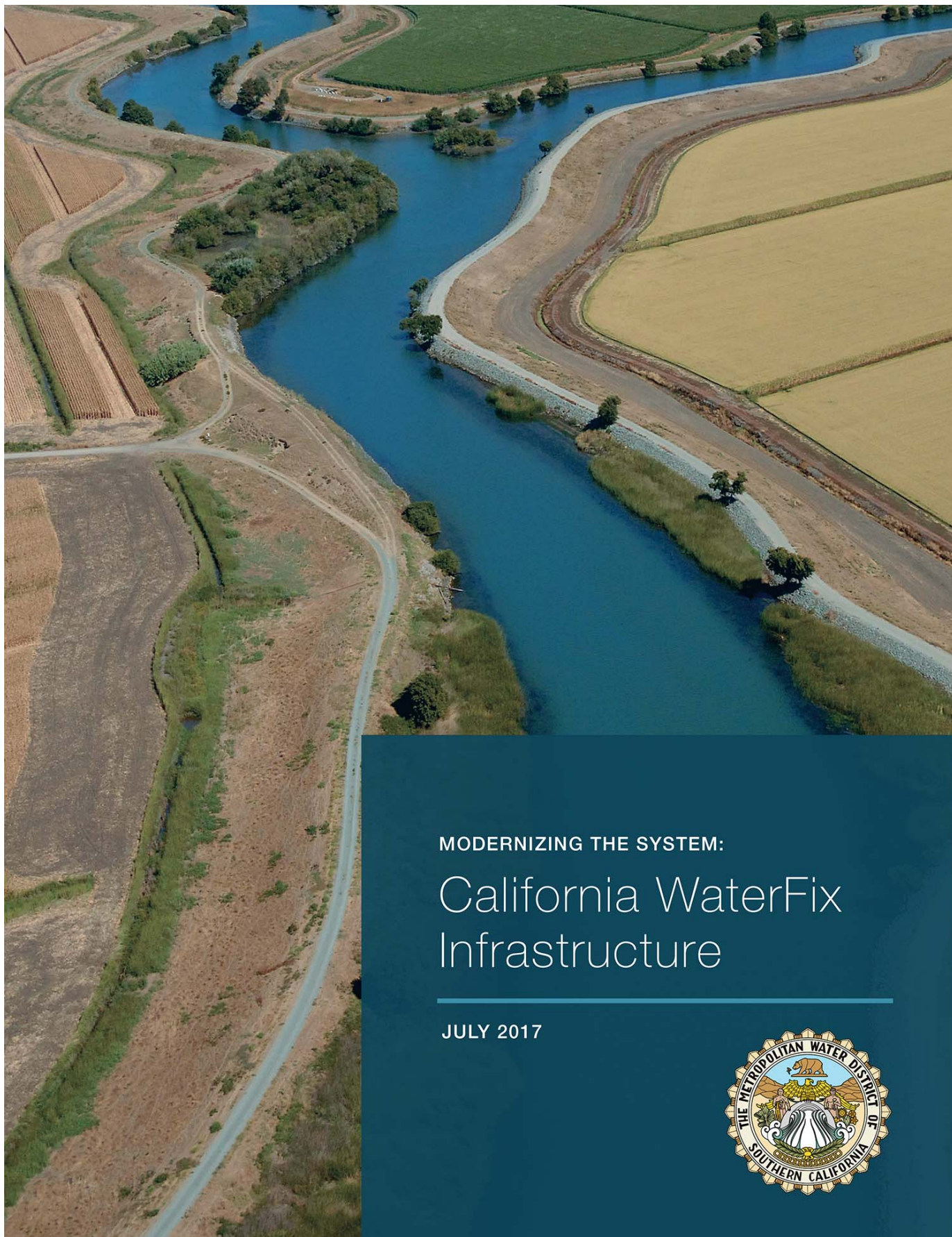


RTD-1006



MODERNIZING THE SYSTEM:

California WaterFix Infrastructure

JULY 2017



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Introduction

This is the first of three policy white papers prepared for the Metropolitan Water District of Southern California's Board of Directors on the proposed California WaterFix. The overall objective of these papers is to provide relevant information for the Board before the Board considers decisions on the project.

This initial paper focuses on the project's planned infrastructure improvements. It presents the key project features, including proposed facilities, governance structure, current cost estimates and implementation schedule, as well as the planned approach to managing and mitigating project risks. The remaining two policy white papers will focus on operations and financing/cost allocation.

Specific objectives of this paper are:

1. To review the physical infrastructure of California WaterFix, with a focus on the key project facilities (see Figure 1);
2. To outline the State's approach to managing and implementing the project through a proposed Delta Conveyance Design/Construction Joint Powers Authority, designated the Design and Construction Authority, or "DCA," and Metropolitan's potential role in the new DCA;
3. To outline the project's planned approach to risk management and present key risk-related issues, including steps being taken to mitigate potential risks to keep the project within cost and schedule targets.

Summary

Water from the State Water Project (SWP) flows through the Sacramento-San Joaquin Delta to the Bay Area, San Joaquin Valley, Central Coast and Southern California. Metropolitan and the 28 other State Water Project contractors rely on the Department of Water Resources (DWR) to deliver water from the State Water Project (SWP); 24 of the contractors, including Metropolitan, would directly benefit from receiving water via the Delta through California WaterFix facilities. The other five water contractors receive water further upstream in the watershed or from the North Bay Aqueduct.

As Metropolitan's Board and the state Legislature have recognized, the current water delivery system in the Delta, with its 700-mile web of waterways, sloughs, canals, and islands, supported by about 1,100 miles of earthen levees, is unsustainable. Threats of earthquakes, floods, subsidence, climate change, rising sea levels, and increasing regulatory constraints on water operations, as well as other risks and uncertainties in the Delta, are contributing to a decline in water supply reliability and in the ecosystem. The Delta's ecosystem and water supply reliability will continue to decline unless action is taken.

Delta conveyance has been studied extensively, and many solutions have been proposed over the last 50 years. A summary of these efforts is presented in Table 1.

In 2007, Metropolitan's Board adopted its Delta Action Plan (DAP) and Delta Conveyance Criteria as policy direction. The Delta Conveyance policy established six specific criteria for comparing Delta conveyance options: providing water supply reliability, enhancing the Delta ecosystem, improving export water quality, allowing flexible pumping operations in a dynamic fishery environment, reducing seismic risks to the water supply and reducing long-term risks from salinity intrusion associated with rising sea levels. As proposed, California WaterFix addresses each of these criteria.

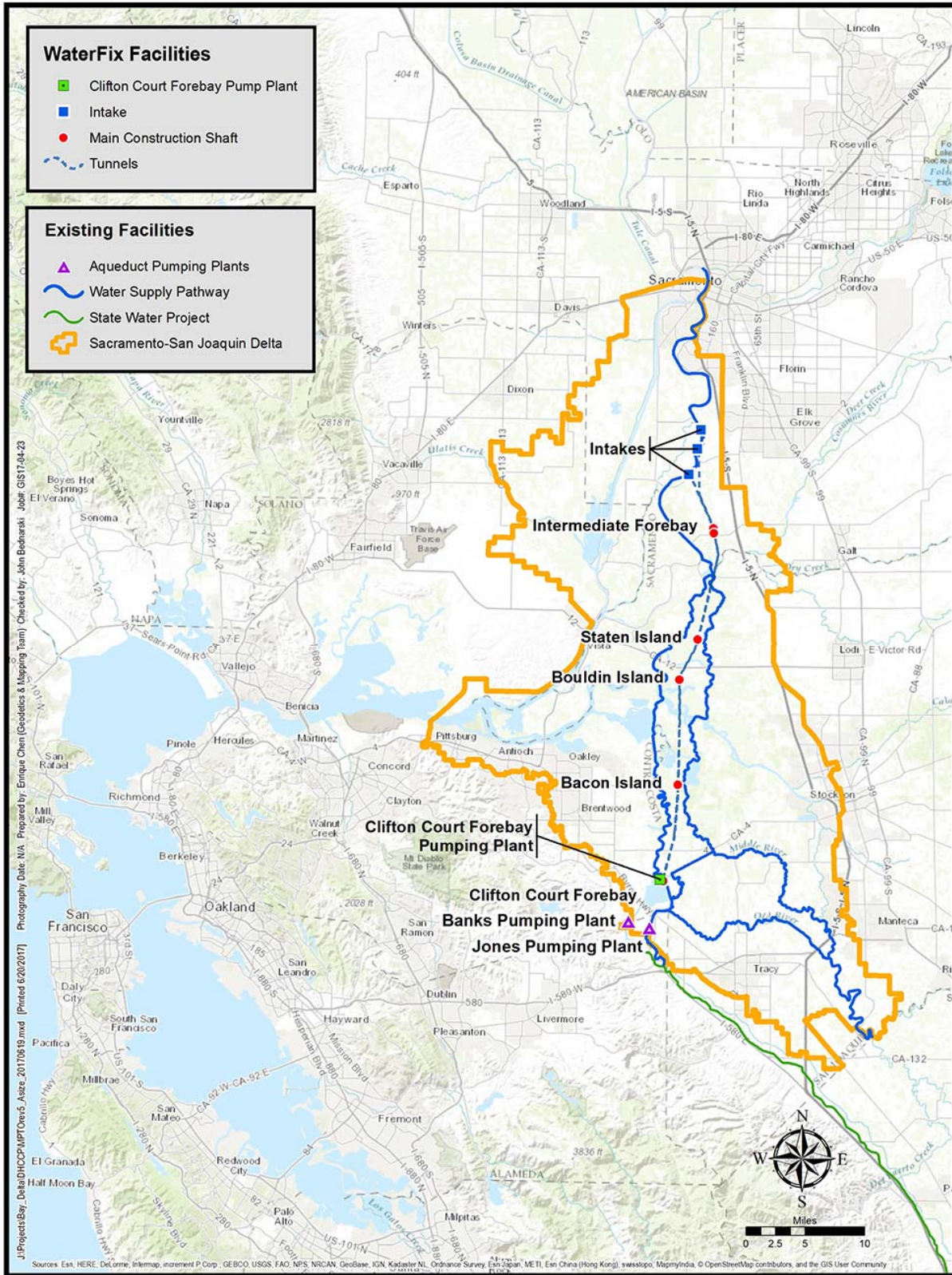


FIGURE 1: OVERVIEW OF THE DELTA AND CALIFORNIA WATERFIX FACILITIES

TABLE 1: DELTA CONVEYANCE STUDIES AND PROPOSALS TIMELINE

| Year | Activity |
|--------------|--|
| 1960s | <p>California Department of Fish and Game, now known as the California Department of Fish and Wildlife, biologists publish an article in American Fisheries Society Special Publication #3, showing that the best protection for native fish populations, and solution to the Delta's environmental problems, is abandoning sensitive river channels for water transport.</p> <p>U.S. Fish and Wildlife Service backs the Peripheral Canal proposal, calling it the only engineering plan that would not have detrimental effects on fish and wildlife while offering the biggest opportunity for fish enhancement.</p> <p>Interagency Delta Committee completes its report recommending various Delta facilities, including the Peripheral Canal.</p> |
| 1994 | Bay Delta Accord is signed, authorizing "CALFED," a joint state and federal agency process to develop water quality standards, coordinate operations of the SWP and CVP and work toward long-term Delta solutions. |
| 1998 | CALFED "Diversion Effects on Fish Team" finds that an isolated facility would substantially reduce entrainment and predation effects on the Delta's native fish populations. |
| 2000 | CALFED Bay-Delta Program releases "California's Water Future, a Framework for Action." Among the list of comprehensive actions, it identifies the need to evaluate a screened diversion facility on the Sacramento River to improve water quality in the Delta and at the export facilities. Construction would begin by late 2007. |
| 2007 | Delta Vision Blue Ribbon Task Force recommends an assessment of dual conveyance, saying new facilities for conveyance and storage, and better linkage between the two, are needed to better manage California's water resources for both the Delta and exports. |
| 2008 | Public Policy Institute of California states a peripheral canal is the best Delta conveyance option for meeting the coequal goals of a healthy Delta ecosystem and water supply reliability. |
| 2009 | The Governor enacts the Delta Reform Act, which includes the coequal goals of providing a more reliable water supply for California and protecting, restoring and enhancing the Delta ecosystem in a way that protects the Delta's unique characteristics. The law directs state and federal officials to examine a reasonable range of ways to change Delta water project diversions, including isolated conveyance. |
| 2010 | The first administrative draft Bay Delta Conservation Plan (BDCP) was released. |
| 2012 | The second administrative draft Bay Delta Conservation Plan was released. |
| 2013 | Release of Draft BDCP and Draft EIR/EIS in compliance with the California Environmental Quality Act (CEQA) and the National Environmental Policy Act (NEPA) for formal public review and comment. |
| 2014 | Announcement of further refinements to the water delivery facilities to reduce impacts to Delta communities, minimize disturbances or dislocation to Greater Sandhill Cranes and improve the long-term reliability and operation of the proposed infrastructure. |
| 2015 | Announcement of a modified preferred alternative, Alternative 4A, known as California WaterFix. |
| 2015 | Release of Partially Recirculated Draft Environmental Impact Report/Supplemental Draft Environmental Impact Statement on the Bay Delta Conservation Plan/California WaterFix. |
| 2016 | Final BDCP/CA WaterFix and EIR/S. |

Sources:

1. The information from the 1960s to 2009 is from "The History of Water Project Conveyance in the Delta," which is a publication from the California WaterFix website. The following link is to a PDF version of this document: http://cms.capitoltechsolutions.com/ClientData/CaliforniaWaterFix/uploads/83my6_FIX_FS_ConveyanceHistory.pdf
2. The information from 2010 to 2016 is from the Bay Delta Conservation Plan (BDCP) website at the link: <http://baydeltaconservationplan.com/Library/BDCPLibrary/BDCPPlanningProcess/BDCPPlanningProcessHistory.aspx>.

California WaterFix aims to provide the facilities necessary to support Delta water exports through dual-conveyance operation. Dual conveyance would divert water from the Sacramento River in the north Delta under certain hydrologic conditions using new facilities, while retaining current south Delta diversions through existing facilities. To divert water from the north Delta, three new screened intakes would be constructed along the Sacramento River, along with associated tunnels and pumping facilities. The new facilities would allow water to be delivered directly from the Sacramento River intake locations to the existing south Delta export pumps located at the State Water Project's Banks and Central Valley Project's Jones pumping facilities. Under appropriate south Delta conditions, north Delta diversions can be appropriately modulated, and water from the north Delta can be diverted through the existing south Delta facilities. This dual conveyance capability would potentially allow for diversions from both north and south Delta locations while taking into account the presence and needs of fish species. As part of the planning process, potential impacts of the proposed system facilities have been identified and appropriate risk management measures have been incorporated into the project as mitigation.

Dependent on the approval of Metropolitan's Board and other public water agencies, a new special purpose Design and Construction Joint Powers Authority (the Design and Construction Authority, or "DCA") composed of public water agencies, including Metropolitan, would design and construct California WaterFix, subject to DWR's oversight and ultimate decision-making authority. The DCA would be responsible for day-to-day implementation of all project aspects. This includes the management, design, construction and commissioning of California WaterFix facilities; managing the overall project budget of \$14.9 billion, plus about \$800 million for project mitigation (both in 2014 dollars); and ensuring that the project is completed within the proposed schedule, which currently estimates project completion 16 years after authorization. The DCA is expected to employ an active risk management strategy that identifies and takes action to address potential issues that could pose significant risk to the project's overall scope, schedule and budget. Subject to Board approval, Metropolitan, as the largest contractor for State Water Project water, would play an important and direct role in the DCA and overall governance of the project team.

California WaterFix has undergone an unprecedented level of public outreach, review and comment, along with extensive scientific analysis as part of the environmental planning process. Significant changes and refinements to the physical configuration and operational characteristics were made to address issues raised during the environmental planning process and to address the outcomes from the biological assessment/opinion processes. Taken together, these revisions have refined and improved the project and have reduced environmental impacts, while maintaining the underlying core capabilities of the proposed system. The planning process has been completed, and the federal and state lead resource agencies for California WaterFix —the California Department of Water Resources (DWR) and the U.S. Bureau of Reclamation (Reclamation)— have completed the environmental review process under the California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA). In addition, the U.S. Fish and Wildlife Service and National Marine Fisheries Service (NMFS) have issued biological opinions on the project.

Based on the information available to date, it is staff's view that the facilities as currently proposed would meet Metropolitan's adopted policy direction and, under the guidance of the DCA, the facilities could be completed within budget and on schedule with a high degree of confidence.

Why California WaterFix

THE CURRENT SITUATION IN THE DELTA

The Sacramento-San Joaquin Delta is where California's two largest rivers meet, an area where saltwater from the Pacific mixes with freshwater from the rivers. Water flowing through the Delta supplies water to about 25 million Californians and about 3 million acres of agricultural production. Some regions of California are 100 percent dependent on Delta diversions for their water supplies.

Current operations of the State Water Project (SWP) and Federal Central Valley Project (CVP) rely on a series of channelized waterways to convey water through the Delta to state and federal pumping facilities located at the south end of the Delta. The pumping facilities then lift the water into the SWP aqueduct and Federal CVP canal.

There are many stressors affecting the Delta. The 1,100 mile levee system was developed beginning in the late 1800s to support agricultural activities, which changed the tidal wetland environment of the Delta. The levees and other Delta infrastructure are increasingly vulnerable to failure caused by continued subsidence, natural degradation, earthquake risks, flood conditions and sea level rise. The current water delivery system in the Delta is also increasingly affected by regulatory constraints on water project operations, salinity intrusion due to sea level rise, the presence of non-native species and the presence of endangered fish near the southern export pumps at certain times of year, which limit when or at what rate the pumps can export water. The continued decline of the Delta's ecosystem has led to severe restrictions in water supply deliveries, resulting in the need to improve California's water reliability and restore the Delta's fragile ecosystem.

The Bay Delta Conservation Plan/California WaterFix Final EIR/Final EIS states that improvements to the water conveyance system are needed to respond to increased demands on the system and risks to water supply reliability, water quality, and the aquatic ecosystem. Improvements are also needed because sea water intrusion from sea level rise causes more need for Delta outflow, which results in impacts to water supply. Operational flexibility can be increased to provide improved water supply reliability and minimize and avoid adverse effects on listed species. DWR's fundamental purpose in proposing the proposed project is to make physical and operational improvements to the SWP system in the Delta that are necessary to restore and protect ecosystem health, water supplies of the SWP and CVP south of the Delta and water quality within a stable regulatory framework, consistent with statutory and contractual obligations. (Bay Delta Conservation Plan/California WaterFix Proposed Final EIR/Final EIS, 2016, Chapter 2).

THE DUAL CONVEYANCE SOLUTION

To address these current and potential threats to the existing Delta conveyance system, California WaterFix proposes a new dual conveyance system that would allow water from both the north Delta and south Delta to be delivered to the Banks and Jones pumping plants. The new north Delta facilities (see Figure 1 and Figure 2) could divert up to 9,000 cubic feet per second (cfs) from the Sacramento River, improving water supply reliability and export water quality. Retaining the current south Delta water exports under California WaterFix ensures an additional avenue to deliver water to the south Delta pumps when water quality and other environmental conditions (e.g., absence of fish species) permit. Providing flexibility in how water is conveyed across the Delta to the existing Banks and Jones pumping plants can avoid adverse impacts to sensitive fish species.

PROJECT FEATURES AND BENEFITS

California WaterFix would include the following features (see also Figure 2 and Figure 3):

- A. **Isolated Deliveries:** Delivers water directly from the Sacramento River in the north Delta to pumping plants in the south Delta. This allows water delivered by California WaterFix facilities to flow to state and federal pumps without commingling with in-Delta channel water, thereby providing greater flexibility to protect fish when they are present.
- B. **Operational Flexibility:** Works in conjunction with the existing south Delta delivery system. If desired, diversions from the Sacramento River in the north Delta could take place simultaneously with diversions from the existing south Delta facilities, or from one system or the other.
- C. **Operational Efficiency:** Allows for water deliveries to occur entirely by gravity flow under certain hydraulic conditions. The remainder of the time, water would flow by gravity through the tunnels to the south Delta, where a new pumping plant would lift water into the North Clifton Court Forebay. Using gravity to make deliveries simplifies overall operations and reduces long-term system operation and maintenance costs.

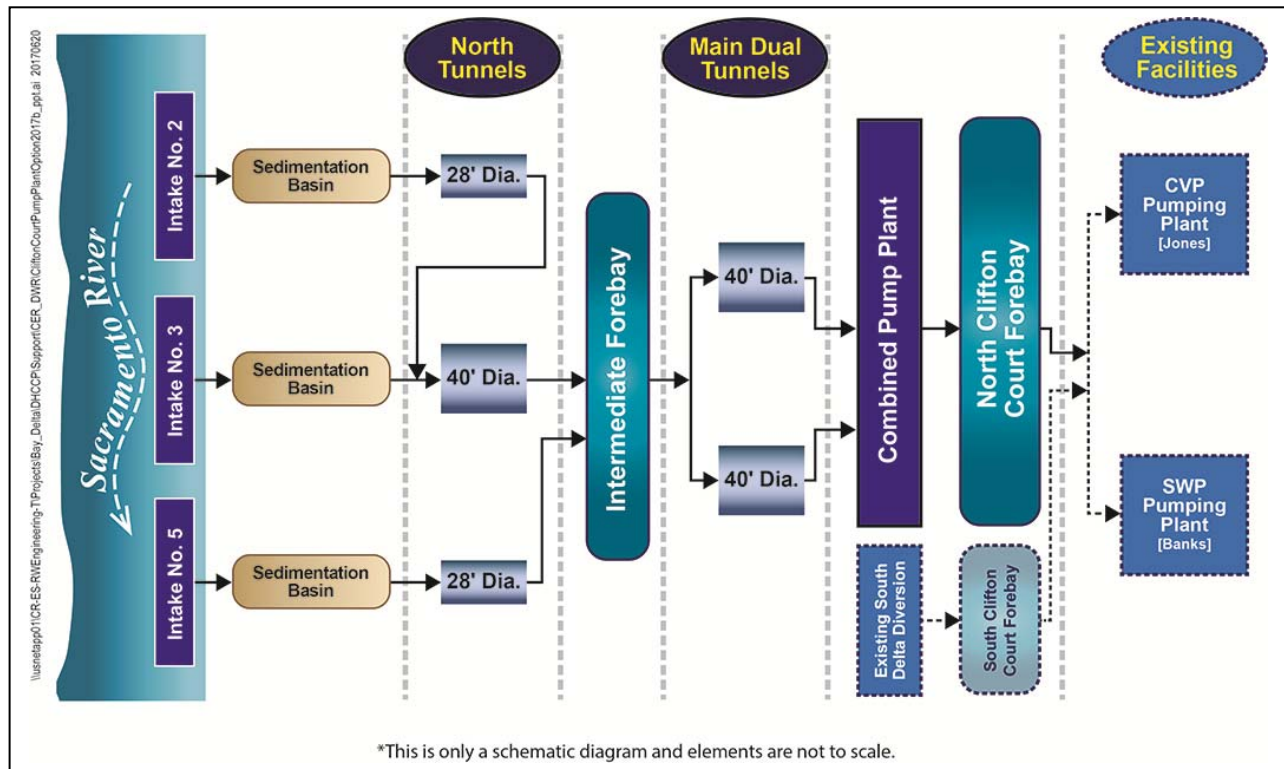


FIGURE 2: SYSTEM CONFIGURATION OF CALIFORNIA WATERFIX FACILITIES

- D. **Modernized Facilities:** Upgrades a decades-old system with new facilities, equipment, and technologies that would improve and modernize operations. State-of-the-art fish screens and intake structures would allow for more efficient delivery of water from the new facilities, even when endangered species of fish are near the new intake structures.
- E. **Use of Public Lands:** Maximizes the use of public lands, reducing the impact to agriculture and other resources. This reduces the time and cost associated with purchasing private property, easements or rights of way.
- F. **Reduced Environmental Footprint:** Minimizes above-ground facilities by 1) using tunnels instead of canals to convey the water through the system, and 2) incorporating a number of refinements made during the design phase, such as eliminating the pumping stations at each of the three new intakes and reducing the size of the intermediate forebay. This represents a smaller footprint in comparison with other alternate intake facility proposals, reducing project impacts and mitigation costs.
- G. **Other Environmental Considerations:** Considers the environment and incorporates refinements resulting from the environmental review process to reduce impacts to the environment. This approach was used throughout the design process, from the alignment chosen, to the conceptual design of the fish screens at the intake facilities, to the extensive environmental commitments, avoidance and minimization measures incorporated into the project. Mitigation measures also would be incorporated where potentially significant impacts cannot be avoided. As stated, the current configuration would minimize adverse environmental impacts by:
- Allowing for a more natural flow direction during fish-sensitive periods in the Delta to protect and benefit sensitive native fish species; and
 - Providing the flexibility to divert water while complying with state and federal laws and regulations that protect sensitive fish species.

- H. **Water Supply Reliability:** Safely and reliably captures water during periods of heavy rain and high Delta flows to refill reservoirs and replenish groundwater basins, with the flexibility to reduce pumping in dry periods, which would reduce impacts to sensitive fish species.
- I. **Emergency Preparedness:** Ensures that more water is available for drought and emergency needs, including an earthquake or other natural disaster that collapses Delta levees or otherwise disrupts the current system. The facilities would also enable diversions that would mitigate the impacts of temporarily losing the ability to divert water from the south Delta.

California WaterFix Facilities

MAJOR COMPONENTS AND FACILITIES

Sacramento River Intakes

Three intakes, each with a capacity of 3,000 cfs, are proposed along the Sacramento River (see Figure 3). The location of each intake was determined by extensive collaboration between DWR and state and federal fishery agencies to identify locations that would minimize incidental take of listed species.

Each of the three intake facilities consists of on-bank screened intake structures; gravity-fed intake conduits; flow meters and control gates; sedimentation basins to allow suspended material from the river to be removed from the water before the water enters the tunnel system; and a drop-shaft at the far end of the sedimentation basins to connect the intakes to the adjacent tunnel network. The bottom-most portion of each intake screen would be situated three to five feet above the river bottom in order to prevent large debris and other heavy suspended materials from entering the intakes or becoming impinged on the screens.

A main factor in sizing and configuring the intake structures was the need to meet specific flow velocities for the water moving past and through the screens. To meet recommended criteria set by state and federal fishery agencies to protect Delta smelt and migrating salmon, the screen area has been set to ensure the approach velocity of the water toward the screens would be no greater than 0.2 feet per second under design flow conditions.

Tunnels and Shafts

The tunnel portions of California WaterFix have been divided into two general sections, the North Tunnels and the Main Tunnels (see Figure 2 and Figure 3). The North Tunnels extend from the intakes to the intermediate forebay and have been sized so water flows from the diversions could be equally split between any or among all of the three river intakes that are in operation at any given time. The two Main Tunnels extend from the intermediate forebay to the combined pump plant at Clifton Court Forebay and have been sized so that each tunnel would be capable of delivering up to 4,500 cfs under design conditions. Dual parallel tunnels for the Main Tunnel reaches are proposed to meet the total desired capacity of 9,000 cfs and ensure system reliability, allowing one tunnel to be isolated for maintenance or major repairs while the second tunnel is kept in operation.

All tunnels would be excavated using tunnel boring machines (TBMs) instead of cut-and-cover construction. Although the Main Tunnels span about 30 miles, the tunnels would be constructed in segments or reaches about six to eight miles long. Each reach would be connected to subsequent tunnel reaches at shaft structures located along the alignment, as shown in Figure 3. As the TBMs advance, soil would be removed from the tunnel and concrete segments would be installed to form the tunnel lining system. This concrete segmented liner serves as the final lining system for the tunnels. This approach is commonplace on construction projects throughout the world and is used in both transportation and water infrastructure projects. The liner would be sealed with a series of gaskets and bolted connections between the adjacent segments to avoid leakage.

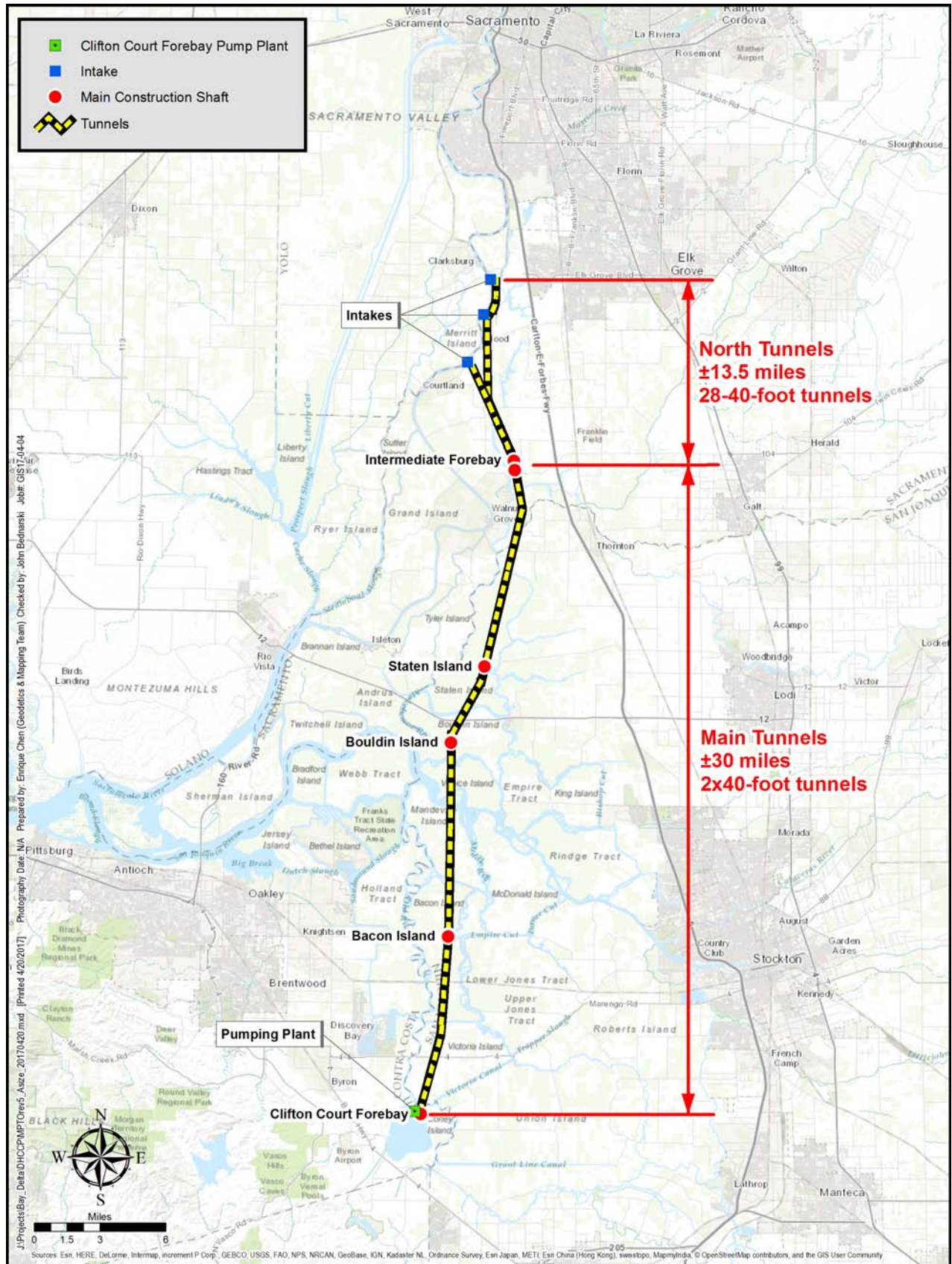


FIGURE 3: CALIFORNIA WATERFIX FACILITIES

Much of the Delta geology is covered with organic peat deposits. Although the peat deposits are very advantageous for agricultural purposes, they present a significant risk of liquefaction in a seismic event. However, the extent of the peat deposits is relatively well understood in the Delta, and ground conditions beneath the peat are generally characterized as dense deposits of silts, sands and clay layers. These dense layers would be very suitable for the planned tunnels because they would not be subject to liquefaction or settlement in the event of a seismic event. The tunnels would be constructed at sufficient depth below the ground surface (about 150 feet from ground surface to the bottom of the tunnel) to avoid existing surface infrastructure and liquefiable soil materials like peat. It is not anticipated that any cut-cover pipelines in the challenging Delta surface geology conditions would be part of California WaterFix facilities.

Deep shafts would be required along the tunnel alignments to facilitate construction, operation and maintenance of the conveyance system. During construction, the shafts would be used to launch and retrieve the TBMs, provide an access point into the tunnels for delivery of tunnel building supplies and labor, and provide a location to join adjacent tunnels to the larger tunnel system. After construction, some of the construction shafts would be modified and used to support long term operations and maintenance needs for the tunnels. Other shafts used in the construction process, such as maintenance shafts, would be sealed and buried to a depth that would support farming activities after construction concludes.

A significant area for investigation during the design activities would be developing the connection of the tunnels with the shafts. Special construction details would be developed through computer modeling to ensure that the tunnel-shaft connection points would be well understood, and so that the interaction of these two structures (tunnel and shaft) could sustain anticipated movement during a seismic event.

Intermediate Forebay

The 30-acre Intermediate Forebay allows for flows from the three separate intakes to be blended before entering the two Main Tunnels. The forebay would also help dampen hydraulic surge waves that could occur in the Main Tunnels if there is a power outage at the Clifton Court pump station. The forebay, along with flow meters and control gates in the intakes, would enhance the ability for independent operation of each river intake and the two Main Tunnels while providing for the overall operational stability of the system. The forebay would be comprised of earthen embankments and tunnel shaft structures, with the shaft structures allowing water to enter at the forebay's north end and exit at the forebay's south end.

Clifton Court Forebay

To achieve the dual goal of isolating delivery of water diverted from the Sacramento River to the pumps at the south end of the Delta while maintaining south Delta export capabilities, the existing Clifton Court Forebay would be separated into the North Clifton Court Forebay and the South Clifton Court Forebay (see Figure 4). Water from the new conveyance system would be pumped or flow from the tunnels into North Clifton Court. South delta diversions would enter South Clifton Court through the existing Old River gate structure.

The new South Clifton Court Forebay would be expanded by creating an additional storage area to the south of the existing levees, as shown in Figure 4. Separating the existing forebay into two sections allows fish-screened water from the north Delta intakes to be isolated from other waters throughout the delivery system. Additional new canals, gate structures and flow meters would also be constructed so water from the North and South Clifton Court Forebays can be conveyed to the existing Jones and Banks pumping plants. These canals and gates would be designed to allow single-mode diversion or simultaneous dual-mode deliveries of both waters to the pumping plants.

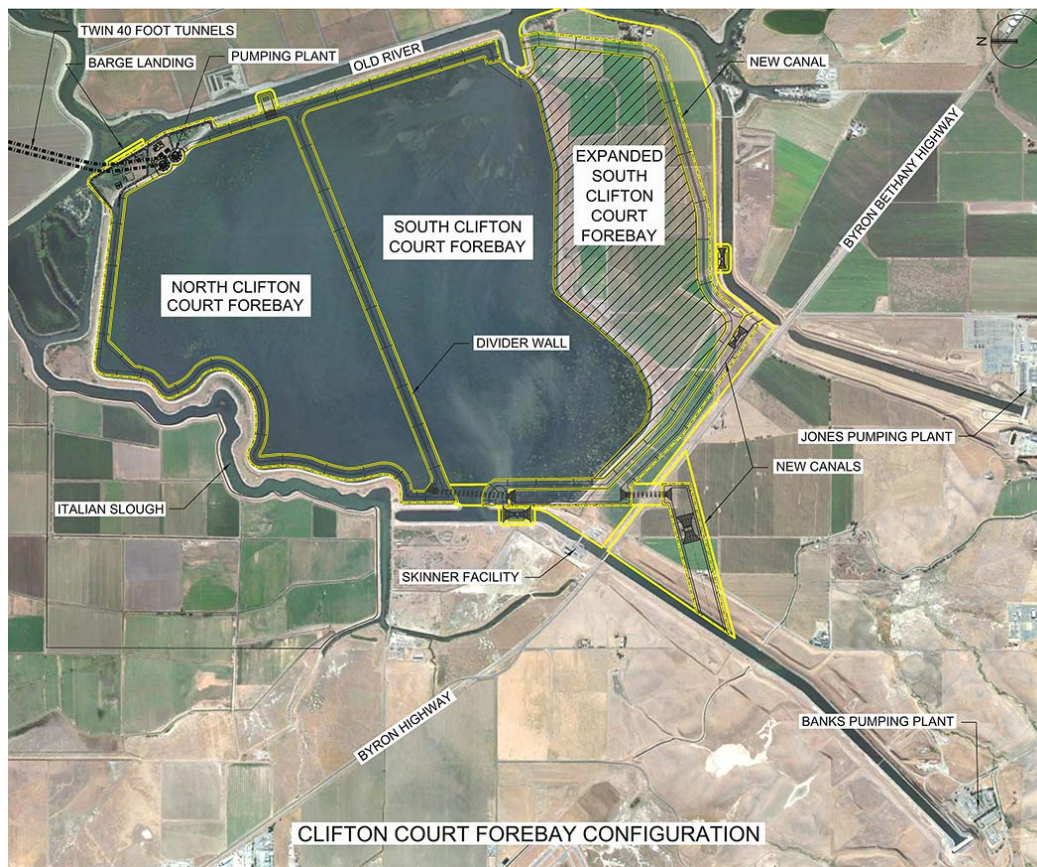


FIGURE 4: CLIFTON COURT FOREBAY, INCLUDING PROPOSED MODIFICATIONS

Pumping Station at Clifton Court Forebay

A 9,000 cfs pumping station would be constructed at the northeast corner of the Clifton Court Forebay to lift the water from the Main Tunnels into the North Clifton Court Forebay. The pumping station would consist of two pumping plants, each rated at 4,500 cfs capacity. Each pumping plant would be located directly above the end of the Main Tunnel (see Figure 5). Water flowing south in the Main Tunnels would fill up a pumping well in the bottom of each pump plant before vertical turbine pumps lift the water into North Clifton Court.

Under certain hydraulic conditions in the Sacramento River, water can flow by gravity from the Sacramento River into North Clifton Court without using the pumping station. In these conditions, the pumps would be shut off, and water would flow by gravity directly from the tunnels through the surge channel in the pump plant and into North Clifton Court. In the event of a power outage at the pump plant, hydraulic surge waves would be dissipated at the pump station by allowing water to flow over the surge channel and into North Clifton Court.

SUPPORTING INFRASTRUCTURE

In addition to the major components of the project, construction of supporting infrastructure would be required for the operation of the new facilities and as a prerequisite for construction activities. Some of the required permanent and temporary infrastructure includes:

- High voltage electrical power lines to run the TBMs and operate the pumping facilities;
- Initial site grading and site preparation work;
- Access roadways and barge landings at key work sites;
- Improvements to existing municipal/private roads to support anticipated construction traffic;
- Restoration of public and private roads used to support project activities to pre-construction conditions once the project is complete;

- Improvements around critical infrastructure, including levees, to ensure stability during subsequent work; and
- Removal/relocation of existing gas and water wells that could conflict with tunnel or intake construction.

Completing these activities prior to the major construction work would help ensure that the overall program schedule and budgets would be maintained.

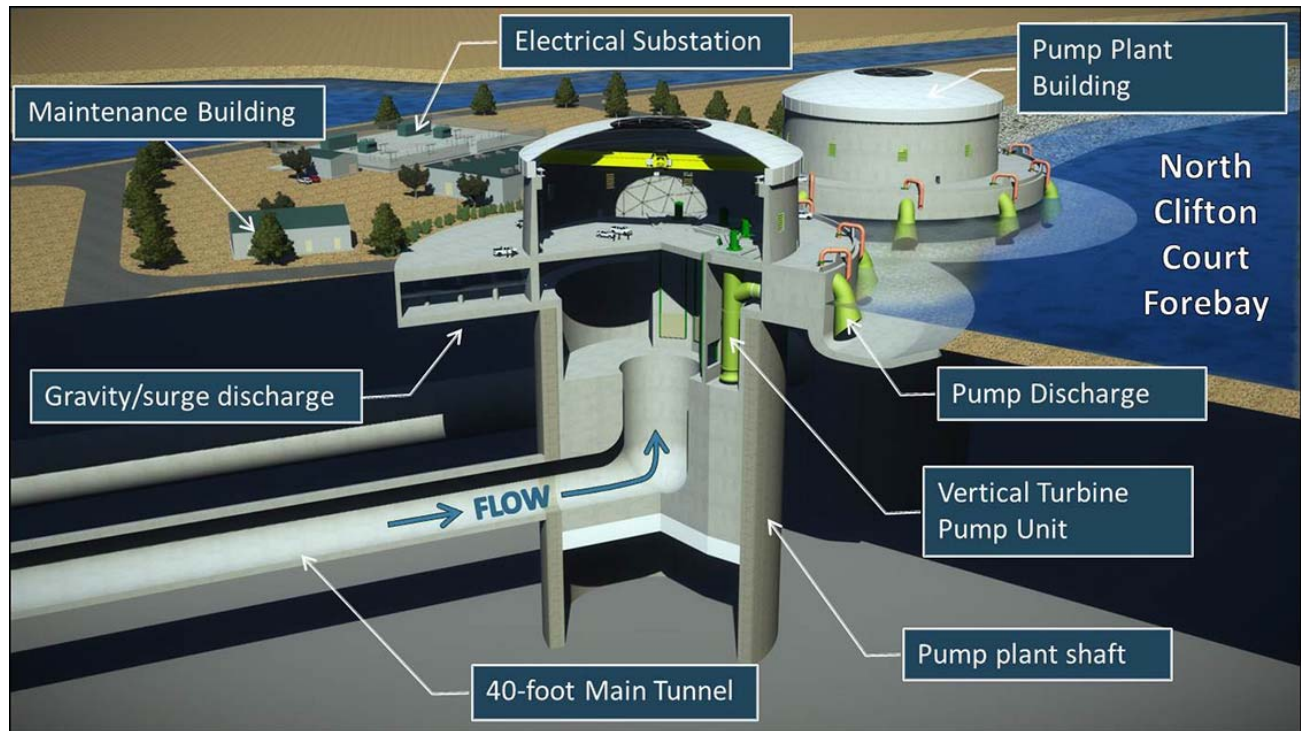


FIGURE 5: PROPOSED PUMPING FACILITIES AT CLIFTON COURT FOREBAY

APPROACH TO DESIGN AND CONSTRUCTION

The proposed configuration of California WaterFix is the result of an extensive planning process that evaluated various alignments, facility configurations and environmental considerations. The results of this conceptual planning/engineering effort are documented in a series of Conceptual Engineering Reports, with the final draft report being released in 2015, and in the EIR/EIS, which was released in 2016. As part of the environmental documentation process, all alternatives received extensive environmental analysis consistent with CEQA, NEPA, and the Delta Reform Act, which included consideration of comments received during initial scoping, and the public review periods of the draft EIR/EIS (2013), partially recirculated draft EIR/supplemental draft EIS (2015) and the proposed Final EIR/Final EIS (2016).

As mentioned earlier, having dual 40-foot main tunnels ensures system reliability by providing redundancy, and the construction approach would use technologies and methodologies that are well understood within the construction industry. Tunnels of this size have been successfully constructed, or are in the planning/design phase, in many locations throughout the world (see Figure 6). As shown in this figure, the planned California WaterFix tunneling machines are at the lower end of the range for large tunnel projects that have been implemented.

During the planning process, an alternative to a twin tunnel configuration for California WaterFix, a single bore main tunnel sized to convey up to 9,000 cfs, was also investigated. Preliminary analysis indicated that a single-bore tunnel would require a tunnel with an inside diameter of about 56 feet. This tunnel size would require a TBM size of 60 feet or more in diameter (assuming use of a 24-inch thick concrete segmental liner). Currently, the two largest TBMs in the world are the Tuen Mun-Chep Lap Kok Hong Kong TBM at 57.7 feet in diameter and the Alaska

Way TBM in Seattle, Washington at 57.3 feet in diameter. At the time, the TBM used in the Seattle project was the largest TBM ever built, and the issues and multi-year delays experienced on this project are well documented. A potential California WaterFix single bore TBM at about 60 feet in diameter would represent a machine that is four percent larger than current technology experience, and a tunnel that large would set an engineering design and construction precedent, increasing the overall project risk.

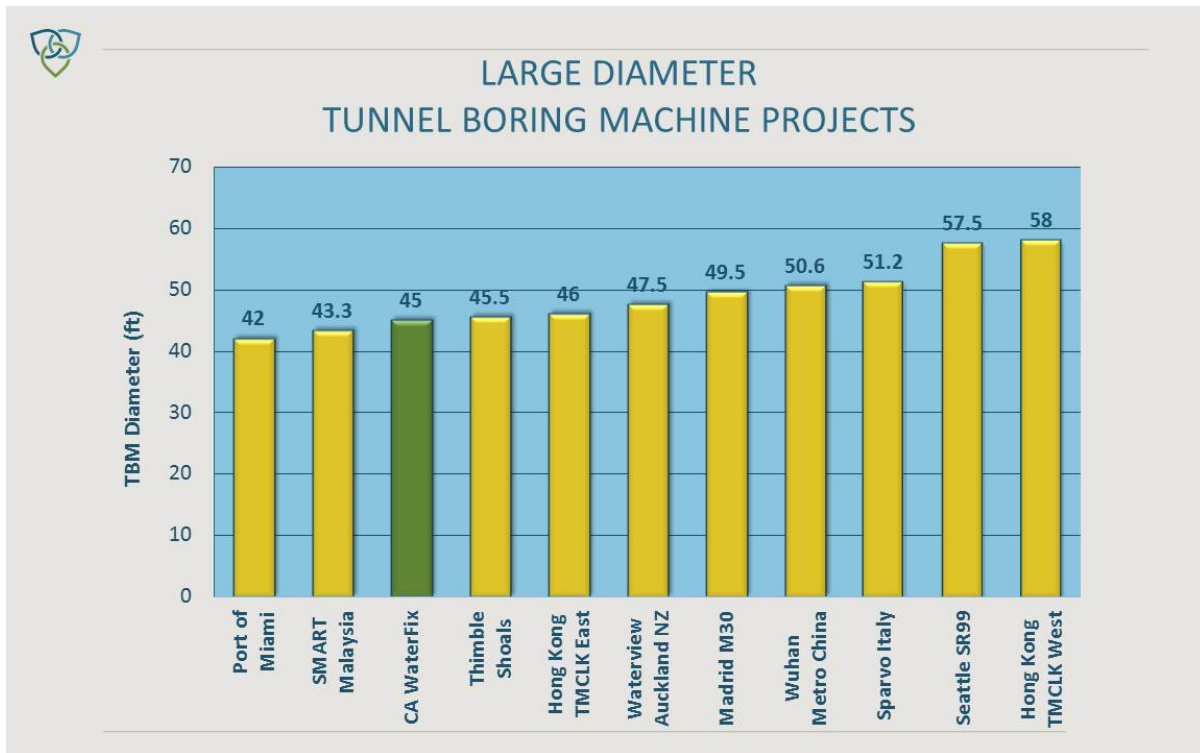


FIGURE 6: LARGE DIAMETER TUNNEL BORING MACHINE (TBM) PROJECTS

ENVIRONMENTAL CONSIDERATIONS

California WaterFix facilities have been planned and configured in response to comments and input received during the environmental planning process to reduce the impacts of construction and operation of the facilities on the existing Delta environment. Specific steps taken during the design effort to limit or eliminate the impact of the new facilities on the environment include:

- A. **Reducing the Size of Overall Project:** As originally configured in the BDCP, water conveyance facilities consisted of five (5) screened intakes along the Sacramento River, each sized at 3,000 cfs, for a total system capacity of 15,000 cfs. The overall capacity was eventually reduced to 9,000 cfs, requiring only three of the original five intake locations.
- B. **Using Tunnels instead of Open Canals:** The original alignment consisted of a series of large canals to convey water from the three intakes to Clifton Court. The main canal footprint was estimated to be approximately 1,400 feet wide (including the embankments, spoil stockpiling, and access roads). This project configuration would have caused significant impacts to surface features in the Delta. The surface impacts alone of this alternative totaled more than 19,000 acres. The surface canal approach would have split or eliminated many private property holdings, disrupted irrigation patterns, caused migration barriers for terrestrial species, been subject to potential deformation during seismic events and generated substantial quantities of air pollutants associated with earthmoving during construction. The proposed all-tunnel configuration reduces surface impacts by approximately 90 percent with the use of tunnels, a majority of the tunnel construction equipment is electric operated, subsurface tunnel easements will reduce disruptions to surface features and terrestrial migration patterns remain undisturbed.

- C. **Expanding the Use of Tunnels Instead of Pipelines:** Early non-canal conveyance alignments relied on a combination of open-cut high-head pipelines and tunnels to convey water from the intakes to the intermediate forebay. Construction of the open-cut pipelines would have been very disruptive to local communities because of the size of the pipelines required. Under those conditions, excavations suitable for installation of double-barreled 16-foot high-head pipelines would be required in some locations, and would potentially run for several miles. In addition, it was anticipated that surface deposits of peat and high groundwater tables could be encountered during construction. Engineering refinements during the environmental process identified the use of tunnels as a preferred way to connect the river intakes to the intermediate forebay. Relatively short tunnels significantly reduce disruptions to the local communities and provide a way to efficiently address groundwater table conditions.
- D. **Revising Tunnel Alignments and Tunnel Contracting:** As originally configured, the project's main 40-foot diameter tunnels crossed under numerous rivers, sloughs and other waterways. At each of these locations, additional construction activities would have been necessary to protect the levees that line each of the waterways while the tunnel boring machines (TBMs) were being operated, potentially leading to unnecessary project risks. Additionally, the original main tunnel alignment crossed under a number of sensitive surface features, travelled under many private property holdings and would have required nearly double the number of construction contracts when compared to the current revised plans. Mitigation measures employed during the planning and conceptual engineering process attempted to minimize as many of these issues as possible. The current alignment 1) reduces tunneling under most sensitive surface features and private property, instead tunneling under publically held lands and avoiding crossing Army Corps levees wherever feasible; 2) minimizes the number of water-feature crossings; and 3) reduces the number of tunnel contracts to avoid unnecessary surface disruptions.
- E. **Revising the Size and Location of Intermediate Forebay:** The original forebay configuration consisted of about 750 acres of water surface area, along with the area required for the forebay embankments. Following input from local communities and reclamation districts, the size and location of this facility were revised. Current plans call for an intermediate forebay site of about 100 acres, which includes the forebay surface area, embankments and appurtenant facilities required for construction and operation.
- F. **Reducing Pumping Requirements for the Overall System:** The original configuration of California WaterFix facilities relied on pumping plants at each of the three river intakes to lift water out of the Sacramento River and into the tunnel system for conveyance to Clifton Court in the south Delta. This configuration did not allow the system to be gravity fed, even under extremely high water levels in the Sacramento River. Based on input received during the planning process, and the need to address certain technical tunnel design issues, the configuration was changed so the three individual pump stations at the Sacramento River were consolidated and moved to a single pumping plant located at Clifton Court Forebay. As currently configured, under some hydraulic conditions in the Sacramento River, and under certain delivery scenarios, California WaterFix would operate as a fully gravity-fed delivery system that can divert up to 4,500 cfs to Clifton Court. The remainder of the time, the pumps at Clifton Court Forebay would be operated. This approach would reduce the overall conveyance system's energy consumption when compared to the original concept.
- G. **Reducing Construction Impacts along Sacramento River:** Replacing the three river intake pumping plants with a consolidated pump plant at Clifton Court and revising the construction methods for the intake sedimentation basins would reduce temporary and permanent impacts to the communities that surround the intake locations. Eliminating the pump plants at the Sacramento River would also significantly reduce overall construction impacts at all three river intakes and avoids the permanent aesthetic impacts of the pump plants at each location, including the need for permanent overhead high voltage power lines and traffic impacts associated with DWR's operation of the pump plants. In addition, the design of the sedimentation basins, originally configured as pile-supported concrete basins, was revised to the current earthen configuration. This change would significantly reduce construction impacts at each intake site by eliminating the need to drive thousands of foundation support piles and the construction work associated with placing thousands of cubic yards of concrete in the basins.

- H. **Optimizing Location of Key Construction Sites:** While located relatively close to major urban communities such as Sacramento and Stockton, the Delta is considered a uniquely remote environment from a construction standpoint because of its limited highway access. Two state highways cross the Delta in an east-west direction, but north-south transportation routes through the Delta are generally limited to water routes. The original configuration placed several of the key construction sites in areas that were logistically difficult to access for major construction purposes. To access these sites, new roads, along with the use of existing levee roads, or water access points, would have to be established, potentially impacting local residents and agricultural interests. Based on comments received during the planning process, some construction sites were relocated closer to major transportation routes, reducing potential disruptions to local communities and traffic patterns.

Incorporating these revisions and commitments into the overall project planning process has led to the development of modernized conveyance facilities that are sensitive to the environment, landowners and public use of the Delta, while retaining the operational features required to reliably and efficiently deliver water to the state and federal water projects.

Cost Estimate and Schedule

ESTIMATE

The current cost estimate for California WaterFix is summarized below in Figure 7. All costs have been adjusted by the state to July 2014 dollars. The cost estimate will be updated periodically as additional information becomes available, particularly with respect to environmental mitigation.

| ITEM | AMOUNT (\$BILLIONS) |
|---|------------------------|
| Overall Cost | \$ 15.74 |
| Conveyance System Cost | \$ 14.94 |
| Program management, construction management, and engineering | \$ 1.91 |
| Tunnels/Shafts construction | \$ 6.82 |
| Remaining construction | \$ 2.68 |
| Contingency (~36% for Tunnel/Shafts and Remaining Construction) | \$ 3.38 |
| Land Acquisition (includes 20% contingency) | \$ 0.15 |
| Environmental Mitigation (includes 35% contingency) | \$ 0.80 |

Program Estimate in 2014 Dollars

FIGURE 7: CALIFORNIA WATERFIX PROGRAM ESTIMATE

The resources used to develop the construction cost estimate include the items listed below:

1. Conceptual Engineering Report (CER), Modified Pipeline/Tunnel Option – Clifton Court Forebay Pumping Plant, Volume 2- Conceptual Engineering Report Drawings, Final Draft: April 1, 2015.
2. Wage and Workman's Compensation rates used by the consultant (SRMK) are Prevailing Rates as listed by the California Department of Industrial Relations, General Decision Number: CA140029 08/08/2014 CA29.
3. Equipment Ownership and Operating Cost. SRMK used US Army Corps of Engineers rates EP-1110-1-8, Vol. 07 published April, 2014.

ESTIMATE METHODOLOGY

The methodology used to prepare the overall California WaterFix estimate was as follows:

- A. **Program Management, Construction Management and Engineering:** The \$1.91 billion cost is based on the anticipated program organization, the program schedule and the Conceptual Engineering Report (CER). For each organizational team, the number of full time equivalents needed to perform the functions of the team and the expected duration consistent with the program schedule was established. The program schedule accounts for staffing the organization in a sequential manner to allow for initiation, planning and execution of the needed functions. Costs for various levels of managers and staff were applied to the program schedule.
- B. **Tunnels/Shafts and Remaining Construction:** The construction cost estimate for the tunnels and shafts and remaining construction was prepared by a consultant, 5RMK. The construction cost estimate is a detailed Class 3 bottoms-up cost estimate as defined by the Association for the Advancement of Cost Engineering International (AACEI). A Class 3 estimate requires a design definition between 10 to 30 percent complete; the design definition for California WaterFix currently is between 5 to 10 percent complete. The common design definition between the Class 3 requirement and the current design definition for California WaterFix was 10 percent, and 5RMK was instructed to use this value to provide a more detailed Class 3 estimate.

Cost estimators used the same basic approach that a construction contractor would use if bidding the project. Based on information in the CER and past knowledge and experience, the cost estimators developed a work breakdown structure for all project features (such as intakes, tunnels, forebays, pump plants and utilities, etc.). Each feature was further broken down to components and systems to develop detailed quantities of material, labor and equipment to construct the facilities. Cost estimators established crews and equipment, production rates and assumed work schedules. Once these were established, the cost estimators applied prevailing wage rates, material and equipment costs based on vendor and subcontractor quotations.

The cost estimate for the tunnels/shafts and remaining construction also includes the following:

- Engineering, quality control and environmental staff time required to manage subcontracts;
- Construction contractor's management, supervision and staff along with all support staff and expendables (office supplies, communications, utilities);
- General automotive expenses for management and staff; and
- General plant expenses including offices, warehouse, site roads and other administrative costs.

Overhead, profit and General and Administrative (G&A) expenses were calculated as 12 percent of the construction cost.

- C. **Contingency:** Contingency as a percent of construction was established at 35.6 percent, which is consistent with an AACEI design definition of 7.5 percent, and is consistent with the level of design completed for California WaterFix to date.
- D. **Land Acquisition:** The land acquisition cost of \$150 million was developed based on the number of acres for the surface footprint, staging, borrow and subsurface easements required for California WaterFix, multiplied by current market rate per acre. The costs include mineral rights, gas well relocation, due diligence and transaction costs. A 20 percent contingency for unknown expenses related to land acquisition is also included.
- E. **Mitigation Cost:** The project is carrying a mitigation cost estimate of \$800 million. This includes estimated costs for environmental commitments such as natural community protection, channel margin enhancement, tidal and riparian natural communities, grassland and non-tidal marsh restoration, natural communities management, localized reduction of predatory fish, protections for cultural and biological resources and air quality enhancements. The cost also includes program administration, monitoring of

terrestrial and aquatic species, and property tax revenue replacement. In addition, a 35 percent contingency was added to account for unknown expenses/scope related to this project component.

PROJECT SCHEDULE

The current high-level program summary schedule is presented in Figure 8. The schedule is primarily based on the information in the 2015 Conceptual Engineering Report as well as other available data for similar large-scale construction projects. The schedule includes estimates of 12 to 15 months to fully staff the DCA, up to four years to complete the design phase and about 13 years to complete construction. Once the DCA is established and the design is advanced, the design and construction teams would look for opportunities to reduce the overall schedule.

Upon project authorization, detailed schedules would be prepared for various project activities, based on the detailed Work Breakdown Structure (WBS) and applicable project documents. These detailed schedules would identify major milestones, time-sensitive areas and critical path activities. Any issues that have a real or potential impact on the schedule would be highlighted and would include the source of the issue and any mitigation measures taken to minimize or eliminate the impact. Schedule reports would be issued on a regular basis (at least monthly), as determined during program start-up.

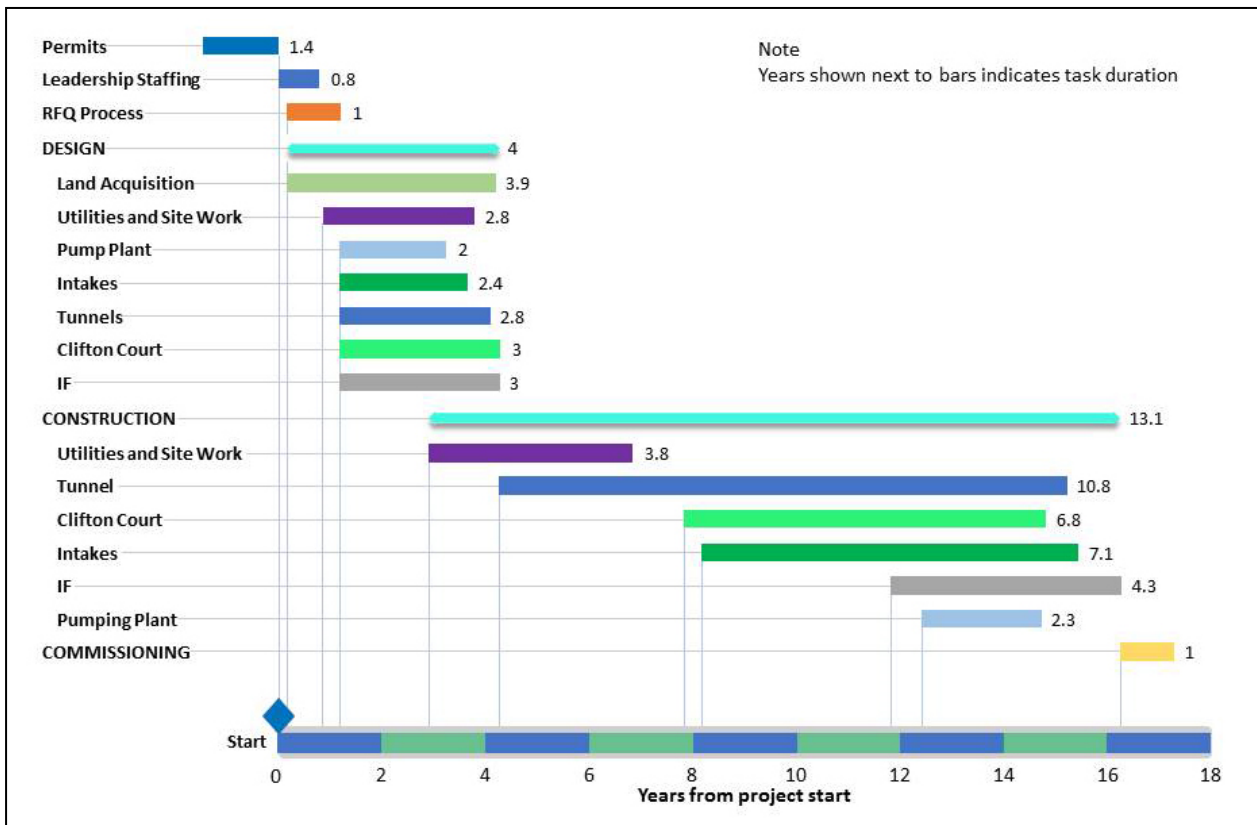


FIGURE 8: CALIFORNIA WATERFIX PROGRAM SUMMARY SCHEDULE

Key Risk Areas

Two key risk areas related to design and construction have been identified during the planning process for California WaterFix: the program’s management structure –specifically, the ability of the program’s management team to control cost and schedule– and the overall constructability and operation of the infrastructure. Table 2 summarizes the risk areas and provides a structure that includes tools to mitigate the risk associated with each area:

TABLE 2: KEY RISK AREAS AND MITIGATION TOOLS

| Key Risk | Tools to Mitigate the Key Risk |
|--|--|
| Management for Cost and Schedule Containment | <ol style="list-style-type: none"> 1. Forming the DCA as a new and separate purpose-driven organization with responsibility to implement the design and construction of California WaterFix. 2. Establishing key functions within the DCA structure that focus on critical areas, including: <ul style="list-style-type: none"> • <u>Risk Management</u>: Would ensure that all program risks are identified, tracked and mitigated throughout all phases of the program; • <u>QA/QC</u>: Would ensure that all design and construction work is conducted in strict accordance with program quality objectives; • <u>Internal Audit</u>: Would implement a continuous audit program to ensure that all program participants adhere to program policies, practices and protocols; • <u>Program Controls</u>: Would provide real-time budget, cost and schedule reports to the program teams and to the auditor on an as-needed basis; and • <u>Cost Estimations</u>: Would provide new cost estimates on an as-needed basis and review cost information prepared by project designers and change order requests from contractors. |
| Infrastructure Constructability and Operations | <ol style="list-style-type: none"> 1. Simplifying the configuration of the overall program infrastructure to utilize standard design and construction methodologies; 2. Utilizing gravity-fed operations when possible to simplify long-term system operation and reduce overall operational costs; 3. Where possible, locating key project features on publicly-owned properties to enhance access during construction and operation; 4. Establishing key construction work sites near existing, well-established transportation routes; 5. Utilizing tunnel boring machines consistent with current construction industry standard practices to reduce overall construction risks; 6. Stockpiling material excavated from tunnel construction in such a manner that the material would be potentially available for future Delta restoration projects; 7. Reducing the number of program facilities to be constructed near existing population centers or in environmentally sensitive areas such as wetlands; 8. Reducing the size of facilities and/or eliminating some facilities to reduce overall system complexity and cost; 9. Consolidating three pumping facilities into a single combined facility at Clifton Court to simplify construction and operational activities; and 10. Implementing a well-planned and thorough geotechnical investigation program as part of the preliminary and final design process for facilities. |

Delta Conveyance Design and Construction Joint Powers Authority

The design and construction of California WaterFix would be managed under contract with DWR through a proposed Delta Conveyance Design and Construction Joint Powers Authority designated the Design and Construction Authority, or "DCA." This approach was successfully used in the mid-1990s when DWR contracted with the Central Coast Water Authority to design and construct a portion of the Coastal Branch of the California Aqueduct. The Central Coast Water Authority was established as a public entity organized under a joint exercise of powers agreement and constructed water treatment and conveyance facilities to bring State Water Project supplies to Santa Barbara and San Luis Obispo counties.

In coordination with DWR, the DCA would design, construct and deliver completed California WaterFix facilities to DWR upon completion of system commissioning. The DCA would be a public agency, organized as a special purpose public agency pursuant to the Joint Exercise of Powers Act, consisting of certain public water agency members. A detailed agreement between DWR and the DCA would govern the roles and responsibilities of the parties to carry out the design and construction of California WaterFix. The overall goal of the DCA would be to safely design, construct and deliver the project on time, on budget and in accordance with approved specifications, while managing risk prudently.

Recognizing DWR staff resources are stretched to an extreme level due to the necessary commitment to complete significant repairs to the Oroville Reservoir spillways as a result of damage during heavy runoff in 2017, there is a need to employ different but proven approaches to pool resources for the design and construction of California WaterFix. Staff resources are needed for a period of about 13 to 17 years and would ultimately be reduced at the end of construction. Pooling experienced expertise in a manner that avoids the need to hire significant additional new staff at DWR is prudent. In any major infrastructure process, there is a period of acquiring needed additional staff, and then once the project approaches completion, there is a period of downsizing. Utilizing the DCA to pool experienced resources to manage activities and contractors is preferable and can avoid the expansion and contraction of staff at DWR. The DCA would sunset as California WaterFix is completed.

ORGANIZATIONAL STRUCTURE

The anticipated organizational structure is shown in Figure 9 and the responsibilities of the offices within the structure are described below.

Note: The assumed organizational structure is based on a 2016 Draft Agreement Regarding Construction of Conveyance Project between the Department of Water Resources and the Conveyance Project Coordination Agency, which will no longer be executed. Nonetheless, it is expected that much of the organizational structure and functions described in that agreement would be adopted by the DCA.

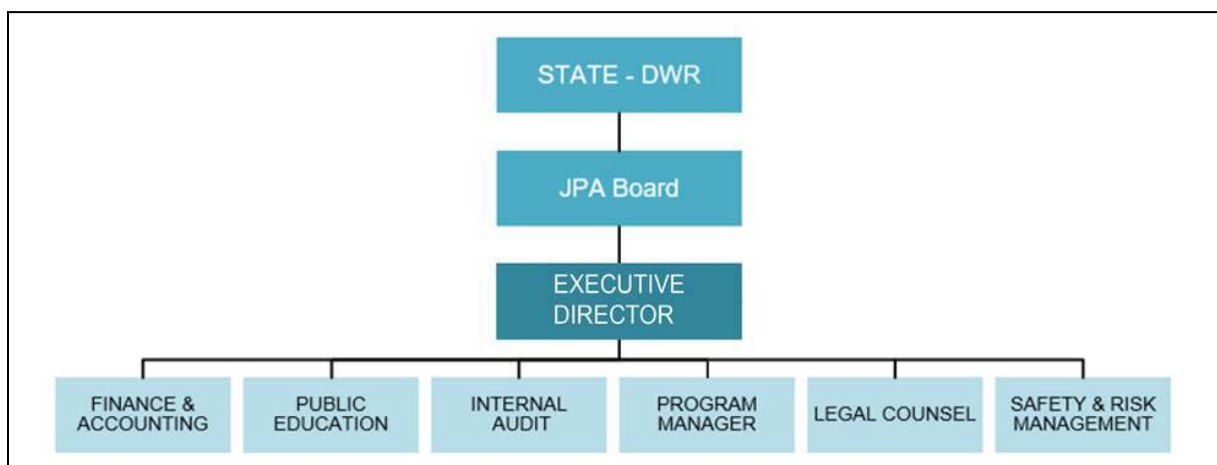


FIGURE 9: ORGANIZATION CHART

Executive Director

The Executive Director would be the single point of accountability to the Board of Directors for delivery of the program design and construction. The Executive Director would set the overall direction of the program, coordinate all program execution with the Program Manager and Chief Engineer and ensure activities are on schedule, within budget and adhere to specifications. In addition, the Executive Director would lead external interactions and administrative support functions of the program organization and interaction with the DCA directors and DWR.

Program Manager

The Program Manager would be responsible for all functions directly related to delivery of the facility. The Program Manager would:

- Provide program leadership, management and direction to ensure the design is completed according to the preferred project identified in the final EIR/EIS and consistent with mitigation requirements and plans;
- Establish and approve detailed program scope, schedule and budget activities;
- Be responsible for implementing team plans, staffing levels and setting team responsibilities;
- Ensure coordination and cooperation between teams; and
- Represent the program in interactions with the Board, DWR and external stakeholders as needed.

Finance and Accounting

The Finance and Accounting group would manage cash flow requirement forecasts, monitor program funding and handle payments.

Public Education

A dedicated Public Education group would initiate, coordinate, monitor and report on local public outreach and support DWR's Public Affairs Office on program related matters.

Internal Audit

The Internal Audit group would assure conformance with approved processes and procedures. It would also review the various team actions/documents, develop monitoring and audit reports, review corrective action plans and verify corrections.

Legal Counsel

The Legal Counsel would provide the program with legal direction and ensure compliance with applicable laws and regulations. They would also review each Request for Qualifications (RFQ), entity agreements, contracts, task orders and scope of services to assess compliance.

Safety and Risk Management

The Safety and Risk Management team would minimize program risks to control costs and schedule. In addition, the team would identify the program insurance requirements and enforce safety program requirements.

Workgroups

In addition to the above organizations, it is anticipated under the DCA structure that multiple workgroups would be formed from time-to-time to address specific aspects of the project. Workgroups would include a Technical Review Workgroup for purposes of reviewing and resolving technical design issues at the staff level. The workgroups would be focused in nature and may be formed and dissolved depending upon the subject matter and project status.

PROJECT GOVERNANCE

The DCA would be responsible for delivering the project in accordance with baseline specifications for the project, including design specification, budget, schedule and mitigation obligations. As design work progresses, changes to the baseline specifications would be requested by the DCA at its discretion for approval by DWR. In addition, certain “material changes” on the project would require DWR approval. These include:

- A. **Cost:** Any actions that cumulatively could cause more than a 5% increase in budgeted costs for each major design feature or management item;
- B. **Schedule:** Any actions that could cumulatively add 6 months to the approved project schedule;
- C. **Operation:** Any actions that could impact the water delivery capability, reduce project life, or significantly increase operations and maintenance costs of the project; and
- D. **Permits:** Any actions that could be inconsistent with, or would require an amendment of, a major permit for the project.

Coordination with DWR and Reporting

DWR’s Delta Conveyance Office would be responsible for managing the agreement with the DCA on behalf of DWR and be the DCA’s primary point of contact within DWR for all matters relating to project design and construction.

The DCA would provide detailed written reports at least monthly to DWR and the state and federal contractors regarding progress made toward completing the project, including 1) actual and forecasted expenditures, 2) the DCA’s review of expenditures and forecasts against the approved budget and 3) progress relative to the approved schedule. The DCA would prepare an annual report describing the DCA’s activities during the immediately preceding calendar year as well as project status. A draft of the annual report would be provided to DWR for review and comment.

Dispute Resolution

A Technical Review Workgroup would be used to resolve technical and design-related disputes within the DCA and between the DCA and DWR and material changes to baseline specifications. All other disputes would be resolved at the staff level if possible. If the dispute cannot be resolved through the Technical Review Workgroup or at the staff level, a defined meet-and-confer process would be used to consider options and determine whether agreement can be reached on the matter, with ultimate escalation to the Director of DWR and Executive Director for resolution.

At any time, DWR or the DCA may initiate a non-binding review process concerning the dispute. In this process, DWR and the DCA would form a three member panel of experts, with one panel member selected by DWR, one by the DCA and a third by mutual agreement of the first two panel members. If a dispute between DWR and the DCA cannot be resolved, the Director of DWR would make the final decision after considering the recommendations of the non-binding review panel, as well as any other relevant information concerning the issue.

Risk Management and Mitigation

RISK MANAGEMENT PROCESS

The goal of the risk management process for California WaterFix would be to identify problem areas early. Each identified risk would be evaluated for its potential impact to cost, schedule, quality and safety. Risks that have the potential to have a significant impact on any of these items would be highlighted. The Risk and Safety Management Team, in coordination with program staff, would develop a methodology to identify and quantify

specific risks to the project, determine their consequences and associated probability and develop mitigation strategies. The overall risk management process is summarized in Figure 10.



FIGURE 10: RISK MANAGEMENT PROCESS

The Safety and Risk Management Team would be responsible for initially identifying project risks, with input as necessary from other groups and teams. The focus would be on risks that could impact project scope, schedule or budget, with each identified risk being added to a Project Risk Register for further discussion and evaluation. The Risk Register would be the basis for developing a “Risk Dashboard,” which would provide a simplified list of high-priority risks, a summary of the associated action plan and a summary of any known impacts. If a risk moves from “potential” to “actual,” the risk would become part of the Project Change Authorization process and incorporated into the project estimate.

DESIGN, CONSTRUCTION AND OPERATION

A number of critical issues related to the design, construction and operation of California WaterFix were investigated and addressed through the course of the planning and conceptual engineering efforts. These issues included the following:

1. The ability to successfully design and construct large tunnels;
2. The suitability of facilities to withstand anticipated seismic events that may occur in the Delta;
3. The risk of flooding and future sea level rise in the Delta;
4. The potential for various tunnel-related issues, including leakage, surface settlement and tunnel induced vibrations; and
5. The risks associated with levels of understanding regarding Delta geology.

Each issue and potential mitigation measures are described below.

Large Tunnels: As part of planning and conceptual engineering for California WaterFix, the engineering team performed a survey of large-diameter tunnel projects to determine if other large tunnel projects used TBMs similar in size to the 45-foot diameter machines that would be used as part of California WaterFix. The survey confirmed that numerous large-diameter (greater than 40 feet) soft-ground TBM projects have been successfully performed throughout the world and that several more large-diameter tunnel projects are planned in the near future. The survey results confirmed that the proposed California WaterFix TBMs are well within the existing industry knowledge and experience.

A separate survey was undertaken to gain a better understanding of recent challenges on large tunnel projects and to identify best management practices to ensure project success. This survey attempted to identify tunnel projects that were similar to California WaterFix tunnels in key areas such as design, construction and project management in order to anticipate and manage similar issues that could occur. A total of nine projects were surveyed, including projects in the United States, Asia and Europe. Each of these projects is well documented by media and industry coverage, and each has been recently completed or is considered substantially complete from a tunneling perspective. The survey results provided valuable lessons-learned that would be evaluated as part of the design process for California WaterFix, including the following:

- Extensive and high quality geotechnical information is the key for success on any tunnel project; and
- A proactive risk identification and management program is critical to success of large- or mega-projects.

Tunnel Leakage: The segmented lining system to be used for California WaterFix tunnels would be designed to withstand the maximum internal pressure calculated for the conveyance system, which is anticipated to be present in the northern-most reaches of the tunnel system, as well as all applicable static and ground loads. The individual segments would be fitted with embedded gaskets that would be compressed against one another as the tunnel rings are constructed. The installation of the tunnel segments, along with the compression of the gaskets during the tunnel ring building process, would be designed and constructed to minimize inflows or outflows from the tunnel under a wide range of operational and maintenance conditions.

An assessment completed in February 2017 of the potential leakage rates from the tunnels concluded that there would be negligible leakage from the tunnels or inflow to the tunnels. In fact, when taken as a complete system, it is estimated that there would be a net inflow of 3 cfs to the tunnel over the roughly 73.5 miles of project tunnels, or an inflow rate of 18 gallons per minute per mile of tunnel. Inflow to the tunnels and leakage from the tunnels calculated based on anticipated conditions for filling, dewatering and operation are anticipated to be minimal and well within typical ranges for tunnels of the size and length proposed for California WaterFix.

Tunnel-Induced Ground Vibration: California WaterFix tunnel alignments pass under or near sensitive surface structures such as historic buildings, levees, aqueducts and residential communities. In these locations, it is anticipated that the proposed tunnels would be constructed a minimum of 100 feet below ground. That depth would ensure that material over the tunnels would dampen and absorb any energy generated during tunneling and construction activities. Induced vibration to structures should be minimal and would not likely be perceptible to the communities on the surface and is not anticipated to have any impact on any of these structures.

Surface Settlement Along the Tunnel Alignment: California WaterFix would use the following to mitigate the risk of settlement effects and structural damage:

- Detailed geotechnical exploration;
- Pre-construction surveys for critical and settlement-sensitive facilities, utilities and surface features;
- Development and implementation of acceptable tunneling protocols and permissible settlement criteria;
- Real-time sophisticated TBM control and monitoring systems;
- Improved structure protection methodologies, including pre-excavation grouting; and
- Advanced ground settlement and vibration monitoring systems.

Seismic Considerations and Mitigation: Preliminary modeling of active and potentially active earthquake faults in the region was developed and evaluated as part of the Delta Risk Management Strategy (DRMS) study conducted in 2007. The results of this study are summarized below.

- Tunnel Alignment:** The proposed Delta tunnel alignment does not cross any major fault rupture or creep zones.
- Seismic Sources:** Potential seismic sources in the form of “blind” faults were identified. These blind faults have no surface features and limited information or data is available to characterize these fault zones.

- C. **Ground Motion Estimates:** Estimates of potential ground motion during a seismic event were developed as part of the conceptual engineering studies based on a 1,000 year event (85th percentile) and adjusted for buried tunnel lining systems.
- D. **Liquefaction:** Liquefaction was investigated, primarily as it would potentially affect surface facilities such as intakes, forebays, pumping stations and tunnel shafts. Studies indicate the deep tunnels would not be subject to liquefaction potential because they would be constructed below the elevation where liquefiable materials occur.
- E. **Lined and Grouted Tunnels:** Studies indicate that lined and grouted tunnels, such as those utilized in California WaterFix, perform better than unlined tunnels. Performance can be further enhanced by improving the contact between the liner and the ground (grouting of annular space between the liner and the surrounding soil).

Based on the results of the studies already conducted, seismic mitigation would be addressed as follows:

- For surface facilities and tunnel shafts, additional geotechnical investigations would be conducted on a site-specific basis to gain a more complete understanding of the expanse and depth of liquefiable material at each site. Based on the investigation results, appropriate design and construction methodologies would be used to eliminate or minimize the impacts of liquefaction on surface facilities.
- Additional field explorations and design solutions, including finite element modeling of the tunnels and shafts, would occur in the design phase of the project. These measures would address any seismically induced liquefaction or deformation potential at the specific locations where the tunnels connect to the shafts.
- The tunnel design concept includes the use of precast segmental lining systems. This system was selected because the same concept has been successfully used on an extensive basis in seismically active areas such as Japan, Puerto Rico, Taiwan, Turkey, Italy, Greece and the United States since the 1980s. Results of segmentally lined tunnel performance in seismic events show the tunnels would perform very well during and after such an event.

Geotechnical Considerations and Mitigations

The Delta is an arm of the San Francisco Bay estuary that extends into the Central Valley. The geology of the Delta has been shaped by the landward spread of tidal environments resulting from sea level rise after the last glacial period. Since the last glacial age, flood-borne deposits, supplied by the major river systems in the Delta, have overlaid the region with sediment deposits and biomass accumulations. Taken together, the region, prior to the advent of agricultural interests in the late-1800s, was largely a tidal wetland and alluvial floodplain consisting of consolidated silts, sands and clays overlain with peat and peat muds.

During the development of the planning documents for California WaterFix, approximately 240 boring and cone penetrometer tests were conducted at the intakes, forebays and along the various conveyance alignments. Most of the investigations were conducted at depths between 100 and 200 feet, well within the foundational depth of planned facilities, including the tunnels and pump plants. Based on these investigations, and the use of existing historical information on the Delta, a preliminary geologic understanding of the Delta in the vicinity of California WaterFix facilities was developed.

At tunnel depths ranging from 100 to 150 feet below the ground surface, dense layers of silts, sands and clays are anticipated. This material would be suitable for the planned tunneling activities. At the ground surface, widely varying depths of peat and other organic material are expected. Data indicates that depths of peat in the Delta along the alignment vary from non-existent to about 40 feet deep, with the deepest deposits located in the center of the Delta near Bouldin, Venice and Mandeville islands. Construction in peat conditions would require specialized design approaches because of the unstable nature of the material.

In some locations along the alignment, there are geotechnical data gaps of several miles, due to the inability to gain access to private property during the planning phase of the project for geotechnical investigations. To

mitigate these data gaps and other known uncertainties related to geology along the alignment, the project would rely on existing information, along with the implementation of a new two-phase geotechnical investigation program. Under this multi-phased investigation plan, up to 2,000 additional investigations would be conducted, consisting of borings, cone penetrometer and other physical data collection methods. The initial phase of the effort would focus on determining if variations exist in what otherwise appear to be relatively consistent subsurface conditions. Based on the findings from the first phase of work, additional investigations are planned to fine-tune information and gather sufficient information so that accurate estimates of subsurface construction methods and costs can be determined. Additionally, this information would be used to finalize methods to successfully address constructing in ground conditions that are overlain with peat and contain high groundwater levels.

Flood Protection Considerations

Flood protection for California WaterFix facilities would be consistent with DWR's *Proposed Interim Levee Design for Urban and Urbanizing Area State-Federal Project Levees* (DWR 2009). The conceptual engineering completed to date includes plans that the facilities would be engineered and designed to withstand water level rise resulting from both a 200 year storm event plus sea level rise of 18 inches in the Delta. This sea level rise estimate corresponds with 55 inches of sea level rise at the Golden Gate that has been used in the State's long term planning criteria over the next 100 years. Such protection would be provided by constructing the new facilities at elevations above those identified for flooding or sea level rise through a combination of raising and strengthening levees in all project construction locations, as well as other embankment and equipment pad layouts and elevations.

ENVIRONMENTAL MITIGATION

Upon project approval, DWR will adopt a Mitigation Monitoring and Reporting Program (MMRP) that includes Avoidance and Minimization Measures, Environmental Commitments and Mitigation Measures to avoid or substantially lessen construction and operational impacts of California WaterFix. Mitigation may also be required to fulfill conditions in the biological opinions, CESA incidental take permits and other project permits.

California WaterFix is designed to mitigate its own construction impacts and for operations to not jeopardize any species listed under the Federal Endangered Species Act. This project and its mitigation complement other important state efforts to address the coequal goal of a restored Delta, including California EcoRestore, the Smelt Resiliency Plan and the Salmon Resiliency Plan.

PROJECT CONFIDENCE

As a component of the risk assessment process, and to assist with creating the budget contingency, the California WaterFix project team evaluated the risks associated with the project budget to establish a baseline confidence level that the project would be completed within the estimated budget. This is a common practice with large construction projects, with the resulting confidence curves being used as one of the factors in determining overall project risk.

For California WaterFix, Aldea Services developed confidence curves for a variety of different cost scenarios, ranging from base cost, which does not consider mitigation costs or risk, to a total cost that includes the base cost, risk, mitigation and inflation. The resulting confidence curves, which were based in part on the risk assessment workshops and probabilistic analyses conducted by Aldea Service and the project team, are presented below in Figure 11. The results of these analyses indicate a 75 percent confidence level that the project would be completed within the budget estimate, based on information available at this stage of the project. A typical confidence level for projects of similar scope and size is 60 percent; however, because of the size and complexity of the program; a more conservative confidence interval of 75 percent was targeted.

At a 75 percent confidence level, the chart in Figure 12 shows how the base costs (blue) along with risk costs (red) and inflation costs (purple) are distributed over the estimated construction period on a year-by-year basis. The risk (red) costs are a direct calculation from the risk analysis and inflation is based on the average inflation rate

over 20 years prior to the analysis and applied to the scheduled construction period. The chart is consistent with the risk adjusted cost estimate and schedule included in the conceptual engineering report. As funding is available, additional information would be gathered, the program would be refined during design and the risk management process would be adjusted to the charted confidence curves.

Table 3 shows the comparison between the risk adjusted cost at a 75 percent confidence level in the second column and the 5RMK construction cost estimate in the third column. The table also includes the results of Class 3 bottoms-up construction estimate prepared by Jacobs Engineering as a check estimate. Jacobs Engineering prepared its estimate independent of the 5RMK estimate. The 5RMK and Jacobs Engineering estimates include a contingency of approximately 36 percent. Program Management (PM), Construction Management (CM), and Engineering (ENG) costs are held constant at \$1.91 billion and land acquisition costs at \$150 million. This table used three separate estimates to show the program can be completed within the proposed budget of \$14.94 billion.

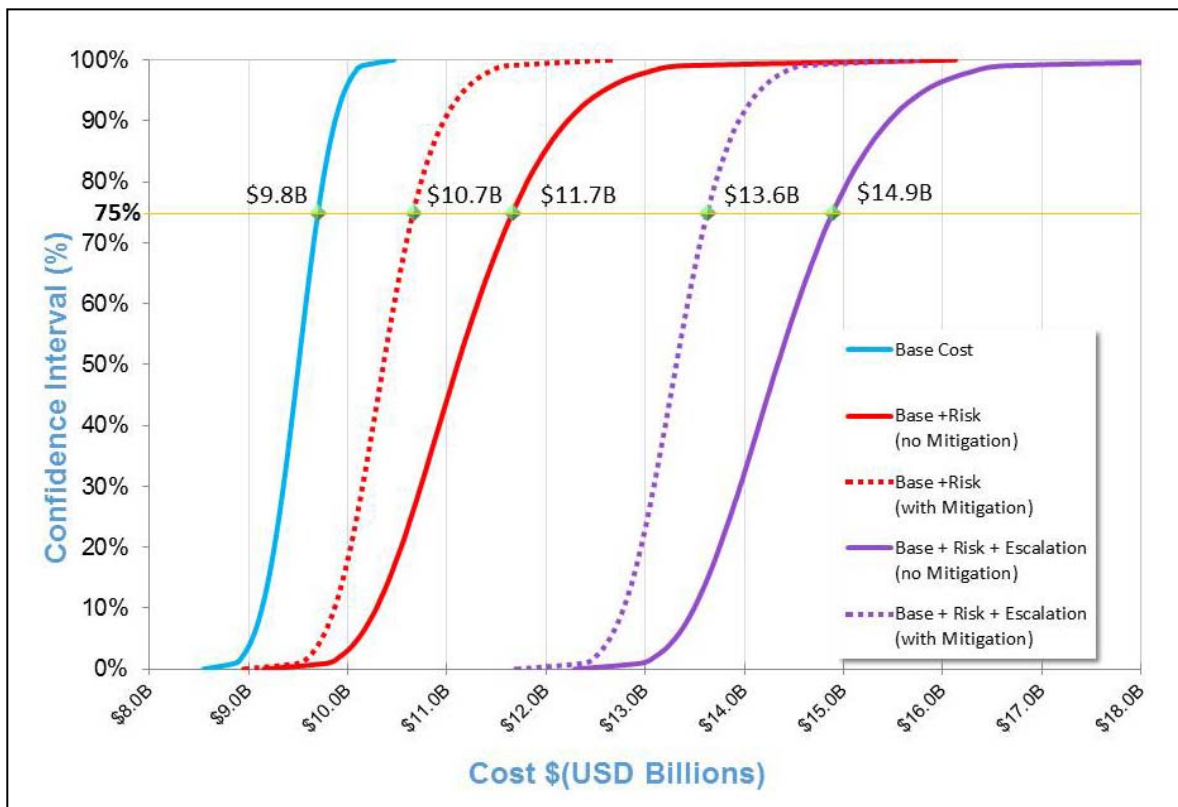


FIGURE 11: CONFIDENCE CURVES SHOWING 75% CONFIDENCE INTERVAL

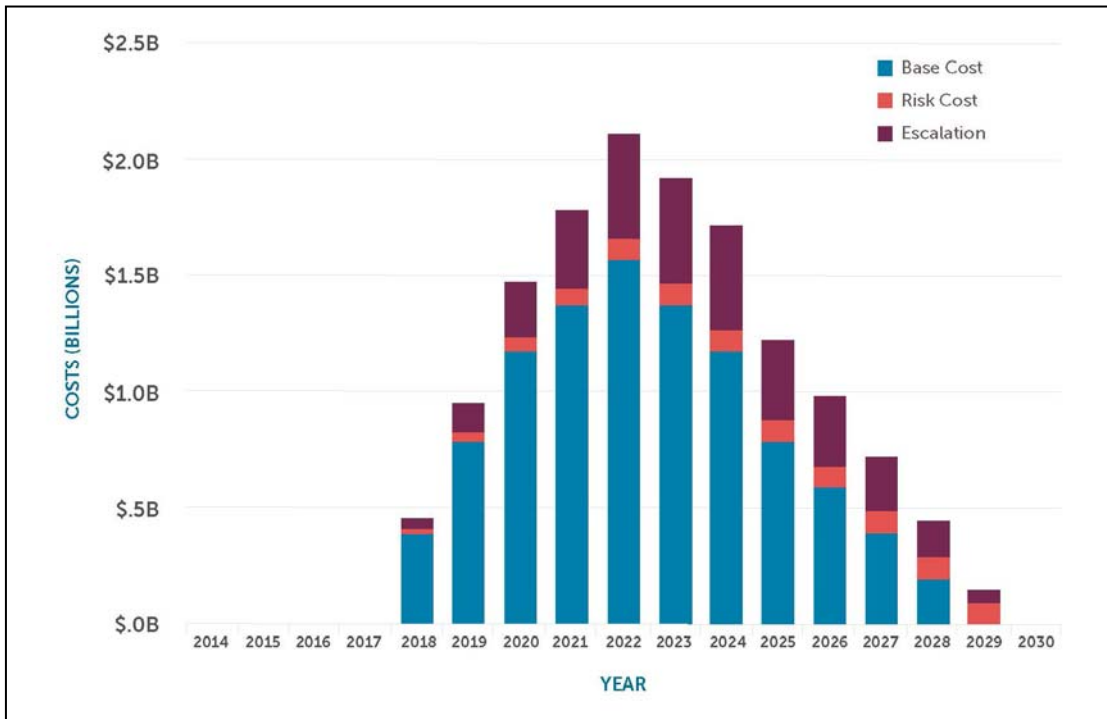


FIGURE 12: ANNUAL CONSTRUCTION EXPENDITURES FOR BASE, RISK AND ESCALATION

TABLE 3: COST COMPARISON, RISK ADJUSTED COST AT 75% CONFIDENCE LEVEL VS. INITIAL COST ESTIMATES

| Item | (1) 5RMK Estimate ^(*) , ^(**) (Billions) | (2) Jacobs Eng Estimate ^(*) , ^(**) (Billions) | (3) Risk Adjusted Estimate with Mitigation at 75% Confidence Interval ^(*) , ^(***) (Billions) |
|-----------------------|--|--|--|
| Construction | \$9.50 | \$8.86 | \$10.66 |
| Contingency | \$3.38 | \$3.15 | — |
| Construction Subtotal | \$12.88 | \$12.01 | \$10.66 |
| PM/CM/Eng | \$1.91 | \$1.91 | \$1.91 |
| Land acquisition | \$0.15 | \$0.15 | \$0.15 |
| Grand Total | \$14.94 | \$14.07 | \$12.72 |

^(*) Program estimates in 2014 dollars
^(**) ~36% Contingency on construction for 5RMK and Jacob Engineering estimates
^(***) Based on risks known at time of assessment

Conclusion

Note: This is first of three policy white papers related to California WaterFix. The second white paper will address the operational aspects of California WaterFix as well as potential water supply and risk mitigation measures related to operational requirements and regulations. The third white paper will focus on how California WaterFix can be financed through different funding mechanisms and the allocation of costs between state and federal contractors and between the State Water Project contractors.

The reliable and continued supply of high quality water through the Delta faces many risks, including fishery declines, earthquakes, floods and rising sea levels. Despite previous actions and efforts by local, state and federal entities to address these issues, as well as other challenges in the Delta, the region's ecosystem has continued to decline. California WaterFix addresses these long-standing issues by providing a pathway to reliable water supplies with infrastructure that is designed to withstand earthquakes and adapt to flood and rising sea levels, while protecting habitat, species and the Delta ecosystem.

The project has undergone an unprecedented level of public review, comment and scientific input. Extensive analyses and risk assessments have been conducted to better understand and mitigate risks commonly associated with infrastructure projects of this size. For California WaterFix, the key risk areas have been identified, and tools to mitigate these risks have been incorporated into the project's risk management process.

In addition to meeting the needs of the state, California WaterFix as presented meets all of the Delta Conveyance Criteria adopted by Metropolitan's Board in 2007.

Metropolitan's 2015 Integrated Resources Plan Update, as adopted by Metropolitan's Board in 2016, includes a goal to stabilize SWP supplies, to pursue a successful outcome in California WaterFix and to establish efforts for long-term average supplies of about 1.2 million acre-feet. The proposed project is expected to achieve this goal.

The physical project meets the attributes of a potentially successful project based on staff analysis and comparison to the Board's Delta Conveyance Criteria. The proposed program management has evolved in a way to increase staff confidence in the ability to minimize and manage risks.