to 6.84	N/A	N/A
	Hydraulic Power per Pump (MW)[14]	1.49	1.73	1.83	1.60	1.61 to 1.71	N/A	N/A
	Hydraulic Power at EFWS Connection (MW)[15]	3.44	4.02	4.60	5.64	5.64	N/A	N/A
50,000 gpm	Discharge Pressure (psi)[5]	344 (or 343)	395 (or 399)	419 (or 422)	373 (or 373)	374 to 393 (or 374 to 395)	N/A	N/A
	Discharge Pipe ID (in.)[9,10]	54 (or 2x42)	48 (or 2x36)	48 (or 2x36)	48 (or 2x36)	48 (or 2x36)	N/A	N/A
	Flow Velocity (fps)	6.92 (or 5.72)	8.75 (or 7.78)	8.75 (or 7.78)	8.75 (or 7.78)	8.75 (or 7.78)	N/A	N/A
	Total Hydraulic Power (MW)[13]	7.38	8.49	9.01	8.00	8.03 to 8.43	N/A	N/A
	Hydraulic Power per Pump (MW)[14]	1.48	1.70	1.80	1.60	1.61 to 1.69	N/A	N/A
	Hydraulic Power at EFWS Connection (MW)[15]	4.30	5.03	5.76	7.04	7.04	N/A	N/A

Notes:

1. Could connect to new PEFWS on west side of City (shorter distances), but this would preclude connecting to high pressure EFWS, which PEFWS will not connect to.
2. Assume also operate/test at least monthly to exercise pumps/appurtenances and ensure proper operation. Assume discharge of seawater back to source via test/recirculation piping.
3. Distances are approximate for a pump station located at or near the shoreline within each region. Also assumed 300 ft elevation increase from shore to high pressure EFWS connection points in Pacific Ocean region, 100 ft elevation increase in San Francisco Bay region.
4. Could also use for multiple alarm fires but would need to flush high pressure EFWS piping afterwards with potable (or possibly recycled) water.
5. Assume all piping is welded steel pipe with a maximum allowed pressure of 475 psi.
6. Slant wells generally not considered feasible due to silty bottom of SF Bay and regulatory challenges.

		Pump Station Design Considerations by Subregion					Existing Seawater Pump Stations	
	Subregion	Ocean/Southern Dunes	Ocean/Rocky Area South	Ocean/Rocky Area North	SF Bay/North Bayfront	SF Bay/East Bayfront	SWPS No. 1	SWPS No. 2

7. Actual design discharge pressure for existing SWPS No. 1 and 2 is 300 psi.
8. Actual capacity of existing SWPS No. 1 and 2 is 10,800 gpm (4 pumps @ 2,700 gpm each).
9. Required discharge pipe size for single (or dual) discharge pipes. Corresponding required discharge pressure and flow velocity for dual discharge pipes shown in parenthesis.
10. Existing SWPS No. 1 and No. 2 both have dual 20" diameter discharge pipes.
11. Typical normal static EFWS connection pressure when piping in each zone (Lower, Upper, Twin Peaks) is supplied by its assigned reservoir (Jones St, Ashbury, Twin Peaks). Actual static pressure will depend on the connection location and elevation and could vary widely.
12. Typical maximum static EFWS connection pressure when all zones are supplied by Twin Peaks Reservoir. Actual maximum static pressure will depend on the connection location and elevation and could vary widely.
13. Required total hydraulic power output of pump station. Determined assuming all zones are supplied by Twin Peaks Reservoir.
14. Total hydraulic power/# of primary duty pumps. Assumed capacity of one pump per 10,000 gpm except for 10,000 gpm capacity pump station, which assumes two 5,000 gpm pumps. Only one pump assumed for 3,000 and 6,000 gpm capacity stations.
15. Hydraulic power at nearest connection to high pressure EFWS assuming all zones are supplied by Twin Peaks Reservoir.
16. Assume recirculation/test piping is same diameter as discharge piping (for discharges back to Ocean or SF Bay).

Subregion within Twin Peaks Zone, EFWS piping normally supplied from Twin Peaks Reservoir (10.5 million-gallon (MG) capacity, max. water surface elevation (WSE) = 758 ft.).
Subregion within Upper Zone, EFWS piping normally supplied from Ashbury Tank (0.5 MG capacity, max. WSE = 494 ft.).
Subregion within Lower Zone, EFWS piping normally supplied from Jones St. Tank (0.75 MG capacity, max. WSE = 369 ft.).

6.4 Pacific Ocean Region

This section provides a discussion of the preliminary engineering design considerations and other select topics for a future seawater pump station or multiple pump stations located along the Pacific Ocean coastline in San Francisco. This includes the Southern Dunes, Rocky Area South, and Rocky Area North subregions as shown in Figure 5-1.

6.4.1 Engineering Considerations

6.4.1.1 Southern Dunes Subregion

This subregion was described previously in Section 5.1.1. A seawater pump station located anywhere along Ocean Beach is anticipated to have the same or very similar geotechnical, seismic, and hydrogeologic conditions and be subject to the same natural hazards (*e.g.*, earthquake ground motions, tsunami inundation, liquefaction, flooding, sea level rise). Due to the elevation rise from the beach, a pump station at or near Fort Funston would be a less desirable location. The discharge piping from a pump station near this location would also need to be routed around Lake Merced, several public and private golf courses, and the San Francisco State University campus to connect into the nearest existing 20-inch diameter EFWS piping. This site would also be relatively close to the future planned Lake Merced Pump Station for PEFWS.

The engineering considerations for a seawater pump station along Ocean Beach are shown in Table 6-1 in the “Ocean/Southern Dunes” column. The nearest existing EFWS piping to this area runs north along Highway 1 (19th Ave) from Ulloa Street to Irving Street, just south of Golden Gate Park, as shown in Figure 5-2. The static pressure in this existing 20-inch diameter piping, which is within the Twin Peaks Zone of the EFWS fed by Twin Peaks Reservoir, ranges from approximately 140 to 236 psi, depending on location. The distance from Ocean Beach to the existing EFWS piping is approximately 1.70 miles, with a maximum elevation change of approximately 435 feet at Quintara Street east of Sunset Reservoir.

Both slant wells and open-water intake tunnels are considered feasible within this subregion. A drawback for slant wells is the number required to produce a desired flow rate. Preliminary estimates for slant well production along Ocean Beach based on a desktop review of available hydrogeologic data is approximately 3,000 gpm per well. For 10,000 gpm of total capacity, up to four slant wells would therefore be required. For 50,000 gpm of total capacity, up to 17 wells would be required.

Depending on the capacity of the seawater pump station (or combined capacity of the slant wells), recommended discharge pipe diameters to the existing EFWS network range from 18 inches for 3,000 gpm up to 54 inches for 50,000 gpm. It is also possible to split the discharge into two smaller diameter pipes (*e.g.*, two 24-inch-diameter pipes carrying 5,000 gpm each in lieu of one 30-inch-diameter pipe carrying 10,000 gpm). This would make it easier to tie into to the existing EFWS network hydraulically, which has a maximum pipe size of 20 inches. For a new seawater pump station or array of slant wells, it may be necessary to upsize the existing EFWS piping for some distance beyond the connection point(s) to accommodate the additional inflow.

Discharge pressure requirements for a seawater intake facility located near Ocean Beach are on the order of 350 psi for all capacities, discharge pipe sizes, or number of pipes, with flow velocities ranging from 3.7 to 7.0 feet per second (fps), as shown in Table 6-1. This is at the rated working pressure of 350 psi for ductile iron pipe (DIP), which is assumed to be used for discharge piping up to 24-inch diameter. Welded steel pipe (WSP) with the same minimum pressure rating is assumed to be used for discharge piping over 24-inches.

6.4.1.2 Rocky Area South Subregion

This subregion was described previously in Section 5.1.2. The very southern end of this subregion at Balboa Street may be a suitable location for a new seawater pump station as it has relatively easy access to Ocean Beach. Siting a pump station anywhere north of this area would be a greater challenge due to the cliffs and difficult terrain.

The engineering considerations for a seawater pump station in this area are shown in Table 6-1 in the "Ocean/Rocky Area South" column. The nearest existing EFWS piping to this area runs north along 12th Avenue from Cabrillo Street to California Street, as shown in Figure 5-5. The static pressure in this existing 12-inch-diameter piping, which is within the Upper Zone of the EFWS fed by the Asbury Tank, ranges from approximately 114 to 152 psi depending on location. Its distance is approximately 1.7 miles from Ocean Beach with a maximum elevation of approximately 230 feet at Balboa Street. After the Ashbury Tank empties, the existing EFWS piping in this subregion would be supplied from Twin Peaks Reservoir. In this event, the static pressure range at the EFWS connection point would increase to between approximately 228 and 266 psi, depending on location.

Both slant wells and an open-water intake tunnel are considered feasible near Balboa Street and the Great Highway. North of this area amongst the cliffs and bluffs only an open-water intake tunnel supplying a land-based seawater pump station would be considered feasible, but would likely be difficult and costly to construct, as discussed previously in Section 5.1.2.

Depending on the capacity of the seawater pump station or slant well array, recommended discharge pipe diameters range from 14 inches for 3,000 gpm up to 48 inches for 50,000 gpm. It is also possible to split the discharge into two smaller diameter pipes (*e.g.*, two 18-inch-diameter pipes carrying 5,000 gpm each in lieu of one 24-inch-diameter pipe carrying 10,000 gpm). This would allow multiple connections to the EFWS network with less expected negative impact to the existing piping at each connection. Even if the flow is split, it may be necessary to upsize the existing EFWS piping for some distance beyond the connection point(s) to accommodate the additional inflow, regardless of the tie-in location(s).

Discharge pressure requirements for a pump station or slant well array located near Balboa Street and the Great Highway range between approximately 395 and 436 psi for all capacities, discharge pipe sizes, or number of pipes with flow velocities ranging from 6.17 to 9.34 fps, as shown in Table 6-1. These values assume the existing EFWS piping is supplied by Twin Peaks Reservoir, as the Ashbury Tank would likely be drained quickly due to its relatively small capacity of 500,000 gallons. It is also assumed WSP will be used for all discharge piping within the subregion due to the high pressure requirements.

6.4.1.3 Rocky Area North Subregion

This subregion was described previously in Section 5.1.3. Baker Beach may be a feasible location for a new seawater pump station or slant well array in this subregion. The areas north and south of Baker Beach along the shoreline have a similar terrain to most of the Rocky Area South subregion with steep, rocky cliffs rising from a narrow, rocky beach with limited to no access. An exception is China Beach located just southwest of Baker Beach; however, China Beach is a much smaller beach with more limited and difficult access than Baker Beach.

The engineering considerations for a seawater pump station or slant well array in this subregion are shown in Table 6-1 in the "Ocean/Rocky Area North" column. The nearest existing EFWS piping to Baker Beach is the piping that runs north along 12th Avenue from Cabrillo Street to California Street, as shown in Figure 5-8. The static pressure in this existing 12-inch-diameter piping, which is also within the Upper Zone of the EFWS normally fed from the Ashbury Tank, ranges from approximately 114 to 152 psi depending on location. The distance from Baker Beach along existing roads to 12th Avenue is approximately 1.5 miles. The connection point would be anticipated to be at the north end of this segment near California Street. After the Ashbury Tank empties, the existing EFWS piping in this subregion would be supplied from Twin Peaks Reservoir. In this event, the static pressure range at the EFWS connection point would increase to between approximately 228 and 266 psi, depending on location.

Both slant wells and an open-water intake tunnel are considered feasible on Baker Beach. Outside of this area amongst the cliffs and bluffs, only an open-water intake tunnel would be considered feasible, just as in the Rocky Area South subregion.

Depending on the capacity of the seawater pump station or slant well array, recommended discharge pipe diameters range from 14 inches for 3,000 gpm up to 48 inches for 50,000 gpm. It is also possible to split the discharge into two smaller diameter pipes (*e.g.*, two 16-inch-diameter pipes carrying 5,000 gpm each in lieu of one 20-inch-diameter pipe carrying 10,000 gpm). This would allow multiple connections to the EFWS network with less expected negative impact to the existing piping at each connection. Even if the flow is split, it may be necessary to upsize the existing EFWS piping for some distance beyond the connection point(s) to accommodate the additional inflow regardless of the tie-in locations.

Discharge pressure requirements for a pump station or slant well array located at Baker Beach near Battery Chamberlain range between approximately 419 and 474 psi for all capacities, discharge pipe sizes, or number of pipes with flow velocities ranging from 6.17 to 10.08 fps, as shown in Table 6-1. These values assume the existing EFWS piping is supplied by Twin Peaks Reservoir, as the Ashbury Tank would likely be drained quickly due to its relatively small capacity of 500,000 gallons. It is also assumed WSP will be used for all discharge piping within the subregion due to the high pressure requirements.

6.4.2 Geologic and Geotechnical Considerations

Geotechnical and seismic induced hazards for facilities located along the Pacific Ocean coastline include liquefaction, landslides, tsunami runup, and seismic ground shaking. Factors influencing these hazards include geologic conditions, topography, groundwater levels, and distance to active faults.

The underlying geology of San Francisco is characterized by rock of Late Mesozoic or Early Cretaceous age covered by a variably thick sequence of Quaternary alluvial and eolian sediments as thick as 300 feet. The oceanside locations for the intake facilities would generally lie either in the beach and sand dune geologic unit along the Southern Dunes and Rocky Area North Subregions or Franciscan Complex sedimentary rocks of the Rocky Area South Subregion and portions of the Rocky Area North Subregion. The dune deposits cover most of the slopes and hills in western and northern San Francisco. The deposits occur mainly in large sheets, with beach sands mapped along the active Pacific and Golden Gate shorelines. These deposits consist of well sorted fine to medium-grained sand that is wave sorted and subject to shallow saline groundwater. The depth of bedrock is estimated to be greater than 60 feet along the Southern Dunes and Rocky Area North subregions. Franciscan rocks exposed in San Francisco range in age from Late Jurassic through Cretaceous age (165 to 65 million years old).

Historical groundwater depths in the oceanside region vary from 10 to 30 feet in the Southern Dunes and depths of 50 feet in the rocky areas. Given the high groundwater and soft sands, the Southern Dunes area is an area of potential liquefaction. Additionally, these soft materials can amplify seismic ground motions in the event of an earthquake. Based on the topography the rocky areas may be subjected to landslides.

Peak ground acceleration as a result of a moment magnitude (M) 7.8 on the San Andreas fault is estimated as 0.84 g along the Southern Dunes, 0.72 g along the Rocky Area South and 0.64 g in the Rocky Area North, at the 84^{th} percentile level (AECOM/AGS, 2013a). Peak ground velocity is estimated as 4.0 to 3.3 fps along the Southern Dunes and 3.3 to 2.6 fps along the rocky areas, at the 84^{th} percentile level (AECOM/AGS, 2013a).

The seismic induced hazards include settlements of the ground surface, lateral deformations, development of excess pore water pressure, buoyancy effects on below groundwater structures, loss of allowable bearing pressure, and increased lateral pressures on utilities and retaining structures extending below the groundwater table. Seismic-induced hazards may be mitigated through a program of ground improvement. Available techniques for soil improvement include vibro-replacement stone columns, deep soil mixing, and grouting techniques. Alternatively, liquefaction-induced settlements can be minimized by supporting structures on deep foundations.

6.4.3 Coastal Hazards and Sea Level Rise Considerations

Any new oceanside pump station facilities along the Southern Dunes, Rocky Area South, or Rocky Area North Subregions would need to consider potential coastal hazards in their siting and design. Coastal hazards include existing and future inundation and flooding from tides and storm surge, wave runup and overtopping, wind-blown sand, event-based storm erosion, and long-term shoreline change.

Existing coastal flood hazards along the Pacific coastline are delineated in Flood Insurance Rate Maps (FIRMs) prepared by the Federal Emergency Management Agency (FEMA) for the City and County of San Francisco. The FIRMs depict coastal hazards due to tides, storm surge, wave runup, wave overtopping, and event-based dune erosion. The FIRMs do not depict hazards from seasonal and inter-annual beach width fluctuations, wind-blown sand, event-based bluff or cliff erosion, and long-term shoreline change. Any facility constructed within the coastal zone would likely require a site-specific study to evaluate the potential for these additional hazards to impact the facility over its anticipated lifespan.

Future coastal flood hazards along the Pacific coastline have been evaluated by the U.S. Geological Survey (USGS) and FEMA for the City and County of San Francisco. Both datasets provide projections of future flood and erosion hazards along the Pacific coastline and can be used to perform high-level assessments of potential future coastal hazards for planning level analyses and site assessments. The USGS (Barnard, *et al.* 2020) evaluated future storm-induced coastal flooding and erosion along the Pacific coastline using the Coastal Storm Modeling System (CoSMoS) tool. Digital hazard layers are available online from the USGS website[2]. In addition, FEMA conducted a sea level rise and shoreline change pilot study in San Francisco (AECOM, 2016) that mapped the projected extent of the Special Flood Hazard Area (including the effects of sea level rise and long-term shoreline change). Both consider projected sea level rise and shoreline change through 2100.

At the local level, the City and County of San Francisco provides additional guidance on the incorporation of sea level rise considerations into City capital projects through its Guidance for Incorporating Sea Level Rise into Capital Planning[3]. The City's Sea Level Rise Vulnerability Zone (Figure 6-5) identifies areas of the City that may be exposed to sea level rise related hazards through 2100. Projects that fall within this zone with costs exceeding $5 million are required to complete the City's Sea Level Rise Checklist, which guides the project team through a standardized process to identify and evaluate potential sea level rise related vulnerabilities and risks to the project.

[2] https://www.sciencebase.gov/catalog/item/5b280118e4b0592076260491
[3] https://onesanfrancisco.org/sea-level-rise-guidance

Figure 6-5: San Francisco Sea Level Rise Vulnerability Zone

Strategies to address existing and future coastal hazards to oceanside pump station facilities would likely include hazard avoidance (*e.g*., locating pump stations beyond the landward limit of potential future coastal hazards) or protection (*e.g.*, locating pump stations behind existing or new coastal protection structures such as seawalls). Site modifications to landside facilities such as raising site elevations, elevating critical electrical and mechanical equipment above projected future flood elevations, or floodproofing buildings or equipment enclosures would also mitigate future flood risks.

6.4.4 Operation and Maintenance

Operation and maintenance practices for new seawater pump stations located in the Pacific Ocean region should include the following items at a minimum:

- All pumps and motors should be exercised regularly (*e.g.*, monthly) to ensure their proper operation.
- After each use, the pumps and all inlet and outlet piping should be flushed thoroughly with potable or recycled water to the extent possible to expel corrosive seawater from the pipes.
- Fuel for diesel engines should be used or replaced at regular intervals to ensure it remains fresh. Fuel tanks should always be topped off and left full after each use.
- Motor oil and other critical engine fluids should be checked and changed regularly. Air intakes and exhaust manifolds should also be regularly inspected and maintained in good condition.

- Emergency generators should be operated periodically (*e.g.*, monthly) to ensure their proper operation. Fuel should be used or replaced at regular intervals to ensure it remains fresh. Fuel tanks should always be topped off and left full after each use.
- Sites should be well maintained and kept free from accumulated trash, debris, weeds, graffiti, blown sand, *etc.* Unencumbered access should always be maintained (*e.g.*, entrance gates not blocked by parked vehicles, *etc.*). Building interiors should also be maintained in a clean, uncluttered, and safe condition.
- Security systems should be checked and tested regularly to ensure proper operation.
- All metallic components (visible piping and valves, motors, electrical cabinets, *etc.*) should be regularly inspected for corrosion and refinished or repaired as necessary. Protective coatings should be maintained to prolong service life of equipment.

6.4.5 Security Considerations

As at all SFPUC facilities, security at each pump station site or slant well array wellhead enclosure will be essential. It is assumed that all sites will be well lit, fully alarmed and monitored, and have multiple motion-activated and infrared capable pan-tilt-zoom surveillance cameras. Sites will also be surrounded by a perimeter security wall or fencing with remote or keycard access unless they are incorporated into a public park, open space, *etc.* and fencing is not aesthetically desired. Other security features, such as an invisible electronic barrier set inside the perimeter fencing that is tripped by a person or large object crossing it, could also be considered. In addition to triggering the alarm, this barrier would also be integrated with the surveillance cameras. When the barrier is tripped, the nearest camera(s) would be triggered and would focus on the violated zone to capture and record the event. This would provide a "belt-and-suspenders" approach in the event a person was able to scale the fence or wall and initially slip past the surveillance cameras undetected. All security features would be capable of being operated by emergency generator or uninterruptable power supply inside the pump station building or wellhead enclosure in the event of a temporary power outage.

6.5 San Francisco Bay Region

This section provides a discussion of the preliminary engineering design considerations and other select topics for a future seawater pump station or multiple pump stations located along the San Francisco Bay shoreline in San Francisco. This includes both the North Bayfront and East Bayfront subregions as shown in Figure 5-1.

6.5.1 Engineering Considerations

6.5.1.1 North Bayfront Subregion

This subregion was described previously in Section 5.2.1. Most of this subregion from Crissy Field eastward could be a good potential location for a new seawater pump station. Existing SWPS No. 2 is already located in this subregion near the northeast corner of Fort Mason.

The engineering considerations for a seawater pump station in this subregion are shown in Table 6-1 in the "SF Bay/North Bayfront" column. There is existing EFWS piping near the shoreline throughout this entire area east of Crissy Field to the Bay Bridge, as shown in Figure 5-10. Most of this existing piping is either 10, 12, or 14 inches in diameter, depending on location, with some 20-inch pipe near SWPS No. 2. The static pressure in this piping, which is within the Lower Zone of the EFWS fed by the Jones Street Tank, is approximately 160 psi. The distance from the shoreline to the existing piping is only a few hundred feet or less with minimal elevation gain. After the Jones Street Tank empties, the existing EFWS piping in this subregion would be supplied from Twin Peaks Reservoir. In this event, the static pressure at the EFWS connection points would increase to approximately 328 psi.

As has noted previously, only open-water intakes are considered feasible to supply a new seawater pump station along San Francisco Bay in either subregion due primarily to the unfavorable hydrogeologic conditions for slant wells.

Depending on the capacity of the seawater pump station, recommended discharge pipe diameters range from 12 inches for 3,000 gpm up to 48 inches for 50,000 gpm. It is also possible to split the discharge from the pump station into two smaller diameter pipes (*e.g.*, two 16-inch-diameter pipes carrying 5,000 gpm each in lieu of one 20-inch-diameter pipe carrying 10,000 gpm). This would allow multiple connections to the EFWS network with less expected negative impact to the existing piping at each connection. Even if the flow is split, it may be necessary to upsize the existing EFWS piping in the vicinity of the connection(s) and for some distance beyond to accommodate the additional inflow, regardless of the tie-in locations.

Discharge pressure requirements for a new pump station located along the shoreline have a very narrow range of approximately 373 to 375 psi for all capacities, discharge pipe sizes, or number of pipes, while flow velocities range from approximately 7.47 to 10.08 fps depending on pipe size and discharge rate, as shown in Table 6-1. These values assume the existing EFWS piping is supplied by Twin Peaks Reservoir, as the Jones Street Tank, like the Ashbury Tank in the Upper Zone, would likely be drained quickly due to its relatively small capacity of 750,000 gallons. It is also assumed WSP will be used for all discharge piping within the subregion due to the high pressure requirements.

6.5.1.2 East Bayfront Subregion

This subregion was described previously in Section 5.2.2. Most of this subregion could be a potential location for a new seawater pump station. Existing SWPS No. 1 is also within this subregion underneath the SFFD Headquarters Building near Oracle Park.

The engineering considerations for a seawater pump station in this area are shown in Table 6-1 in the “SF Bay/East Bayfront” column. The distance from the shoreline to the nearest existing EFWS piping varies greatly depending on location. In the area from the Bay Bridge south to Islais Creek, the distance from the shoreline to existing EFWS piping ranges from approximately 500 feet to 2,000 feet, with the distance generally increasing as one moves farther south. Most of the existing EFWS piping in this area is either 12 or 14-inches in diameter, with a few sections of 16- and 20-inch pipe near SWPS No. 1 and the Chase Center. South of Islais Creek in the Hunters Point and Candlestick Point areas, the distance from the shoreline to the nearest existing EFWS piping varies from approximately 500 feet to 1.5 miles. This pipe is either 12 or 20 inches in diameter. The static pressure in the existing piping, which is within the Lower Zone of the EFWS fed by the Jones Street Tank, is approximately 160 psi, depending on its distance from the shoreline (pressure generally decreases as one moves farther inland). After the Jones Street Tank empties, the existing EFWS piping in this subregion would be supplied from Twin Peaks Reservoir. In this event, the static pressure at the EFWS connection points would increase to approximately 328 psi, same as in the North Bayfront Subregion.

As with the North Bayfront subregion, only open-water intakes are considered feasible to supply a new seawater pump station in this subregion.

Depending on the capacity of the seawater pump station and the distance to nearest existing EFWS piping from the shoreline, recommended discharge pipe diameters range from 20 or 24 inches for 10,000 gpm (20 inches for short distances, 24 inches for longer distances) up to 48 inches for 50,000 gpm. As with pump stations in the other subregions, it is possible to split the discharge from the pump station into two smaller diameter pipes (*e.g.*, two 16-inch-diameter pipes carrying 5,000 gpm each in lieu of one 20-inch-diameter pipe carrying 10,000 gpm). This would allow multiple connections to the EFWS network with less expected negative impact to the existing piping at each connection. It may be necessary to upsize the existing EFWS piping in the vicinity of the connection(s) and for some distance beyond to accommodate the additional inflow

Discharge pressure requirements for a new seawater pump station located in this subregion range between approximately 374 and 421 psi for all capacities, discharge pipe sizes, or number of pipes, while flow velocities range from approximately 6.17 to 10.08 fps, depending on pipe size and discharge rate, as shown in Table 6-1. These values assume the existing EFWS piping is supplied by Twin Peaks Reservoir, as the Jones Street Tank, like the Ashbury Tank in the Upper Zone, would likely be drained quickly due to its relatively small capacity of 750,000 gallons. It is also assumed WSP will be used for all discharge piping within the subregion due to the high pressure requirements.

6.5.2 Geologic and Geotechnical Considerations

Geotechnical and seismic induced hazards for facilities located along San Francisco Bay include liquefaction, landslides, tsunami runup and seismic ground shaking. Factors influencing these hazards include geologic conditions, topography, groundwater levels, and distance to active faults.

The underlying geology of San Francisco is characterized by rock of Late Mesozoic or Early Cretaceous age covered by a variably thick sequence of Quaternary alluvial and eolian sediments, as thick as 300 feet. The bayside locations for the intake facilities lie in regions with beach and dune sand geologic units or bay muds and artificial fill. Younger Bay Muds are around the shore of the San Francisco Bay and mostly covered by artificial fill. The thickness of the Younger Bay Mud is variable from 10 to 70 feet around the San Francisco Bay. The Younger Bay Mud is soft or very soft, organic-rich clay to silty clay; and often containing numerous clam shells. Most of the artificial fill was non-engineered. The fill was often placed directly over Bay Mud with a consistency and density that is highly variable. The depth of bedrock is estimated to be greater than 60 feet along most of the bayside.

Historical groundwater depths are 5 to 10 feet in the North and East Bayfront subregions. Given the high groundwater, younger Bay muds and artificial fill, the North and East Bayfronts are an area of potential liquefaction. Additionally, these soft materials can amplify seismic ground motions in the event of an earthquake.

Peak ground acceleration due to a moment magnitude (M) 7.8 on the San Andreas fault is estimated as 0.60 to 0.45 g along the North and East Bayfront subregions, at the 84th percentile level. Peak ground velocity is estimated as 2.6 to 1.5 fps along the North and East Bayfronts, at the 84th percentile level (AECOM/AGS, 2013a).

The seismic induced hazards include settlements of the ground surface, lateral deformations, development of excess pore water pressure, buoyancy effects on below groundwater structures, loss of allowable bearing pressure, and increased lateral pressures on utilities and retaining structures extending below the groundwater table. Seismic-induced hazards may be mitigated through a program of ground improvement. Available techniques for soil improvement include vibro-replacement stone columns, deep soil mixing, and grouting techniques. Alternatively, liquefaction-induced settlements can be minimized by supporting structures on deep foundations.

6.5.3 Coastal Hazards and Sea Level Rise Considerations

Any new bayside pump station facilities along the North and East Bayfront subregions would need to consider potential coastal hazards in their siting and design. Coastal hazards include existing and future inundation and flooding from tides and storm surge and wave runup and overtopping. Shoreline erosion is less of a concern along the bay shoreline than the Pacific coastline since most of San Francisco's bay shoreline is armored; however, any supporting landside facilities located along unarmored portions of the shoreline should consider the potential for erosion.

Existing coastal flood hazards along the Bay shoreline are delineated in Flood Insurance Rate Maps (FIRMs) prepared by the Federal Emergency Management Agency (FEMA) for the City and County of San Francisco. The FIRMs depict coastal hazards due to tides, storm surge, wave runup, and wave overtopping.

Future coastal flood hazards along the Pacific coastline have been evaluated by the U.S. Geological Survey (USGS)[4] and San Francisco Bay Conservation and Development Commission (BCDC)[5] for the City and County of San Francisco. Both datasets provide projections of future flood hazards (permanent inundation due to daily high tides and temporary flooding due to storm surge events) along the Bay shoreline and can be used to perform high-level assessments of potential future coastal hazards for planning level analyses and site assessments.

At the local level, the City and County of San Francisco's Guidance for Incorporating Sea Level Rise into Capital Planning would also apply to landside facilities located within the City's Sea Level Rise Vulnerability Zone, as described in Section 6.4.3.

Strategies to address existing and future coastal hazards to bayside pump station facilities would likely include hazard avoidance (*e.g.*, locating landside facilities beyond the landward limit of potential future inundation and flooding) or protection (*e.g*., locating landside facilities behind existing or new coastal protection structures such as seawalls). Site modifications to landside facilities such as raising site elevations, elevating critical electrical and mechanical equipment above projected future flood elevations, or floodproofing buildings or equipment enclosures would also mitigate future flood risks.

6.5.4 Operations and Maintenance

Operation and maintenance practices for new seawater pump stations located in the San Francisco Bay region are the same as in the Pacific Ocean region and should include the following items at a minimum:

- All pumps and motors should be exercised regularly (*e.g.*, monthly) to ensure their proper operation.
- After each use, the pumps and all inlet and outlet piping should be flushed thoroughly with potable or recycled water to the extent possible to expel corrosive seawater from the pipes.
- Fuel for diesel engines should be used or replaced at regular intervals to ensure it remains fresh. Fuel tanks should always be topped off and left full after each use.
- Motor oil and other critical engine fluids should be checked and changed regularly. Air intakes and exhaust manifolds should also be regularly inspected and maintained in good condition.
- Emergency generators should be operated periodically (*e.g.*, monthly) to ensure their proper operation. Fuel should be used or replaced at regular intervals to ensure it remains fresh. Fuel tanks should always be topped off and left full after each use.
- Sites should be well maintained and kept free from accumulated trash, debris, weeds, graffiti, *etc.* Unencumbered access should always be maintained (*e.g.*, entrance gates not blocked by parked vehicles, *etc.*). Building interiors should also be maintained in a clean, uncluttered, and safe condition.
- Security systems should be checked and tested regularly to ensure proper operation.

[4] http://ourcoastourfuture.org/
[5] https://www.adaptingtorisingtides.org/maps-and-data-products/

- All metallic components (visible piping and valves, motors, electrical cabinets, *etc.*) should be regularly inspected for corrosion and refinished or repaired as necessary. Protective coatings should be maintained to prolong service life of equipment.

6.5.5 Security Considerations

Security considerations and facilities will be similar for all new seawater supplies for the EFWS, whether located within the Pacific Ocean region or the San Francisco Bay region. General security considerations for onshore pump stations are discussed in Section 6.2.5. A floating pump station as described in Section 2 may have additional security considerations, including a security perimeter on the floating portion of the pumping barge.

Chapter 7: Intake Concepts

This chapter presents engineering, operation and maintenance elements of prospective seawater intake systems that could support an expanded EFWS, including geological and coastal hazards, hydrogeological factors, as well as security considerations within each of the five subregions analyzed.

7.1 Overview

There are two types of intakes being considered for this study to supply seawater to the existing EFWS network that could be constructed by SFPUC in the future: (1) open-water intakes and (2) slant wells. Both are discussed in the sections below.

The California Ocean Plan in general requires subsurface seawater intakes (assuming they are feasible), rather than open water intakes. If subsurface intakes are not feasible, open water intakes must be screened to reduce entrainment of marine life. This generally requires screens with openings less than 1.0 mm, to prevent entrainment of small aquatic organisms. To minimize impingement of marine life on open water intake screens, the through-screen velocity must generally be less than 0.5 feet per second. Similar criteria exist for open water intakes in San Francisco Bay.

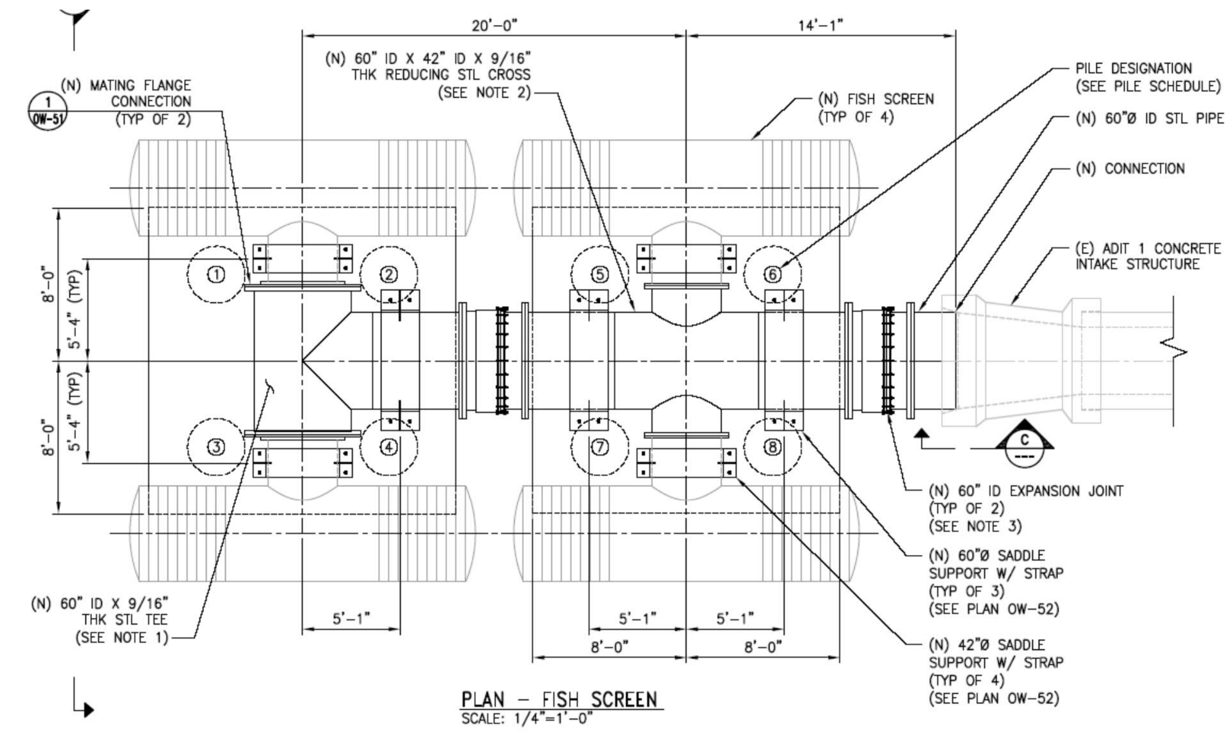
For either the ocean or bay sides of the City, consideration will be required for site-specific oceanic conditions. San Francisco Bay and the Golden Gate areas of the shoreline are subject to strong currents and sediment migration (Barnard, *et al.*, 2006). The intakes of PS1 and PS2 have historically required dredging due to sand accumulation, and the potential for this issue will need to be considered in siting any new pump stations.

7.1.1 Open-Water Intakes

An open-water intake is essentially a large pipe or conduit installed underwater with its inlet located above the seafloor or lakebed. The inlet is usually covered with one or multiple self-cleaning, stainless steel screens in a variety of configurations to prevent entrainment or impingement of aquatic life, underwater vegetation, trash, or debris.

A common in-parallel multiple screen configuration is shown in Figure 7-1 and Figure 7-2. In these figures, each double-sided “barrel” section is considered one screen (total of four screens shown). Figure 7-3 shows similar screens installed in a vertical configuration. In this arrangement, the screens are installed on rails or channels that allow them to be lowered and raised. This enables the screens to be raised out of the water as needed for cleaning and maintenance or to be stowed while not being used, or to be set at specific depths below the water surface.

Existing SWPS Nos. 1 and 2 both employ 60-inch-diameter reinforced concrete pipe open-water intake tunnels that extend into San Francisco Bay just beyond the existing seawall. The length of the intake tunnel for SWPS No. 1 is approximately 1,100 feet while the intake tunnel length for SWPS No. 2 is approximately 160 feet. Both tunnels have flared entrances on their inlets and per the as-built drawings the openings are covered by a single cast-iron bar screen with 3/4-inch spacing between bars.



Source: SFPUC Calaveras Dam Replacement Project

Figure 7-1: Example of Intake Screens on Open-Water Intake Tunnel

Source: SFPUC Calaveras Dam Replacement Project

Figure 7-2: Completed Intake Screens on Open-Water Intake Tunnel

Source: SFPUC Alameda Creek Diversion Dam Fish Passage and Screening Improvements

Figure 7-3: Intake Screens at Alameda Creek Diversion Dam

7.1.2 Slant Wells

Slant wells are essentially groundwater wells installed at an angle, typically around 20 degrees from horizontal. They contain submersible pumps and motors to pump the water into a distribution system, storage facility, or other destination such as a water treatment plant. They are constructed near the shoreline with the well screen extending partially underneath the adjacent water body. A conceptual section view of a slant well along Ocean Beach within the Southern Dunes subregion is shown in Figure 7-4. Figure 7-5 shows a photograph of the installation of a slant well in Monterey Bay, CA. A detailed section view of this slant well depicting the local aquifers is shown in Appendix C. This well was successfully installed by California American Water Company (CalAm) within a similar ocean dune setting to Ocean Beach.

The slant wells constructed for the CalAm project will not be housed in buildings but will be in below-ground vaults within fenced sites, with above ground electrical equipment. For slant wells constructed to supply seawater to the EFWS in San Francisco, it is assumed that the wells and electrical equipment will be fully enclosed in a building for added security and protection. A conceptual layout of a slant well building housing three slant wells is shown in Appendix D. Slant wells are a proven technology and have been utilized in numerous locations around the world. They are commonly used as intakes for reverse osmosis desalination facilities located on ocean coastlines, as proposed in the CalAm project.

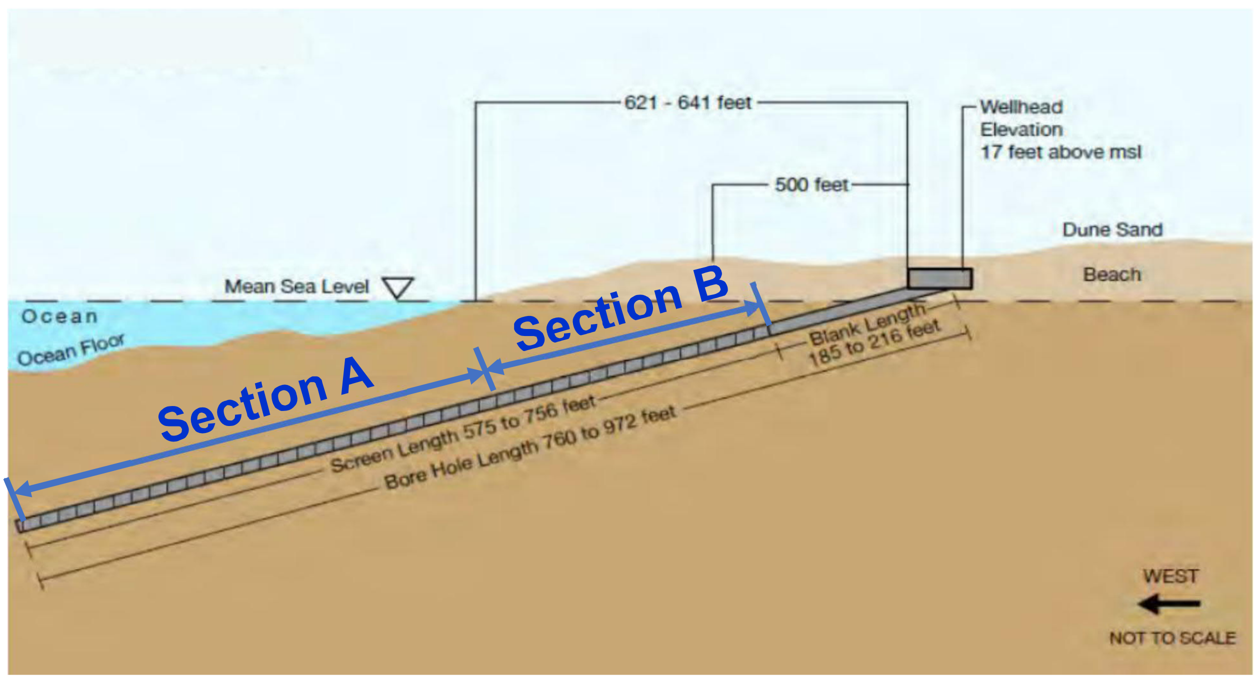
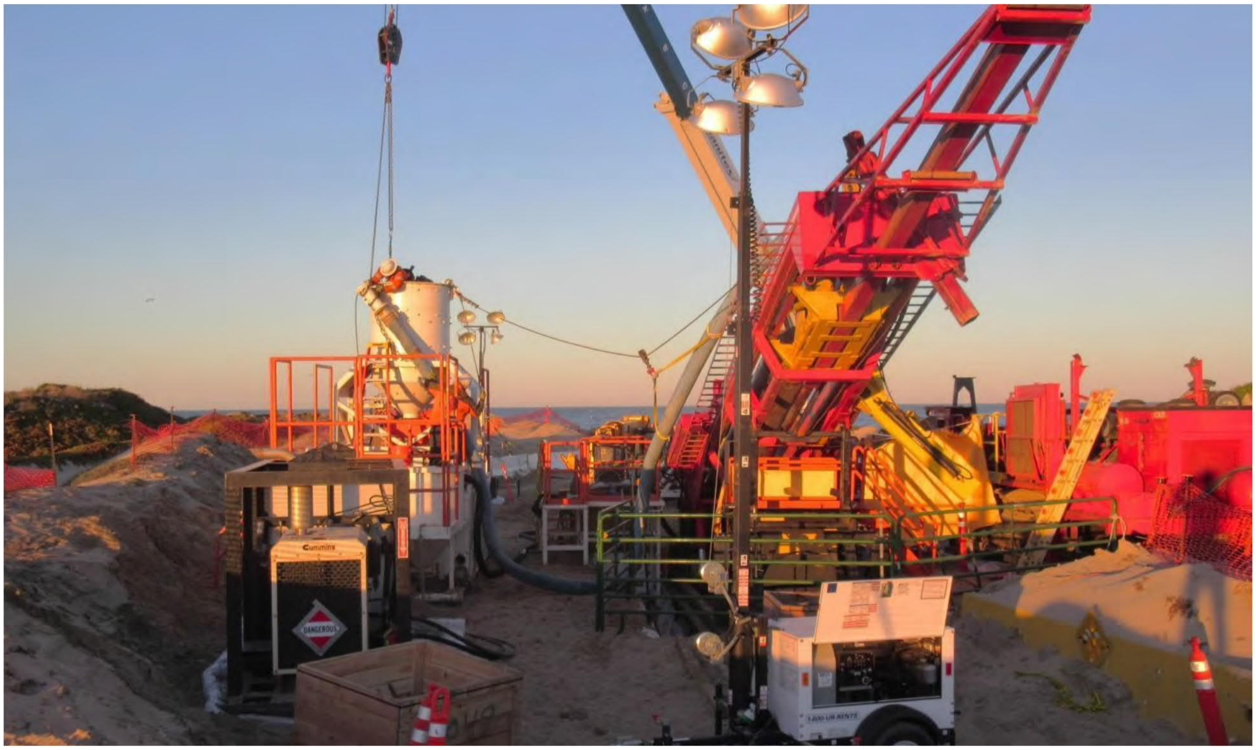


Figure 7-4: Conceptual Slant Well at Ocean Beach



Source: CalAm Monterey Peninsula Water Supply Project

Figure 7-5: Slant Well Installation

At most locations, multiple slant wells are generally required to provide a desired design flow rate to the destination facility because of their somewhat limited production. Figure 7-6 depicts commonly used methods to group multiple slant wells together. All wells in one of these arrays would discharge into a common discharge header with a single outlet pipe carrying the combined flow to the destination facility or distribution pipe network. The submersible well pumps would provide sufficient head to convey the extracted seawater to the destination.

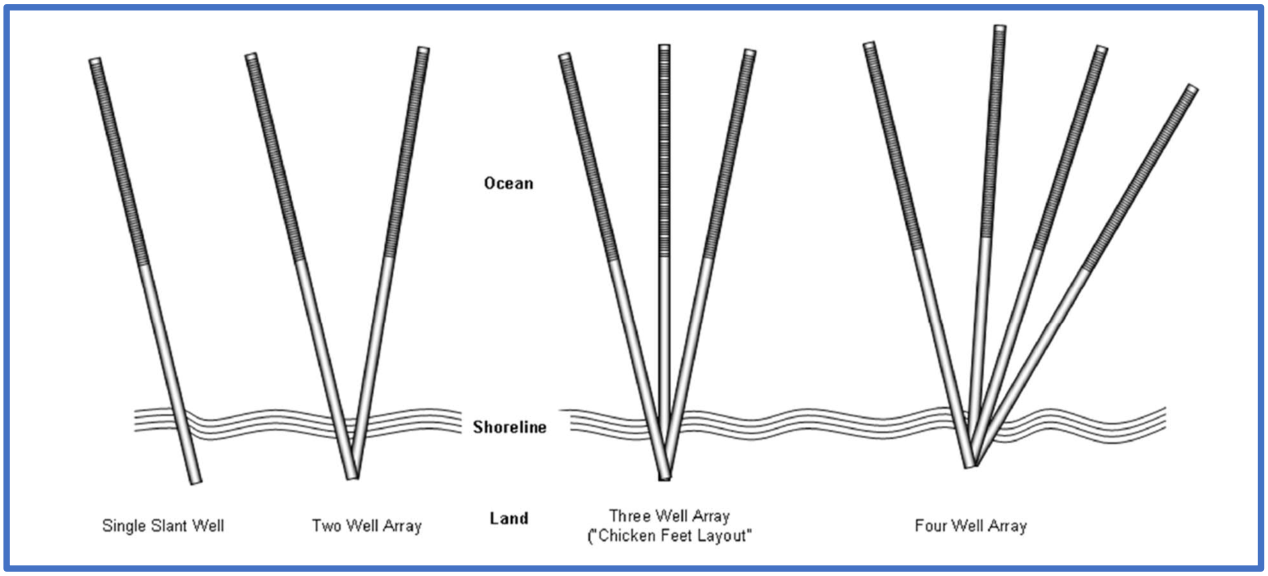


Figure 7-6: Slant Well Installation Arrays

A conceptual layout of slant wells along Ocean Beach that could supply up to 50,000 gpm is shown in Figure 7-7.

Figure 7-7: Conceptual Layout of Slant Wells at Ocean Beach

7.1.3 Intake Selection Considerations

For a new seawater supply facility located near the Pacific Ocean coastline in San Francisco, both slant wells and open-water intakes are in general deemed feasible from an engineering perspective. This includes the Southern Dunes, Rocky Area South, and Rocky Area North subregions of this study. However, within certain areas of each subregion, only one type of intake may be considered feasible based on the geology or other reasons.

For a new seawater supply facility located near the San Francisco Bay shoreline, only an open-water intake is considered feasible, primarily due to the silty bottom of the bay which could severely limit the production of slant wells due to low soil permeability.

Preliminary design considerations have also been developed for seawater intakes located within the five subregions. These design considerations are listed in Table 7-1 and discussed in the sections below.

7.1.4 Other Considerations

A summary of the existing geotechnical and geologic/seismic conditions and related hazards along with a brief discussion of the potential future impacts of sea level rise near the coastline are presented in the sections below. These conditions are expected to be the same or very similar as those described in Chapter 6 for seawater pump stations within each region. Additionally, Section 7.2.4 briefly describes the hydrogeology of the Pacific Ocean coastline and its anticipated relationship with slant wells. A discussion of the hydrogeology of the San Francisco Bay shoreline is not included since slant wells are not considered feasible in that region.

7.2 Pacific Ocean Region

This section provides a discussion of the preliminary engineering design considerations and other select topics for intakes to support future seawater supply facilities located along the Pacific Ocean coastline in San Francisco. This includes the Southern Dunes, Rocky Area South, and Rocky Area North subregions as shown in Figure 5-1.

7.2.1 Engineering Considerations

7.2.1.1 Southern Dunes Subregion

Both slant wells and open-water intakes are considered feasible in this area. Per the Ocean Plan and CCC policy regarding seawater intake systems, the use of subsurface intakes, such as slant wells for ocean intakes, is strongly preferred over open-water intakes. A drawback for slant wells is the number required to produce large flows. Preliminary estimates for slant well production along Ocean Beach (based on a desktop review of available hydrogeologic data) is approximately 3,000 gpm per well. For 10,000 gpm of total capacity, up to four slant wells would therefore be required. For 50,000 gpm of total capacity, up to 17 wells would be required.

Table 7-1: Open-Water Intake and Slant Well Preliminary Design Considerations

Intake Parameters vs. Seawater Supply Capacity	Subregion	Intake Design Considerations by Subregion					Existing Seawater Pump Stations	
	Subregion	Ocean/Southern Dunes	Ocean/Rocky Area South	Ocean/Rocky Area North	SF Bay/North Bayfront	SF Bay/East Bayfront	SWPS No. 1	SWPS No. 2
	Potential Intake Types	Slant Well(s)/Open Water	Slant Well(s)/Open Water	Slant Well(s)/Open Water	Open Water[5]	Open Water[5]	Open Water	Open Water
3,000 gpm	Number of Wells[3]	1	1	1	N/A	N/A	N/A	N/A
	Well Screen Diameter (in.)[4]	18	18	18	N/A	N/A	N/A	N/A
	Well Screen Length (ft.)[9]	700	700	700	N/A	N/A	N/A	N/A
	Open Water Intake Diameter (in.)[1,6]	30	30	30	30	30	N/A	N/A
	Open Water Intake Length (ft.)	2,000	2,000	1,500	200	200	N/A	N/A
	Flow Velocity (fps)	1.34	1.34	1.34	1.34	1.34	N/A	N/A
	Fish Screen Slot Size (in.)[2]	0.04	0.04	0.04	TBD	TBD	N/A	N/A
	Number of Screens[8]	1	1	1	1	1	N/A	N/A
6,000 gpm	Number of Wells[3]	2	2	2	N/A	N/A	N/A	N/A
	Well Screen Diameter (in.)[4]	18	18	18	N/A	N/A	N/A	N/A
	Well Screen Length (ft.)[9]	700	700	700	N/A	N/A	N/A	N/A
	Open Water Intake Diameter (in.)[1,6]	42	42	42	42	42	N/A	N/A
	Open Water Intake Length (ft.)	2,000	2,000	1,500	200	200	N/A	N/A
	Flow Velocity (fps)	1.37	1.37	1.37	1.37	1.37	N/A	N/A
	Fish Screen Slot Size (in.)[2]	0.04	0.04	0.04	TBD	TBD	N/A	N/A
	Number of Screens[8]	1	1	1	1	1	N/A	N/A
10,000 gpm[7]	Number of Wells[3]	4	4	4	N/A	N/A	N/A	N/A
	Well Screen Diameter (in.)[4]	18	18	18	N/A	N/A	N/A	N/A
	Well Screen Length (ft.)[9]	700	700	700	N/A	N/A	N/A	N/A

Intake Parameters vs. Seawater Supply Capacity	Subregion	Intake Design Considerations by Subregion					Existing Seawater Pump Stations	
		Ocean/Southern Dunes	Ocean/Rocky Area South	Ocean/Rocky Area North	SF Bay/North Bayfront	SF Bay/East Bayfront	SWPS No. 1	SWPS No. 2
	Potential Intake Types	Slant Well(s)/Open Water	Slant Well(s)/Open Water	Slant Well(s)/Open Water	Open Water[5]	Open Water[5]	Open Water	Open Water
	Open Water Intake Diameter (in.)[1,6]	60	60	60	60	60	60	60
	Open Water Intake Length (ft.)	2,000	2,000	1,500	200	200	1,100	160
	Flow Velocity (fps)	1.12	1.12	1.12	1.12	1.12	1.21	1.21
	Fish Screen Slot Size (in.)[2]	0.04	0.04	0.04	TBD	TBD	3/4	3/4
	Number of Screens[8]	1	1	1	1	1	1	1
20,000 gpm	Number of Wells[3]	7	7	7	N/A	N/A	N/A	N/A
	Well Screen Diameter (in.)[4]	18	18	18	N/A	N/A	N/A	N/A
	Well Screen Length (ft.)[9]	700	700	700	N/A	N/A	N/A	N/A
	Open Water Intake Diameter (in.)[1,6]	72	72	72	72	72	N/A	N/A
	Open Water Intake Length (ft.)	2,000	2,000	1,500	200	200	N/A	N/A
	Flow Velocity (fps)	1.56	1.56	1.56	1.56	1.56	N/A	N/A
	Fish Screen Slot Size (in.)[2]	0.04	0.04	0.04	TBD	TBD	N/A	N/A
	Number of Screens[8]	2	2	2	2	2	N/A	N/A
30,000 gpm	Number of Wells[3]	10	10	10	N/A	N/A	N/A	N/A
	Well Screen Diameter (in.)[4]	18	18	18	N/A	N/A	N/A	N/A
	Well Screen Length (ft.)[9]	700	700	700	N/A	N/A	N/A	N/A
	Open Water Intake Diameter (in.)[1,6]	96	96	96	96	96	N/A	N/A
	Open Water Intake Length (ft.)	2,000	2,000	1,500	200	200	N/A	N/A
	Flow Velocity (fps)	1.31	1.31	1.31	1.31	1.31	N/A	N/A

Intake Parameters vs. Seawater Supply Capacity	Subregion	Intake Design Considerations by Subregion					Existing Seawater Pump Stations	
		Ocean/Southern Dunes	Ocean/Rocky Area South	Ocean/Rocky Area North	SF Bay/North Bayfront	SF Bay/East Bayfront	SWPS No. 1	SWPS No. 2
	Potential Intake Types	Slant Well(s)/Open Water	Slant Well(s)/Open Water	Slant Well(s)/Open Water	Open Water[5]	Open Water[5]	Open Water	Open Water
	Fish Screen Slot Size (in.)[2]	0.04	0.04	0.04	TBD	TBD	N/A	N/A
	Number of Screens[8]	3	3	3	3	3	N/A	N/A
40,000 gpm	Number of Wells[3]	14	14	14	N/A	N/A	N/A	N/A
	Well Screen Diameter (in.)[4]	18	18	18	N/A	N/A	N/A	N/A
	Well Screen Length (ft.)[9]	700	700	700	N/A	N/A	N/A	N/A
	Open Water Intake Diameter (in.)[1,6]	108	108	108	108	108	N/A	N/A
	Open Water Intake Length (ft.)	2,000	2,000	1,500	200	200	N/A	N/A
	Flow Velocity (fps)	1.38	1.38	1.38	1.38	1.38	N/A	N/A
	Fish Screen Slot Size (in.)[2]	0.04	0.04	0.04	TBD	TBD	N/A	N/A
	Number of Screens[8]	4	4	4	4	4	N/A	N/A
50,000 gpm	Number of Wells[3]	17	17	17	N/A	N/A	N/A	N/A
	Well Screen Diameter (in.)[4]	18	18	18	N/A	N/A	N/A	N/A
	Well Screen Length (ft.)[9]	700	700	700	N/A	N/A	N/A	N/A
	Open Water Intake Diameter (in.)[1,6]	120	120	120	120	120	N/A	N/A
	Open Water Intake Length (ft.)	2,000	2,000	1,500	200	200	N/A	N/A
	Flow Velocity (fps)	1.40	1.40	1.40	1.40	1.40	N/A	N/A
	Fish Screen Slot Size (in.)[2]	0.04	0.04	0.04	TBD	TBD	N/A	N/A
	Number of Screens[8]	5	5	5	5	5	N/A	N/A

Notes:

1. Assumed to be reinforced concrete pipe (RCP).

2. Slot size for ocean intake screens: 1 mm (0.04 inches). Slot size for screens on bay side to be determined (TBD). Actual size shown for existing SWPS Nos.1 and 2.

3. Estimated production of 3,000 gpm per well; needs to be confirmed by additional analysis.
4. Estimated diameter; needs to be confirmed by additional analysis.
5. Slant wells generally not considered feasible due to silty bottom of SF Bay and regulatory challenges.
6. Actual diameter of intake tunnels for existing SWPS No. 1 and 2 is 60-inch.
7. Actual capacity of existing SWPS No. 1 and 2 is 10,800 gpm (4 pumps @ 2,700 gpm each).
8. Assuming up to 10,000 gpm per tee screen, with maximum through-screen velocity of < 0.5 fps
9. Estimated length, needs to be confirmed by additional analysis.

For an open-water intake supplying a traditional pump station, the size of the intake pipe required will depend on the desired pump station capacity. The preliminary estimated intake tunnel diameters for each of the considered pump station capacities are shown in Table 7-1 for each subregion in which this type of intake is feasible. Diameters range from 60 inches (for 10,000 gpm) to 120 inches (for 50,000 gpm) and are the same size for all subregions for a given capacity. This size of intake pipeline or tunnel will produce a flow velocity under approximately 1.5 fps at peak intake capacity. Table 7-1 also lists other required design criteria for open-water intakes. Most of the missing or unconfirmed data will need to be determined during the next phase of this project following additional evaluation.

It is assumed for this study that open water intakes will be constructed of reinforced concrete pipe for corrosion resistance. Most of an intake conduit could be buried with only the intake head containing the screens exposed above the seafloor, supported on concrete piles drilled into the seafloor. The top elevation of the fish screens should be well below mean high-water level yet their inverts high enough off the seafloor to not get buried by accumulating silt over time. The intake conduit would run nearly horizontal to a gallery or wet well at the pump station, where the seawater would be pumped out of and discharged via a common outlet pipe, or pipes, into the high pressure EFWS network as needed. If a vertical fish screen configuration is employed, a concrete intake structure could be built at the edge of the shoreline with the intake conduit running to the pump station.

7.2.1.2 Rocky Area South Subregion

Depending on the location, either type of intake type or just slant wells are feasible for this subregion. Both open water intake and slant well options are considered feasible for a facility located near Balboa Street and the Great Highway, where direct access to the north end Ocean Beach could be obtained. However, north of this area in the cliff region only open-water intakes may be feasible.

The subsurface geology of the cliffs and bluffs is predominately bedrock, which is not conducive to slant well installation or production. The intake tunnel would need to be bored underneath the beach and cliffs and a submerged intake pipe extended out into the ocean above the seafloor with screens on the end and supported by drilled concrete piles. Alternatively, the tunnel could travel underneath the seafloor then rise above the seafloor at the end via a vertical intake structure. A vertical access shaft would be required for pumps to lift seawater to the ground surface to deliver directly into the existing EFWS network in the area. The pump station on the surface would house the electrical, communications, and security equipment and emergency generator.

7.2.1.3 Rocky Area North Subregion

For a seawater pump station located on Baker Beach within this subregion, both types of intake are considered feasible. Outside of Baker Beach only open-water intakes may be feasible. The installation method and construction challenges for an intake tunnel would be the same as described for the Rocky Area South subregion.

7.2.2 Geologic and Geotechnical Considerations

Geotechnical and seismic induced hazards for facilities located along the Pacific Ocean coastline include liquefaction, landslides, tsunami runup and seismic ground shaking. Factors influencing these hazards include geologic conditions, topography, groundwater levels and distance to active faults.

The underlying geology of San Francisco is characterized by rock of Late Mesozoic or Early Cretaceous age covered by a variably thick sequence of Quaternary alluvial and eolian sediments, as thick as 300 feet. The oceanside locations for the pump station facilities would generally lie either in the beach and sand dune geologic unit along the Southern Dunes and Rocky Area North subregions or Franciscan

Complex sedimentary rocks of the Rocky Area South and portions of the Rocky Area North subregions. The dune deposits cover most of the slopes and hills in western and northern San Francisco. The deposits occur mainly in large sheets, with beach sands mapped along the active Pacific and Golden Gate shorelines. These deposits consist of well sorted fine to medium-grained sand that is wave sorted and subject to shallow saline groundwater. The depth of bedrock is estimated to be greater than 60 feet along the Southern Dunes and Rocky Area North. Franciscan rocks exposed in San Francisco range in age from Late Jurassic through Cretaceous age (165 to 65 million years old).

Historical groundwater depths in the oceanside region vary from 10 to 30 feet in the Southern Dunes and depths of 50 feet in the rocky areas. Given the high groundwater and soft sands, the Southern Dunes area is an area of potential liquefaction. Additionally, these soft materials can amplify seismic ground motions in the event of an earthquake. Based on the topography the rocky areas may be subjected to landslides.

Peak ground acceleration due to a moment magnitude (M) 7.8 on the San Andreas fault is estimated as 0.84 g along the Southern Dunes, 0.72 g along the Rocky Area South and 0.64 g in the Rocky Area North, at the 84th percentile level. Peak ground velocity is estimated as 4.0 to 3.3 fps along the Southern Dunes and 3.3 to 2.6 fps along the rocky areas, at the 84th percentile level (AECOM/AGS, 2013a).

The seismic induced hazards include settlements of the ground surface, lateral deformations, development of excess pore water pressure, buoyancy effects on below groundwater structures, loss of allowable bearing pressure, and increased lateral pressures on utilities and retaining structures extending below the groundwater table. Seismic-induced hazards may be mitigated through a program of ground improvement. Available techniques for soil improvement include vibro-replacement stone columns, deep soil mixing, and grouting techniques. Alternatively, liquefaction-induced settlements can be minimized by supporting structures on deep foundations.

7.2.3 Coastal Hazards and Sea Level Rise Considerations

Any new oceanside intake facilities (such as slant wells and well heads) along the Southern Dunes, Rocky Area South, or Rocky Area North subregions would need to consider potential coastal hazards in their siting and design. Coastal hazards include existing and future inundation and flooding from tides and storm surge, wave runup and overtopping, seasonal and inter-annual beach width fluctuations, wind-blown sand, event-based storm erosion, and long-term shoreline change. Open-water intakes should also consider potential wave and geomorphic hazards (such as sediment burial or scour), depending on their location and depth.

Data sources depicting coastal flood and erosion hazards for existing and future conditions along the Pacific coastline are described in Section 6.4.3. The City and County of San Francisco's Guidance for Incorporating Sea Level Rise into Capital Planning would also apply to seawater intake projects located within the city's Sea Level Rise Vulnerability Zone, as described in Section 6.4.3.

Strategies to address existing and future coastal hazards to oceanside intake facilities would likely include hazard avoidance (*e.g.*, locating well heads beyond the landward limit of potential future coastal hazards) or protection (*e.g.*, locating well heads behind existing or new coastal protection structures such as seawalls). Slant wells buried under the sandy beach should consider event-based, seasonal, inter-annual, and long-term shoreline change to minimize the likelihood of exposure of the pipes due to beach profile changes. Slant wells bored through coastal bluffs or cliffs should consider projected cliff retreat to avoid potential erosion hazards.

7.2.4 Hydrogeology of the Pacific Ocean Coastline

Figure 7-8 depicts a geologic map of the San Francisco area and perimeter shorelines (Graymer *et. al.*, 2006). The various colors on this map illustrate the following Quaternary units: Gray= Artificial Fill (AF), Pink= Landslide and hillslope deposits (Qsl), Yellow = Sand dunes (Qd), Orange = Colma Formation (Qc), Green = older Quaternary Alluvium (Qpa), and Merced Formation = light blue. Franciscan Complex Bedrock is not shown.

Most of the Pacific coastline from Fort Funston on the south to the north end of Ocean Beach is characterized as sand dunes (Qd, shaded yellow) with localized areas of landslide and hillslope deposits (Qsl, shaded pink) near the southern end (north and south of Lake Merced). Much of the coastline north of Ocean Beach to the Golden Gate Bridge is bedrock, with sand dunes near China and Baker Beaches and areas of landslide and hillslope deposits near the cliffs in the Lands End area and south of the bridge. This map also depicts the shoreline of San Francisco Bay circa 1850 (blue line) and extent of historic marshes circa 1898 (blue crosshatch) compared to the current existing shoreline at the edge of reclaimed lands (af, shaded grey).

Figure 7-8: Geologic Map of San Francisco

Figure 7-9 shows the offshore geology of the Pacific coastline in San Francisco (simplified from Greene *et. al.*, 2014, 2015). This map indicates that at Ocean Beach, the area offshore consists of Holocene marine and San Francisco Bay sand deposits, Holocene sand wave deposits, and Holocene inner ebb-tidal delta deposits. All the offshore area within approximately 3,000 feet of the coastline (*i.e.*, the area where slant wells will be installed) consists of Holocene marine and San Francisco Bay sand deposits, which is considered conducive to slant wells. Bathymetry of the offshore of San Francisco shows the sea water depth increases towards the west (ocean) slowly (*i.e.*, seafloor is relatively flat), and the water depth is relatively uniform from north to south in the vicinity of the coastline (within approximately 3,000 feet of the coastline) at Ocean Beach.

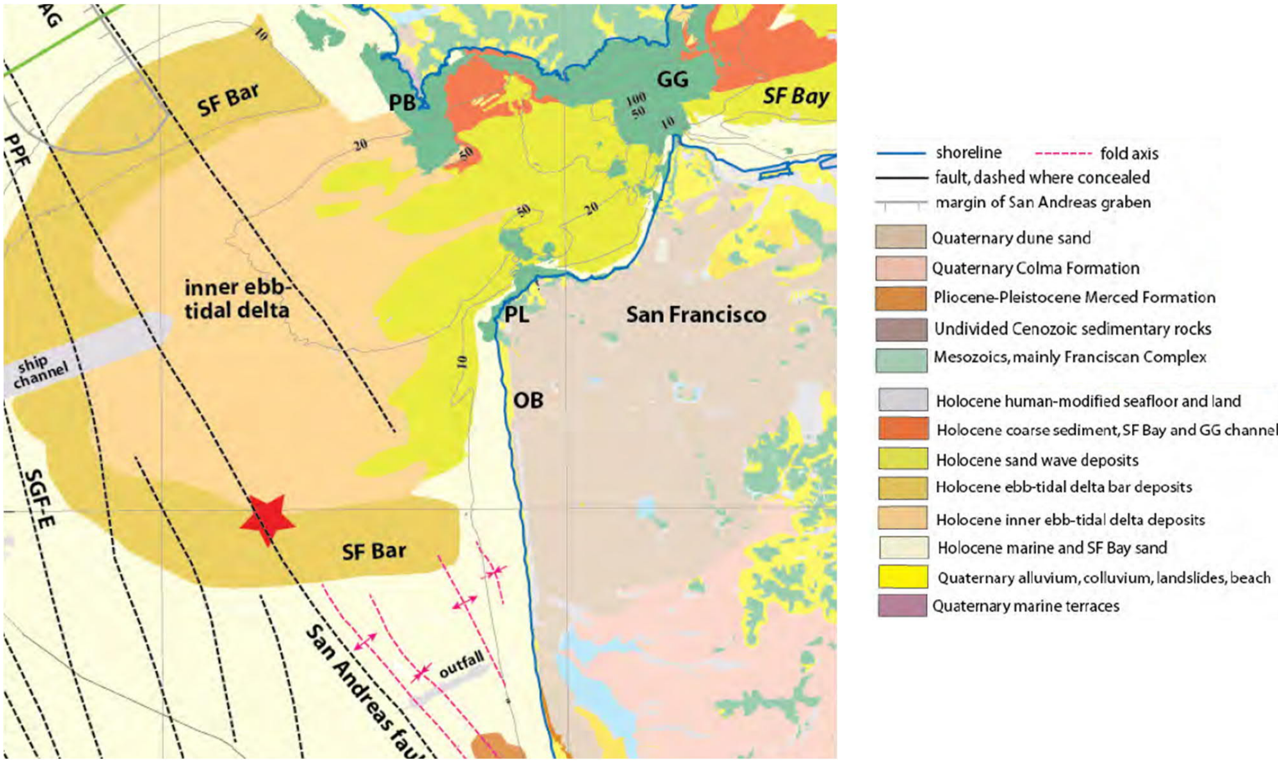


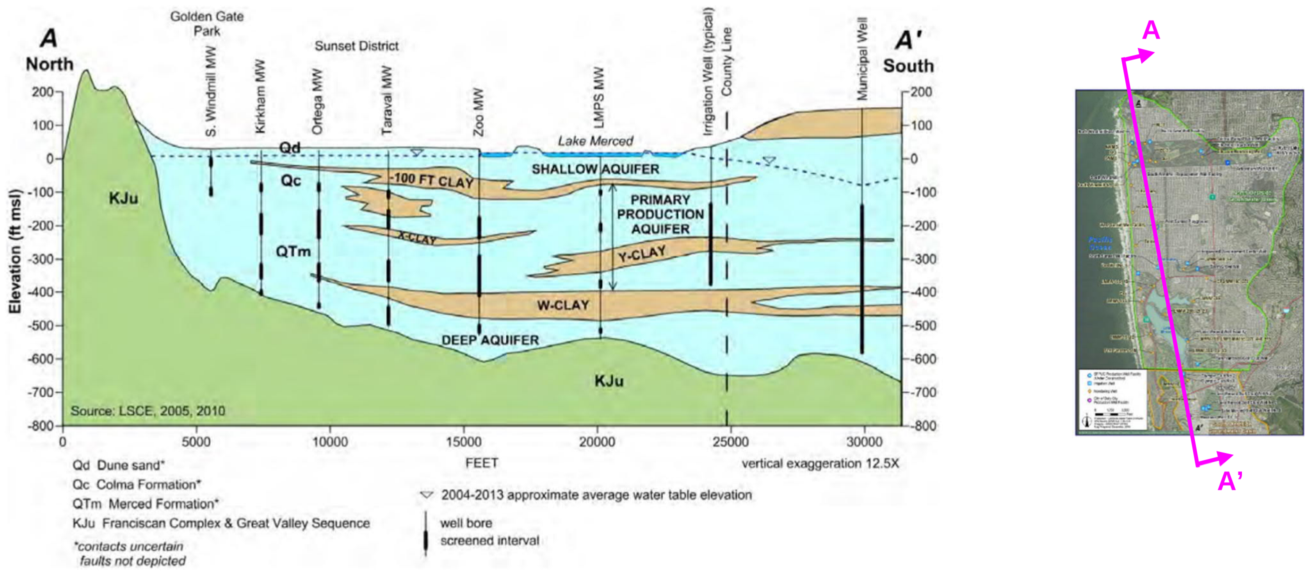
Figure 7-9: Offshore Geologic Map of Pacific Coastline in San Francisco

Ocean Beach is the western edge of the Westside Groundwater Basin as shown in Figure 7-10. This is the largest groundwater basin in San Francisco and is located primarily within the Outer Sunset District, portions of Golden Gate Park, and the Outer Richmond District in San Francisco. The primary water-yielding formations within the Westside Groundwater Basin are the Pliocene to Pleistocene Merced Formation, the Pleistocene Colma Formation, and Quaternary dune sand, which overlay bedrock of the Franciscan Complex. Groundwater development has primarily occurred in the Colma and Merced Formations, although the deeper Merced Formation is the principal water-producing aquifer in the basin. The shallower Colma Formation is also of interest because Lake Merced and Pine Lake are incised within this formation.

Figure 7-11 shows a geologic cross-section of the Pacific coastline from the southern City/County limits to Lands End. Known aquifers and clay layers are shown on this figure, including the shallow aquifer above approximately 100 feet below ground surface (bgs), primary production aquifer between approximately 100 ft to 400 ft bgs, and the deep aquifer below that to bedrock. This figure also shows bedrock rising from approximately 500 to 600 ft bgs to surface exposure in the Lands End area on the left side of the figure. Also shown is the location and depth of several existing municipal wells and irrigation wells installed near this cross-section cut. In general, slant wells will be much shallower than typical vertical groundwater wells.

Source: https://www.westsidewaterresources.org/projects/project1/

Figure 7-10: Westside Groundwater Basin in San Francisco



Source: San Francisco Public Utilities Commission, 2016

Figure 7-11: Geologic Cross Section of North Westside Groundwater Basin

Table 7-2 lists general considerations for slant wells installed along the Pacific coastline. Table 7-3 identifies capacity, design, and construction considerations for slant wells.

Table 7-2: General Considerations for Slant Wells

Item #	Description
1	The most favorable conditions for a subsurface feedwater supply using slant wells are where permeable alluvial deposits extend offshore (typically near the mouths of streams and rivers).
2	Slant wells receive a high percentage of their recharge from ocean water sources including vertical leakage through the seabed and horizontal recharge from offshore aquifers.
3	For slant wells, there is no theoretical limit on the maximum number of wells. The only limitation is on the permeability of the near-shore and offshore aquifers, areal and vertical extent of these deposits.
4	For multiple well arrays, interference between wells and well pods govern the number and spacing of wells, while geologic conditions and coastline land availability governs the limitation on spatial and vertical extent of the well fields
5	Regarding permits, slant wells typically have a more favorable view by regulatory agencies and environmental community, making them easier to permit than other intake systems.
6	Percentage of recharge from inland and ocean water sources, as well as potential impacts, are typically determined using site-specific calibrated groundwater models (flow and transport models).
7	Proven well design methods developed for vertical water supply wells may be applied to slant wells; and proven well construction technology embraces the principle of “simple and strong.”
8	Well casing and screen need to be strong and made of corrosion resistant materials capable of withstanding the initial construction as well as multiple rehabilitations in a seawater environment.
9	Well logging of slant wells requires special tools and methods for successful logging.
10	Slant well layouts include multiple wells from one central wellhead area.
11	Coastal erosion and sea level rise are factors affecting the siting of slant well layouts.
12	Slant well angles and lengths can be varied to minimize salinity variations and as required for site-specific aquifers.

Item #	Description
13	The cone of depression in the vicinity of slant wells is oval shaped with the highest drawdown occurring in the center of the vertical projection of the well screen.
14	Sustainability of a slant well supply includes periodic rehabilitation with an expected frequency ranging between three to five years, or more, depending on site conditions and operation.
15	Experience with Monterey Peninsula Water Supply Project has shown that telescoping can extend 250 to 320 ft before a reduction in diameter is required.
16	Slant wells can be pumped at high capacities using submersible pumps placed on an angle and centered within the pump house chamber.

Table 7-3: Capacity-Design-Construction Considerations for Slant Wells

Subject Area	Item #	Description
Slant Well Capacity, Design, and Construction	1	Does the near-shore and subsea materials consist of sand and gravel? Or is the aquifer highly permeable underneath the seafloor?
	2	Does the high permeable aquifer have sufficient thickness (*e.g.*, high transmissivity), and are in hydraulic continuity with the ocean? Are there confining layers (clay layers) inhibiting either horizontal or vertical recharge to the well?
	3	If the subsea materials consist of consolidated rocks (*e.g.*, sandstone, limestone, granite, or other rock), do these rocks contain sufficient secondary porosity features (joints and fissures) in hydraulic continuity with the seafloor? - Production and filtration are generally not as efficient as alluvial systems except for karstic limestones.
	4	Slant well capacity is a function of the aquifer parameters (*e.g.*, horizontal and vertical hydraulic conductivity, storability, leakance, *etc.*), as well as the screened interval of the well and angle below horizontal. Especially critical is the amount of vertical leakage through the benthic zone of the sea floor.
	5	Well capacity can be evaluated by long term pumping test. Well capacity can be extrapolated from the specific capacity diagram developed from the Test Slant Well step drawdown test and modified for additional well screen length.
	6	Proper slant well design should maximize aquifer production, stabilize fine-grained materials, and maintain as large a screen slot opening as possible. The single most important design objective is prevention of fine-grained materials (sand and silt) from entering the well.
	7	Well capacity can be evaluated by numerical groundwater model (MODFLOW model) if the seafloor aquifer is well characterized.

Subject Area	Item #	Description
Wellhead Location (permitting, access, environmental and operational factors)	1	Slant wells should be located as close to the ocean as possible (to maximize recharge from ocean sources and minimize impacts to inland resources). This maximizes both vertical leakage through the seabed and horizontal recharge from offshore aquifers.
	2	Other factors include coastal erosion, 100-year flood event, sea level rise, and proximity to sensitive habitat, well construction footprints and access to the well drilling site and equipment staging area
	3	Access and Maintenance: Periodic access to the wellhead area for regular measurements within the well and routine well redevelopment
	4	Wellhead Depth Below Land Surface: Typically, slant well wellheads are buried 3-5 ft below ground surface to minimize any nuisance and still allow access to the site
	5	Environmental Concerns: a). Adverse impacts to the natural environment (*e.g.*, sensitive ecological or environmental areas) during construction and operation; b). Slant wellfield production and its pumping (resulting cone of depression) may result in lowering of water levels in upgradient area (east of great highway), thus potentially affecting the vegetation and native riparian species sensitive to water level decreasing; and c). Pumping-induced drawdown causes higher gradient towards ocean and higher groundwater migration towards the ocean (potentially causing faster COC migrations towards the sea if there are any COC plumes near the coast).
	6	Geotechnical Issues: Beach facilities geotechnical conditions, potential geologic and seismic hazards, including seismic shaking, liquefaction, and beach erosion.
	7	Operational Concerns (Project Impacts): Impacts may occur from interference with onshore groundwater pumping levels (lower the pumping rates of inland wells) and effects on nearby water body.
	8	Changes in Freshwater/Saltwater Interface: Where seawater intrusion exists, slant well pumping from offshore aquifers can constitute a seawater intrusion control measure due to the interception of seawater and stabilization of the interface which otherwise would move inland, contributing to seawater intrusion
	9	Other Factors: Other important factors include coastal erosion, the landward extent of a 100-year flood event, and sea-level rise (risk of sea level changes during a 50-year life cycle) in designing an adequate set-back distance from the ocean.

7.2.5 Operations and Maintenance

Operation and maintenance practices for open-water intake structures or slant wells constructed in the Pacific Ocean region should include the following items at a minimum:

- Submersible pumps and motors in slant wells should be exercised regularly (*e.g.*, monthly) to ensure their proper operation.
- Permanently submerged fish screens for open water intakes should be regularly inspected, cleaned, and maintained using a diver.
- The dry land area over slant wells should be kept free from potential sources of contamination that could possibly infiltrate into the aquifer and contaminate the groundwater.
- Interior of well screens for slant wells should be regularly inspected (*e.g.*, annually) via underwater video camera.
- Slant well array wellhead enclosure sites should be well maintained and kept free from accumulated trash, debris, weeds, graffiti, blown sand, *etc.* Unencumbered access should

always be maintained (*e.g.*, entrance gates not blocked by parked vehicles, *etc.*). Enclosure interiors should also be maintained in a clean, uncluttered, and safe condition.

- Security systems should be checked and tested regularly to ensure proper operation.
- All metallic components (visible piping and valves, electrical cabinets, *etc.*) should be regularly inspected for corrosion and repaired as necessary. Protective coatings should be maintained in excellent condition.
- Emergency generators should be operated periodically (*e.g.*, monthly) to ensure their proper operation. Fuel should be used or replaced at regular intervals to ensure it remains fresh. Fuel tanks should always be topped off and left full after each use.

7.3 San Francisco Bay Region

This section provides a discussion of the preliminary engineering design considerations and other select topics for intakes to support future seawater supply facilities located along the San Francisco Bay shoreline in San Francisco. This includes both the North Bayfront and East Bayfront subregions as shown in Figure 5-1.

7.3.1 Engineering Considerations

7.3.1.1 North and East Bayfront Subregions

Only open-water intakes are considered feasible to support new seawater pump stations installed along the bay in either subregion. As mentioned in Section 7.1.1, for an open-water intake, the size of the intake conduit required is dependent upon the desired pump station capacity. The preliminary estimated intake conduit diameters for each of the considered pump station capacities are shown in Table 7-1 for these two subregions. Diameters range from 60 inches (for 10,000 gpm) to 120 inches (for 50,000 gpm) and are the same size in all subregions for a given capacity. This size of tunnel will produce a flow velocity under approximately 1.5 fps at peak intake capacity. Table 7-1 also lists other required design criteria for open-water intakes. Most of the unknown or unconfirmed data will need to be determined during the next phase of this project following additional evaluation.

7.3.2 Geologic and Geotechnical Considerations

Geotechnical and seismic induced hazards for facilities located along the bay include liquefaction, landslides, tsunami runup and seismic ground shaking. Factors influencing these hazards include geologic conditions, topography, groundwater levels and distance to active faults.

The underlying geology of San Francisco is characterized by rock of Late Mesozoic or Early Cretaceous age covered by a variably thick sequence of Quaternary alluvial and eolian sediments, as thick as 300 feet. The bayside locations for the pump station facilities lie in regions with beach and dune sand geologic units or bay muds and artificial fill. Younger Bay Muds are around the shore of the San Francisco Bay and mostly covered by artificial fill. The thickness of the Younger Bay Mud is variable from 10 to 70 feet around the San Francisco Bay. The Younger Bay Mud is soft or very soft, organic-rich clay to silty clay; and often containing numerous clam shells. Most of the artificial fill was non-engineered. The fill was often placed directly over Bay Mud with a consistency and density that is highly variable. The depth of bedrock is estimated to be greater than 60 feet along most of the bayside.

Historical groundwater depths are 5 to 10 feet in the North and East Bayfront subregions. Given the high groundwater, younger Bay muds and artificial fill, the North and East Bayfronts are areas of potential liquefaction. Additionally, these soft materials can amplify seismic ground motions in the event of an earthquake.

Peak ground acceleration due to a moment magnitude (M) 7.8 on the San Andreas fault is estimated as 0.60 to 0.45 g along the North and East Bayfronts, at the 84th percentile level. Peak ground velocity is estimated as 2.6 to 1.5 fps along the North and East Bayfronts, at the 84th percentile level (AECOM/AGS, 2013a).

The seismic induced hazards include settlements of the ground surface, lateral deformations, development of excess pore water pressure, buoyancy effects on below groundwater structures, loss of allowable bearing pressure, and increased lateral pressures on utilities and retaining structures extending below the groundwater table. Seismic-induced hazards may be mitigated through a program of ground improvement. Available techniques for soil improvement include vibro-replacement stone columns, deep soil mixing, and grouting techniques. Alternatively, liquefaction-induced settlements can be minimized by supporting structures on deep foundations.

7.3.3 Coastal Hazards and Sea Level Rise Considerations

Any new bayside intake facilities (such as open-water intakes and supporting landside infrastructure) along the North and East Bayfront subregions would need to consider potential coastal hazards in their siting and design. Coastal hazards include existing and future inundation and flooding from tides and storm surge and wave runup and overtopping. Shoreline erosion is less of a concern along the bay shoreline than the Pacific coastline since most of San Francisco's bay shoreline is armored; however, any supporting landside facilities located along unarmored portions of the shoreline should consider the potential for erosion. Like open water intakes within the Pacific Ocean region, open water intakes within the Bay region should also consider potential wave and geomorphic hazards (such as sediment burial or scour), depending on their location and depth.

Data sources depicting coastal flood hazards for existing and future conditions along the bay shoreline are described in Section 6.3.3. The City and County of San Francisco's Guidance for Incorporating Sea Level Rise into Capital Planning would also apply to seawater intake projects located within the city's Sea Level Rise Vulnerability Zone, as described in Section 6.2.3.

Strategies to address existing and future coastal hazards to bayside intake facilities would likely include hazard avoidance (*e.g.*, locating facilities beyond the landward limit of potential future inundation and flooding) or protection (*e.g.*, locating facilities behind existing or new coastal protection structures such as seawalls). Site modifications to landside facilities such as raising site elevations, elevating critical electrical and mechanical equipment above projected future flood elevations, or floodproofing buildings or equipment enclosures would also mitigate future flood risks.

7.3.4 Operations and Maintenance

Operation and maintenance practices for open-water intake structures constructed in the San Francisco Bay region are the same as the Pacific Ocean region and should include the following items at a minimum:

- Submersible pumps and motors in slant wells should be exercised regularly (*e.g.*, monthly) to ensure their proper operation.
- Permanently submerged fish screens should be regularly inspected, cleaned, and maintained using a diver.
- Security systems should be checked and tested regularly to ensure proper operation.
- All metallic components (visible piping and valves, electrical cabinets, *etc.*) should be regularly inspected for corrosion and repaired as necessary. Protective coatings should be maintained in excellent condition.

- Emergency generators should be operated periodically (*e.g.*, monthly) to ensure their proper operation. Fuel should be used or replaced at regular intervals to ensure it remains fresh. Fuel tanks should always be topped off and left full after each use.

Chapter 8: Integration with Other City Initiatives

This chapter provides an overview of the need for consideration of other development and redevelopment plans within the city, and how expansion of the EFWS could impact (positively or negatively) other infrastructure initiatives.

The City of San Francisco is ever changing in terms of population, business, and industries. The infrastructure to support the city and region is continually expanded, upgraded, and adapted to meet ever-changing needs. There are numerous development and redevelopment initiatives in progress or planned throughout the city; it is important to consider this context when evaluating options for additional seawater supplies for the EFWS.

Similarly, it is important to consider environmental, social, and governance (ESG) issues underway within the City. Social, economic, racial, gender, and other equity concerns are a factor in San Francisco decision-making, and may impact development of new seawater pump stations.

Examples of planned development and redevelopment on the Bay side and ocean side of the city are shown in Figure 8-1 and Figure 8-2.

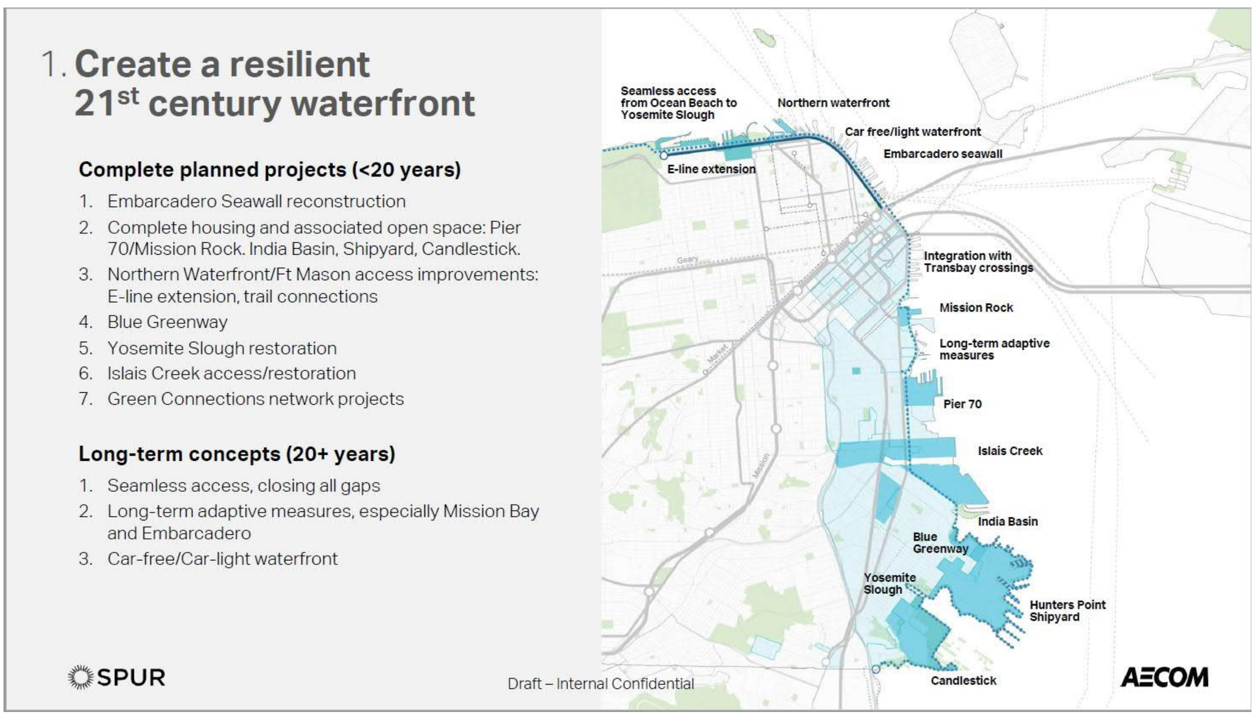


Figure 8-1: Potential Bay-Side Redevelopment

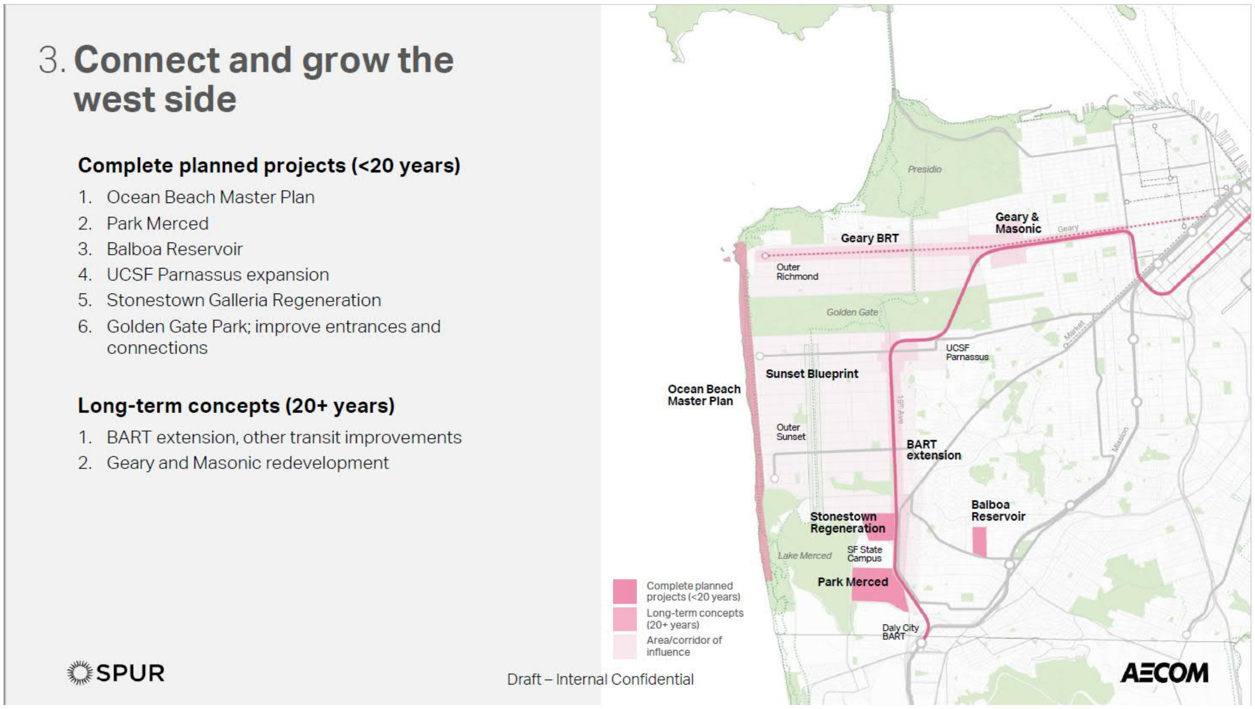


Figure 8-2: Potential Ocean-Side Redevelopment

Addition of new seawater supplies for the EFWS will need to be coordinated with these development and redevelopment efforts. Opportunities exist for creation of co-benefits, such as integrating new EFWS components into the urban landscape with the inclusion of amenities, as has been done in other urban settings.

An example of such co-benefits is the False Creek Pump Station at David Lam Park in Vancouver, BC, shown in Figure 8-3. The pump station is an integral part of this downtown waterfront park. During monthly testing of the pump station systems, water displays occur on the first Friday of each month.

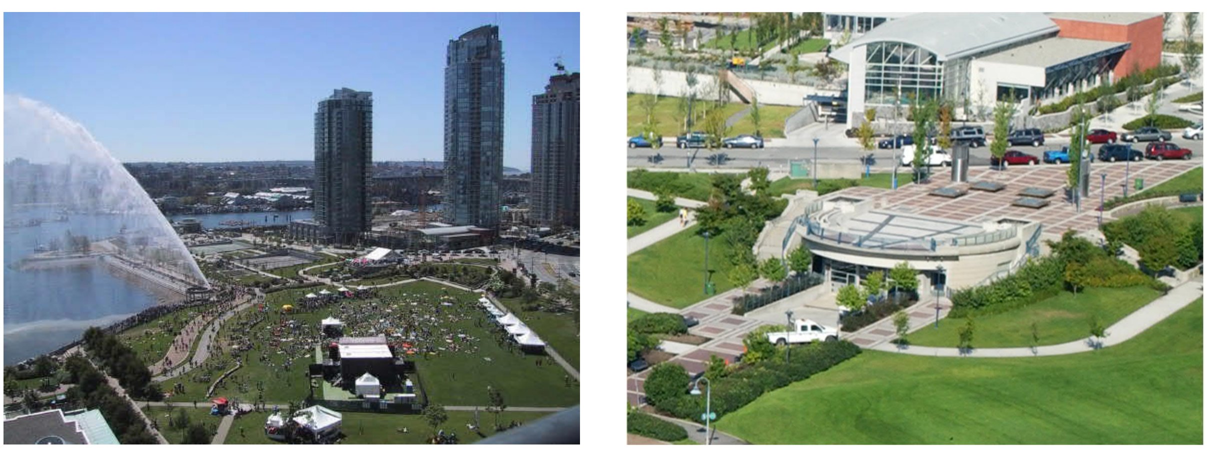


Figure 8-3: False Creek Pump Station at David Lam Park, Vancouver BC

Chapter 9: Costs

This chapter provides a summary of the initial and lifecycle costs of addition of new seawater intake sources for the EFWS. Details of the cost estimates are included in Appendix E.

9.1 Initial Design & Construction

Estimated initial costs at this pre-feasibility study level for the different subregions and flow rates are summarized in Table 9-1. These values include design, permitting, and related up-front costs from the intake location to the closest tie-in to the existing EFWS, but do not include costs associated with increasing piping sizes of the existing EFWS to accommodate additional flows.

Table 9-1: Estimated Initial Costs

	Ocean Side							Bay Side	
	Southern Dunes		Rocky Area South			Rocky Area North		North Bayfront	East Bayfront
Intake Type:	Slant Wells	Open Water	Slant Wells	Open Water (Ocean Beach)	Open Water (Bluffs)	Slant Wells	Open Water	Open Water	Open Water
3,000 gpm	41	68	39	67	70	39	62	24	25
6,000 gpm	51	76	50	75	79	48	68	25	26
10,000 gpm	78	100	79	101	122	69	87	43	44
20,000 gpm	99	123	104	128	174	97	115	57	58
30,000 gpm	120	155	124	159	239	116	144	74	74
40,000 gpm	146	189	149	192	314	141	175	92	93
50,000 gpm	169	224	174	229	404	164	209	112	113
Color scheme for each flow:	Lowest Initial Cost		Highest Initial Cost			(Million $, 2020 basis)			

The costs summarized in Table 9-1 are allocated among costs for environmental / permitting / land acquisition; costs for the pump station itself; and costs for the piping to connect to the EFWS, as shown in Table 9-2.

Table 9-2: Estimated Initial Costs by Cost Category

		Ocean Side							Bay Side	
		Southern Dunes		Rocky Area South			Rocky Area North		North Bayfront	East Bayfront
Flow	Component	Slant Wells	Open Water	Slant Wells	Open Water (Ocean Beach)	Open Water (Bluffs)	Slant Wells	Open Water	Open Water	Open Water
3,000 gpm	Environmental / Permitting / Land Acq.	8.0	8.9	8.0	8.9	8.9	8.0	8.9	8.9	8.9
	Pump Station	7.7	34.3	7.7	34.3	33.3	7.2	28.8	14.2	14.2
	Piping	25.0	25.0	23.3	23.3	28.0	23.8	23.8	0.9	1.8
	TOTAL (rounded up)	**41**	**68**	**39**	**67**	**70**	**39**	**62**	**24**	**25**
6,000 gpm	Environmental / Permitting / Land Acq.	8.2	9.2	8.2	9.2	9.2	8.2	9.2	9.2	9.2
	Pump Station	11.2	35.1	11.2	35.1	34.1	10.7	29.6	15.0	15.0
	Piping	31.2	31.2	31.0	31.0	35.5	29.2	29.2	1.0	1.8
	TOTAL (rounded up)	**51**	**76**	**50**	**75**	**79**	**48**	**68**	**25**	**26**
10,000 gpm	Environmental / Permitting / Land Acq.	10.4	12.1	10.4	12.1	12.1	10.4	12.1	13.8	13.8
	Pump Station	29.7	50.1	29.7	50.1	69.0	29.2	44.6	28.2	28.2
	Piping	37.5	37.5	38.7	38.7	41.0	29.8	29.8	1.1	2.0
	TOTAL (rounded up)	**78**	**100**	**79**	**101**	**122**	**69**	**87**	**43**	**44**
20,000 gpm	Environmental / Permitting / Land Acq.	11.9	13.6	11.9	13.6	13.6	11.9	13.6	16.0	16.0
	Pump Station	45.9	68.0	45.9	68.0	111.2	45.4	61.5	40.1	40.1
	Piping	41.6	41.6	46.5	46.5	49.5	39.5	39.5	1.2	2.2
	TOTAL (rounded up)	**99**	**123**	**104**	**128**	**174**	**97**	**115**	**57**	**58**
30,000 gpm	Environmental / Permitting / Land Acq.	13.4	15.1	13.4	15.1	15.1	13.4	15.1	18.1	18.1
	Pump Station	58.7	92.4	58.7	92.4	168.0	58.2	83.9	54.1	54.1
	Piping	47.9	47.9	51.6	51.6	55.5	44.8	44.8	1.3	2.2
	TOTAL (rounded up)	**120**	**155**	**124**	**159**	**239**	**116**	**144**	**74**	**74**
40,000 gpm	Environmental / Permitting / Land Acq.	14.9	16.8	14.9	16.8	16.8	14.9	16.8	20.7	20.7
	Pump Station	74.9	115.4	74.9	115.4	233.2	74.4	105.9	69.6	69.6
	Piping	56.2	56.2	59.4	59.4	64.0	51.8	51.8	1.4	2.3
	TOTAL (rounded up)	**146**	**189**	**149**	**192**	**314**	**141**	**175**	**92**	**93**
50,000 gpm	Environmental / Permitting / Land Acq.	16.3	18.8	16.3	18.8	18.8	16.3	18.8	23.6	23.6
	Pump Station	87.7	140.8	87.7	140.8	309.9	87.2	130.3	86.6	86.6
	Piping	64.5	64.5	69.7	69.7	74.8	60.2	60.2	1.6	2.5
	TOTAL (rounded up)	**169**	**224**	**174**	**229**	**404**	**164**	**209**	**112**	**113**
	Color scheme for each flow:		Lowest Initial Cost		Highest Initial Cost			(Million $, 2020 basis)		

9.2 Lifecycle Cost

Lifecycle costs for the seawater intakes in the different subregions are shown in Table 9-3 below. These costs are based on a 45-year lifecycle and 4% interest rate, assuming shorter-lived components (*i.e.* the slant well intakes and pumps or the open water intake screens) will be replaced at the 15th and 30th years, and account for periodic operations and maintenance.

Periodic operations and maintenance costs considered include estimated diesel fuel (pump station) or electric power (slant wells) costs, assume monthly testing, and for one major multiple alarm fire per year with the pump station or slant wells in operation.

Table 9-3: Estimated Lifecycle Costs (Net Present Value)

	Ocean Side							Bay Side	
	Southern Dunes		Rocky Area South			Rocky Area North		North Bayfront	East Bayfront
Intake Type:	Slant Wells	Open Water	Slant Wells	Open Water (Ocean Beach)	Open Water (Bluffs)	Slant Wells	Open Water	Open Water	Open Water
3,000 gpm	56	80	54	78	82	54	73	35	36
6,000 gpm	73	87	72	87	90	70	79	37	37
10,000 gpm	131	111	132	112	134	123	98	55	55
20,000 gpm	184	137	189	142	188	181	128	71	72
30,000 gpm	229	172	232	176	255	225	160	90	91
40,000 gpm	286	212	289	215	338	281	198	115	116
50,000 gpm	334	251	339	256	430	329	236	139	140
	*assuming 45 year term and 4% interest rate								
Color scheme for each flow:		Lowest NPV		HighestNPV			(Million $, 2020 basis)		

Chapter 10: Project Development / Next Steps

This chapter provides a high-level summary of tasks and activities required to advance the EFWS Seawater Supply from this initial study towards a full feasibility study and (potentially) to design and implementation.

Advancing the concept of additional seawater intake supplies to the City's EFWS will require further engineering and analysis, including assessment of flow requirements, refinement of engineering aspects, and environmental / permitting requirements.

10.1 Flow Requirements

The information contained in this study has assumed a range of potential flow rates for new seawater supply sources for the EFWS (ranging from 3,000 gpm to 50,000 gpm) in five geographically dispersed areas around the waterfront of the City. Further definition of the required firefighting demands (both in terms of quantity and location(s) of supplemental flow) is needed to advance to the next stage of planning and analysis.

SFPUC is currently conducting a long-range planning study for the EFWS, taking into consideration currently planned and potential future modifications to the overall EFWS system. That study will provide further definition of the required supplemental flows, both in terms of quantity and geographic region where flows are required.

10.2 Engineering

Advancing the concepts presented in this report to the next stage of development will require additional engineering analyses and investigations, including Feasibility Studies, Conceptual Engineering Reports, and Alternatives Analysis Reports.

Some of the anticipated future investigations as part of this process include:

- Hydraulic Modeling: Modeling of the existing and potential enhancements to the EFWS, to determine appropriate sizes of seawater intake/pumping facilities and distribution piping to connect to the existing EFWS
- Geotechnical Engineering: Investigation of offshore sediment characteristics and permeability, to provide key information for design of slant wells or foundations for open water intakes
- Structural Engineering: Assessment of static, live, and seismic loadings (based on site-specific locations) for intake and pumping facilities, as well as transmission lines to connect to the existing EFWS
- Civil Engineering: Assessments related to site selection, grading, pipeline routing, and utility conflicts
- Mechanical Engineering: Selection of specific pumping equipment and appurtenances, based on flow capacities and required discharge pressures for specific seawater pump station locations and EFWS tie-in point
- Electrical / Power Engineering: Assessment of required sizes of diesel or electric prime movers (and relevant backup energy sources), based upon seawater supply flow rates and required discharge pressures

- Supporting Engineering Disciplines:
    - Topographic surveys of potential intake/pump station sites and pipeline alignments to connect with the existing EFWS
    - Bathymetric surveys of coastal areas for potential intake locations
    - Coastal engineering analyses of currents and potential for sediment deposition
    - Detailed cost estimates and construction schedules of concepts selected

10.3 Environmental / Permitting

Understanding and early coordination of environmental compliance and permit acquisition efforts will result in a more efficient project planning and public outreach efforts.

Environmental compliance includes the preparation of NEPA and CEQA documentation so that affected NEPA lead federal agencies and the City of San Francisco (as a lead CEQA agency) can document their decision-making process under the federal and state policies.

It will be important to identify the relevant NEPA lead agency early once a preferred course of action has been identified.

Concurrent and subsequent efforts associated with permit acquisition and various encroachment and lease approvals from public agencies would also be required.

10.4 Implementation Timeline

The timeline to advance the concept of adding new seawater supply sources to the EFWS is largely dependent on identification of preferred alternative(s) for development. A general timeline is as follows:

- Planning: Determining flow requirements; conducting feasibility studies, alternatives analyses, and selecting a preferred alternative may take 12- 24 months.
- Environmental Review & Permitting: Depending on the preferred course of action, NEPA and CEQA efforts may take 18 to 24 months, and subsequent permitting would take up to 24 months.
- Design: Depending on the preferred course of action (*e.g.* location(s) & size(s) of seawater intakes), engineering design activities may take 12 – 36 months.
- Construction & Commissioning: Depending on the preferred course of action (*e.g.* location(s) & size(s) of seawater intakes), construction and commissioning activities may take 24 – 48 months.

The total project timeline is anticipated to range from 90 – 156 months (7.5 – 15 years).

Chapter 11: References

AECOM, 2016. Sea Level Rise Pilot Study, Future Conditions Analysis and Mapping, San Francisco County, CA. California Coastal Analysis and Mapping Project Open Pacific Coast Study. Prepared for FEMA Region IX. January 2016.

AECOM, 2019. Potable Emergency Firefighting Water System Sunset Pump Station Summary TM, September 25, 2019

AECOM, 2020(a). Emergency Firefighting Water System Supply Analysis Technical Memorandum. Prepared for San Francisco Public Utilities Commission. March 12.

AECOM, 2020(b). Potable Emergency Firefighting Water System Pipeline Alternatives Analysis Report, July 1, 2020.

AECOM, 2020(c). Potable Emergency Firefighting Water System Pipeline Conceptual Engineering Report, July 1, 2020.

AECOM, 2021.Emergency Firefighting Water System Future Planning Study, (in preparation).

AECOM / AGS, 2013(a). CS-199 Planning Support Services for Auxiliary Water Supply System (AWSS), Task 4 – Geologic, Seismologic, and Geotechnical Hazards, January 23, 2013.

AECOM / AGS, 2013(b). CS-199 Planning Support Services for Auxiliary Water Supply System (AWSS), Task 7 – Seawater Intake Tunnels Technical Memorandum, January 2013.

AECOM / AGS, 2013(c). CS-199 Planning Support Services for Auxiliary Water Supply System (AWSS), Technical Memorandum - Task 13.4 – Pump Station No. 2 Alternatives, July 2013.

Barnard, P.L., Hanes, D.M, Rubin, D.M, and Kvitek, R.G. (2006). Giant sand waves at the mouth of San Francisco Bay. *EOS, Transactions American Geophysical Union,* 87(29, 285-289.

Barnard, P.L., Erikson, L.H., Foxgrover, A.C., Limber, P.L., O'Neill, A.C., and Vitousek, S., 2018, Coastal Storm Modeling System (CoSMoS) for Central California, v3.1 (ver. 1f, May 2020): U.S. Geological Survey Data Release, https://doi.org/10.5066/P9NUO62B.

City and County of San Francisco 2018-2019 Civil Grand Jury, 2019. Act Now Before It is Too Late: Aggressively Expand and Enhance our High-Pressure Emergency Firefighting Water System.

Graymer, R.W., Moring, B.C., Saucedo, G.J., Wentworth, C.M., Brabb, E.E., and Knudsen, K.L., 2006, Geologic map of the San Francisco Bay region: U.S. Geological Survey Scientific Investigations Map, SIM-2918, 1 sheet, scale 1:275,000.

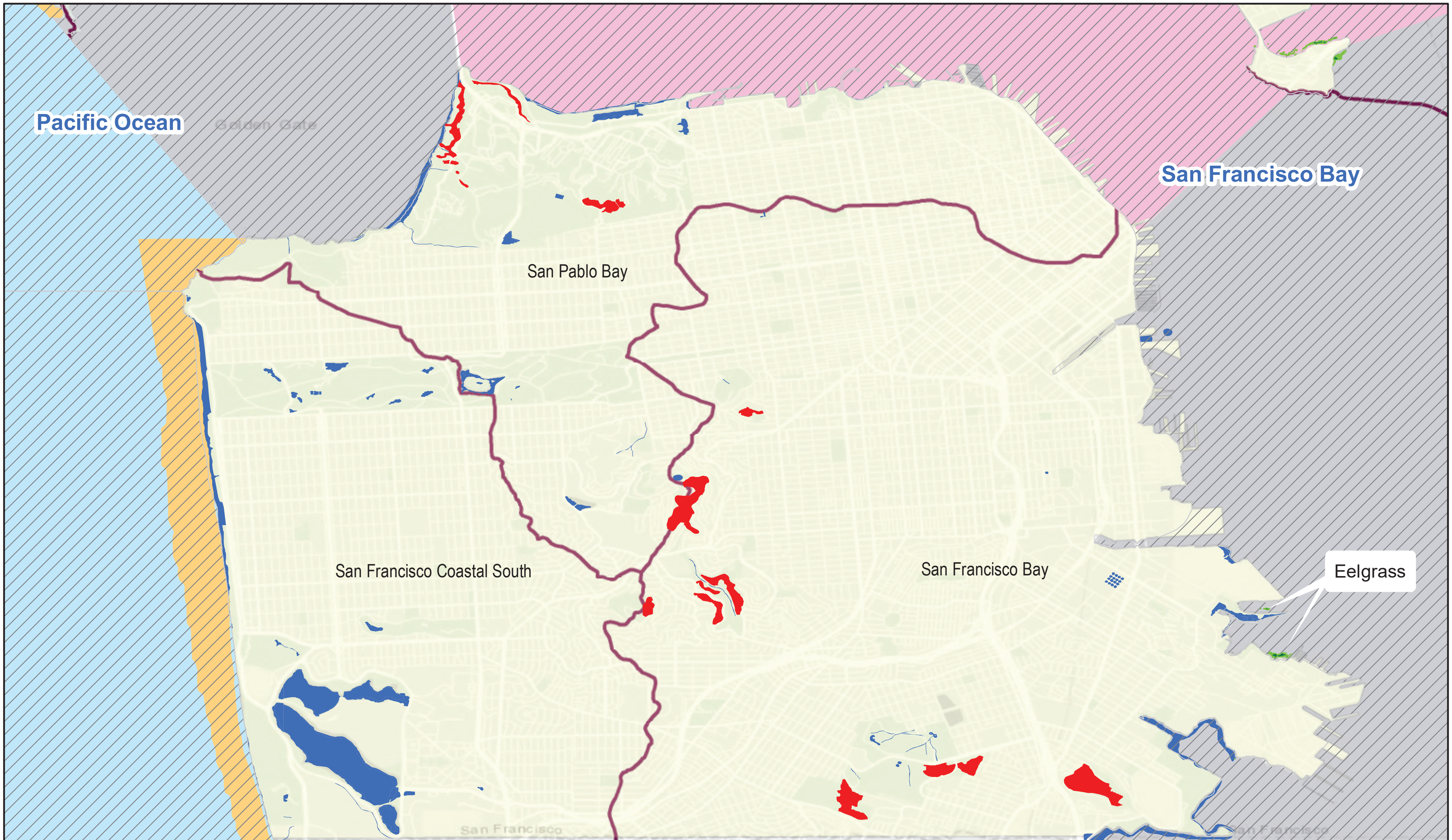
Greene, H.G., Hartwell, S.R., Manson, M.W., Johnson, S.Y., Dieter, B.E., Phillips, E.L., and Watt, J.T., 2014, Offshore and onshore geology and geomorphology, Offshore of Pacifica map area, California, sheet 10, in Cochran, S.A. and Edwards, B.D., eds., California State Waters Map Series—Offshore of Pacifica, California: U.S. Geological Survey Open-File Report 2014-1260, pamphlet 38 p., 10 sheets, scale 1:24,000, http://dx.doi.org/10.3133/ofr20141260. IP-052391.

Greene, H.G., Johnson, S.Y., Manson, M.W., Hartwell, S.R., Endris, C.A., and Bruns, T.R., 2015, Offshore and onshore geology and geomorphology, Offshore of San Francisco map area, California, sheet 10, in Cochrane. G.R. and Cochran, S.A., eds., California State Waters Map Series—Offshore of

San Francisco, California: U.S. Geological Survey Open-File Report 2015-1068, pamphlet 39 p., 10 sheets, scale 1:24,000, http://dx.doi.org/10.3133/ofr20151068. IP-052334.

San Francisco Public Utilities Commission, 2016, North Westside Basin Groundwater Sustainability Plan, draft: February 2016.

Appendix A: Planning and Resource Area Maps



Natural Resources

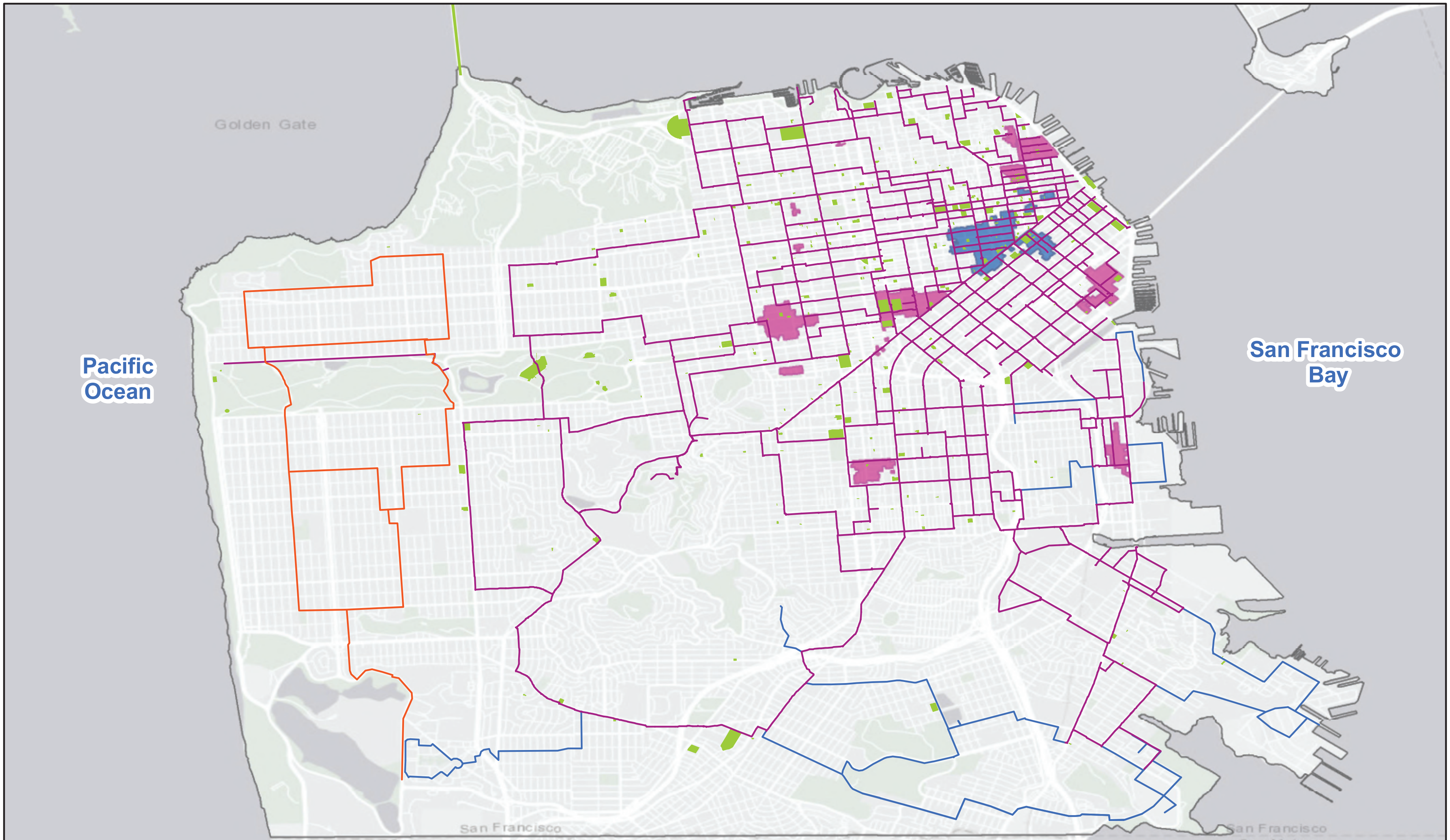
- City of San Francisco Boundary
- Eelgrass
- Watershed
- Jurisdictional Wetland

ESA Critical Habitat Designations (Additional fine-scale species data should be reviewed for CEQA & NEPA purposes once alternative sites are identified)

- Arctostaphylos Franciscana
- Green Sturgeon
- Black Abalone
- Salmon, Chinook
- Leatherback Sea Turtle

0 0.5 1 Miles

Data Sources:
City of San Francisco: https://data.sfgov.org/Geographic-Locations-and-Boundaries/SF-Shoreline-and-Islands/rgcx-5tix
Eelgrass: https://www.sfei.org/data/eelgrass-survey-gis-data#sthash.rL44t8lz.dpbs
Watersheds and Wetlands: https://www.fws.gov/wetlands/data/Mapper.html
ESA Critical Habitat Designations: https://www.fisheries.noaa.gov/resources/maps?title=critical+habitat&field_management_area_value%5BWest+Coast%5D=West+Coast&field_species_vocab_target_id=&sort_by=created

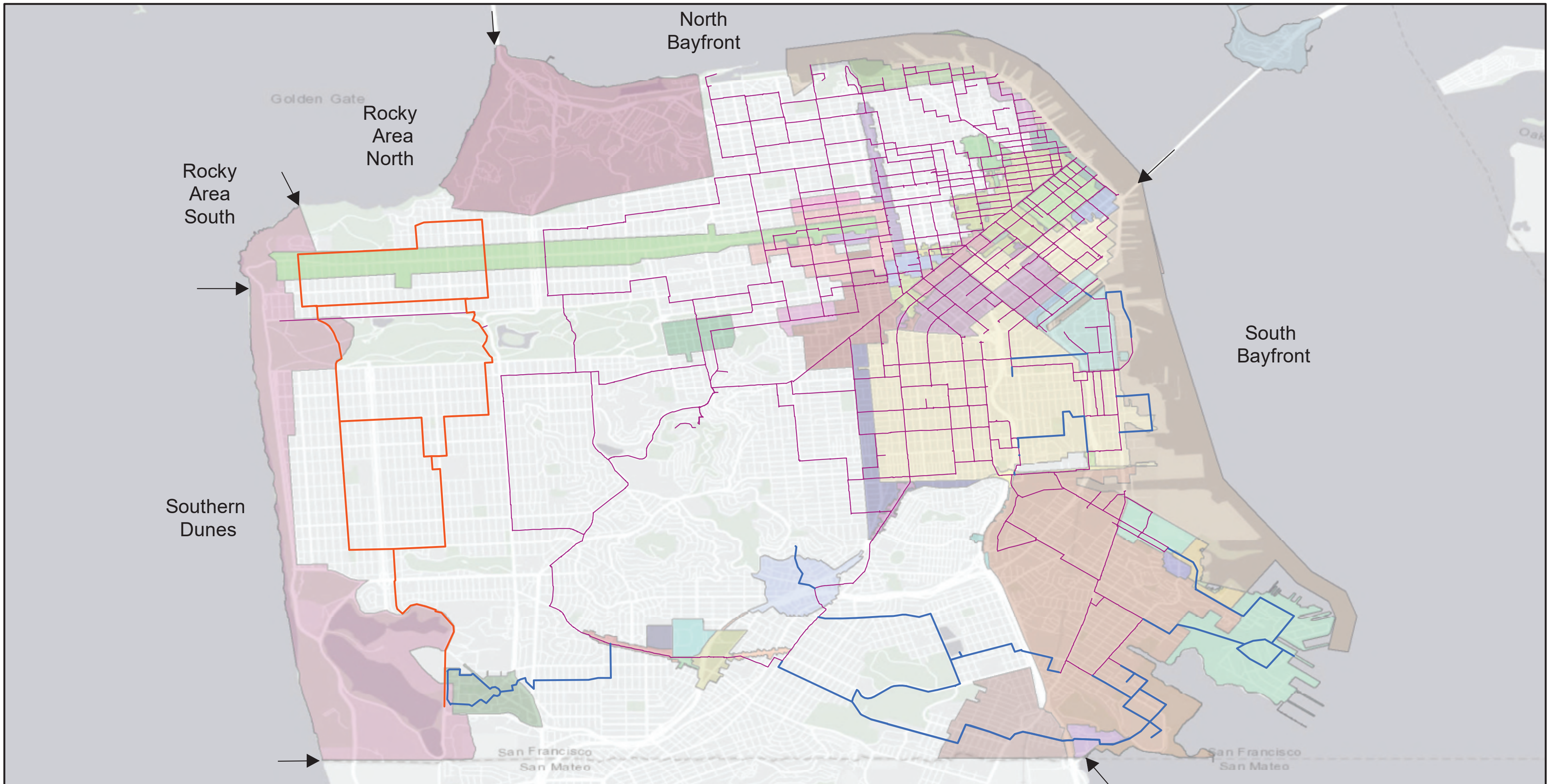


Historic Resources

- PEFWS Pipes
- Existing EFWS Pipes
- Planned EFWS Pipes
- Historic Landmarks
- Landmark Districts
- Conservation Districts
- City of San Francisco Boundary

0 0.5 1 Miles

Data Sources:
City of San Francisco: https://data.sfgov.org/Geographic-Locations-and-Boundaries/SF-Shoreline-and-Islands/rgcx-5tix
Conservation Districts: https://data.sfgov.org/Geographic-Locations-and-Boundaries/Conservation-Districts-as-listed-in-Article-11-of-/4exc-em5v
Landmark Districts: https://data.sfgov.org/Geographic-Locations-and-Boundaries/Landmark-Districts/vnrd-fpg7
Historic Landmarks: https://data.sfgov.org/dataset/Landmarks/hfwn-m3tm

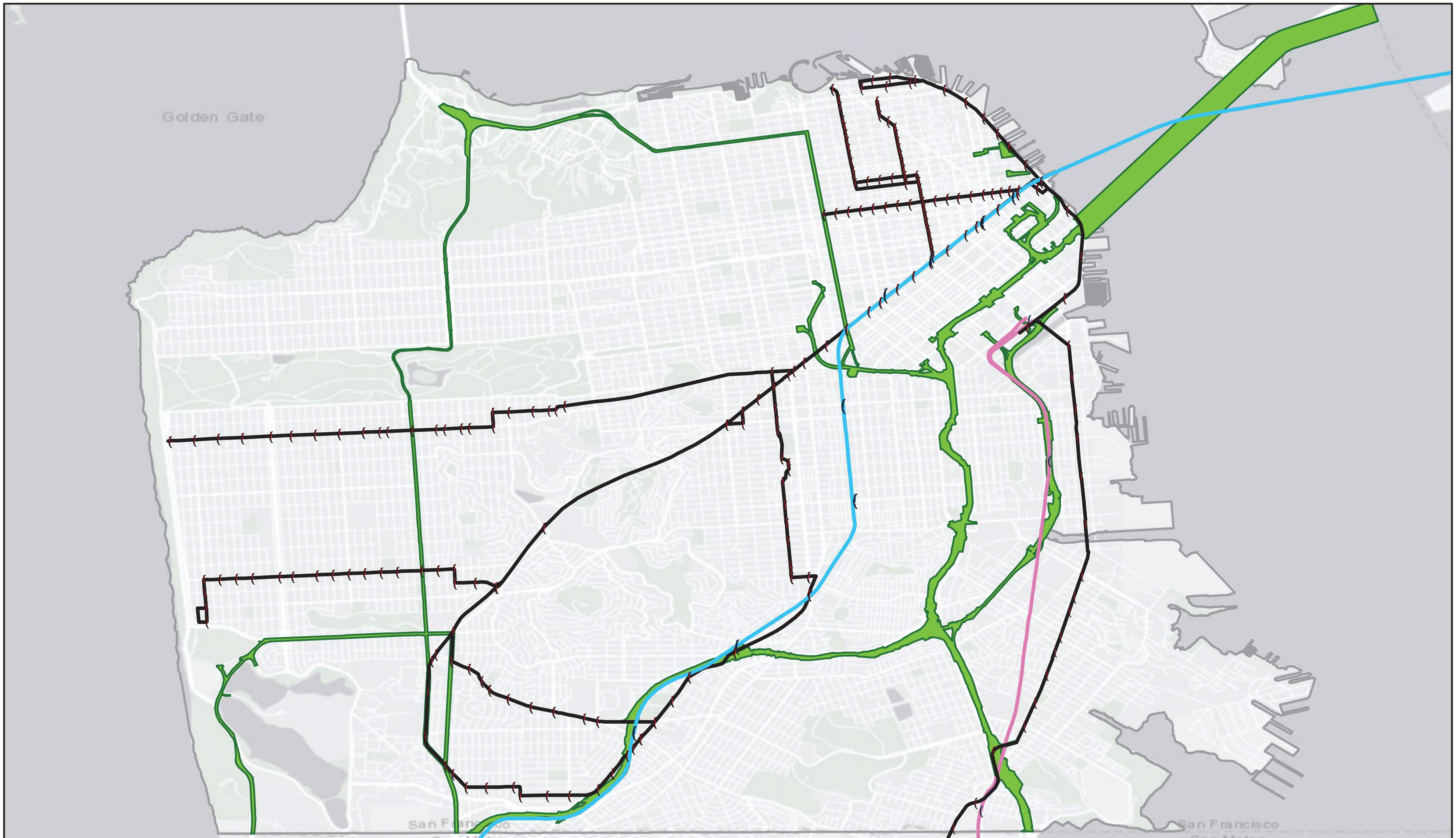


Representation of City of San Francisco Planning Areas

- A-1
- A-2
- BP: City College
- BP: Ocean Avenue Commercial District
- BP: Reservoir
- BP: Transit Station
- Balboa Park
- Base of Telegraph Hill Subarea
- Bayshore Boulevard
- Bayview Hunters Point
- Candlestick Point
- Central SoMa
- Central Waterfront (EN)
- Cesar Chavez East Caltrans EJ Grant
- Chinatown
- Civic Center
- Civic Center Public Realm Plan
- Dogpatch Public Realm Plan
- Downtown
- Downtown Streetscape Plan
- East SoMa (EN)
- Eastern Neighborhoods (Complete)
- Eastern Neighborhoods w/Valencia
- Executive Park
- Ferry Building Subarea
- Fisherman?s Wharf Public Realm Plan
- Geary Corridor
- Glen Park
- Glen Park (superseded)
- Haight Ashbury Public Realm Plan
- Hunters Point Shipyard
- Hunters View
- India Basin
- India Basin Industrial Park
- India Basin Shoreline/Area C
- Japantown
- Lower Haight Public Realm Plan
- Market and Octavia
- Market and Octavia Living Alleys
- Mid-Market
- Mission (EN)
- Mission Bay
- Mission District Streetscape Plan
- Mission Public Life Plan
- Northeast Embarcadero Study
- Northeast Waterfront
- Ocean and Geneva Corridor Design Plan
- Parkmerced
- Pier 70
- Port
- Presidio
- Railyard
- Rincon Hill
- Rincon Hill Streetscape Plan
- Schlage Lock
- Sea Wall Lot 337
- Showplace Square Open Space Plan
- Showplace Square/Potrero Hill (EN)
- South Beach Subarea
- South of Market
- The Market Street Hub Project
- Transbay
- Transbay Zone 1
- Transit Center District
- Transit Center District Streetscape Plan
- Treasure Island
- Van Ness Corridor
- Visitacion Valley
- Western Shoreline
- Western SoMa (EN)
- Yerba Buena
- Planned EFWS Pipes
- PEFWS Pipes
- Existing EFWS Pipes
- Shoreline Subregion Boundary

0 0.5 1 Miles

Data Source for Planning Areas: https://data.sfgov.org/City-Infrastructure/Planning-Areas/bkzf-eahq

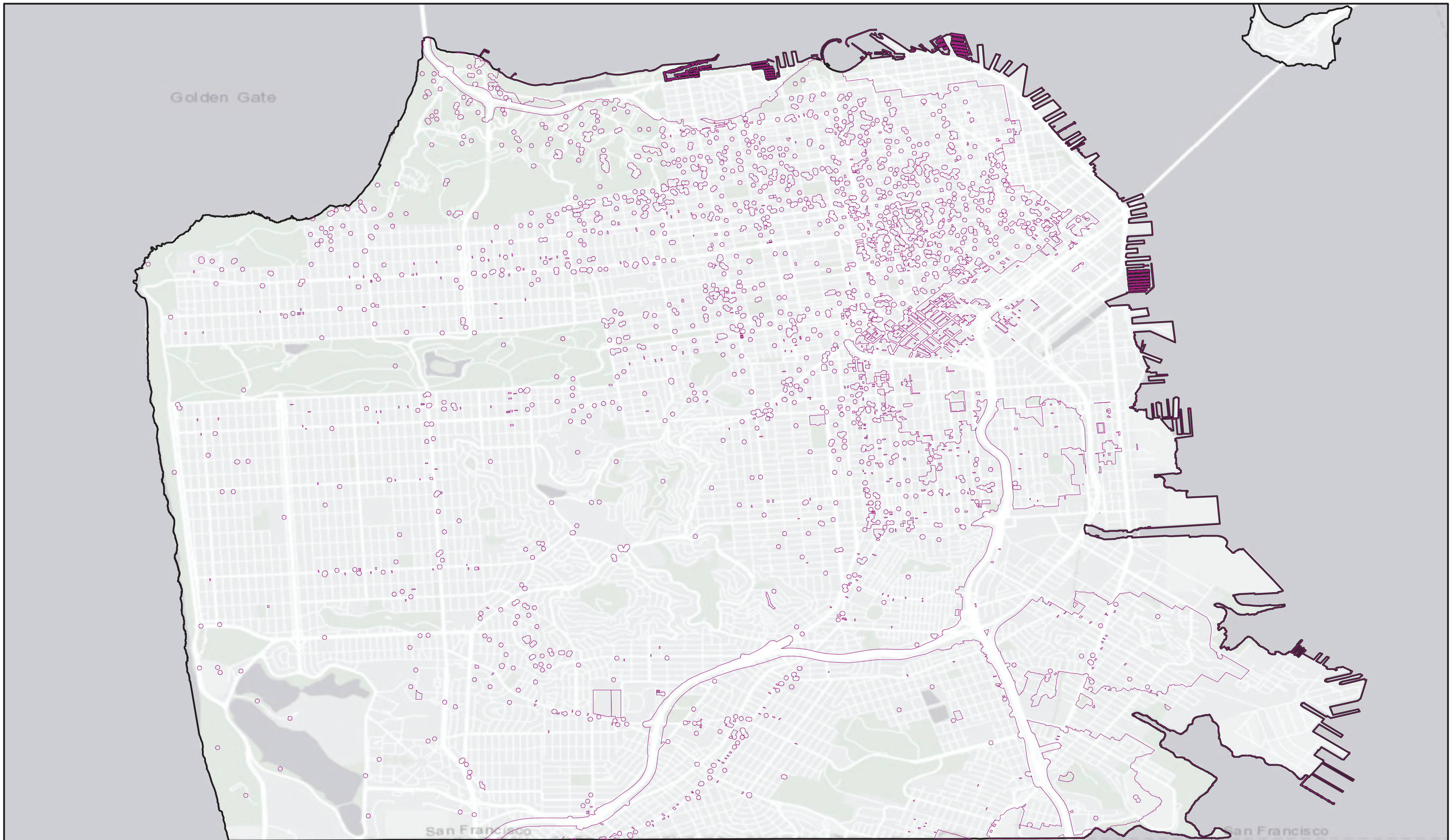


Highway and Transit Corridors in City of San Francisco

Caltrans Right of Way	Passenger Railways	Passenger Rail Stations
City of San Francisco Boundary	BART	BART
	Caltrain	CALTRAIN
	MUNI	San Francisco MUNI

0 0.5 1 Miles

Data Sources:
Caltrans Right of Way: https://caltrans.maps.arcgis.com/apps/webappviewer/index.html?id=04efb9a9f14c4da2aabd9ce36b7dda48/
Passenger Railways: https://opendata.mtc.ca.gov/datasets/passenger-railways-2019
Passenger Rail Stations: https://opendata.mtc.ca.gov/datasets/passenger-rail-stations-2019



Hazardous Materials Sites

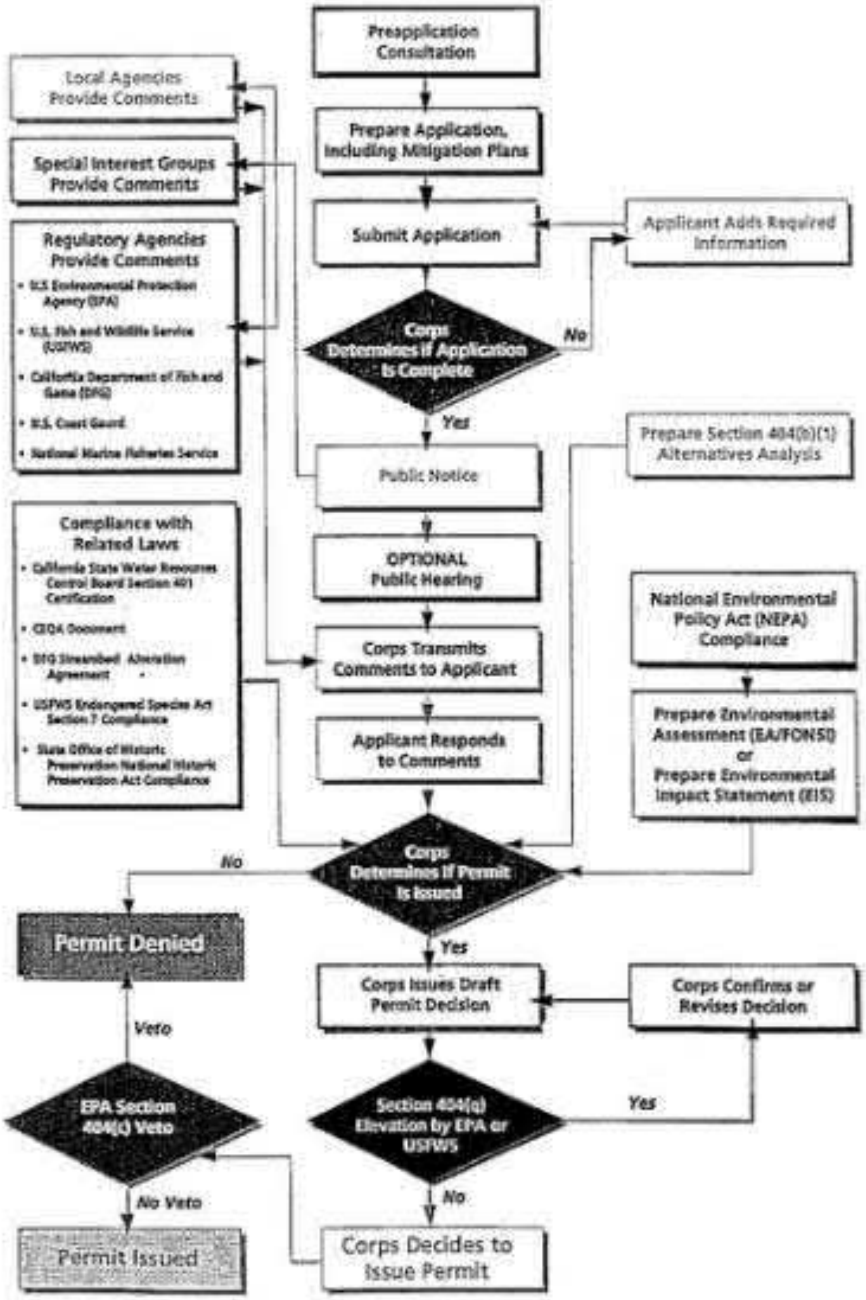
City of San Francisco Boundary
Hazardous Material Sites

Hazardous Material Sites presents development projects that are located on sites with known or suspected soil and/or groundwater contamination are subject to the provisions of Health Code Article 22A, which is administered by the Department of Public Health.

0 0.5 1 Miles

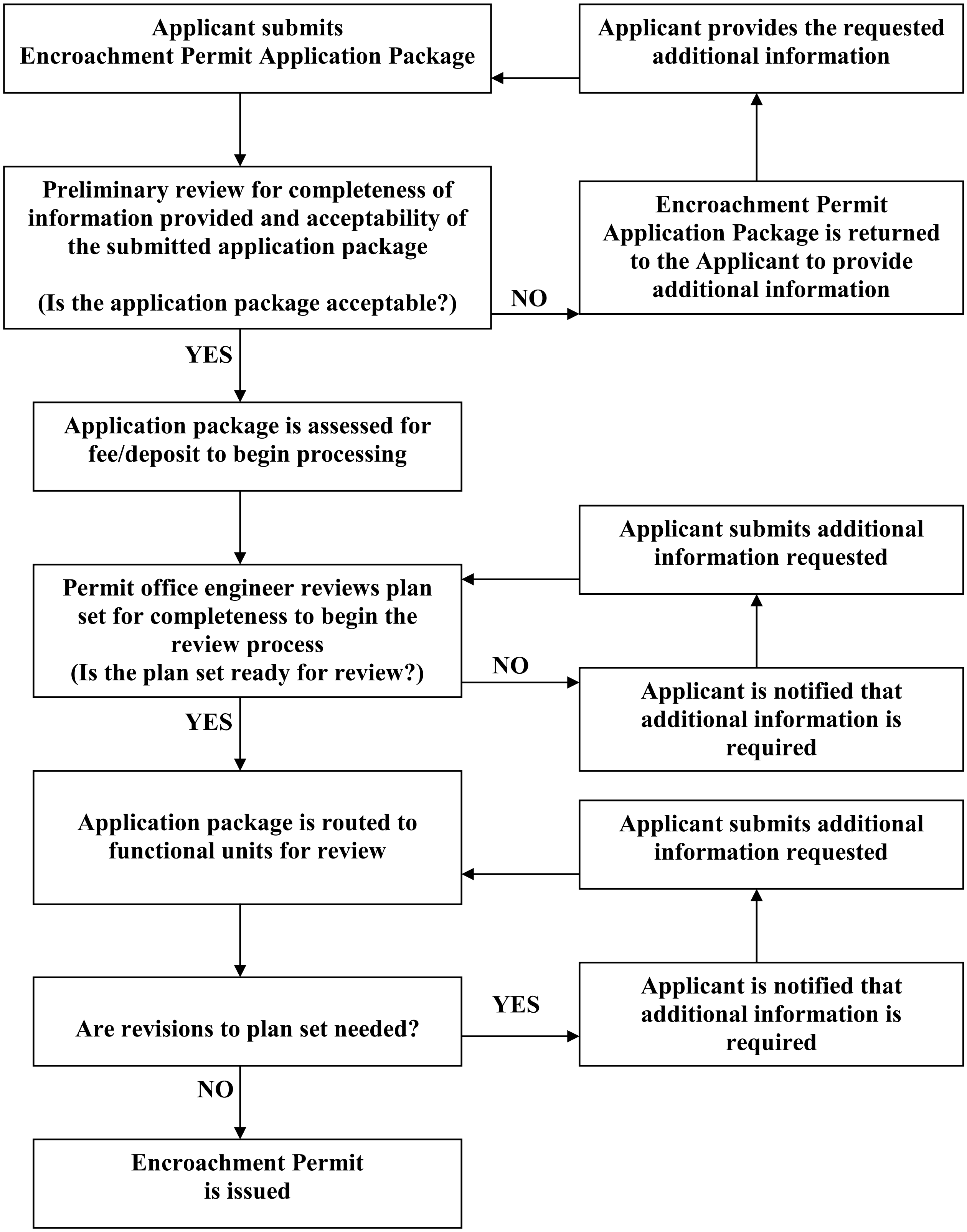
Data Sources:
City of San Francisco Boundary: https://data.sfgov.org/Geographic-Locations-and-Boundaries/SF-Shoreline-and-Islands/rgcx-5tix
Hazardous Material Sites: https://data.sfgov.org/Energy-and-Environment/Maher/hqsk-4xmh

Appendix B: Regulatory Decision Trees



Preapplication Consultation
Local Agencies Provide Comments
Prepare Application, Including Mitigation Plans
Special Interest Groups Provide Comments
Submit Application
Applicant Adds Required Information
Regulatory Agencies Provide Comments
• U.S. Environmental Protection Agency (EPA)
• U.S. Fish and Wildlife Service (USFWS)
• California Department of Fish and Game (DFG)
• U.S. Coast Guard
• National Marine Fisheries Service
Corps Determines if Application Is Complete
No
Yes
Prepare Section 404(b)(1) Alternatives Analysis
Public Notice
Compliance with Related Laws
• California State Water Resources Control Board Section 401 Certification
• CEQA Document
• DFG Streambed Alteration Agreement
• USFWS Endangered Species Act Section 7 Compliance
• State Office of Historic Preservation National Historic Preservation Act Compliance
OPTIONAL Public Hearing
National Environmental Policy Act (NEPA) Compliance
Corps Transmits Comments to Applicant
Prepare Environmental Assessment (EA/FONSI) or Prepare Environmental Impact Statement (EIS)
Applicant Responds to Comments
No
Corps Determines if Permit Is Issued
Permit Denied
Yes
Corps Issues Draft Permit Decision
Corps Confirms or Revises Decision
Veto
EPA Section 404(c) Veto
Section 404(q) Elevation by EPA or USFWS
Yes
No Veto
No
Permit Issued
Corps Decides to Issue Permit

ENCROACHMENT PERMIT APPLICATION REVIEW PROCESS



San Francisco Planning

49 South Van Ness Avenue, Suite 1400
San Francisco, CA 94103
www.sfplanning.org

HISTORIC RESOURCE DETERMINATION (HRE)

INFORMATIONAL AND SUPPLEMENTAL APPLICATION PACKET

ATTENTION: A Project Application must be completed and/or attached prior to submitting this Supplemental Application. See the Project Application for instructions.

Pursuant to the California Environmental Quality Act (CEQA), public agencies must review the environmental impacts of proposed projects, including impacts to historic resources. This form provides additional information to assist the Department in analyzing whether a property qualifies as a historic resource under CEQA.

For questions, you can call the Planning counter at 628.652.7300 or email pic@sfgov.org where planners are able to assist you.

Español: Si desea ayuda sobre cómo llenar esta solicitud en español, por favor llame al 628.652.7550. Tenga en cuenta que el Departamento de Planificación requerirá al menos un día hábil para responder.

中文：如果您希望獲得使用中文填寫這份申請表的幫助，請致電628.652.7550。請注意，規劃部門需要至少一個工作日來回應。

Filipino: Kung gusto mo ng tulong sa pagkumpleto ng application na ito sa Filipino, paki tawagan ang 628.652.7550. Paki tandaan na mangangailangan ang Planning Department ng hindi kukulangin sa isang araw na pantrabaho para makasagot.

WHAT IS A HISTORIC RESOURCE DETERMINATION?

The Supplemental Information for Historic Resource Determination provides additional information about a particular property or set of properties that is to be analyzed for historic resource impacts under the California Environmental Quality Act (CEQA). The information requested in this document helps Department staff determine whether a property is a historic resource under CEQA, and if required, the impacts of a proposed project to the historic resource.

WHEN IS A HISTORIC RESOURCE DETERMINATION NECESSARY?

CEQA law requires the Department to analyze a project's impact to any known or potential historical resource. Before the impact of a project can be analyzed, the Department must first determine whether the subject property qualifies as a historical resource. The material requested in this Supplemental Information for Historic Resource Determination provides

Department staff with the documentation for this analysis.

This Application must be submitted when:

1. The project involves an alteration to a structure constructed more than 45 years ago that exceeds the scope of the Categorical Exemption Determination form; or
2. The Department requests this information in order to determine whether a property is a Historic Resource (Category A) or not a Historic Resource (Category C).

Please consult the Property Information Map on the Department's website to determine whether a property has been identified as a CEQA historic resource.

For more information on the CEQA review processes, including the thresholds for full Historic Resource Evaluation review of projects, please refer to the Environmental Evaluation Screening Form found in the Project Application.

HOW DOES THE PROCESS WORK?

If required, the Supplemental Information for Historic Resource Determination must be submitted along with the Project Application. Once the application has been assigned to an Environmental Planner, the information in this document and project details will be forwarded to a Preservation Planner for historic resource review. The Preservation Planner will go through the material and prepare a report analyzing the property against the requirements in CEQA to determine if the building is a historic resource. Once completed, the final report is sent back to the Environmental Planner for other CEQA analysis (if applicable).

INSTRUCTIONS

Please refer to the Environmental Evaluation Screening Form for the instructions on what materials are required for complete CEQA analysis. The attached forms outline the materials that the Preservation Planner must have in order to evaluate whether a property or set of properties is a historic resource under CEQA.

All available resources must be researched and materials gathered from these sources that are relevant to the subject property must be submitted. The CEQA historic resource analysis will not begin until the Department determines that the material submitted is complete. For information on how to compile the required information, refer to the "How to Research a Property's History" section of this document.

Please provide the following materials with this application:

- ☐ Photocopies: Copies are required to be submitted of all documentation used to complete this form, including copies of building permits and drawings, historic maps, and articles.
- ☐ Photographs: The application must be accompanied by unmounted photographs, large enough to show the nature of the property and the adjacent properties and area, but not over 11 X 17 inches.

All documents and other exhibits submitted with this application will be retained as part of the permanent public record in this case.

FEES

Please refer to the Planning Department Fee Schedule available at **www.sfplanning.org** For questions related to the Fee Schedule, you can call the Planning counter at 628.652.7300 or email pic@sfgov.org where planners are able to assist you.

Fees will be determined based on the estimated construction costs. Should the cost of staff time exceed the initial fee paid, an additional fee for time and materials may be billed upon completion of the hearing process or permit approval. Additional fees may also be collected for preparation and recordation of any documents with the San Francisco Assessor-Recorder's office and for monitoring compliance with any conditions of approval.

HOW TO RESEARCH A PROPERTY'S HISTORY

Below is an outline of items that should be researched along with local resources available to the public. Please be aware that the address or block/lot may have changed from the date of construction, so be sure to have all available addresses, block/lot before beginning research.

A. Building Permit History. Start with a search for the full construction and permit history. The Department of Building Inspection (DBI) has copies of all building permits issued, often accompanied by architectural drawings. The original construction permit can tell when a property was built and what its original appearance was. Requests for permit history must be made in person at DBI, 1660 Mission Street, at the Customer Service Division. Please refer to http://

www. sfdbi.org/ for more information.

B. Water Department Records. Now a part of the Public Utilities Commission, the original SF Water Department's records can indicate when a building was constructed if the original building permits are not available. These records show when a property was 'tapped' into the City's main water system and typically occurred close to the construction date. These records should be investigated for any property that was constructed prior to 1906. The Water Department Records are available at the Main Branch of the San Francisco Public Library located at 100 Larkin Street.

C. Assessor-Recorder's Office. Used when researching the ownership history of a property, the Assessor- Recorder's Office has original deeds, sales records, and map books that show ownership history, records about owners, room counts, and building construction dates. Other data available at the Assessor-Recorder's Office include Map Books and Homestead Maps, both of which should be consulted for properties constructed prior to 1912. Research must be done in person at the Assessor-Recorder's Office located in City Hall, Room #190. For more information about the Assessor-Recorder's Officeand the material located there, refer to http://www. sfassessor.org.

D. San Francisco History Room. Located at the Main Branch of the Public Library, the San Francisco History Room has extensive records that are helpful when researching the history of an owner/occupant(s) of a property, the history of a neighborhood, and information on an architect or builder. The San Francisco Historical Photograph Collection is located within the History Room and may provide an early view of a building or street. The collection in the History Room is where historic newspapers, such as the Chronicle and the Examiner, can be researched, along with Our Society Blue Books, and various real estate circulars. The Library also publishes "How to Research a San Francisco Building" that lists all resources available as well as steps to take when researching a property. The Main Branch of the San Francisco Public Library is located at 100 Larkin Street and additional information on the SF History Room is available on the library's website. Please refer to http://www.sfpl.org/.

E. Other Data at the Main Branch of San Francisco Public Library. There are two additional resources that should be consulted when researching a property's history - the City Directories and U.S. Census Records. These resources are useful for documenting a building's occupant history. For information on researching census records, refer to the Government Information Center division of the Library; the City Directories are a part of the General Collection. The Main Branch of the San Francisco Public Library is located at 100 Larkin Street and additional information on both Library sections are available on the library's website. Please refer to http://www.sfpl.org/.

F. Other Research Collections. There are several other resources available for researching a property's history.

- The California Historical Society houses extensive collections of historic photographs, histories of peoples and neighborhoods in San Francisco. For more information about the Society and their library hours, please refer to http://www. californiahistoricalsociety.org.
- The Environmental Design Library at UC Berkley is one of the premier repositories for architecture, landscape architecture, regional and urban planning materials in the country. The collections include periodicals such as Architectural Record and Architect & Engineer, original architectural drawings by premier architects, and rare books. For more information on the Library and its hours, please refer to http://www.lib.berkeley.edu/ENVI/.
- San Francisco Architectural Heritage is a local organization whose mission is "to preserve and enhance San Francisco's unique architectural and cultural identity." SF Heritage has a library collection that focuses on historic buildings and includes a variety of material including newspaper articles and architect biographies. For more information about SF Heritage, please refer to http://www.sfheritage.org/.

If required, this Supplemental Information for a Historic Resource Determination must be submitted along with the *Project Application.*

PLANNING APPLICATION RECORD NUMBER

San Francisco Planning

HISTORIC RESOURCE DETERMINATION (HRE)

SUPPLEMENTAL APPLICATION

Property Information

Project Address: Block/Lot(s):

Date of Construction: Architect or Builder:

Is property included in a historic survey? Survey Name: Survey Rating:

☐ Yes ☐ No

Designated Property: ☐ Article 10 or Article 11 ☐ CA Register ☐ National Register

Permit History Table

Please list out all building permit issued from the date of construction to present. Attach photocopies of each.

Permit:	Date	Description of Work
1		
2		
3		
4		
5		
6		
7		
8		

Please describe any additional projects or information about a particular project(s) that is not included in this table:

Ownership History Table

Please list out all owners of the property from the date of construction to present

Owner:	Date (to-from):	Name(s):	**Occupation:**
1			
2			
3			
4			
5			
6			
7			
8			

Please describe any additional owners or information about a particular owner(s) that is not included in this table:

☐ *See attachment (if more space is needed)*

Occupant History Table

Please list out all occupants/tenants of the property from the date of construction to present.

Occup.	Date (to-from):	Name(s):	**Occupation:**
1			
2			
3			
4			
5			
6			
7			
8			

Please describe any additional occupants or information about a particular occupant(s) that is not included in this table:

☐ *See attachment (if more space is needed)*

Property/Architecture Description

Please provide a detailed narrative describing the existing building and any associated buildings on the property. Be sure to describe the architectural style and include descriptions of the non-visible portions of the building. Attach photographs of the building and property, including the rear facade.

Adjacent Properties/Neighborhood Description

Please provide a detailed narrative describing the adjacent buildings and the buildings on the subject block and the block directly across the street from the subject property. Be sure to describe the architectural styles. Attach photographs of all properties.

APPLICANT'S AFFIDAVIT

Under penalty of perjury the following declarations are made:

a) The undersigned is the owner or authorized agent of the owner of this property.

b) The information presented is true and correct to the best of my knowledge.

c) Other information or applications may be required.

d) I hereby authorize City and County of San Francisco Planning staff to conduct a site visit of this property as part of the City's review of this application, making all portions of the interior and exterior accessible through completion of construction and in response to the monitoring of any condition of approval.

e) I attest that personally identifiable information (PII) - i.e. social security numbers, driver's license numbers, bank accounts - have not been provided as part of this application. Furthermore, where supplemental information is required by this application, PII has been redacted prior to submittal to the Planning Department. I understand that any information provided to the Planning Department becomes part of the public record and can be made available to the public for review and/or posted to Department websites.

____
Signature

____
Name (Printed)

____
Date

____
Relationship to Project
(i.e. Owner, Architect, etc.)

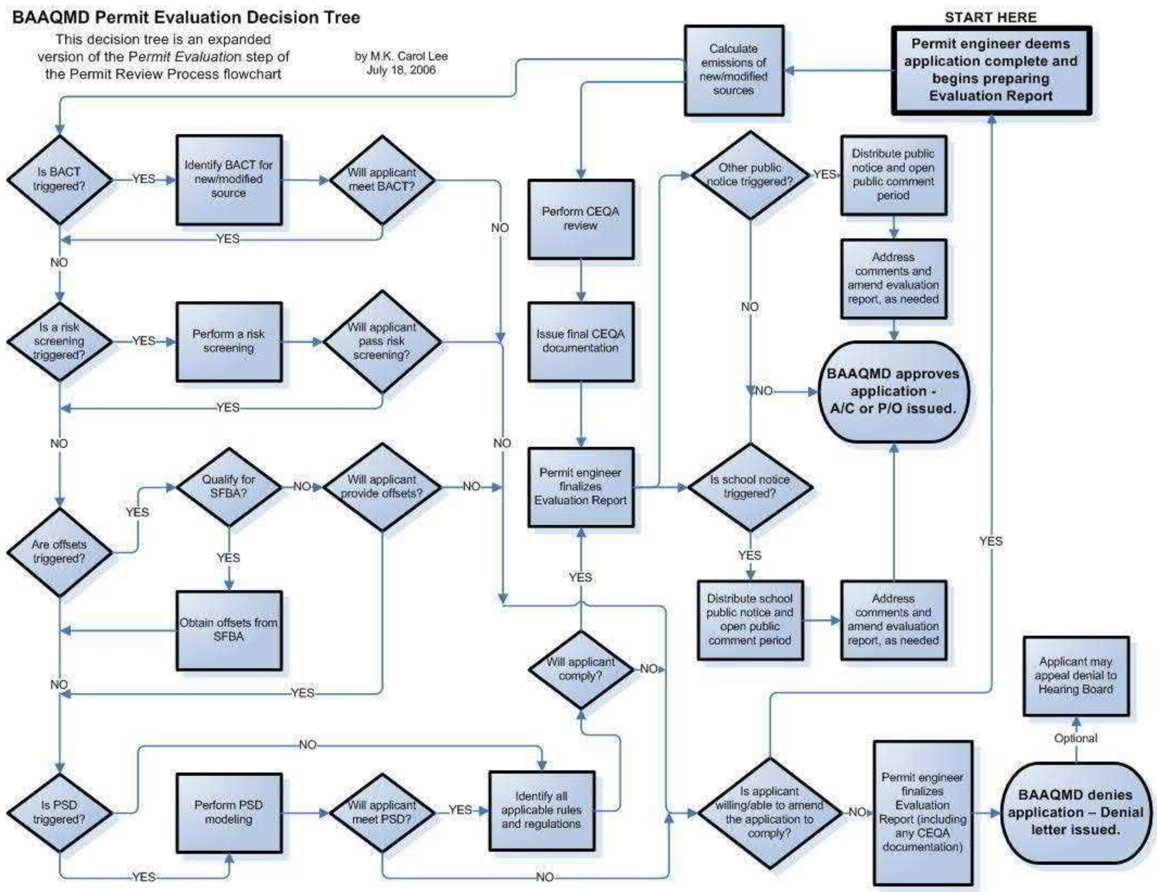
____
Phone

____
Email

For Department Use Only

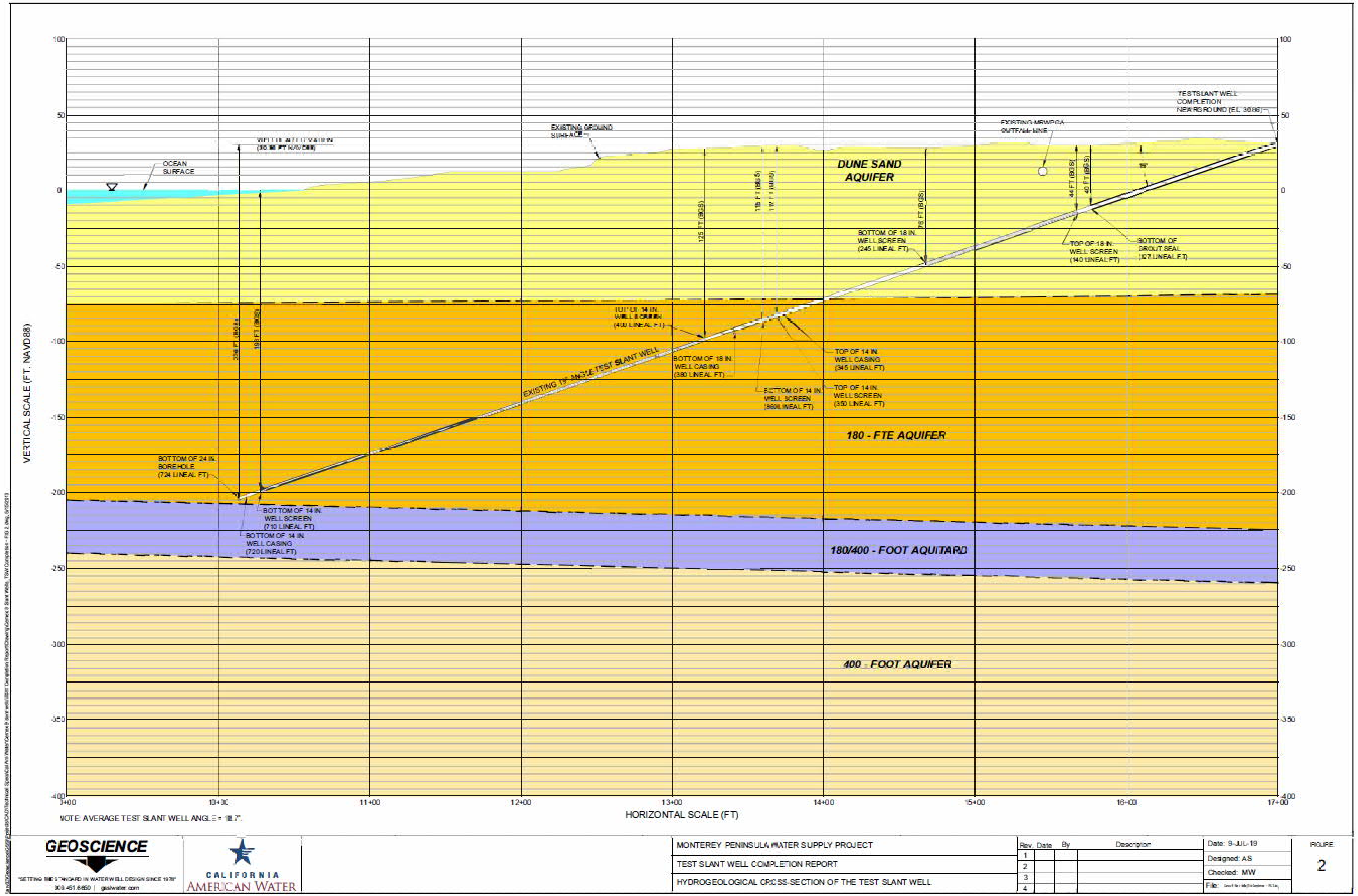
Application received by Planning Department:

By: ____________________________ Date: ____________________


BAAQMD Permit Evaluation Decision Tree
This decision tree is an expanded version of the Permit Evaluation step of the Permit Review Process flowchart
by M.K. Carol Lee
July 18, 2006
START HERE
Permit engineer deems application complete and begins preparing Evaluation Report
Calculate emissions of new/modified sources
Is BACT triggered?
YES
Identify BACT for new/modified source
Will applicant meet BACT?
YES
NO
Is a risk screening triggered?
Perform a risk screening
Will applicant pass risk screening?
Qualify for SFBA?
Will applicant provide offsets?
Are offsets triggered?
Obtain offsets from SFBA
Is PSD triggered?
Perform PSD modeling
Will applicant meet PSD?
Identify all applicable rules and regulations
Will applicant comply?
Perform CEQA review
Issue final CEQA documentation
Permit engineer finalizes Evaluation Report
Other public notice triggered?
Distribute public notice and open public comment period
Address comments and amend evaluation report, as needed
BAAQMD approves application - A/C or P/O issued.
Is school notice triggered?
Distribute school public notice and open public comment period
Is applicant willing/able to amend the application to comply?
Permit engineer finalizes Evaluation Report (including any CEQA documentation)
BAAQMD denies application – Denial letter issued.
Optional
Applicant may appeal denial to Hearing Board

Appendix C: Maps and Figures

Slant Well Elevation Detail

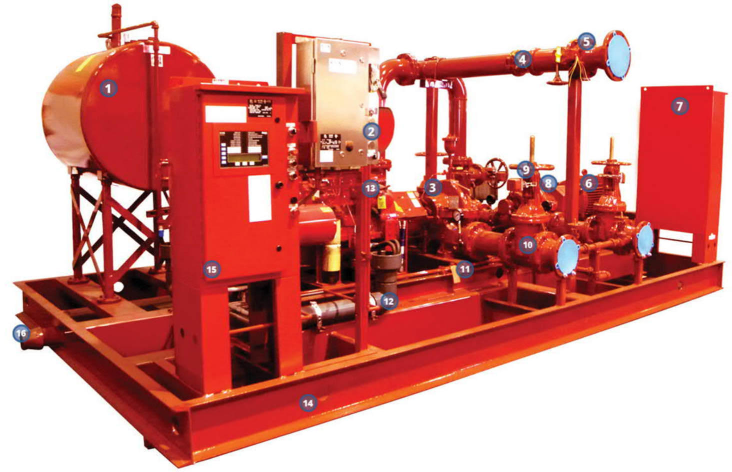


Source: CalAm Monterey Peninsula Water Supply Project

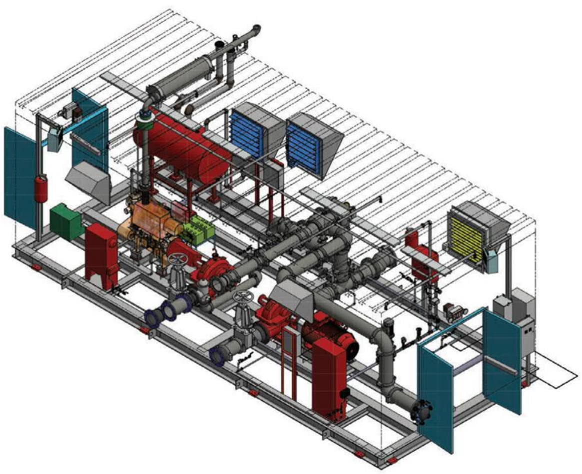
Appendix D: Pump Station Conceptual Configurations & Layouts

Conceptual Configurations for 3,000-6,000 gpm Capacity “Package” Stations

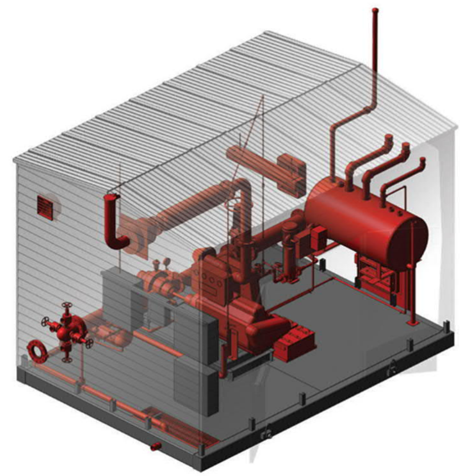
Source: *www.ruhrpumpen.com*



Source: *www.ruhrpumpen.com*

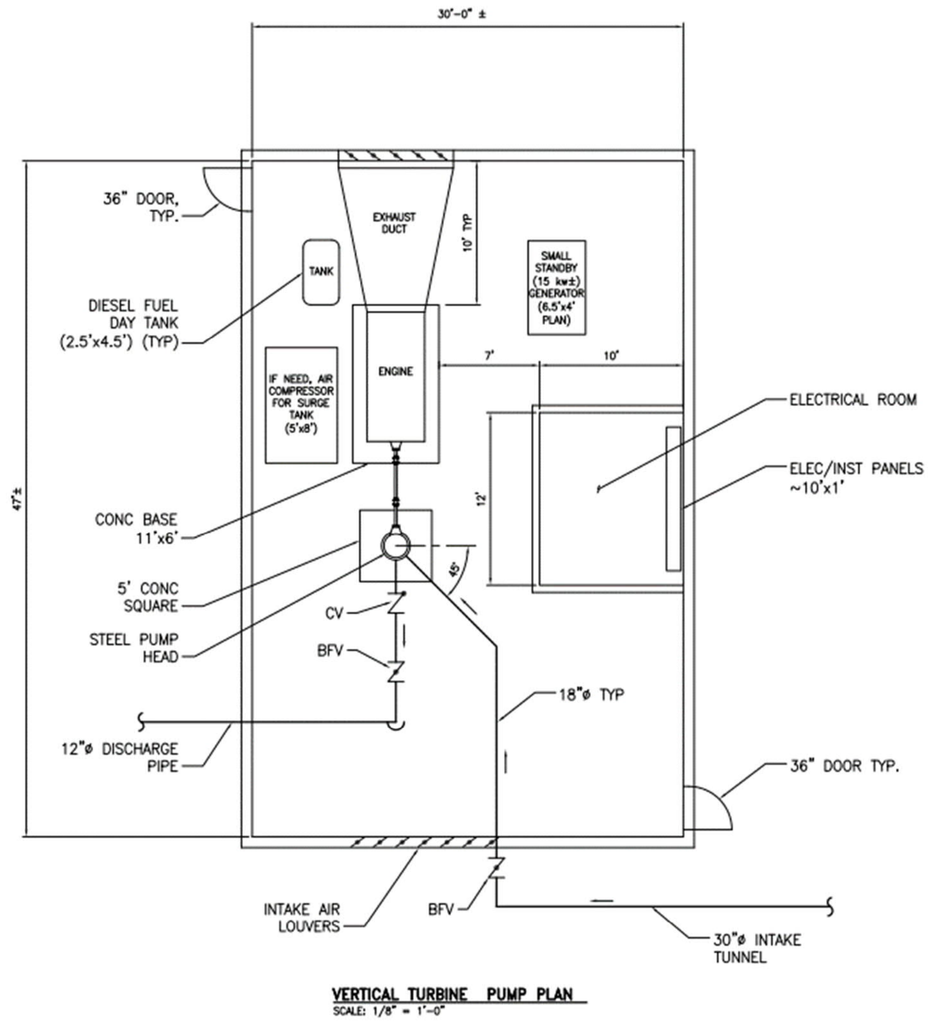


Source: *www.ruhrpumpen.com*

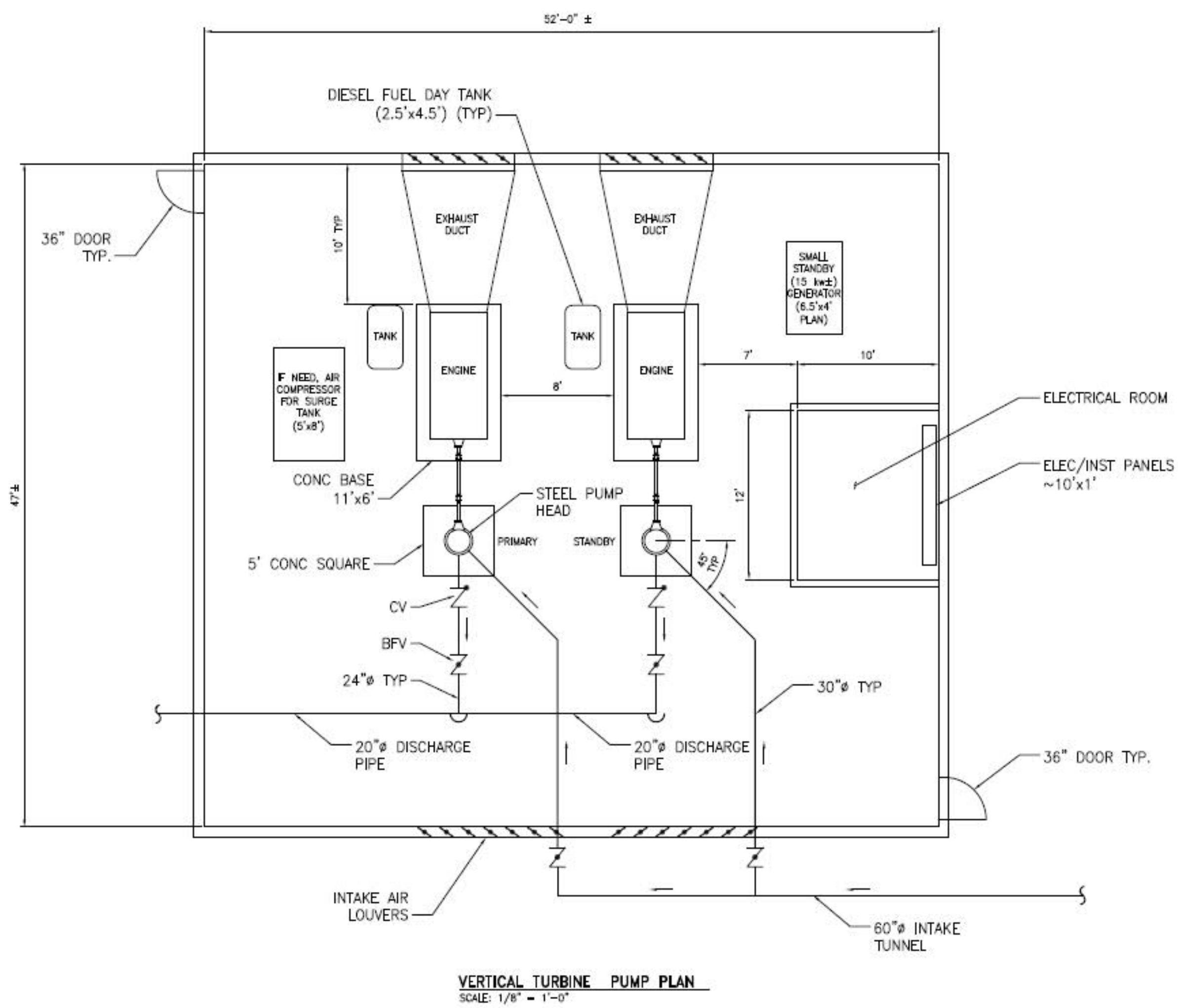


Source: *www.armstrongintegrated.com*

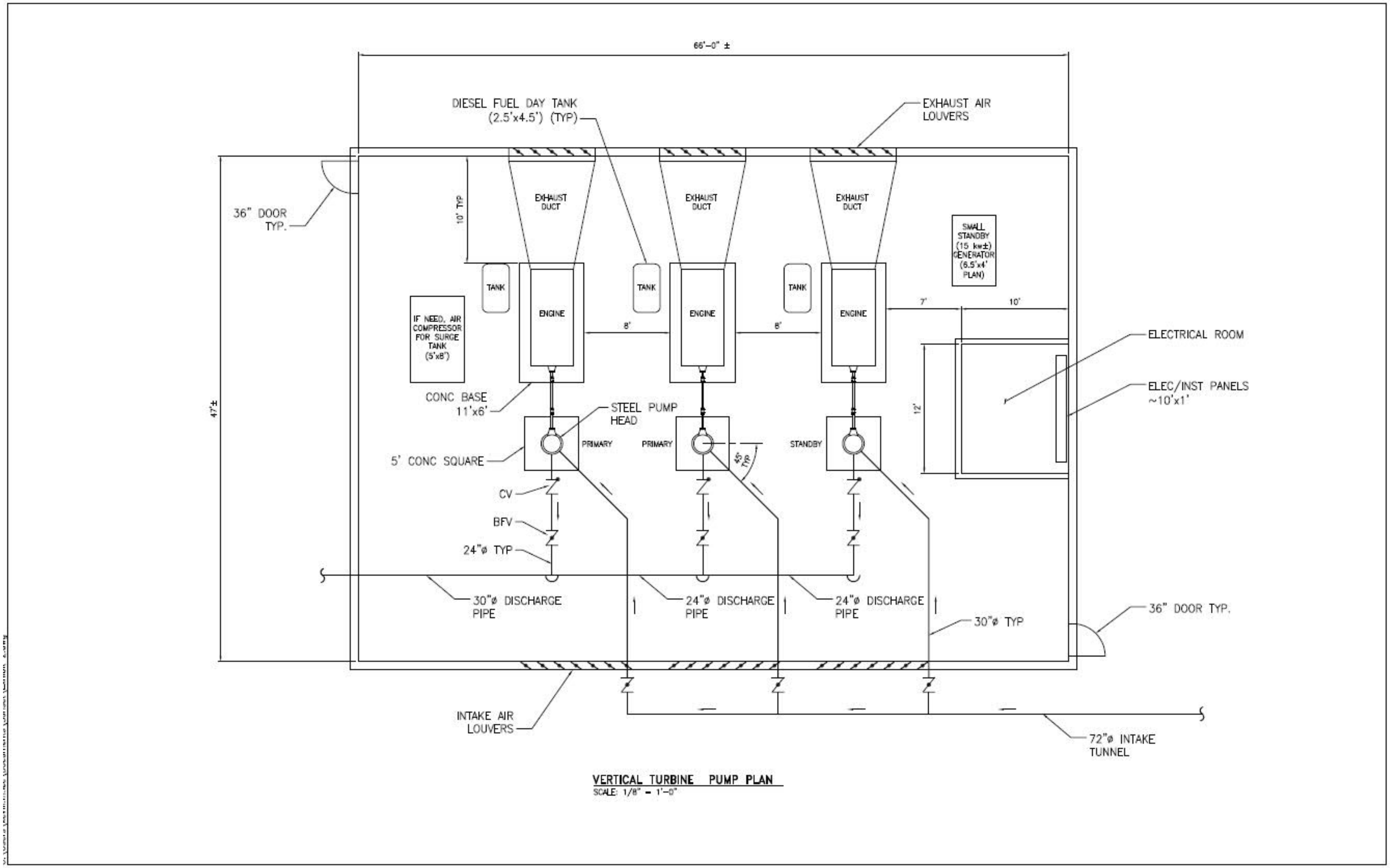
Conceptual Plan for "Traditional" 3,000 or 6,000 gpm Capacity Seawater Pump Station



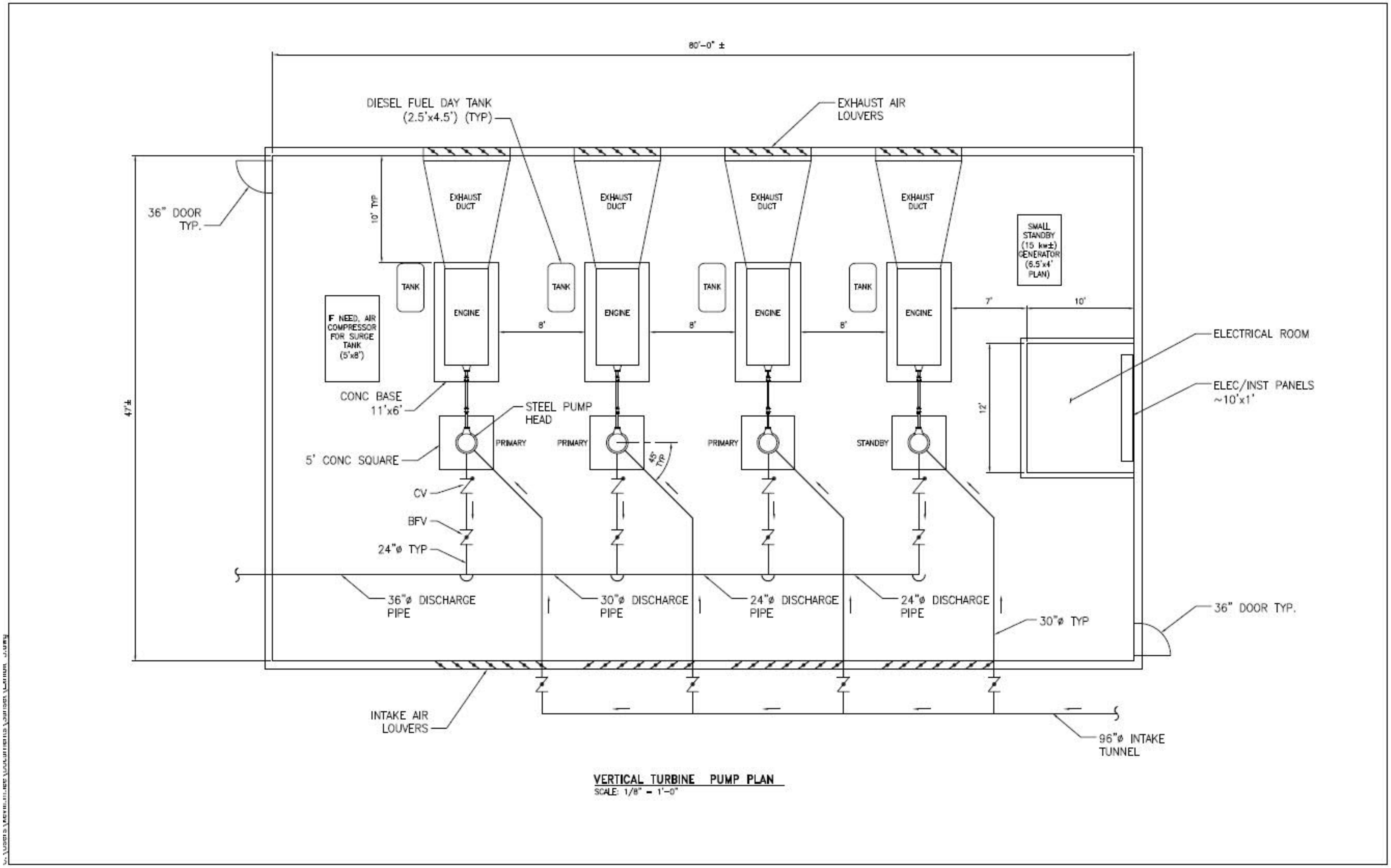
Conceptual Plan for "Traditional" 10,000-gpm Capacity Seawater Pump Station



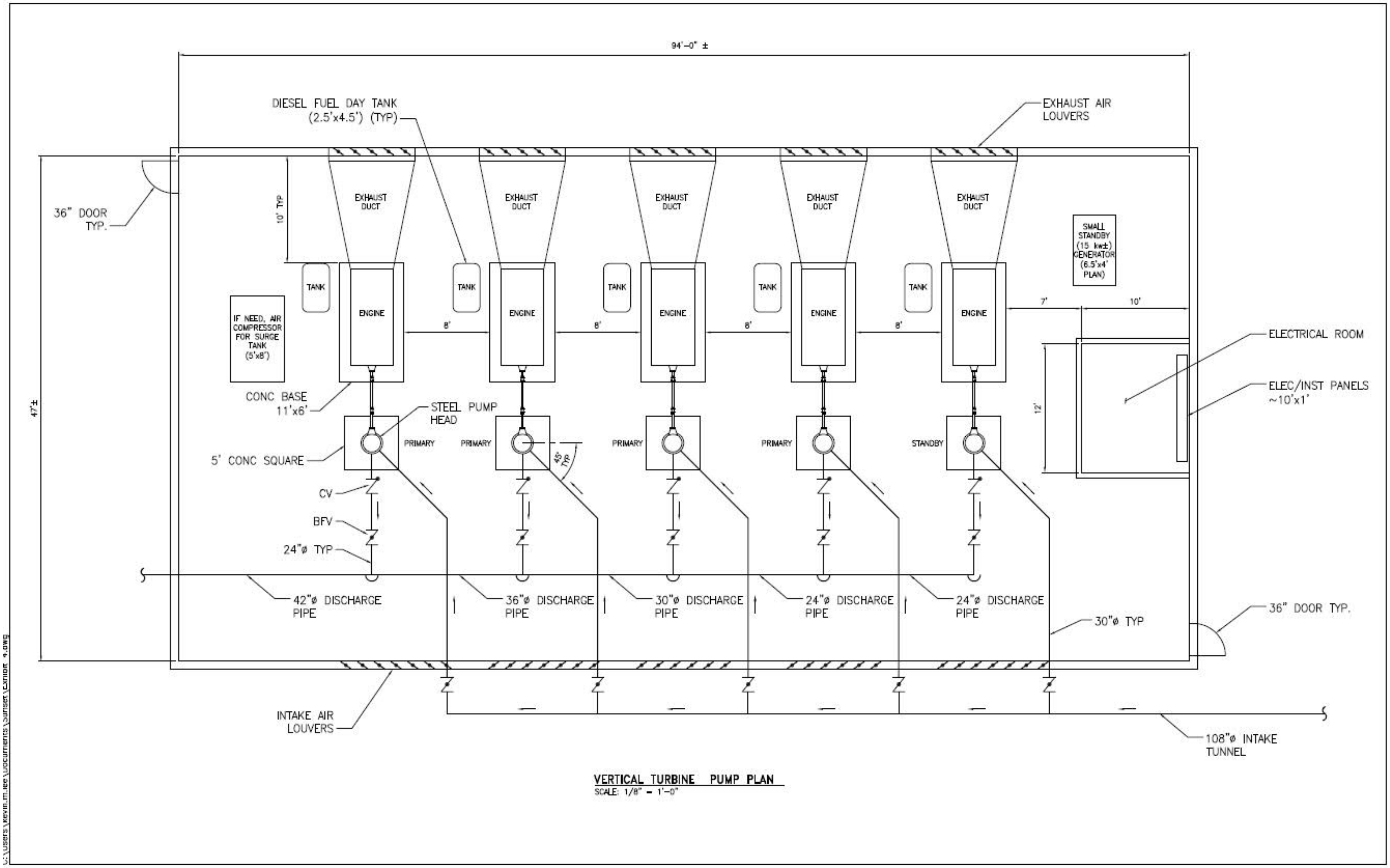
Conceptual Plan for "Traditional" 20,000-gpm Capacity Seawater Pump Station



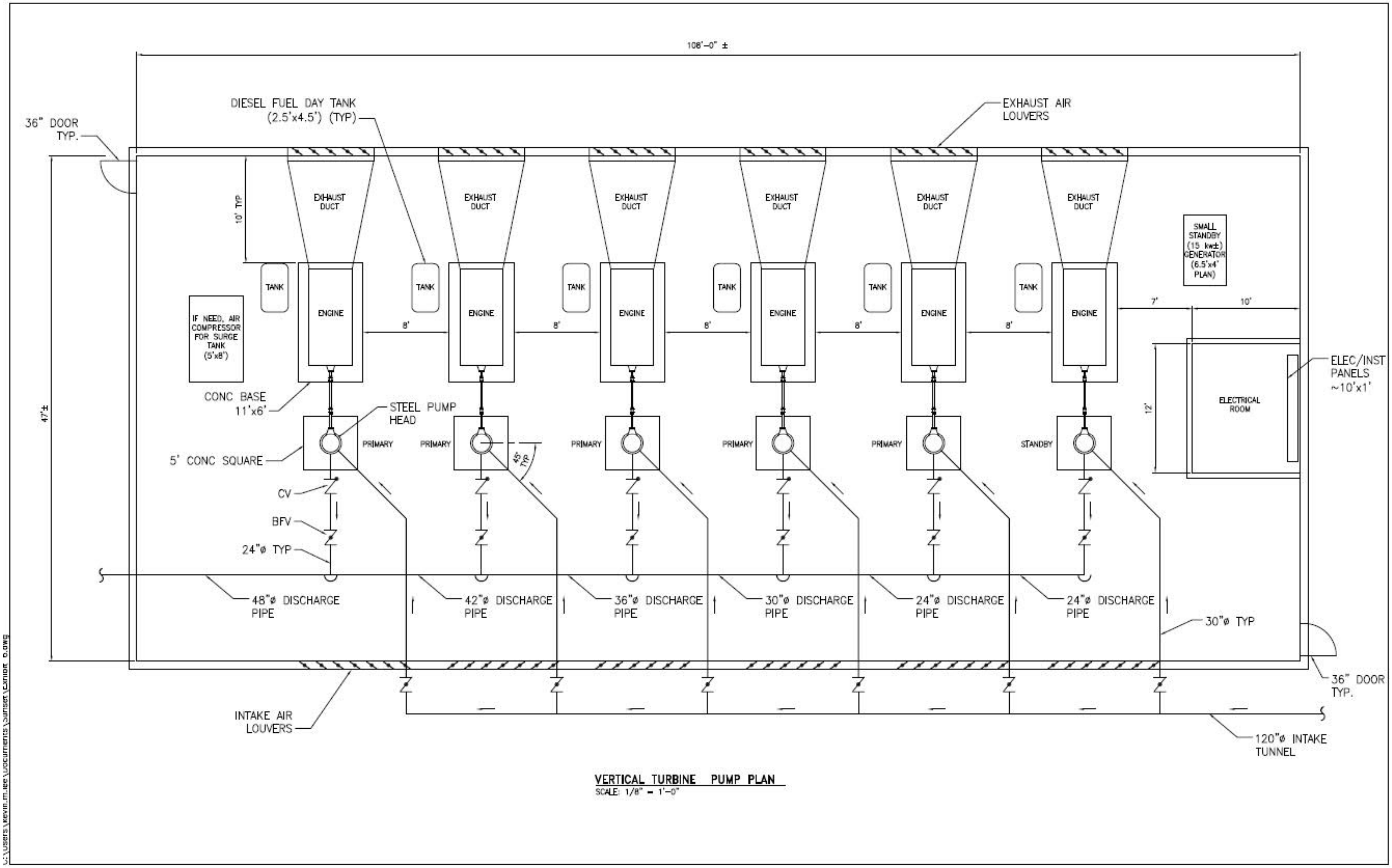
Conceptual Plan for "Traditional" 30,000-gpm Capacity Seawater Pump Station



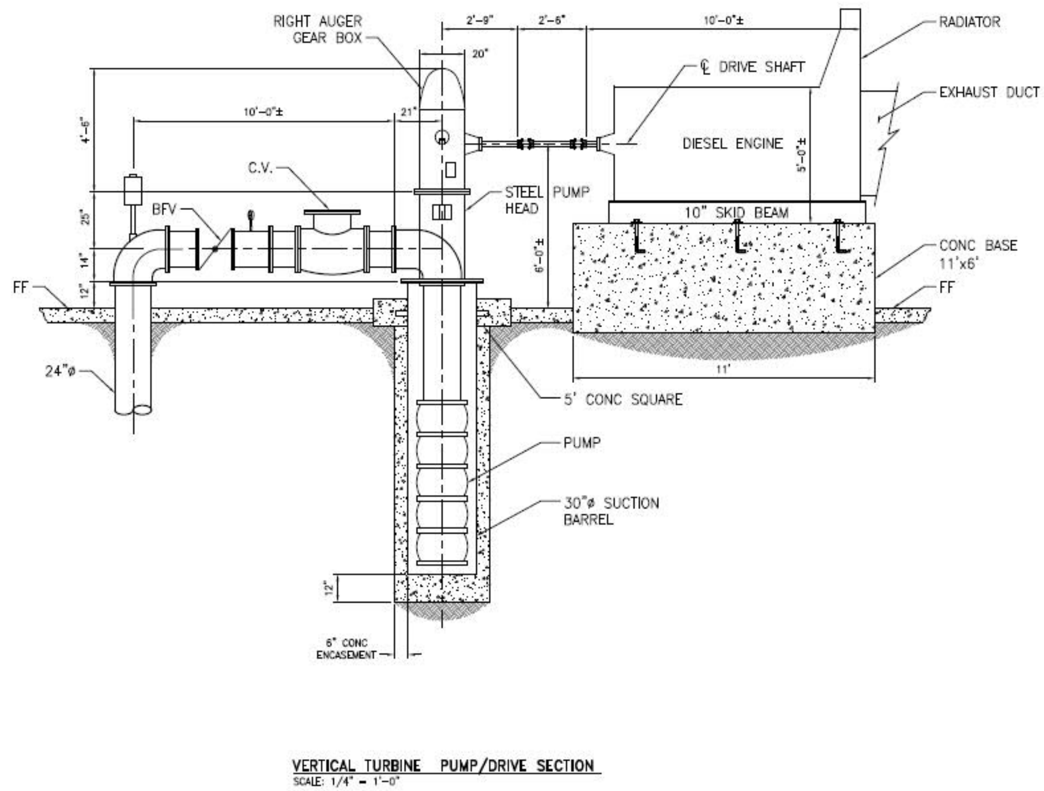
Conceptual Plan for "Traditional" 40,000-gpm Capacity Seawater Pump Station



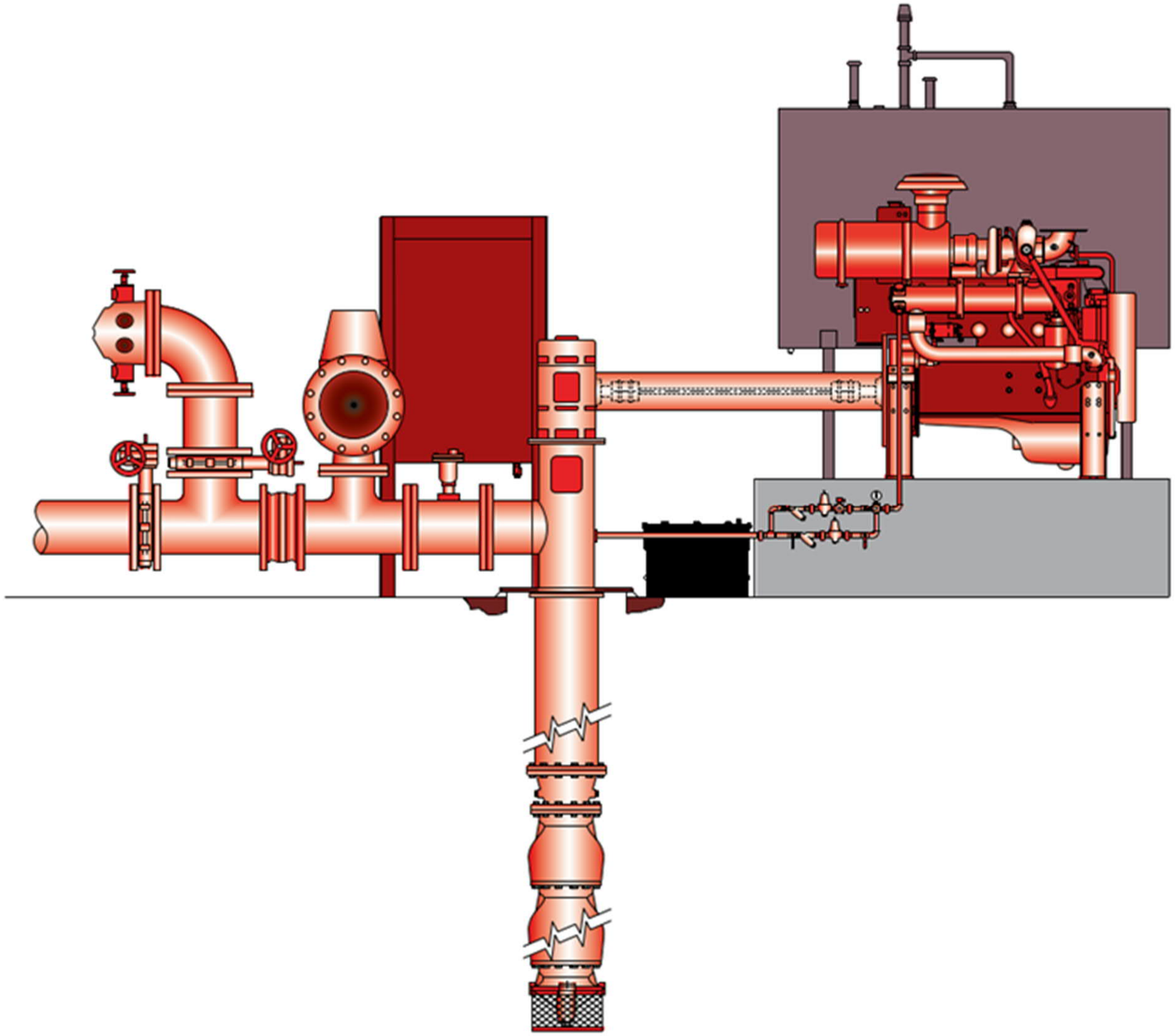
Conceptual Plan for "Traditional" 50,000-gpm Capacity Seawater Pump Station



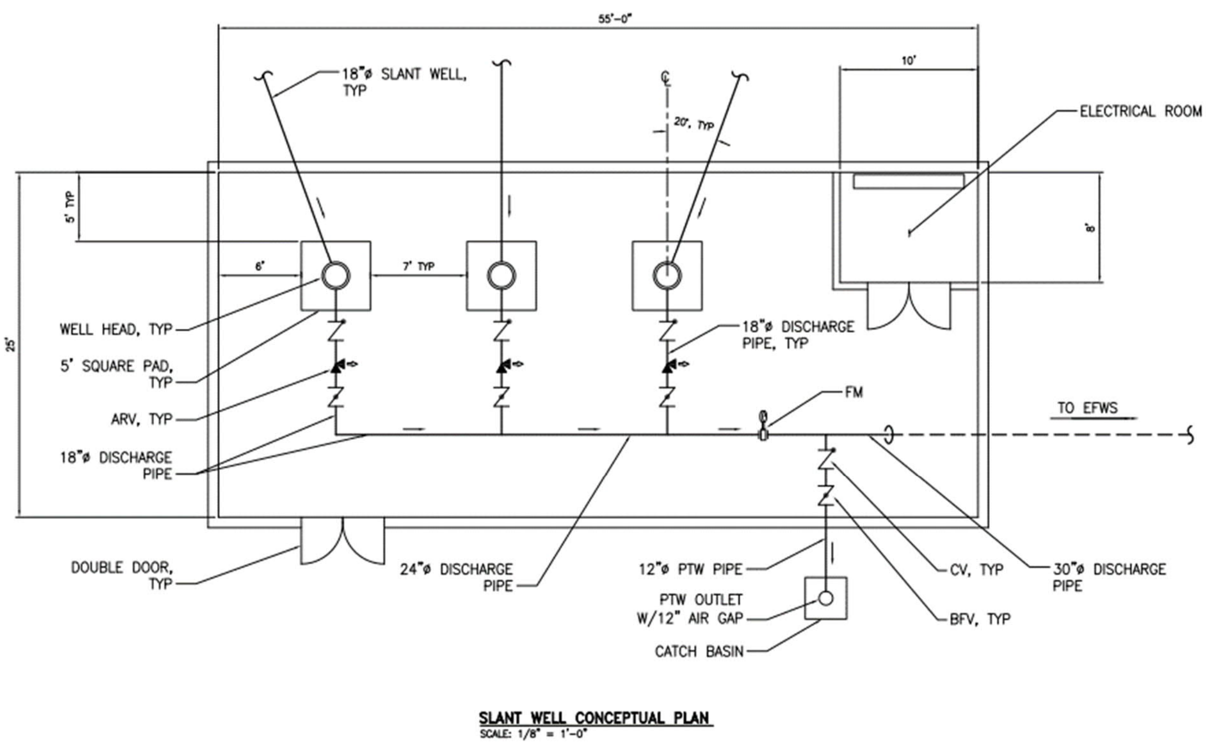
Conceptual Cross Section for “Traditional” Pump Assemblies



Rendering of Conceptual Vertical Turbine Pump



Conceptual Plan for 9,000-gpm Capacity Slant Well Seawater Pump Station



Appendix E: Cost Estimates

3,000 gpm PS

Engineering Parameters

	Ocean Side							Bay Side		
	Southern Dunes		Rocky Area South			Rocky Area North		North Bayfront	East Bayfront	notes
Intake Type:	Slant Wells	Open Water	Slant Wells	Open Water (Ocean Beach)	Open Water (Bluffs)	Slant Wells	Open Water	Open Water	Open Water	
Distance to Nearest EFWS Piping (miles)	1.7	1.7	2.2	2.2	2.2	1.5	1.5	0.05	0.15	
Distance for microtunneling of Disch. Piping (ft)	NA	NA	NA	NA	700	1,100	1,100	NA	NA	est from Google Earth
Discharge Piping Diameter (inches)	18	18	14	14	14	14	14	12	12	
Intake Tunnel Diameter (inches)	NA	30	NA	30	30	NA	30	30	30	
Vertical Excavation Depth (ft)	NA	46	NA	46	209	NA	46	31	31	Depth from ground surface to invert of intake tunnel assuming 10 ft cover below MSL
Vertical Excavation Diameter (ft)	NA	15	NA	15	15	NA	15	15	15	
Pump Station/Wellhead Building Size (sf)	1,375	1,410	1,375	1,410	1,410	1,375	1,410	1,410	1,410	Assumed wellhead building dimensions of 55 ft x 25 ft; pump station building dimensions of 47 ft x 30 ft. Wellhead buildings assumed spaced min of ~750 ft apart.
Number of Pumps	1	1	1	1	1	1	1	1	1	
Number of Wellhead Bldgs	1	NA	1	NA	NA	1	NA	NA	NA	
Number of Screen Modules	NA	1	NA	1	1	NA	1	1	1	Assume ISI T42-66 tee screen, approx 10,000 gpm / screen w/ < 0.5 fps slot velocity
Land Area Required (sf)	2,500	3,700	2,500	3,700	3,700	2,500	3,700	3,700	3,700	
Length of Intake Piping (ft)	NA	2,000	NA	2,000	1,500	NA	1,500	200	200	Pushed intake piping out farther into ocean beyond surf zone
Length of Recirculation/Test Piping (ft)	2,000	2,000	2,000	2,000	1,500	1,500	1,500	200	200	Same length as intake piping
Volume Dredged (cy)	93,000	93,000	93,000	93,000	69,000	69,000	69,000	9,000	9,000	Added dredging for recirculation/test piping at slant well locations

Initial Costs

	Southern Dunes Slant Wells	Southern Dunes Open Water	Rocky Area South Slant Wells	Rocky Area South Open Water (Ocean Beach)	Rocky Area South Open Water (Bluffs)	Rocky Area North Slant Wells	Rocky Area North Open Water	North Bayfront Open Water	East Bayfront Open Water	notes
Land Purchase	$975,000	$1,443,000	$975,000	$1,443,000	$1,443,000	$975,000	$1,443,000	$2,405,000	$2,405,000	based on land area req'd & unit rate; updated per communication w/ D. Brasil, 4/15/21
Easements / Leases*	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	plug estimate (e.g. State Lands Commission, CALTRANS, etc.)
NEPA / CEQA / Permitting	$6,000,000	$6,500,000	$6,000,000	$6,500,000	$6,500,000	$6,000,000	$6,500,000	$5,500,000	$5,500,000	based upon review disc. w/ Scott MacPherson of PUC BEM
Open Water Intake (concrete box)	NA	$2,000,000	NA	$2,000,000	$2,000,000	NA	$2,000,000	$2,000,000	$2,000,000	assumed
Intake Screens	NA	$500,000	NA	$500,000	$500,000	NA	$500,000	$500,000	$500,000	assume
Dredging	$1,900,000	$1,900,000	$1,900,000	$1,900,000	$1,400,000	$1,400,000	$1,400,000	$200,000	$200,000	Added dredging costs for recirculation/test piping at slant well locations
Intake Tunnel	NA	$20,000,000	NA	$20,000,000	$15,000,000	NA	$15,000,000	$2,000,000	$2,000,000	Based on updated lengths in row 16
Vertical Excavation	NA	$1,300,000	NA	$1,300,000	$5,800,000	NA	$1,300,000	$900,000	$900,000	See estimated depths in row 11.
Slant Well Drilling / Development / Setup	$3,000,000	NA	$3,000,000	NA	NA	$3,000,000	NA	NA	NA	
Pumps (equipment)	$500,000	$800,000	$500,000	$800,000	$800,000	$500,000	$800,000	$800,000	$800,000	Assume $X / pump, each @ 10,000 gpm (for Open Water), $500k/pump (for slant wells)
Pump Station/Wellhead Buildings	$2,250,000	$7,800,000	$2,250,000	$7,800,000	$7,800,000	$2,250,000	$7,800,000	$7,800,000	$7,800,000	Includes common wellhead enclosure costs. Open water PS cost includes PRV in vault for recirculation/test piping ($270k).
Discharge Piping (to connect w/ EFWS) (base cost, assuming cut & cover)	$20,400,000	$20,400,000	$19,800,000	$19,800,000	$19,800,000	$13,500,000	$13,500,000	$450,000	$1,350,000	Assume $15M / mi for 24" dia Kubota; scale down/up accordingly
Microtunneling / etc. for disch. Piping	NA	NA	NA	NA	$5,600,000	$7,700,000	$7,700,000	NA	NA	(use unit rates in O36/37, upsize/downsize based on diameter
Recirculation/Test Piping (return to ocean/bay)	$4,600,000	$4,600,000	$3,500,000	$3,500,000	$2,600,000	$2,600,000	$2,600,000	$400,000	$400,000	Assume same diam as disch. piping and same length as intake tunnel/piping, @ $xxxx/mile, with PRV @ PS
Up-Sizing Existing EFWS Piping	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	Costs cannot be determined at this point; will depend on location(s) and capacities selected based on hyd. Modeling
TOTAL	$40,700,000	$68,300,000	$39,000,000	$66,600,000	$70,300,000	$39,000,000	$61,600,000	$24,000,000	$24,900,000	

* State Lands Lease, ROW Crossings,
** soft costs included in items above

	Southern Dunes Slant Wells	Southern Dunes Open Water	Rocky Area South Slant Wells	Rocky Area South Open Water (Ocean Beach)	Rocky Area South Open Water (Bluffs)	Rocky Area North Slant Wells	Rocky Area North Open Water	North Bayfront Open Water	East Bayfront Open Water
Environmental / Permitting / Land Acq.	$7,975,000	$8,943,000	$7,975,000	$8,943,000	$8,943,000	$7,975,000	$8,943,000	$8,905,000	$8,905,000
Pump Station	$7,650,000	$34,300,000	$7,650,000	$34,300,000	$33,300,000	$7,150,000	$28,800,000	$14,200,000	$14,200,000
Piping	$25,000,000	$25,000,000	$23,300,000	$23,300,000	$28,000,000	$23,800,000	$23,800,000	$850,000	$1,750,000
TOTAL (rounded up)	$40,700,000	$68,300,000	$39,000,000	$66,600,000	$70,300,000	$39,000,000	$61,600,000	$24,000,000	$24,900,000

Lifecycle Costs

	Southern Dunes Slant Wells	Southern Dunes Open Water	Rocky Area South Slant Wells	Rocky Area South Open Water (Ocean Beach)	Rocky Area South Open Water (Bluffs)	Rocky Area North Slant Wells	Rocky Area North Open Water	North Bayfront Open Water	East Bayfront Open Water
Initial Cost	$40,700,000	$68,300,000	$39,000,000	$66,600,000	$70,300,000	$39,000,000	$61,600,000	$24,000,000	$24,900,000
Annual ODC / Fuel / Fixed Costs	$145,000	$145,000	$145,000	$145,000	$145,000	$145,000	$145,000	$145,000	$145,000
Annual Staffing Cost	$36,000	$90,000	$36,000	$90,000	$90,000	$36,000	$90,000	$90,000	$90,000
Slant Well Renewal *	$3,000,000	NA	$3,000,000	NA	NA	$3,000,000	NA	NA	NA
Slant Well Pump Replacement *	$500,000	NA	$500,000	NA	NA	$500,000	NA	NA	NA
Intake Screen Replacement *	NA	$500,000	NA	$500,000	$500,000	NA	$500,000	$500,000	$500,000
NPV @ 4% Interest	$55,700,000	$79,700,000	$54,000,000	$78,000,000	$81,700,000	$54,000,000	$73,000,000	$35,400,000	$36,300,000

*for open water option, assume screen will be replaced every 15 years, the PS has a total of 45 year life
*for slant well option, assume each slant well and pump will be replaced every 15 years

Staffing

	Southern Dunes Slant Wells	Southern Dunes Open Water	Rocky Area South Slant Wells	Rocky Area South Open Water (Ocean Beach)	Rocky Area South Open Water (Bluffs)	Rocky Area North Slant Wells	Rocky Area North Open Water	North Bayfront Open Water	East Bayfront Open Water
Staff Required for routine O&M (FTE)	0.2	0.5	0.2	0.5	0.5	0.2	0.5	0.5	0.5

6,000 gpm PS

Engineering Parameters

	Ocean Side							Bay Side		
	Southern Dunes		Rocky Area South			Rocky Area North		North Bayfront	East Bayfront	notes
Intake Type:	Slant Wells	Open Water	Slant Wells	Open Water (Ocean Beach)	Open Water (Bluffs)	Slant Wells	Open Water	Open Water	Open Water	
Distance to Nearest EFWS Piping (miles)	1.7	1.7	2.2	2.2	2.2	1.5	1.5	0.05	0.15	
Distance for microtunneling of Disch. Piping (ft)	NA	NA	NA	NA	700	1,100	1,100	NA	NA	est from Google Earth
Discharge Piping Diameter (inches)	24	24	18	18	18	18	18	18	16	
Intake Tunnel Diameter (inches)	NA	42	NA	42	42	NA	42	42	42	
Vertical Excavation Depth (ft)	NA	46	NA	46	209	NA	46	31	31	Depth from ground surface to invert of intake tunnel assuming 10 ft cover below MSL
Vertical Excavation Diameter (ft)	NA	15	NA	15	15	NA	15	15	15	
Pump Station/Wellhead Building Size (sf)	1,375	1,410	1,375	1,410	1,410	1,375	1,410	1,410	1,410	Assumed wellhead building dimensions of 55 ft x 25 ft; pump station building dimensions of 47 ft x 30 ft. Wellhead buildings assumed spaced min of ~750 ft apart.
Number of Pumps	2	1	2	1	1	2	1	1	1	
Number of Wellhead Bldgs	1	NA	1	NA	NA	1	NA	NA	NA	
Number of Screen Modules	NA	1	NA	1	1	NA	1	1	1	Assume ISI T42-66 tee screen, approx 10,000 gpm / screen w/ < 0.5 fps slot velocity
Land Area Required (sf)	2,500	3,700	2,500	3,700	3,700	2,500	3,700	3,700	3,700	
Length of Intake Piping (ft)	NA	2,000	NA	2,000	1,500	NA	1,500	200	200	Pushed intake piping out farther into ocean beyond surf zone
Length of Recirculation/Test Piping (ft)	2,000	2,000	2,000	2,000	1,500	1,500	1,500	200	200	Same length as intake piping
Volume Dredged (cy)	93,000	93,000	93,000	93,000	69,000	69,000	69,000	9,000	9,000	Added dredging for recirculation/test piping at slant well locations

Initial Costs

Land Purchase	$975,000	$1,443,000	$975,000	$1,443,000	$1,443,000	$975,000	$1,443,000	$2,405,000	$2,405,000	based on land area req'd & unit rate
Easements / Leases*	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	plug estimate (e.g. State Lands Commission, CALTRANS, etc.)
NEPA / CEQA / Permitting	$6,250,000	$6,750,000	$6,250,000	$6,750,000	$6,750,000	$6,250,000	$6,750,000	$5,750,000	$5,750,000	based upon review disc. w/ Scott MacPherson of PUC BEM
Open Water Intake (concrete box)	NA	$2,000,000	NA	$2,000,000	$2,000,000	NA	$2,000,000	$2,000,000	$2,000,000	assumed
Intake Screens	NA	$500,000	NA	$500,000	$500,000	NA	$500,000	$500,000	$500,000	assume
Dredging	$1,900,000	$1,900,000	$1,900,000	$1,900,000	$1,400,000	$1,400,000	$1,400,000	$200,000	$200,000	Added dredging costs for recirculation/test piping at slant well locations
Intake Tunnel	NA	$20,000,000	NA	$20,000,000	$15,000,000	NA	$15,000,000	$2,000,000	$2,000,000	Based on updated lengths in row 16
Vertical Excavation	NA	$1,300,000	NA	$1,300,000	$5,800,000	NA	$1,300,000	$900,000	$900,000	See estimated depths in row 11.
Slant Well Drilling / Development / Setup	$6,000,000	NA	$6,000,000	NA	NA	$6,000,000	NA	NA	NA	
Pumps (equipment)	$1,000,000	$1,600,000	$1,000,000	$1,600,000	$1,600,000	$1,000,000	$1,600,000	$1,600,000	$1,600,000	Assume $X / pump, each @ 10,000 gpm (for Open Water), $500k/pump (for slant wells)
Pump Station/Wellhead Buildings	$2,250,000	$7,800,000	$2,250,000	$7,800,000	$7,800,000	$2,250,000	$7,800,000	$7,800,000	$7,800,000	Includes common wellhead enclosure costs. Open water PS cost includes PRV in vault for recirculation/test piping ($270k).
Discharge Piping (to connect w/ EFWS) (base cost, assuming cut & cover)	$25,500,000	$25,500,000	$26,400,000	$26,400,000	$26,400,000	$18,000,000	$18,000,000	$450,000	$1,350,000	Assume $15M / mi for 24" dia Kubota; scale down/up accordingly
Microtunneling / etc. for disch. Piping	NA	NA	NA	NA	$5,600,000	$7,700,000	$7,700,000	NA	NA	(use unit rates in O36/37, upsize/downsize based on diameter
Recirculation/Test Piping (return to ocean/bay)	$5,700,000	$5,700,000	$4,600,000	$4,600,000	$3,500,000	$3,500,000	$3,500,000	$500,000	$400,000	Assume same diam as disch. piping and same length as intake tunnel/piping, @ $xxxx/mile, with PRV @ PS
Up-Sizing Existing EFWS Piping	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	Costs cannot be determined at this point; will depend on location(s) and capacities selected based on hyd. Modeling
TOTAL	$50,600,000	$75,500,000	$50,400,000	$75,300,000	$78,800,000	$48,100,000	$68,000,000	$25,200,000	$26,000,000	

* State Lands Lease, ROW Crossings,
** soft costs included in items above

Environmental / Permitting / Land Acq.	$8,225,000	$9,193,000	$8,225,000	$9,193,000	$9,193,000	$8,225,000	$9,193,000	$9,155,000	$9,155,000
Pump Station	$11,150,000	$35,100,000	$11,150,000	$35,100,000	$34,100,000	$10,650,000	$29,600,000	$15,000,000	$15,000,000
Piping	$31,200,000	$31,200,000	$31,000,000	$31,000,000	$35,500,000	$29,200,000	$29,200,000	$950,000	$1,750,000
TOTAL (rounded up)	$50,600,000	$75,500,000	$50,400,000	$75,300,000	$78,800,000	$48,100,000	$68,000,000	$25,200,000	$26,000,000

Lifecycle Costs

Initial Cost	$50,600,000	$75,500,000	$50,400,000	$75,300,000	$78,800,000	$48,100,000	$68,000,000	$25,200,000	$26,000,000
Annual ODC / Fuel / Fixed Costs	$145,000	$145,000	$145,000	$145,000	$145,000	$145,000	$145,000	$145,000	$145,000
Annual Staffing Cost	$36,000	$90,000	$36,000	$90,000	$90,000	$36,000	$90,000	$90,000	$90,000
Slant Well Renewal *	$6,000,000	NA	$6,000,000	NA	NA	$6,000,000	NA	NA	NA
Slant Well Pump Replacement *	$1,000,000	NA	$1,000,000	NA	NA	$1,000,000	NA	NA	NA
Intake Screen Replacement *	NA	$500,000	NA	$500,000	$500,000	NA	$500,000	$500,000	$500,000
NPV @ 4% Interest	$72,600,000	$86,900,000	$72,400,000	$86,700,000	$90,200,000	$70,100,000	$79,400,000	$36,600,000	$37,400,000

*for open water option, assume screen will be replaced every 15 years, the PS has a total of 45 year life
*for slant well option, assume each slant well and pump will be replaced every 15 years

Staffing

Staff Required for routine O&M (FTE)	0.2	0.5	0.2	0.5	0.5	0.2	0.5	0.5	0.5

10,000 gpm PS

Engineering Parameters

	Ocean Side							Bay Side		
	Southern Dunes		Rocky Area South			Rocky Area North		North Bayfront	East Bayfront	notes
Intake Type:	Slant Wells	Open Water	Slant Wells	Open Water (Ocean Beach)	Open Water (Bluffs)	Slant Wells	Open Water	Open Water	Open Water	
Distance to Nearest EFWS Piping (miles)	1.7	1.7	2.2	2.2	2.2	1.5	1.5	0.05	0.15	
Distance for microtunneling of Disch. Piping (ft)	NA	NA	NA	NA	700	1,100	1,100	NA	NA	est from Google Earth
Discharge Piping Diameter (inches)	30	30	24	24	24	20	20	20	20	
Intake Tunnel Diameter (inches)	NA	60	NA	60	60	NA	60	60	60	
Vertical Excavation Depth (ft)	NA	46	NA	46	209	NA	46	31	31	Depth from ground surface to invert of intake tunnel assuming 10 ft cover below MSL
Vertical Excavation Diameter (ft)	NA	35	NA	35	35	NA	35	35	35	
Pump Station/Wellhead Building Size (sf)	1,375	2,444	1,375	2,444	2,444	1,375	2,444	2,444	2,444	Assumed wellhead building dimensions of 55 ft x 25 ft. Assumed spaced min of ~750 ft apart.
Number of Pumps	6	2	6	2	2	6	2	2	2	
Number of Wellhead Bldgs	3	NA	3	NA	NA	3	NA	NA	NA	
Number of Screen Modules	NA	1	NA	1	1	NA	1	1	1	Assume ISI T42-66 tee screen, approx 10,000 gpm / screen w/ < 0.5 fps slot velocity
Land Area Required (sf)	7,500	10,400	7,500	10,400	10,400	7,500	10,400	10,400	10,400	
Length of Intake Piping (ft)	NA	2,000	NA	2,000	1,500	NA	1,500	200	200	Pushed intake piping out farther into ocean beyond surf zone
Length of Recirculation/Test Piping (ft)	2,000	2,000	2,000	2,000	1,500	1,500	1,500	200	200	Same length as intake piping
Volume Dredged (cy)	93,000	93,000	93,000	93,000	69,000	69,000	69,000	9,000	9,000	Added dredging for recirculation/test piping at slant well locations

Initial Costs

	Southern Dunes Slant Wells	Southern Dunes Open Water	Rocky Area South Slant Wells	Rocky Area South Open Water (Ocean Beach)	Rocky Area South Open Water (Bluffs)	Rocky Area North Slant Wells	Rocky Area North Open Water	North Bayfront Open Water	East Bayfront Open Water	notes
Land Purchase	$2,925,000	$4,056,000	$2,925,000	$4,056,000	$4,056,000	$2,925,000	$4,056,000	$6,760,000	$6,760,000	based on land area req'd & unit rate
Easements / Leases*	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	plug estimate (e.g. State Lands Commission, CALTRANS, etc.)
NEPA / CEQA / Permitting	$6,500,000	$7,000,000	$6,500,000	$7,000,000	$7,000,000	$6,500,000	$7,000,000	$6,000,000	$6,000,000	based upon review disc. w/ Scott MacPherson of PUC BEM
Open Water Intake (concrete box)	NA	$2,000,000	NA	$2,000,000	$2,000,000	NA	$2,000,000	$2,000,000	$2,000,000	assumed
Intake Screens	NA	$500,000	NA	$500,000	$500,000	NA	$500,000	$500,000	$500,000	assume
Dredging	$1,900,000	$1,900,000	$1,900,000	$1,900,000	$1,400,000	$1,400,000	$1,400,000	$200,000	$200,000	Added dredging costs for recirculation/test piping at slant well locations
Intake Tunnel	NA	$20,000,000	NA	$20,000,000	$15,000,000	NA	$15,000,000	$2,000,000	$2,000,000	Based on updated lengths in row 16
Vertical Excavation	NA	$6,900,000	NA	$6,900,000	$31,300,000	NA	$6,900,000	$4,700,000	$4,700,000	See estimated depths in row 11.
Slant Well Drilling / Development / Setup	$18,000,000	NA	$18,000,000	NA	NA	$18,000,000	NA	NA	NA	
Pumps (equipment)	$3,000,000	$5,200,000	$3,000,000	$5,200,000	$5,200,000	$3,000,000	$5,200,000	$5,200,000	$5,200,000	Assume $X / pump, each @ 10,000 gpm (for Open Water), $500k/pump (for slant wells)
Pump Station/Wellhead Buildings	$6,750,000	$13,600,000	$6,750,000	$13,600,000	$13,600,000	$6,750,000	$13,600,000	$13,600,000	$13,600,000	Includes common wellhead enclosure costs. Open water PS cost includes PRV in vault for recirculation/test piping ($270k).
Discharge Piping (to connect w/ EFWS) (base cost, assuming cut & cover)	$30,600,000	$30,600,000	$33,000,000	$33,000,000	$31,100,000	$18,100,000	$18,100,000	$450,000	$1,350,000	Assume $15M / mi for 24" dia Kubota; scale down/up accordingly
Microtunneling / etc. for disch. Piping	NA	NA	NA	NA	$5,600,000	$7,700,000	$7,700,000	NA	NA	(use unit rates in O36/37, upsize/downsize based on diameter
Recirculation/Test Piping (return to ocean/bay)	$6,900,000	$6,900,000	$5,700,000	$5,700,000	$4,300,000	$4,000,000	$4,000,000	$600,000	$600,000	Assume same diam as disch. piping and same length as intake tunnel/piping, @ $xxxx/mile, with PRV @ PS
Up-Sizing Existing EFWS Piping	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	Costs cannot be determined at this point; will depend on location(s) and capacities selected based on hyd. Modeling
TOTAL	$77,600,000	$99,700,000	$78,800,000	$100,900,000	$122,100,000	$69,400,000	$86,500,000	$43,100,000	$44,000,000	

* State Lands Lease, ROW Crossings,

** soft costs included in items above

	Southern Dunes Slant Wells	Southern Dunes Open Water	Rocky Area South Slant Wells	Rocky Area South Open Water (Ocean Beach)	Rocky Area South Open Water (Bluffs)	Rocky Area North Slant Wells	Rocky Area North Open Water	North Bayfront Open Water	East Bayfront Open Water
Environmental / Permitting / Land Acq.	$10,425,000	$12,056,000	$10,425,000	$12,056,000	$12,056,000	$10,425,000	$12,056,000	$13,760,000	$13,760,000
Pump Station	$29,650,000	$50,100,000	$29,650,000	$50,100,000	$69,000,000	$29,150,000	$44,600,000	$28,200,000	$28,200,000
Piping	$37,500,000	$37,500,000	$38,700,000	$38,700,000	$41,000,000	$29,800,000	$29,800,000	$1,050,000	$1,950,000
TOTAL (rounded up)	$77,600,000	$99,700,000	$78,800,000	$100,900,000	$122,100,000	$69,400,000	$86,500,000	$43,100,000	$44,000,000

Lifecycle Costs

	Southern Dunes Slant Wells	Southern Dunes Open Water	Rocky Area South Slant Wells	Rocky Area South Open Water (Ocean Beach)	Rocky Area South Open Water (Bluffs)	Rocky Area North Slant Wells	Rocky Area North Open Water	North Bayfront Open Water	East Bayfront Open Water
Initial Cost	$77,600,000	$99,700,000	$78,800,000	$100,900,000	$122,100,000	$69,400,000	$86,500,000	$43,100,000	$44,000,000
Annual ODC / Fuel / Fixed Costs	$145,000	$145,000	$145,000	$145,000	$145,000	$145,000	$145,000	$145,000	$145,000
Annual Staffing Cost	$108,000	$90,000	$108,000	$90,000	$90,000	$108,000	$90,000	$90,000	$90,000
Slant Well Renewal *	$18,000,000	NA	$18,000,000	NA	NA	$18,000,000	NA	NA	NA
Slant Well Pump Replacement *	$3,000,000	NA	$3,000,000	NA	NA	$3,000,000	NA	NA	NA
Intake Screen Replacement *	NA	$500,000	NA	$500,000	$500,000	NA	$500,000	$500,000	$500,000
NPV @ 4% Interest	$130,800,000	$111,100,000	$132,000,000	$112,300,000	$133,500,000	$122,600,000	$97,900,000	$54,500,000	$55,400,000

*for open water option, assume screen will be replaced every 15 years, the PS has a total of 45 year life

*for slant well option, assume each slant well and pump will be replaced every 15 years

Staffing

	Southern Dunes Slant Wells	Southern Dunes Open Water	Rocky Area South Slant Wells	Rocky Area South Open Water (Ocean Beach)	Rocky Area South Open Water (Bluffs)	Rocky Area North Slant Wells	Rocky Area North Open Water	North Bayfront Open Water	East Bayfront Open Water
Staff Required for routine O&M (FTE)	0.6	0.5	0.6	0.5	0.5	0.6	0.5	0.5	0.5

20,000 gpm PS

Engineering Parameters

	Ocean Side							Bay Side		
	Southern Dunes		Rocky Area South			Rocky Area North		North Bayfront	East Bayfront	notes
Intake Type:	Slant Wells	Open Water	Slant Wells	Open Water (Ocean Beach)	Open Water (Bluffs)	Slant Wells	Open Water	Open Water	Open Water	
Distance to Nearest EFWS Piping (miles)	1.7	1.7	2.2	2.2	2.2	1.5	1.5	0.05	0.15	
Distance for microtunneling of Disch. Piping (ft)	NA	NA	NA	NA	700	1,100	1,100	NA	NA	est from Google Earth
Discharge Piping Diameter (inches)	36	36	30	30	30	30	30	30	36	
Intake Tunnel Diameter (inches)	NA	72	NA	72	72	NA	72	72	72	
Vertical Excavation Depth (ft)	NA	46	NA	46	209	NA	46	31	31	Depth from ground surface to invert of intake tunnel assuming 10 ft cover below MSL
Vertical Excavation Diameter (ft)	NA	50	NA	50	50	NA	50	50	50	
Pump Station/Wellhead Building Size (sf)	1,375	3,100	1,375	3,100	3,100	1,375	3,100	3,100	3,100	Assumed wellhead building dimensions of 55 ft x 25 ft. Assumed spaced min of ~750 ft apart.
Number of Pumps	10	3	10	3	3	10	3	3	3	
Number of Wellhead Bldgs	4	NA	4	NA	NA	4	NA	NA	NA	
Number of Screen Modules	NA	2	NA	2	2	NA	2	2	2	Assume ISI T42-66 tee screen, approx 10,000 gpm / screen w/ < 0.5 fps slot velocity
Land Area Required (sf)	10,000	13,000	10,000	13,000	13,000	10,000	13,000	13,000	13,000	
Length of Intake Piping (ft)	NA	2,000	NA	2,000	1,500	NA	1,500	200	200	Pushed intake piping out farther into ocean beyond surf zone
Length of Recirculation/Test Piping (ft)	2,000	2,000	2,000	2,000	1,500	1,500	1,500	200	200	Same length as intake piping
Volume Dredged (cy)	93,000	93,000	93,000	93,000	69,000	69,000	69,000	9,000	9,000	Added dredging for recirculation/test piping at slant well locations

Initial Costs

	Southern Dunes Slant Wells	Southern Dunes Open Water	Rocky Area South Slant Wells	Rocky Area South Open Water (Ocean Beach)	Rocky Area South Open Water (Bluffs)	Rocky Area North Slant Wells	Rocky Area North Open Water	North Bayfront Open Water	East Bayfront Open Water	notes
Land Purchase	$3,900,000	$5,070,000	$3,900,000	$5,070,000	$5,070,000	$3,900,000	$5,070,000	$8,450,000	$8,450,000	based on land area req'd & unit rate
Easements / Leases*	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	plug estimate (e.g. State Lands Commission, CALTRANS, etc.)
NEPA / CEQA / Permitting	$7,000,000	$7,500,000	$7,000,000	$7,500,000	$7,500,000	$7,000,000	$7,500,000	$6,500,000	$6,500,000	based upon review disc. w/ Scott MacPherson of PUC BEM
Open Water Intake (concrete box)	NA	$2,000,000	NA	$2,000,000	$2,000,000	NA	$2,000,000	$2,000,000	$2,000,000	
Intake Screens	NA	$1,000,000	NA	$1,000,000	$1,000,000	NA	$1,000,000	$1,000,000	$1,000,000	
Dredging	$1,900,000	$1,900,000	$1,900,000	$1,900,000	$1,400,000	$1,400,000	$1,400,000	$200,000	$200,000	Added dredging costs for recirculation/test piping at slant well locations
Intake Tunnel	NA	$24,000,000	NA	$24,000,000	$18,000,000	NA	$18,000,000	$2,400,000	$2,400,000	Based on updated lengths in row 16
Vertical Excavation	NA	$14,100,000	NA	$14,100,000	$63,800,000	NA	$14,100,000	$9,500,000	$9,500,000	See estimated depths in row 11.
Slant Well Drilling / Development / Setup	$30,000,000	NA	$30,000,000	NA	NA	$30,000,000	NA	NA	NA	
Pumps (equipment)	$5,000,000	$7,800,000	$5,000,000	$7,800,000	$7,800,000	$5,000,000	$7,800,000	$7,800,000	$7,800,000	Assume $X / pump, each @ 10,000 gpm (for Open Water), $500k/pump (for slant wells)
Pump Station/Wellhead Buildings	$9,000,000	$17,200,000	$9,000,000	$17,200,000	$17,200,000	$9,000,000	$17,200,000	$17,200,000	$17,200,000	Includes common wellhead enclosure costs. Open water PS cost includes PRV in vault for recirculation/test piping ($270k).
Discharge Piping (to connect w/ EFWS) (base cost, assuming cut & cover)	$34,000,000	$34,000,000	$39,600,000	$39,600,000	$37,300,000	$23,300,000	$23,300,000	$450,000	$1,350,000	Assume $15M / mi for 24" dia Kubota; scale down/up accordingly
Microtunneling / etc. for disch. Piping	NA	NA	NA	NA	$7,000,000	$11,000,000	$11,000,000	NA	NA	(use unit rates in O36/37, upsize/downsize based on diameter
Recirculation/Test Piping (return to ocean/bay)	$7,600,000	$7,600,000	$6,900,000	$6,900,000	$5,200,000	$5,200,000	$5,200,000	$700,000	$800,000	Assume same diam as disch. piping and same length as intake tunnel/piping, @ $xxxx/mile, with PRV @ PS
Up-Sizing Existing EFWS Piping	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	Costs cannot be determined at this point; will depend on location(s) and capacities selected based on hyd. Modeling
TOTAL	$99,400,000	$123,200,000	$104,300,000	$128,100,000	$174,300,000	$96,800,000	$114,600,000	$57,200,000	$58,200,000	

* State Lands Lease, ROW Crossings,
** soft costs included in items above

	Southern Dunes Slant Wells	Southern Dunes Open Water	Rocky Area South Slant Wells	Rocky Area South Open Water (Ocean Beach)	Rocky Area South Open Water (Bluffs)	Rocky Area North Slant Wells	Rocky Area North Open Water	North Bayfront Open Water	East Bayfront Open Water
Environmental / Permitting / Land Acq.	$11,900,000	$13,570,000	$11,900,000	$13,570,000	$13,570,000	$11,900,000	$13,570,000	$15,950,000	$15,950,000
Pump Station	$45,900,000	$68,000,000	$45,900,000	$68,000,000	$111,200,000	$45,400,000	$61,500,000	$40,100,000	$40,100,000
Piping	$41,600,000	$41,600,000	$46,500,000	$46,500,000	$49,500,000	$39,500,000	$39,500,000	$1,150,000	$2,150,000
TOTAL (rounded up)	$99,400,000	$123,200,000	$104,300,000	$128,100,000	$174,300,000	$96,800,000	$114,600,000	$57,200,000	$58,200,000

Annualized Costs

	Southern Dunes Slant Wells	Southern Dunes Open Water	Rocky Area South Slant Wells	Rocky Area South Open Water (Ocean Beach)	Rocky Area South Open Water (Bluffs)	Rocky Area North Slant Wells	Rocky Area North Open Water	North Bayfront Open Water	East Bayfront Open Water
Initial Cost	$99,400,000	$123,200,000	$104,300,000	$128,100,000	$174,300,000	$96,800,000	$114,600,000	$57,200,000	$58,200,000
Annual ODC / Fuel / Fixed Costs	$178,000	$178,000	$178,000	$178,000	$178,000	$178,000	$178,000	$178,000	$178,000
Annual Staffing Cost	$144,000	$90,000	$144,000	$90,000	$90,000	$144,000	$90,000	$90,000	$90,000
Slant Well Renewal *	$30,000,000	NA	$30,000,000	NA	NA	$30,000,000	NA	NA	NA
Slant Well Pump Replacement *	$5,000,000	NA	$5,000,000	NA	NA	$5,000,000	NA	NA	NA
Intake Screen Replacement *	NA	$1,000,000	NA	$1,000,000	$1,000,000	NA	$1,000,000	$1,000,000	$1,000,000
NPV @ 4% Interest	$183,600,000	$137,000,000	$188,500,000	$141,900,000	$188,100,000	$181,000,000	$128,400,000	$71,000,000	$72,000,000

*for open water option, assume screen will be replaced every 15 years, the PS has a total of 45 year life
*for slant well option, assume each slant well and pump will be replaced every 15 years

Staffing

	Southern Dunes Slant Wells	Southern Dunes Open Water	Rocky Area South Slant Wells	Rocky Area South Open Water (Ocean Beach)	Rocky Area South Open Water (Bluffs)	Rocky Area North Slant Wells	Rocky Area North Open Water	North Bayfront Open Water	East Bayfront Open Water
Staff Required for routine O&M (FTE)	0.8	0.5	0.8	0.5	0.5	0.8	0.5	0.5	0.5

30,000 gpm PS

Engineering Parameters

	Ocean Side							Bay Side		
	Southern Dunes		Rocky Area South			Rocky Area North		North Bayfront	East Bayfront	notes
Intake Type:	Slant Wells	Open Water	Slant Wells	Open Water (Ocean Beach)	Open Water (Bluffs)	Slant Wells	Open Water	Open Water	Open Water	
Distance to Nearest EFWS Piping (miles)	1.7	1.7	2.2	2.2	2.2	1.5	1.5	0.05	0.15	
Distance for microtunneling of Disch. Piping (ft)	NA	NA	NA	NA	700	1,100	1,100	NA	NA	est from Google Earth
Discharge Piping Diameter (inches)	42	42	36	36	36	36	36	36	36	
Intake Tunnel Diameter (inches)	NA	96	NA	96	96	NA	96	96	96	
Vertical Excavation Depth (ft)	NA	46	NA	46	209	NA	46	31	31	Depth from ground surface to invert of intake tunnel assuming 10 ft cover below MSL
Vertical Excavation Diameter (ft)	NA	65	NA	65	65	NA	65	65	65	
Pump Station/Wellhead Building Size (sf)	1,375	3,760	1,375	3,760	3,760	1,375	3,760	3,760	3,760	Assumed wellhead building dimensions of 55 ft x 25 ft. Assumed spaced min of ~750 ft apart.
Number of Pumps	13	4	13	4	4	13	4	4	4	
Number of Wellhead Bldgs	5	NA	5	NA	NA	5	NA	NA	NA	
Number of Screen Modules	NA	3	NA	3	3	NA	3	3	3	Assume ISI T42-66 tee screen, approx 10,000 gpm / screen w/ < 0.5 fps slot velocity
Land Area Required (sf)	12,500	15,600	12,500	15,600	15,600	12,500	15,600	15,600	15,600	
Length of Intake Piping (ft)	NA	2,000	NA	2,000	1,500	NA	1,500	200	200	Pushed intake piping out farther into ocean beyond surf zone
Length of Recirculation/Test Piping (ft)	2,000	2,000	2,000	2,000	1,500	1,500	1,500	200	200	Same length as intake piping
Volume Dredged (cy)	93,000	93,000	93,000	93,000	69,000	69,000	69,000	9,000	9,000	Added dredging for recirculation/test piping at slant well locations

Initial Costs

	Southern Dunes Slant Wells	Southern Dunes Open Water	Rocky Area South Slant Wells	Rocky Area South Open Water (Ocean Beach)	Rocky Area South Open Water (Bluffs)	Rocky Area North Slant Wells	Rocky Area North Open Water	North Bayfront Open Water	East Bayfront Open Water	notes
Land Purchase	$4,875,000	$6,084,000	$4,875,000	$6,084,000	$6,084,000	$4,875,000	$6,084,000	$10,140,000	$10,140,000	based on land area req'd & unit rate
Easements / Leases*	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	plug estimate (e.g. State Lands Commission, CALTRANS, etc.)
NEPA / CEQA / Permitting	$7,500,000	$8,000,000	$7,500,000	$8,000,000	$8,000,000	$7,500,000	$8,000,000	$7,000,000	$7,000,000	based upon review disc. w/ Scott MacPherson of PUC BEM
Open Water Intake (concrete box)	NA	$2,000,000	NA	$2,000,000	$2,000,000	NA	$2,000,000	$2,000,000	$2,000,000	
Intake Screens	NA	$1,500,000	NA	$1,500,000	$1,500,000	NA	$1,500,000	$1,500,000	$1,500,000	
Dredging	$1,900,000	$1,900,000	$1,900,000	$1,900,000	$1,400,000	$1,400,000	$1,400,000	$200,000	$200,000	Added dredging costs for recirculation/test piping at slant well locations
Intake Tunnel	NA	$32,000,000	NA	$32,000,000	$24,000,000	NA	$24,000,000	$3,200,000	$3,200,000	Based on updated lengths in row 16
Vertical Excavation	NA	$23,800,000	NA	$23,800,000	$107,900,000	NA	$23,800,000	$16,000,000	$16,000,000	See estimated depths in row 11.
Slant Well Drilling / Development / Setup	$39,000,000	NA	$39,000,000	NA	NA	$39,000,000	NA	NA	NA	
Pumps (equipment)	$6,500,000	$10,400,000	$6,500,000	$10,400,000	$10,400,000	$6,500,000	$10,400,000	$10,400,000	$10,400,000	Assume $X / pump, each @ 10,000 gpm (for Open Water), $500k/pump (for slant wells)
Pump Station/Wellhead Buildings	$11,250,000	$20,800,000	$11,250,000	$20,800,000	$20,800,000	$11,250,000	$20,800,000	$20,800,000	$20,800,000	Includes common wellhead enclosure costs. Open water PS cost includes PRV in vault for recirculation/test piping ($270k).
Discharge Piping (to connect w/ EFWS) (base cost, assuming cut & cover)	$39,100,000	$39,100,000	$44,000,000	$44,000,000	$41,400,000	$25,900,000	$25,900,000	$450,000	$1,350,000	Assume $15M / mi for 24" dia Kubota; scale down/up accordingly
Microtunneling / etc. for disch. Piping	NA	NA	NA	NA	$8,400,000	$13,200,000	$13,200,000	NA	NA	(use unit rates in O36/37, upsize/downsize based on diameter
Recirculation/Test Piping (return to ocean/bay)	$8,800,000	$8,800,000	$7,600,000	$7,600,000	$5,700,000	$5,700,000	$5,700,000	$800,000	$800,000	Assume same diam as disch. piping and same length as intake tunnel/piping, @ $xxxx/mile, with PRV @ PS
Up-Sizing Existing EFWS Piping	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	Costs cannot be determined at this point; will depend on location(s) and capacities selected based on hyd. Modeling
TOTAL	$120,000,000	$155,400,000	$123,700,000	$159,100,000	$238,600,000	$116,400,000	$143,800,000	$73,500,000	$74,400,000	

* State Lands Lease, ROW Crossings,
** soft costs included in items above

	Southern Dunes Slant Wells	Southern Dunes Open Water	Rocky Area South Slant Wells	Rocky Area South Open Water (Ocean Beach)	Rocky Area South Open Water (Bluffs)	Rocky Area North Slant Wells	Rocky Area North Open Water	North Bayfront Open Water	East Bayfront Open Water
Environmental / Permitting / Land Acq.	$13,375,000	$15,084,000	$13,375,000	$15,084,000	$15,084,000	$13,375,000	$15,084,000	$18,140,000	$18,140,000
Pump Station	$58,650,000	$92,400,000	$58,650,000	$92,400,000	$168,000,000	$58,150,000	$83,900,000	$54,100,000	$54,100,000
Piping	$47,900,000	$47,900,000	$51,600,000	$51,600,000	$55,500,000	$44,800,000	$44,800,000	$1,250,000	$2,150,000
TOTAL (rounded up)	$120,000,000	$155,400,000	$123,700,000	$159,100,000	$238,600,000	$116,400,000	$143,800,000	$73,500,000	$74,400,000

Annualized Costs

	Southern Dunes Slant Wells	Southern Dunes Open Water	Rocky Area South Slant Wells	Rocky Area South Open Water (Ocean Beach)	Rocky Area South Open Water (Bluffs)	Rocky Area North Slant Wells	Rocky Area North Open Water	North Bayfront Open Water	East Bayfront Open Water
Initial Cost	$120,000,000	$155,400,000	$123,700,000	$159,100,000	$238,600,000	$116,400,000	$143,800,000	$73,500,000	$74,400,000
Annual ODC / Fuel / Fixed Costs	$217,000	$217,000	$217,000	$217,000	$217,000	$217,000	$217,000	$217,000	$217,000
Annual Staffing Cost	$180,000	$90,000	$180,000	$90,000	$90,000	$180,000	$90,000	$90,000	$90,000
Slant Well Renewal *	$39,000,000	NA	$39,000,000	NA	NA	$39,000,000	NA	NA	NA
Slant Well Pump Replacement *	$6,500,000	NA	$6,500,000	NA	NA	$6,500,000	NA	NA	NA
Intake Screen Replacement *	NA	$1,500,000	NA	$1,500,000	$1,500,000	NA	$1,500,000	$1,500,000	$1,500,000
NPV @ 4% Interest	$228,500,000	$172,000,000	$232,200,000	$175,700,000	$255,200,000	$224,900,000	$160,400,000	$90,100,000	$91,000,000

*for open water option, assume screen will be replaced every 15 years, the PS has a total of 45 year life
*for slant well option, assume each slant well and pump will be replaced every 15 years

Staffing

	Southern Dunes Slant Wells	Southern Dunes Open Water	Rocky Area South Slant Wells	Rocky Area South Open Water (Ocean Beach)	Rocky Area South Open Water (Bluffs)	Rocky Area North Slant Wells	Rocky Area North Open Water	North Bayfront Open Water	East Bayfront Open Water
Staff Required for routine O&M (FTE)	0.9	0.5	0.9	0.5	0.5	0.9	0.5	0.5	0.5

40,000 gpm PS

Engineering Parameters

	Ocean Side							Bay Side		
	Southern Dunes		Rocky Area South			Rocky Area North		North Bayfront	East Bayfront	notes
Intake Type:	Slant Wells	Open Water	Slant Wells	Open Water (Ocean Beach)	Open Water (Bluffs)	Slant Wells	Open Water	Open Water	Open Water	
Distance to Nearest EFWS Piping (miles)	1.7	1.7	2.2	2.2	2.2	1.5	1.5	0.05	0.15	
Distance for microtunneling of Disch. Piping (ft)	NA	NA	NA	NA	700	1,100	1,100	NA	NA	est from Google Earth
Discharge Piping Diameter (inches)	48	48	42	42	42	42	42	42	42	
Intake Tunnel Diameter (inches)	NA	108	NA	108	108	NA	108	108	108	
Vertical Excavation Depth (ft)	NA	46	NA	46	209	NA	46	31	31	Depth from ground surface to invert of intake tunnel assuming 10 ft cover below MSL
Vertical Excavation Diameter (ft)	NA	80	NA	80	80	NA	80	80	80	
Pump Station/Wellhead Building Size (sf)	1,375	4,418	1,375	4,418	4,418	1,375	4,418	4,418	4,418	Assumed wellhead building dimensions of 55 ft x 25 ft. Assumed spaced min of ~750 ft apart.
Number of Pumps	17	5	17	5	5	17	5	5	5	
Number of Wellhead Bldgs	6	NA	6	NA	NA	6	NA	NA	NA	
Number of Screen Modules	NA	4	NA	4	4	NA	4	4	4	Assume ISI T42-66 tee screen, approx 10,000 gpm / screen w/ < 0.5 fps slot velocity
Land Area Required (sf)	15,000	18,720	15,000	18,720	18,720	15,000	18,720	18,720	18,720	
Length of Intake Piping (ft)	NA	2,000	NA	2,000	1,500	NA	1,500	200	200	Pushed intake piping out farther into ocean beyond surf zone
Length of Recirculation/Test Piping (ft)	2,000	2,000	2,000	2,000	1,500	1,500	1,500	200	200	Same length as intake piping
Volume Dredged (cy)	93,000	93,000	93,000	93,000	69,000	69,000	69,000	9,000	9,000	Added dredging for recirculation/test piping at slant well locations

Initial Costs

	Southern Dunes Slant Wells	Southern Dunes Open Water	Rocky Area South Slant Wells	Rocky Area South Open Water (Ocean Beach)	Rocky Area South Open Water (Bluffs)	Rocky Area North Slant Wells	Rocky Area North Open Water	North Bayfront Open Water	East Bayfront Open Water	notes
Land Purchase	$5,850,000	$7,300,800	$5,850,000	$7,300,800	$7,300,800	$5,850,000	$7,300,800	$12,168,000	$12,168,000	based on land area req'd & unit rate
Easements / Leases*	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	plug estimate (e.g. State Lands Commission, CALTRANS, etc.)
NEPA / CEQA / Permitting	$8,000,000	$8,500,000	$8,000,000	$8,500,000	$8,500,000	$8,000,000	$8,500,000	$7,500,000	$7,500,000	based upon review disc. w/ Scott MacPherson of PUC BEM
Open Water Intake (concrete box)	NA	$2,000,000	NA	$2,000,000	$2,000,000	NA	$2,000,000	$2,000,000	$2,000,000	
Intake Screens	NA	$2,000,000	NA	$2,000,000	$2,000,000	NA	$2,000,000	$2,000,000	$2,000,000	
Dredging	$1,900,000	$1,900,000	$1,900,000	$1,900,000	$1,400,000	$1,400,000	$1,400,000	$200,000	$200,000	Added dredging costs for recirculation/test piping at slant well locations
Intake Tunnel	NA	$36,000,000	NA	$36,000,000	$27,000,000	NA	$27,000,000	$3,600,000	$3,600,000	Based on updated lengths in row 16
Vertical Excavation	NA	$36,000,000	NA	$36,000,000	$163,300,000	NA	$36,000,000	$24,300,000	$24,300,000	See estimated depths in row 11.
Slant Well Drilling / Development / Setup	$51,000,000	NA	$51,000,000	NA	NA	$51,000,000	NA	NA	NA	
Pumps (equipment)	$8,500,000	$13,000,000	$8,500,000	$13,000,000	$13,000,000	$8,500,000	$13,000,000	$13,000,000	$13,000,000	Assume $X / pump, each @ 10,000 gpm (for Open Water), $500k/pump (for slant wells)
Pump Station/Wellhead Buildings	$13,500,000	$24,500,000	$13,500,000	$24,500,000	$24,500,000	$13,500,000	$24,500,000	$24,500,000	$24,500,000	Includes common wellhead enclosure costs. Open water PS cost includes PRV in vault for recirculation/test piping ($270k).
Discharge Piping (to connect w/ EFWS) (base cost, assuming cut & cover)	$45,900,000	$45,900,000	$50,600,000	$50,600,000	$47,600,000	$29,800,000	$29,800,000	$450,000	$1,350,000	Assume $15M / mi for 24" dia Kubota; scale down/up accordingly
Microtunneling / etc. for disch. Piping	NA	NA	NA	NA	$9,800,000	$15,400,000	$15,400,000	NA	NA	(use unit rates in O36/37, upsize/downsize based on diameter
Recirculation/Test Piping (return to ocean/bay)	$10,300,000	$10,300,000	$8,800,000	$8,800,000	$6,600,000	$6,600,000	$6,600,000	$900,000	$900,000	Assume same diam as disch. piping and same length as intake tunnel/piping, @ $xxxx/mile, with PRV @ PS
Up-Sizing Existing EFWS Piping	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	Costs cannot be determined at this point; will depend on location(s) and capacities selected based on hyd. Modeling
TOTAL	$146,000,000	$188,500,000	$149,200,000	$191,700,000	$314,100,000	$141,100,000	$174,600,000	$91,700,000	$92,600,000	

* State Lands Lease, ROW Crossings,
** soft costs included in items above

	Southern Dunes Slant Wells	Southern Dunes Open Water	Rocky Area South Slant Wells	Rocky Area South Open Water (Ocean Beach)	Rocky Area South Open Water (Bluffs)	Rocky Area North Slant Wells	Rocky Area North Open Water	North Bayfront Open Water	East Bayfront Open Water
Environmental / Permitting / Land Acq.	$14,850,000	$16,800,800	$14,850,000	$16,800,800	$16,800,800	$14,850,000	$16,800,800	$20,668,000	$20,668,000
Pump Station	$74,900,000	$115,400,000	$74,900,000	$115,400,000	$233,200,000	$74,400,000	$105,900,000	$69,600,000	$69,600,000
Piping	$56,200,000	$56,200,000	$59,400,000	$59,400,000	$64,000,000	$51,800,000	$51,800,000	$1,350,000	$2,250,000
TOTAL (rounded up)	$146,000,000	$188,500,000	$149,200,000	$191,700,000	$314,100,000	$141,100,000	$174,600,000	$91,700,000	$92,600,000

Annualized Costs

	Southern Dunes Slant Wells	Southern Dunes Open Water	Rocky Area South Slant Wells	Rocky Area South Open Water (Ocean Beach)	Rocky Area South Open Water (Bluffs)	Rocky Area North Slant Wells	Rocky Area North Open Water	North Bayfront Open Water	East Bayfront Open Water
Initial Cost	$146,000,000	$188,500,000	$149,200,000	$191,700,000	$314,100,000	$141,100,000	$174,600,000	$91,700,000	$92,600,000
Annual ODC / Fuel / Fixed Costs	$263,000	$263,000	$263,000	$263,000	$263,000	$263,000	$263,000	$263,000	$263,000
Annual Staffing Cost	$216,000	$180,000	$216,000	$180,000	$180,000	$216,000	$180,000	$180,000	$180,000
Slant Well Renewal *	$51,000,000	NA	$51,000,000	NA	NA	$51,000,000	NA	NA	NA
Slant Well Pump Replacement *	$8,500,000	NA	$8,500,000	NA	NA	$8,500,000	NA	NA	NA
Intake Screen Replacement *	NA	$2,000,000	NA	$2,000,000	$2,000,000	NA	$2,000,000	$2,000,000	$2,000,000
NPV @ 4% Interest	$286,100,000	$212,000,000	$289,300,000	$215,200,000	$337,600,000	$281,200,000	$198,100,000	$115,200,000	$116,100,000

*for open water option, assume screen will be replaced every 15 years, the PS has a total of 45 year life
*for slant well option, assume each slant well and pump will be replaced every 15 years

Staffing

	Southern Dunes Slant Wells	Southern Dunes Open Water	Rocky Area South Slant Wells	Rocky Area South Open Water (Ocean Beach)	Rocky Area South Open Water (Bluffs)	Rocky Area North Slant Wells	Rocky Area North Open Water	North Bayfront Open Water	East Bayfront Open Water
Staff Required for routine O&M (FTE)	1.1	0.9	1.1	0.9	0.9	1.1	0.9	0.9	0.9

50,000 gpm PS

Engineering Parameters

	Ocean Side							Bay Side		
	Southern Dunes		Rocky Area South			Rocky Area North		North Bayfront	East Bayfront	notes
Intake Type:	Slant Wells	Open Water	Slant Wells	Open Water (Ocean Beach)	Open Water (Bluffs)	Slant Wells	Open Water	Open Water	Open Water	
Distance to Nearest EFWS Piping (miles)	1.7	1.7	2.2	2.2	2.2	1.5	1.5	0.05	0.15	
Distance for microtunneling of Disch. Piping (ft)	NA	NA	NA	NA	700	1,100	1,100	NA	NA	est from Google Earth
Discharge Piping Diameter (inches)	54	54	48	48	48	48	48	48	48	
Intake Tunnel Diameter (inches)	NA	120	NA	120	120	NA	120	120	120	
Vertical Excavation Depth (ft)	NA	46	NA	46	209	NA	46	31	31	Depth from ground surface to invert of intake tunnel assuming 10 ft cover below MSL
Vertical Excavation Diameter (ft)	NA	95	NA	95	95	NA	95	95	95	
Pump Station/Wellhead Building Size (sf)	1,375	5,076	1,375	5,076	5,076	1,375	5,076	5,076	5,076	Assumed wellhead building dimensions of 55 ft x 25 ft. Assumed spaced min of ~750 ft apart.
Number of Pumps	20	6	20	6	6	20	6	6	6	
Number of Wellhead Bldgs	7	NA	7	NA	NA	7	NA	NA	NA	
Number of Screen Modules	NA	5	NA	5	5	NA	5	5	5	Assume ISI T42-66 tee screen, approx 10,000 gpm / screen w/ < 0.5 fps slot velocity
Land Area Required (sf)	17,500	22,464	17,500	22,464	22,464	17,500	22,464	22,464	22,464	
Length of Intake Piping (ft)	NA	2,000	NA	2,000	1,500	NA	1,500	200	200	Pushed intake piping out farther into ocean beyond surf zone
Length of Recirculation/Test Piping (ft)	2,000	2,000	2,000	2,000	1,500	1,500	1,500	200	200	Same length as intake piping
Volume Dredged (cy)	93,000	93,000	93,000	93,000	69,000	69,000	69,000	9,000	9,000	Added dredging for recirculation/test piping at slant well locations

Initial Costs

	Southern Dunes Slant Wells	Southern Dunes Open Water	Rocky Area South Slant Wells	Rocky Area South Open Water (Ocean Beach)	Rocky Area South Open Water (Bluffs)	Rocky Area North Slant Wells	Rocky Area North Open Water	North Bayfront Open Water	East Bayfront Open Water	notes
Land Purchase	$6,825,000	$8,760,960	$6,825,000	$8,760,960	$8,760,960	$6,825,000	$8,760,960	$14,601,600	$14,601,600	based on land area req'd & unit rate
Easements / Leases*	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	plug estimate (e.g. State Lands Commission, CALTRANS, etc.)
NEPA / CEQA / Permitting	$8,500,000	$9,000,000	$8,500,000	$9,000,000	$9,000,000	$8,500,000	$9,000,000	$8,000,000	$8,000,000	based upon review disc. w/ Scott MacPherson of PUC BEM
Open Water Intake (concrete box)	NA	$2,000,000	NA	$2,000,000	$2,000,000	NA	$2,000,000	$2,000,000	$2,000,000	
Intake Screens	NA	$2,500,000	NA	$2,500,000	$2,500,000	NA	$2,500,000	$2,500,000	$2,500,000	
Dredging	$1,900,000	$1,900,000	$1,900,000	$1,900,000	$1,400,000	$1,400,000	$1,400,000	$200,000	$200,000	Added dredging costs for recirculation/test piping at slant well locations
Intake Tunnel	NA	$40,000,000	NA	$40,000,000	$30,000,000	NA	$30,000,000	$4,000,000	$4,000,000	Based on updated lengths in row 16
Vertical Excavation	NA	$50,700,000	NA	$50,700,000	$230,300,000	NA	$50,700,000	$34,200,000	$34,200,000	See estimated depths in row 11.
Slant Well Drilling / Development / Setup	$60,000,000	NA	$60,000,000	NA	NA	$60,000,000	NA	NA	NA	
Pumps (equipment)	$10,000,000	$15,600,000	$10,000,000	$15,600,000	$15,600,000	$10,000,000	$15,600,000	$15,600,000	$15,600,000	Assume $X / pump, each @ 10,000 gpm (for Open Water), $500k/pump (for slant wells)
Pump Station/Wellhead Buildings	$15,750,000	$28,100,000	$15,750,000	$28,100,000	$28,100,000	$15,750,000	$28,100,000	$28,100,000	$28,100,000	Includes common wellhead enclosure costs. Open water PS cost includes PRV in vault for recirculation/test piping ($270k).
Discharge Piping (to connect w/ EFWS) (base cost, assuming cut & cover)	$52,700,000	$52,700,000	$59,400,000	$59,400,000	$55,900,000	$34,900,000	$34,900,000	$450,000	$1,350,000	Assume $15M / mi for 24" dia Kubota; scale down/up accordingly
Microtunneling / etc. for disch. Piping	NA	NA	NA	NA	$11,200,000	$17,600,000	$17,600,000	NA	NA	(use unit rates in O36/37, upsize/downsize based on diameter
Recirculation/Test Piping (return to ocean/bay)	$11,800,000	$11,800,000	$10,300,000	$10,300,000	$7,700,000	$7,700,000	$7,700,000	$1,100,000	$1,100,000	Assume same diam as disch. piping and same length as intake tunnel/piping, @ $xxxx/mile, with PRV @ PS
Up-Sizing Existing EFWS Piping	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	Costs cannot be determined at this point; will depend on location(s) and capacities selected based on hyd. Modeling
TOTAL	$168,500,000	$224,100,000	$173,700,000	$229,300,000	$403,500,000	$163,700,000	$209,300,000	$111,800,000	$112,700,000	

* State Lands Lease, ROW Crossings,
** soft costs included in items above

	Southern Dunes Slant Wells	Southern Dunes Open Water	Rocky Area South Slant Wells	Rocky Area South Open Water (Ocean Beach)	Rocky Area South Open Water (Bluffs)	Rocky Area North Slant Wells	Rocky Area North Open Water	North Bayfront Open Water	East Bayfront Open Water
Environmental / Permitting / Land Acq.	$16,325,000	$18,760,960	$16,325,000	$18,760,960	$18,760,960	$16,325,000	$18,760,960	$23,601,600	$23,601,600
Pump Station	$87,650,000	$140,800,000	$87,650,000	$140,800,000	$309,900,000	$87,150,000	$130,300,000	$86,600,000	$86,600,000
Piping	$64,500,000	$64,500,000	$69,700,000	$69,700,000	$74,800,000	$60,200,000	$60,200,000	$1,550,000	$2,450,000
TOTAL (rounded up)	$168,500,000	$224,100,000	$173,700,000	$229,300,000	$403,500,000	$163,700,000	$209,300,000	$111,800,000	$112,700,000

Annualized Costs

	Southern Dunes Slant Wells	Southern Dunes Open Water	Rocky Area South Slant Wells	Rocky Area South Open Water (Ocean Beach)	Rocky Area South Open Water (Bluffs)	Rocky Area North Slant Wells	Rocky Area North Open Water	North Bayfront Open Water	East Bayfront Open Water
Initial Cost	$168,500,000	$224,100,000	$173,700,000	$229,300,000	$403,500,000	$163,700,000	$209,300,000	$111,800,000	$112,700,000
Annual ODC / Fuel / Fixed Costs	$317,000	$317,000	$317,000	$317,000	$317,000	$317,000	$317,000	$317,000	$317,000
Annual Staffing Cost	$252,000	$180,000	$252,000	$180,000	$180,000	$252,000	$180,000	$180,000	$180,000
Slant Well Renewal *	$60,000,000	NA	$60,000,000	NA	NA	$60,000,000	NA	NA	NA
Slant Well Pump Replacement *	$10,000,000	NA	$10,000,000	NA	NA	$10,000,000	NA	NA	NA
Intake Screen Replacement *	NA	$2,500,000	NA	$2,500,000	$2,500,000	NA	$2,500,000	$2,500,000	$2,500,000
NPV @ 4% Interest	$333,600,000	$251,000,000	$338,800,000	$256,200,000	$430,400,000	$328,800,000	$236,200,000	$138,700,000	$139,600,000

*for open water option, assume screen will be replaced every 15 years, the PS has a total of 45 year life
*for slant well option, assume each slant well and pump will be replaced every 15 years

Staffing

	Southern Dunes Slant Wells	Southern Dunes Open Water	Rocky Area South Slant Wells	Rocky Area South Open Water (Ocean Beach)	Rocky Area South Open Water (Bluffs)	Rocky Area North Slant Wells	Rocky Area North Open Water	North Bayfront Open Water	East Bayfront Open Water
Staff Required for routine O&M (FTE)	1.3	0.9	1.3	0.9	0.9	1.3	0.9	0.9	0.9

Unit Cost Table

Discharging piping cost

Size	Unit Cost per mile	cost per mile including all soft cost
12	$8,000,000	
14	$9,000,000	
16	$10,000,000	
18	$12,000,000	
20	$14,000,000	
24	$15,000,000	
30	$18,000,000	
36	$20,000,000	
42	$23,000,000	
48	$27,000,000	
54	$31,000,000	

Dredging (Bay Side Only)

Unit rate:	$20	$/CY
W	50	ft
D	25	ft
	1	cy
	27	cft

Microtunneling / Jack-Bore (72" and below)

Size	unit cost per LF	
20	$7,000.00	$ / lf
24	$8,000	$ / lf
30	$10,000	$ / lf
36	$12,000	$ / lf
42	$14,000	$ / lf
48	$16,000	$ / lf
54	$18,000	$ / lf

Bigtunneling (96" and above)

Size	unit cost per LF	
60	$10,000	$ / lf
72	$12,000	$ / lf
96	$16,000	$ / lf
108	$18,000	$ / lf
120	$20,000	$ / lf

Access Shaft / Caissons

2 pumps = 35 ft, 3 pumps = 50 ft, 4 pumps = 65 ft, 5 pumps = 80 ft, 6 pumps = 95 ft

shaft only	$20,000,000	40 ft dia @ 150 ft deep:
	10%	equipment
	10%	mobilization
	10%	safety
(all - in)	$29,300,000	40 ft dia @ 150 ft deep:
	188496	cu ft in volumn
	$155	$ / cubic ft

Slant Wells

Wellhead Array Enclosure (ea)	$2,250,000	assume 3,3,2,2 configuration for 10 wells; 4 primary structures + 1 standy structure per location; cost includes emergency generator and PRV vault	Generator: 1.5 MW @ $1M; Building @ $1.25M inc. PRV & Vault)
	$3,000,000	Slant Well Drilling/Development/Testing (ea)	
	$500,000	Slant Well Pumps (ea), 3,000 gpm capacity	

Land Area Required

Capacity GPM	Slant Wells sqft	Open Water sqft	
3,000	2,500	3,700	-20%
6,000	2,500	3,700	-20%
10,000	7,500	10,400	-20%
20,000	10,000	13,000	
30,000	12,500	15,600	20%
40,000	15,000	18,720	20%
50,000	17,500	22,464	20%

Land Purchase

$390	$ unit cost per sqft for the southern dunes and rocky side	added 30% contingency, per D. Brasil, 4/15/21
$650	$ unit cost per sqft for the bayside	added 30% contingency, per D. Brasil, 4/15/21

Pumps

$2,600,000	unit cost per 10,000 gpm open water pump
$780,000	unit cost for 3,000 gpm open water pump
$1,560,000	unit cost for 6,000 gpm open water pump
2.6	multiplier to include all design and soft cost, calculated from sunset cost ($11M subtotal to $28M total cost)

GPM	PS and Bldg cost		
3,000			
6,000			
10,000			
20,000			
30,000	$20,800,000	estiamted from sunset, including soft and other cost	$5,532
40,000			
50,000			

Intake

Qty 1	$2,000,000	screened intake cost, assumed (concrete)

Screens for flows of:

10,000	$500,000	Assumed cost of screen, installed
20,000	$1,000,000	
30000	$1,500,000	
40000	$2,000,000	
50000	$2,500,000	