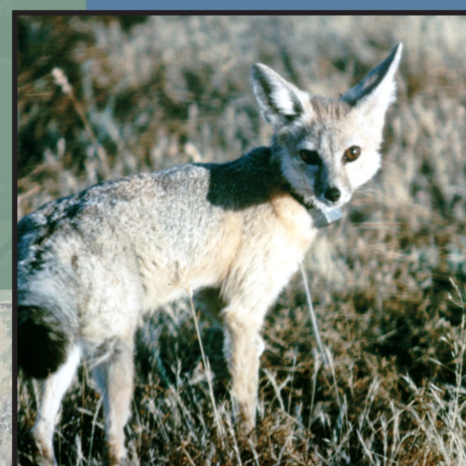
Contra Costa Water District
Proposition 1E Grant Proposal
Round 2
Attachment 7

Technical Justification of Project Physical Benefits



East Contra Costa County Region
Contra Costa Water District
Round 2 Stormwater Flood Management Grant Proposal

ATTACHMENT 7 –
TECHNICAL JUSTIFICATION OF PROJECT

This attachment describes the technical justification of the Contra Costa Canal Levee Elimination and Flood Protection Project. In accordance with the PSP, the following details are provided for the proposed project:

- ✓ Technical justification for the proposed project's claimed physical benefits, including studies or documents used to support the projects
- ✓ A summary table of the types of physical benefits being claimed
- ✓ A narrative description of all of the project's expected physical benefits, which shall address the following items:
    - o Recent and historical conditions that provide background for benefits to be claimed
    - o Estimates of without-project conditions
    - o A description of the project and its relationship to other projects in the Proposal
    - o Description of methods used to estimate physical benefits.
    - o Acknowledgment of all new facilities, policies, and actions required to obtain the physical benefits.
    - o Uncertainty of the benefits, and factors that lead to uncertainty.
    - o Description of any potential adverse physical effects.
    - o If applicable, quantified estimates of physical benefits, listed using Table 7

The following sections present a quantitative and qualitative analysis of project costs and flood damage reduction benefits. Table 7 is included at the end of this section.

Project Description and Summary of Benefits

The full, five-phased Contra Costa Canal Levee Elimination and Flood Protection Project (Project) will replace 21,000 feet of the unlined Contra Costa Canal (the Canal) with a pipeline and install a Canal flood isolation structure that will allow CCWD to remotely isolate the Canal following a major flood or earthquake. Completion of the Project will reduce regional flood risk, improve water supply reliability, and improve delivered water quality for CCWD's 500,000 customers. Secondary benefits include increasing water supply and water supply reliability for the State Water Project (SWP) and Central Valley Project (CVP) and improving public safety by limiting access to the open Canal. Segment 1 of the Project, encasement of the Canal from Pump Plant #1 to Marsh Creek, was completed in 2009.

Construction of the flood isolation structure and Segment 2 pipeline is scheduled to begin in the summer of 2014.

The portion of the Project included in this proposal involves installing approximately 5,000 feet of pipe and replacing the Canal embankments along the portion of the unlined Canal immediately adjacent to the Dutch Slough Properties (Figure 7-1). The proposed Project is intricately linked with the Dutch Slough Tidal Marsh Restoration Project, which will construct 3.4 miles of new flood protection levees surrounding the Emerson, Gilbert and Burroughs Parcels adjacent to the Canal. Together, these projects will improve regional flood protection four-fold. Based on historical water levels, flood frequency curves in the area, and previous damage to the Canal, there is a 2% chance of major failure in the Canal embankments any given year. By eliminating the Canal embankments and upgrading the Dutch Slough levees, the risk of major flood damage in the region decreases from 2% in a given year to 0.5% or less.

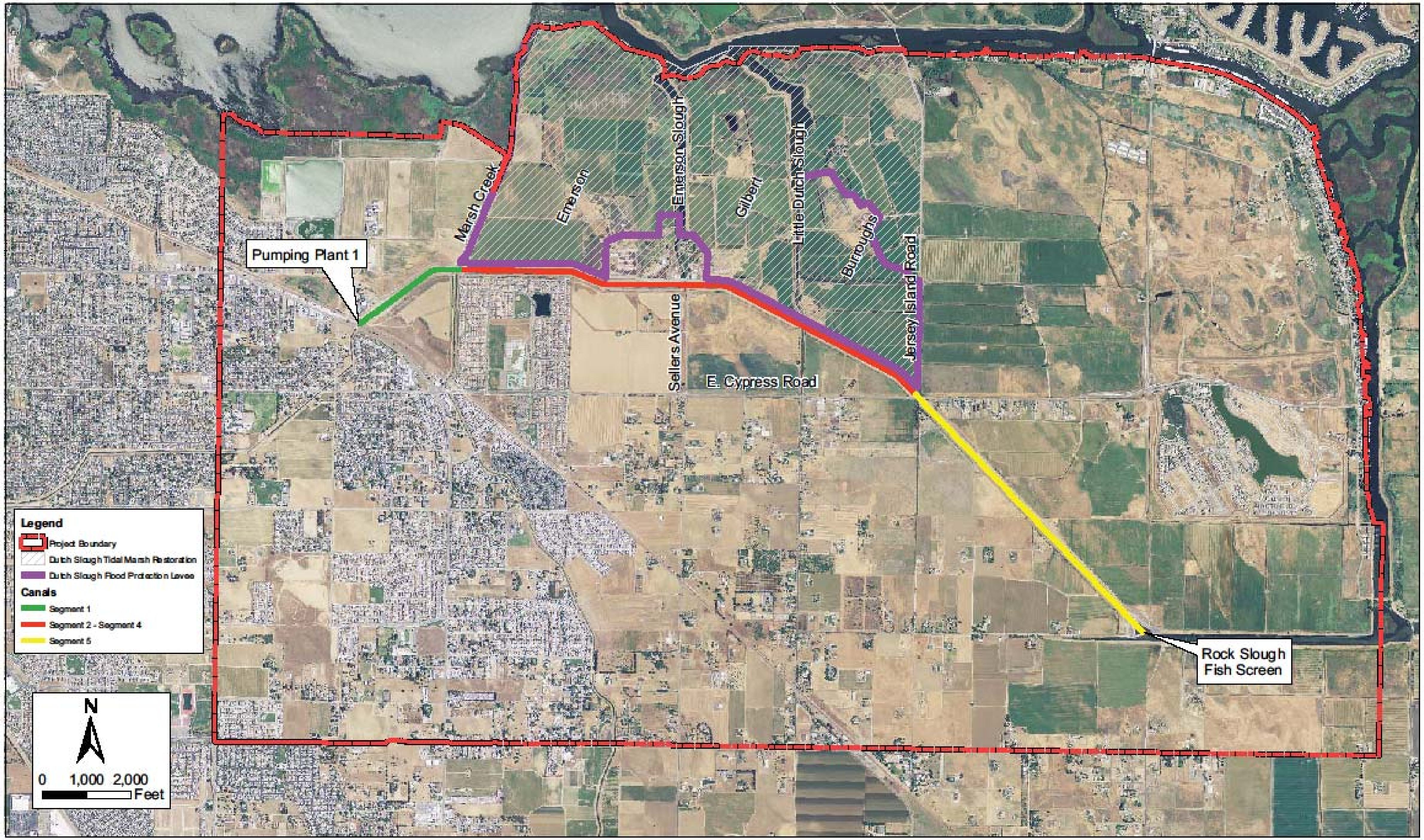
Relationship of Benefits to Segment 5 Benefits

It should be noted that Segment 5, which includes implementation of a flow isolation structure, is currently under development. The flow isolation structure would allow CCWD to hydraulically isolate the Canal from the Delta in the event of a Canal levee failure, flood or earthquake. As such, implementing the flow isolation structure reduces the extent of damage that could result from a major flood but it does not necessarily reduce the risk of the Canal levee failure. As noted below, some of the Canal failures in the past have been associated with heavy rains rather than high waters. Until the entire Canal is encased in a pipeline, the risk of overtopping and levee failure exists. Implementing this Project would eliminate the risk of Canal levee overtopping and / or failure along segments 2 through 4 of the Canal. Without the Project, risk of overtopping and / or levee failure along this stretch of Canal persists, even with implementation of the flow isolation structure. The flood damage avoidance benefits evaluated in this proposal are limited to those damages resulting from hydrologic conditions and associated overtopping / levee failure that would be eliminated through encasement of segments 3 through 4 in a pipeline. Benefits associated with the flow isolation structure have not been claimed.

Summary of Flood Protection Benefits

The region surrounding the unlined Canal has been historically used for agricultural purposes, but land use has changed dramatically since 2003. The region at greatest risk of flooding due to Canal levee failure is bounded by Dutch Slough to the north, Sandmound Slough to the east and the open, unlined Canal to the south. Without the Project, approximately 555 residential units are at risk of flooding, and an additional 628 housing units in the Summer Lakes development would be isolated if the Canal failed. At least 32 miles of road are at risk of flooding, including the sole arterial access road for the majority of the regions' residents. At least 8 active gas wells are at risk of flooding in the region. In addition, there are overhead power transmission lines for Pacific Gas and Electric and Western Alliance Power Association that transect the region. An additional 3,000 acres are planned for urban development, and 1,200 acres will be restored to tidal wetlands as part of the Dutch Slough Tidal Marsh Restoration Project – all of which are at risk should the Canal fail without the Project.

Figure 7-1: Project Location



Aerial Source: NAIP 2012
FEMA Source: http://www.fema.gov/index.shtm
ProjectLocationMap.mxd

Project Location Map

The full, five-segment Project will encase the unlined Canal in a pipeline, eliminating the flooding risk associated with Canal failure and install a flood isolation structure at the mouth of the Canal that will enable CCWD to isolate the Canal from the Delta in the event of flood or other Delta wide emergency. The related Dutch Slough Tidal Marsh Restoration Project will upgrade 3.4 miles of perimeter levees to current urban levee standards. Based on historical water levels, flood frequency curves in the area, and previous damage to the Canal (Appendix 1), there is approximately a 2% chance of major failure of the Canal embankments any given year. By eliminating the Canal embankments, installing a flood isolation structure and upgrading the Dutch Slough levees, the risk of major flood damage in the region decreases from 2% in a given year to 0.5% or less.

As shown in Table 7-1, implementation of the Permanente Creek Flood Protection Project would provide several physical and measurable benefits.

Table 7-1. Summary of Quantifiable Physical Benefits

Contra Costa Canal Levee Elimination and Flood Protection Project	
Flood Protection Benefits	• Flood protection for over 6,000 acres • Emergency access in the event of flooding for 628 homes valued between $250k and $375k in Summer Lakes development • Flood protection for more than 6,200 existing and planned dwelling units in the region, valued at $220k per home • Flood protection for more than ten thousand residents in the region • Flood protection for overhead power transmission lines for PG&E and WAPA • Flood protection for 1,000 acres of prime farmland • Flood protection for 8 natural gas wells • Flood protection for over 32 miles of road
Water Supply Benefits	• Avoided releases from SWP and CVP reservoirs to comply with existing water quality regulations (3,950 AFY, on average) • Additional water stored in CCWD's Los Vaqueros Reservoir that is available for CCWD customers and regional partners in case of an emergency (640 AFY, on average) • Diversions shifted from Old and Middle River intakes that enable SWP/CVP increased operational flexibility during restricted export periods (January – June)

Contra Costa Canal Levee Elimination and Flood Protection Project	
Water Quality Benefits	• Decrease in bromide concentration in the Canal (up to 0.85 mg/L, 0.3 mg/L on average) • Decrease in chloride concentration in the Canal (up to 240 mg/L reduction, 9 mg/L on average) • Elimination of impacts of cattle adjacent to Canal • Decrease in Canal turbidity • Decrease in the risk of cryptosporidium, E. Coli, and other pathogens entering the water supply • Four-fold reduction in turbidity and associated reduction in solids handling
Environmental Benefits	• Enables the Department of Water Resources' 1,200-acre Dutch Slough Tidal Marsh Restoration Project to proceed • Reduces herbicide applied to surface water in the Canal to treat nuisance algae and submerged aquatic vegetation
Recreation/Public Access Benefits	• None
Energy-Related Benefits	• Reduced energy usage (490 MWH per year) • Reduced greenhouse gas emissions (460k lbs of CO_2 equivalents per year)
Other Physical Benefits	• Reduced Canal maintenance • Public safety (reduced drowning risk by 62 percent in any given year) • Avoided patrolling costs

Notes:
1. Qualitative benefits are summarized in Attachment 8.
2. AFY = acre feet per year.

Technical Justification for Physical Benefits Claimed

Contra Costa Water District (CCWD) has completed numerous studies and reports evaluating and quantifying the benefits of the proposed Project. As such, a wealth of information is available for both the with- and without project conditions to substantiate the physical benefits claimed. Phase 1 of the Project has been constructed, and design of the remaining phases is nearing completion. Specific studies and actions completed to-date include the following.

Environmental & Permitting Documentation

- Environmental documentation has been completed in accordance with the California Environmental Quality Act (CEQA) and National Environmental Protection Act (NEPA). A Negative Declaration was approved on November 2006; it was determined that the Project will not have significant effects on the environment. Reclamation approved a NEPA Finding of No Significant Impact (FONSI) in July, 2007. CEQA Addendum and NEPA modifications will be conducted as required for new phases of construction.
- Mitigation Monitoring and Reporting Program for the Contra Costa Canal Replacement Project. State Clearinghouse # 2006042082. November 2006.
- Final Mitigated Negative Declaration for the Contra Costa Canal Replacement Project. November 2006.
- Final Environmental Assessment Contra Costa Canal Replacement Project, contra Costa Cou8nty, California. June 2007.
- Several permits and agreements were secured in 2007, including: Central Valley Regional Water Quality Control Board 401 Permit, CA Department of Fish and Game 1600 and 2081 Permits, State Historic Preservation Officer MOU, US Army Corps of Engineers 404 Permit, National Marine Fisheries Service Letters of Concurrence, US Fish and Wildlife Coordination Act Letter, and Bureau of Reclamation/Western Area Power Administration (WAPA) NEPA EA/FONSI. These permits may require modification to reflect current field conditions consistent with CEQA Addendum and NEPA updates.
- Conservation Easement Deed Holland Tract Preserve. Completed environmental mitigation included a total of 145 acres of mitigation land; 98 acres of upland habitat and 47 acres of wetland habitat in Holland Tract.

Engineering & Design Documentation

- Geotechnical Engineering Investigation Contra Costa Water District Canal Replacement Project Oakley, CA. DCM Engineering/Carollo Engineers, November 2007.
- Recommended Pipeline Alignment. Technical Memorandum. Brown & Caldwell. June 2011.
- Canal Crossings. Technical Memorandum. Brown & Caldwell. June 2011.
- Canal Levee Elimination and Flood Mitigation Project Phase 2 – Pipeline. Access Structure Structural Calculations. Brown and Caldwell. June 2011.
- Cypress Grove Levee Protection. Technical Memorandum. Brown & Caldwell. June 2011
- Pumping Plant 1 Test Report. Technical Memorandum. Brown & Caldwell, June 2011.

- Final Grade Elevations and Imported Backfill. Technical Memorandum. Brown & Caldwell, June 2011.
- 100% Design Drawings Segments 2 – 4
- Volume-1-DIV-00-17-FULL
- Volume-2-Appendices

Flood Benefits Documentation

- Photos and narrative description of historical flood damage: RD 1237, Contra Costa Water District Operations and Maintenance Staff
- Flood frequency curves for Old River at Rock Slough and San Joaquin River at Antioch. Developed by Corps of Engineers, Sacramento California. February 1992.
- FEMA inundation maps.
- Water surface elevations measured at Rock Slough. http://cdec.water.ca.gov/cgi-progs/staMeta?station_id=RSL
- Application for Individual Permit Supplemental Attachment. Dutch Slough Tidal Marsh Restoration (SPK-2004000043). Prepared for U.S. Army Corps of Engineers Sacramento Discrict, Regulatory Division. Prepared by California Department of Water Resources. March 2012.
- Dutch Slough Tidal Marsh Restoration Project Final Environmental Impact Report. SCH # 2006042009. State of California Department of Water Resources. March 2010.
- City of Oakley 2020 General Plan. Updated January 2010. http://www.ci.oakley.ca.us/UserFiles/file/GeneralPlan/General%20Plan%202020_Updated%20January%2026,%202010.pdf
- City of Oakley East Cypress Corridor Specific Plan Final Supplemental Environmental Impact Report. January 2009. http://www.ci.oakley.ca.us/UserFiles/file/planning/East%20Cypress/ECC%20SP%20Draft%20EIR.pdf

Water Supply Benefits Documentation

- Spreadsheet of CCWD daily operations model output
- Contra Costa Water District Daily Operations Model (WRSEL based linear program). Los Vaqueros Expansion Model Documentation. Technical Memorandum. MBK Engineers. November 3, 2010.
- G-model used to estimate water savings to CVP/SWP associated with compliance with water quality standards. Accounting for Antecedent Conditions in Seawater Intrusion Modeling – Applications for the San Francisco Bay-Delta. Richard Denton, 1993. Hydraulic Engineering, Volume 1, ASCE, pp. 448-453.

Water Quality Benefits Documentation

- Water Quality at Contra Costa Water District's Contra Costa Canal Intake: A Review of Rock Slough Water Quality Analyses. Contra Costa Water District Interoffice Memorandum. August 14, 2001.

- Rock Slough Technical Memorandum Evaluating Veale Tract Discharge. FlowScience. December 19, 2003.
- Identification of Water Quality Degradation Sources in Rock Slough and Unlined Portion of Contra Costa Canal. Contra Costa Water District Interoffice Memorandum. October 23, 2003.
- Bay Area Water Quality & Supply Reliability Program. CALFED Bay Delta Program. May 2005.
- Amy, G.L., M. Siddiqui, K. Ozekin, H.W. Zhu, and C. Wang, (1998). Empirically Based Models for Predicting Chlorination and Ozonation By-Product: Haloacetic Acids, Chloral Hydrate, and Bromate. EPA Report CX 819579. USEPA Office of Groundwater and Drinking Water: Cincinnati, OH, 1998.
- Field data collected by Contra Costa Water District and the Department of Water Resources
- Beneficial Use Impact Study, Final Report Ironhouse Sanitary District, Oakley, California. Prepared by HydroFocus. December 2003

Environmental Benefits Documentation

- Dutch Slough Tidal Marsh Restoration Project Final Environmental Impact Report. SCH # 2006042009. State of California Department of Water Resources. March 2010.

Energy Related Benefits Documentation

- Spreadsheet of CCWD daily operations model output
- Contra Costa Water District Daily Operations Model (WRSEL based linear program). Los Vaqueros Expansion Model Documentation. Technical Memorandum. MBK Engineers. November 3, 2010.
- Greenhouse gas (GHG) emissions for the Contra Costa Water District (CCWD) is based on the Climate Registry's (Registry) General Reporting Protocol v3.1 (Protocol) released in January 2009.

Because the Project has been fully evaluated and designed, the projected physical benefits are well-defined and justifiable. The following sections provide the technical justification to support these claimed benefits.

Description of Benefits

Without the project, 6,000 acres in the project area will continue to be flooded in 25-, 50-, 100-, and 500-year events, consistent with historical flooding. Historic flooding events are summarized below.

Background

The Canal was developed as part of the Central Valley Project in the 1930s and is an integral part of the water delivery system for CCWD. The unlined portion of the Canal begins at Rock Slough and continues for four miles until it connects to the 44.6-mile concrete-lined Canal. The Canal levees in the unlined portion are in poor condition; they are not designed to provide flood protection and are not seismically sound. They are composed of unconsolidated dredging spoils from the original construction. At least seven square miles are currently at risk of flooding if the Canal levees failed, including housing developments, roads, small businesses, working farms and a tidal marsh restoration project.

The historically agricultural lands adjacent to the Canal are being converted to urban development. The Project is imperative to ensure compatibility with adjacent land uses, and manage and minimize potential risks to CCWD customers and surrounding neighborhoods. There is currently a population of 10,000 in the immediate area that would be affected by failure of the facility. By 2030, ongoing rapid residential development could result in 30,000 residents endangered by this facility including three primary/secondary schools. Failure of this facility would also compromise the water supply for nearly 500,000 people.

The proposed Project will remove the potential for flooding associated with a Canal failure. By encasing the Canal in a buried pipeline, virtually all concerns with regard to system security and public safety are alleviated as well. Fences and maintenance roads will be maintained along the 300-foot right of way boundary, and security personnel will patrol the area.

A portion of the region at risk of flooding surrounding the unlined portion of the Canal is known as the East Cypress Corridor. The East Cypress Corridor Specific Plan includes development of mixed-uses for the 2,546-acre site. The project has planned up to 5,609 residential units, 92.6 acres of commercial use, 52.6 acres of public schools, 152.3 acres of man-made lake, 190 acres of open space/easements, 20.5 acres of existing and proposed gas well sites, 122.1 acres of wetlands/dunes, 46,100 feet of flood-control levees, 101.7 acres of parks (neighborhood and community), 5.7 acres of light industrial use, 37.3 acres of commercial recreation and a 6-acre beach club. Some of the planned development has been constructed, but some of the proposed development has been delayed due to the poor economy. Twenty-three acres of parks have been developed, and the beach club house has been developed. Development is projected to resume in 2016.

Historical Flooding

The Canal has experienced overtopping events in the past due to hydrologic conditions. Figure 7-2 shows the areas that have suffered failures in the past. In 1996 and 1997, the Canal experienced multiple major levee slumping and overtopping events at the western end of the Canal near Pump Plant #1. At the time, Los Vaqueros Reservoir was not completed, and water continued to be conveyed through the Canal. Due to the complete dependence on the Canal at that time, full repairs were not possible until the summer of 1998 (see attached photos). The repairs took approximately two weeks. Adjacent properties experienced limited flood damage due to emergency response to stabilize the levee. Emergency response and levee repairs cost just over $1M. The engineering report prepared at the time noted that investment was needed to prevent a complete failure of the reach. The greatest risk associated with the 1996-1997 levee damage was sewage from the Ironhouse Sanitary District flowing into the Canal from an adjacent property where sewage was land-applied. This section of the Canal (from Pump Plant #1 to Marsh Creek) was encased in 2009; encasing that portion of the Canal cost $13M (construction cost, not including permits and mitigation).

In February of 1998, the Canal failed at the intersection of Cypress Rd. The road was partially flooded and emergency repairs were made. Emergency repairs (sandbags) cost more than $13,000; rip-rap repairs to this section occurred the same month for an additional cost of $25,000. These cost estimates do not include time spent by Contra Costa County to provide emergency assistance or any repairs to adjacent properties. A conceptual cost estimate was developed in 2012 dollars to determine the full cost of responding to the same type of Canal failure (Appendix 2). To repair a 50 foot section of the Canal that failed would cost approximately $576,000; this does not include the cost of loss of water service to customers or flood damage.

In January of 2006, Emerson Slough overtopped its banks and flooded the southern portion of the Emerson parcel, Sellers Ave, and portions of E. Cypress Rd. The roads were partially flooded and the historic landmark house on the Emerson parcel was flooded. Flood waters needed to be pumped out of the house and the house remained habitable. Waters flooding the roads eventually receded without pumping. Improvements to the Emerson Slough embankments were made by Reclamation District 2137 at a cost of $150,000.

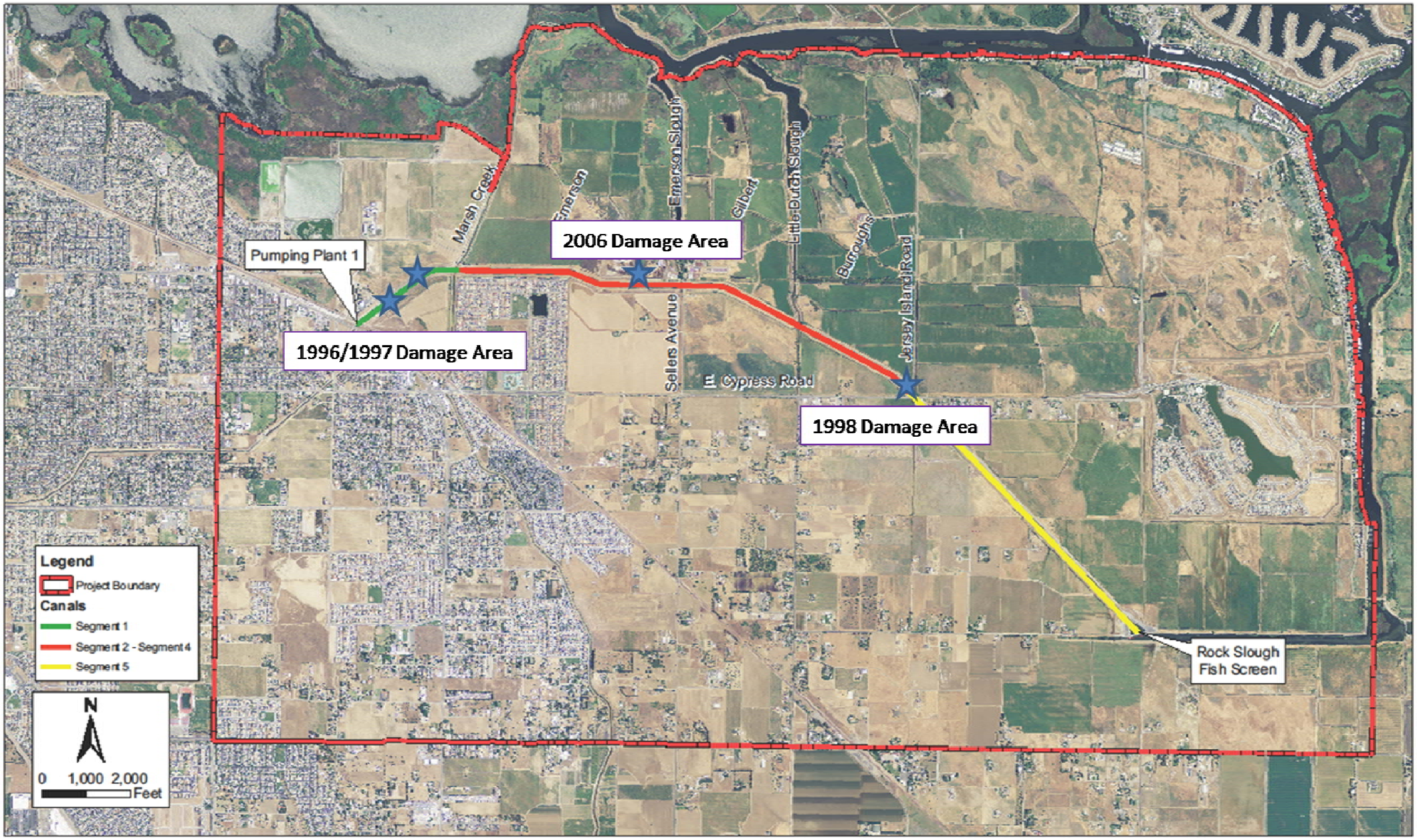
Future Flooding

Without the Project, the risk of Canal levee failure will continue into the future. Future flood probability is assumed to be similar to historical flooding. However, the damage associated with future floods will be greater because it is an area that is being converted from agricultural land to urban land.
Flood frequency curves developed by the U.S. Army Corps of Engineers at nearby gage stations were examined to determine the return interval of water surface levels during events when there was historical damage (Appendix 1). Table 7-2 summaries the USACE water levels of various return intervals for the two nearby gages.

Table 7-2: Flood Frequency Summary for Two Local Gages in Project Region from USACE

	Water Surface Elevation [ft NGVD]			
	25 year	50 year	100 year	500 year
Old River @ Rock Slough	6.7	6.8	7.3	7.8
San Joaquin River @ Antioch	6.2	6.4	6.6	6.8

Figure 7-2: Map of Past Flood Damage



During the 1996 Canal failure, water surface elevation was not high during the time of Canal failure, but there had been significant rainfall for the preceding week. Daily rain gage data for a nearby station in Brentwood from 1985 through 2012 was ranked to estimate the return interval of the rain levels during the historical damage. The most conservative return interval of 50 years, or 2% annual chance, was chosen to represent the existing level of risk of major damage without the Project. Table 7-3 summarizes water surface elevations and precipitation conditions during historical Canal flooding events.

Table 7-3: Flood Frequency Summary for Two Local Gages in Project Region from USACE

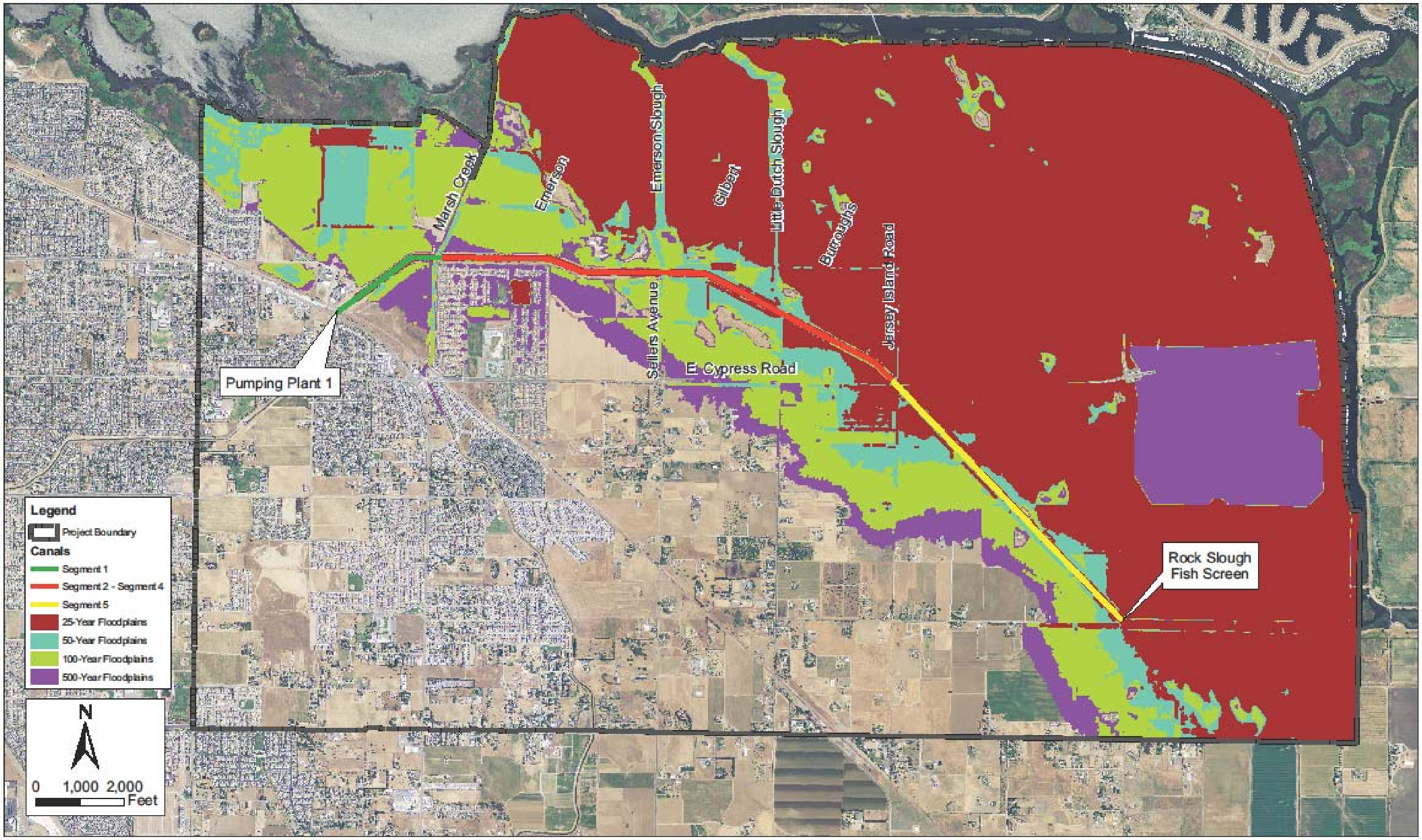
Year of Flood Damage along the Canal	Description of Damage	Maximum Water Surface Elevation at Antioch [ft NGVD]	Estimated Return Interval of Water Surface Elevation	7 Day Rain Total in Brentwood [in][1]	Estimated Return Interval of Precipitation [yrs]	Estimated Probability of Occurrence in a Year
Dec - 1996	Canal embankment failure/sloughing due to recent rains and saturated embankments.	4.54	1 yr	2.17	40 years	3% Based on precipitation
Dec 1997 through Jan 1998	Canal embankment failure near PP1.	6.36	33 years	1.89	30 years	3% Based on Water surface Elevation
Jan - 2006	Emerson Slough overtopped embankments, flooded roads and houses.	6.39	50 years	2.91	80 years	2% Based on water surface elevation

Figure 7-3 below shows the potential inundation areas for the various levels of flooding estimated without the Project.

[1] http://wwwcimis.water.ca.gov/

a.

Figure 7-3: Potential Inundation Areas for Various Levels of Flooding – Without Project Conditions



Aerial Source: NAIP 2012
FEMA Source: http://www.fema.gov/index.shtm
FEMA3.mxd

Expected Benefits and Methods Used to Develop Estimates

The Contra Costa Canal Flood Protection and Levee Elimination Project is expected to provide the following types of physical benefits, summarized in this section:

- Flood damage (FD) reduction benefits
- Water supply (WS) benefits
- Water quality (WQ) benefits
- Environmental (ENV) benefits
- Energy (ERG) benefits
- Other (OTH) benefits

For each category of benefits, the following information is provided.

- Description of physical benefits and methods used to estimate physical benefits
- Acknowledgment of all new facilities, policies, and actions required to obtain the physical benefits
- Description of any potential adverse physical effects in that category

Uncertainty of the benefits, and factors that lead to uncertainty and quantified estimates of physical benefits described using PSP Table 7 are provided in later sections of this attachment.

Flood Damage Reduction Benefits

The following sections summarize avoided flood damages. Quantified avoided flood damages include the following.

FD1: Residential and Commercial Structure and Content Damage

FD2: Loss of Agricultural Land Production

FD3: Loss of Gas Production

FD4: Damage to Dutch Slough Property

FD5: Road Inundation

FD6: Emergency Response Requirements

FD7: Supply Replacement Needs

FD1: Residential and Commercial Structure and Content Damage

To calculate the avoided flood structural damages, existing and future planned land use inventories from the City of Oakley were overlaid with potential inundation maps to calculate the level of damage for Canal failures of various magnitudes. The return intervals of the stream gages developed by the USACE listed in Table 7-3 were used to develop the potential inundation maps. The potential inundation maps were compared to FEMA maps of the areas and were generally in good agreement. The potential inundation maps do not include the water levels that could occur after the flood isolation structure is installed. Once the flood isolation structure is built, it will enable the Canal to be closed off from the Delta. However, the extent to which the structure is able to minimize flooding in the region depends on the response time after a Canal failure has occurred. Because the response time following an emergency is unknown and variable, the inundation maps show the maximum flood damage possible. As noted above, while the flood isolation structure may limit damage, it will not reduce the probability of the Canal failing if the complete Project is not implemented. Based on historical damage, it is estimated that there is at least a 2% chance of a major Canal failure every year (or a failure once every 50 years). Once the Project is implemented and the related Dutch Slough Tidal Marsh Restoration Project & East Cypress Corridor Project move forward, the level of protection for the area will exceed the 200 year urban levee design criteria.

Table 7-4 summarizes the regional infrastructure and structures that could be potentially inundated if the Canal were to fail and the region flooded.[2] With the Project, these damages would be avoided.

Table 7-4: Potential Flood Damage Under Varying Hydrologic Events – Without Project Condition

	25 year Event	50 year Event	100 year Event	500 year Event
Total Acreage	3,215	3,562	4,482	5,512
Number of Homes	6,169	6,189	6,259	7,971
Miles of Road	23	28	37	43
Number of Schools	3	3	3	5
Number of Gas Wells	6	8	8	8
Acres of Farmland	257	561	872	1,030
Acres of Commercial & Industrial Property	319	322	333	383
Acres of Easement for Overhead Power lines	123	123	123	123
Acres of Dutch Slough Tidal Marsh Restoration Project	1200	1200	1200	1200

FD2: Loss of Agricultural Land Production

Adjacent to the Canal is 1,030 acres of prime farmland, the annual revenue of which is estimated to be up to $600 per acre per year. Due to the low-lying nature of the agricultural lands in this area, it was assumed that flooding would result in a 90% loss of agricultural revenue for the inundated areas.

FD3: Loss of Gas Production

Adjacent to the Canal is a gas well field, which would be inundated in a 25-, 50-, 100- or 500-year flood event (6 wells inundated in the 25-year event and 8 wells inundated in all other events). Venoco owns

[2] Includes East Cypress planned development to be implemented beginning in 2016, two years prior to the completion of the proposed Project.

the mineral rights on the Dutch Slough properties.[3] Per Venoco, the field produces natural gas from the Hamilton, Anderson, Martinez and McCormick formations at depths ranging from 6,500 to 8,300 feet. Average net production from the field was 1,344 per thousand cubic feet per day (Mcf/d) in December 2005. As of December 31, 2005, there were five producing wells in the field. Two new wells were drilled in the first quarter of 2006.

Assuming that current average well production is equal to one fifth of the 2005 average production for five wells, production is estimated as 269 Mcf/d per well. Assuming inundation would cause a loss of inundated wells for at least a two-week period (14 days). This equates to a reduced gas production of 22,596 Mcf/d in the 25-year event (14 * 269 * 6) and 30,128 Mcf/d in the 50-year, 100-year, and 500-year event (14 * 269 * 8).[4]

FD4: Damage to Dutch Slough Property

DWR's Dutch Slough Tidal Marsh Restoration Project will restore a tidal wetland just to the north of the Project. This Project is a critical early action to improve the ecosystem health of the Sacramento-San Joaquin Delta, a point highlighted by Governor Schwarzenegger in a July 2007 statement and its inclusion in the Interim Delta Plan. The Dutch Slough property, purchased for approximately $23 M in 2003 ($2003), is located entirely within the inundation area. This translates to a 2012 value of $27.6 M. It is assumed that inundation in the 25-year or greater flood would result in an approximate loss of 50 percent of land value.

FD5: Road Inundation

Road inundation was estimated by comparing aerial imagery of roads within the project area with the inundation maps for each flood event. The following table summarizes the length of each road type expected to be inundated in the 25-, 50-, 100- and 500-year flood events. As shown in Table 7-5, major roads, including E. Cypress Road, Sellers Ave, Bethel Island Rd and Sandmound Rd, would experience significant inundation in all flood events analyzed.

[3] Summary provided at:http://www.wikinvest.com/stock/Venoco_(VQ)/Sacramento%20Basin>
[4] Gas prices estimated based on information accessed on January 28, 2013 from: http://www.eia.gov/dnav/ng/hist/n9190us3m.htm.

Table 7-5: Miles of Roads Inundated Without Project

Road	Category	Miles Inundated			
		25-Year Event	50-Year Event	100-Year Event	500-Year Event
BETHEL ISLAND RD	Major	2.3	2.8	3.71	4.31
BROADWAY	Unsealed	0.31	0.37	0.50	0.57
DUTCH SLOUGH RD	Minor	0.61	0.75	1.00	1.15
CYPRESS AND EAST CYPRESS RD	Major	4.61	5.61	7.41	8.62
JERSEY ISLAND RD	Major	4.61	5.61	7.41	8.62
KNIGHTSEN AVE	Minor	0.31	0.37	0.50	0.57
TULE LN	Minor	0.05	0.06	0.07	0.09
COW POKE LN	Unsealed	0.46	0.56	0.74	0.86
FRANKLIN RD	Unsealed	0.15	0.19	0.25	0.29
WELLS RD	Minor	2.00	2.43	3.22	3.74
CACTUS LN	Minor	0.05	0.06	0.07	0.09
DELTA RD	Minor	0.46	0.56	0.74	0.86
MARINER RD	Minor	0.15	0.19	0.25	0.29
SANDMOUND BLVD	Major	6.15	7.49	9.90	11.50
SELLERS AVE	Minor	0.77	0.94	1.24	1.44
TOTAL		23	28	37	43

FD6: Emergency Response Requirements

As discussed previously, the Canal has experienced overtopping events in the past due to hydrologic conditions.

- In 1996 and 1997, the Canal experienced multiple major levee slumping and overtopping events at the western end of the Canal near Pump Plant #1. At the time, Los Vaqueros Reservoir was not completed, and water continued to be conveyed through the Canal. Due to the complete dependence on the Canal at that time, full repairs were not possible until the summer of 1998 (see attached photos). The repairs took approximately two weeks. Adjacent properties experienced limited flood damage due to emergency response to stabilize the levee. The engineering report prepared at the time noted that investment was needed to prevent a complete failure of the reach.
- In February of 1998, the Canal failed at the intersection of Cypress Rd. The road was partially flooded and emergency repairs were made. Emergency repairs included sandbags and rip-rap repairs, as well as emergency assistance and repairs to adjacent properties.
- In January of 2006, Emerson Slough overtopped its banks and flooded the southern portion of the Emerson parcel, Sellers Ave, and portions of E. Cypress Rd. The roads were partially flooded and the historic landmark house on the Emerson parcel was flooded. Flood waters needed to be pumped out of the house and the house remained habitable. Waters flooding the roads eventually receded without pumping.

In the event of a canal failure, the following emergency response actions are anticipated to be needed by CCWD. In total, 20 days is estimated to be required to repair a 50-foot breach.

Initial Response and Condition Assessment	
	Mobilize; Perform emergency response and assessment of canal; Verify canal berm repair criteria. Duration: 3 days.
Canal Isolation (Cofferdam)	
	Material procurement; Installation of cofferdam. Duration: 5 days.
	Assumptions: - Hydrosack/sandbag cofferdam system
Canal Berm Repair	
	Material hauling from borrow source; stockpile at site; material handling and placement for canal repair. Duration: 7 days.
	Assumptions: - Typical Canal Berm Section (above adjacent ground): 600 square feet - Volume 50' Breech Section: 1,110 cubic yards (say 1,200 cubic yards)
eturn to Service	
	Site restoration; Removal of Cofferdam. Duration: 5 days.
Miscellaneous	
	Contract Administration; Permits; Field Testing Services.

FD7: Supply Replacement Needs

Water supply reliability can be defined in terms of water supply shortages resulting from failures of a system's physical components[5]. If the Canal were to fail and water could not be conveyed through the Canal, CCWD's customers, including the city of Brentwood, could experience a short-term water supply disruption. The city of Brentwood relies on the unlined Canal to meet over 78% of their 25,000 AFY annual demand. While other CCWD customers rely on the Canal, CCWD typically has greater flexibility to provide water to those customers from other sources. In total, CCWD relies on the unlined Canal to meet approximately 45% of its remaining 145,000 AFY annual demand (excluding Brentwood).

Implementing the Project would increase the system reliability from 98% in a given year (meaning there is a 2% chance of the Canal failing or a shortage due to Canal failure in any given year) to 100% in a given year by eliminating the potential for Canal levee failure. Implementing the Project would result in a 2% increase in supply reliability, and would subsequently eliminate any supply interruption or loss of supply that would occur without the Project.

If the Canal failed in a similar fashion to the historical failures in the late 1990s, CCWD estimates that it would take approximately 20 days to repair the Canal and return the Canal to service. 20 days is roughly 5 percent of the year and that percent of CCWD's demand would need to be met by other water sources.

Table 7-6: Supply Replacement Needs in the Event of Canal Failure

	Amount of Demand Met by PP1 Diversions [AF/yr]	Percent of Annual Service Would be Interrupted by 20 day outage	Amount of Water that would need to be replaced in a 20-day outage [AF/yr]
Brentwood [6]	**19,500**	**5.5%**	**1,069**
Complete CCWD Service Area	**65,250**	**5.5%**	**3,589**
Total			**4,658**

Facilities, Policies and Actions Required to Obtain Flood Protection Benefits

In order to achieve the benefits described herein, all of the following project components must be constructed. Project components include:

- Installation of the flood isolation structure
- Completion of pipe installation
- Completion of Dutch Slough Tidal Marsh Restoration Project

Potential Adverse Effects

No adverse flood-related effects are projected to result from project implementation.

[5] Shamir, U. & Howard, D. Water Supply Reliability Theory. Journal of American Water Works Association. V (73), No. 7. July 1981.
[6] http://www.brentwoodca.gov/pdf/newsletters/2010UWMP.pdf

Without-Project Conditions

Without the Project, there will continue to be a 2 percent risk each year that the Canal levees will fail and significant flooding will occur as has been observed in the past.

Water Supply Benefits

Background

CCWD is a wholesale water supplier to three water suppliers in the East County region (City of Pittsburg, City of Antioch, Diablo Water District). The city of Brentwood has a Delta surface supply purchased from ECCID that is diverted by CCWD at its Delta intakes and also has well water. Also, CCWD serves a portion of Brentwood that lies within its service area boundaries using the unlined Canal system. CCWD also has emergency agreements with East Bay Municipal Utility District.

There are three main water supply benefits that will be achieved by the completion of the Project: 1) CCWD will retain more water in Los Vaqueros Reservoir and thereby improve availability and reliability of emergency water supplies for CCWD customers and partner agencies; 2) water quality at Pumping Plant 1 will improve, allowing the Central Valley Project / State Water Project (CVP/SWP) to release less water from upstream reservoirs to meet water quality standards at Rock Slough (compliance measured at Pumping Plant 1) promulgated by the State Water Resources Control Board Decision 1641; 3) because water quality at Pumping Plant 1 will improve, CCWD can shift pumping away from the Old and Middle River Intakes and CVP/SWP will gain operational flexibility and possibly increase maximum exports during times when export operations are normally constrained by Old and Middle River flow regulations. Greater details and explanations of these are provided below. Together these four sources of water supply benefits are expected to yield approximately 25,000 acre-feet per year (AFY).

Expected Benefits and Methods Used to Develop Estimates

This Project is expected to yield the following water supply benefits:

WS1: Increase in emergency water supply available for CCWD customers and partners – 400 AFY
WS2: CVP/SWP water savings from upstream reservoirs that would otherwise be released to meet state water quality regulations as measured at the downstream end of the Canal – 17,000 AFY
WS3: CVP/SWP operational flexibility and possibly increase in water exports during times when regulations set limits on Old and Middle River flows – 5,700 AFY

Estimated benefits and methods for developing these estimates are provided below.

WS1: Increase in Emergency Water Supplies Benefits & Methods – 860 AF during dry times or 400 AFY on average

CCWD owns and operates four intakes in the Delta, as well as the Los Vaqueros Reservoir and two raw water treatment plants. CCWD operations are designed to deliver supplies with chloride concentrations of 65 mg/L or less. Poor water quality in the Canal and Pumping Plant 1 can cause CCWD to reduce or eliminate diversions at Pumping Plant 1, increase diversions at other intakes, or increase releases from Los Vaqueros Reservoir. Implementation of the Project will improve water quality at Pumping Plant 1 which will, in turn, enable CCWD to use Pumping Plant 1 more often to meet a greater portion of customer demand that was previously met by using other intakes and releases from the Los Vaqueros Reservoir. This will have the net effect of decreasing the amount the reservoir is used to meet 'normal' demand, thereby increasing the minimum amount of water in the reservoir at any time available for an emergency.

Replacing the unlined Canal with a pipeline will lead to improved water quality at the Rock Slough intake, which will decrease the amount of water released from Los Vaqueros Reservoir in order to meet CCWD's customer water quality delivery goals. On average, this effectively adds 340 AFY on average to water available in storage but increases available storage up to 860 AFY during dry times, assumed to occur 2 out of every 5 years for an average emergency water supply savings of 340 AFY. In addition, reduced evaporation losses from the open Canal amount to an estimated 60 AFY saved per year. Combined, there is a savings of 400 AFY for CCWD.

Table 7-7: Expected Annual Water Supply Benefit Resulting from Increased Emergency Supplies

	Minimum Storage in Los Vaqueros Reservoir [AF]
Without Project	148,570
With Project	147,710
Emergency Supply Benefit of Project	**860**

WS2: Statewide Water Savings to Meet Water Quality Regulations – 17,000 AFY

Water quality in the Contra Costa Canal affects both CCWD operations and statewide CVP/SWP operations. The federal water and state water projects are required to meet state water quality objectives defined by the State Water Resource Control Board Decision 1641; compliance with two state water quality objectives are measured at Pumping Plant 1. One of the D-1641 objectives specifies that salinity in the Contra Costa Canal as measured at Pumping Plant 1 (PP1) must be below 150 mg/L chlorides for a minimum of 155 days per year and up to 240 days per year depending on water year type. The second objective specifies that water quality at Pumping Plant 1 must be below 250 mg/L chlorides to comply with the secondary maximum contaminant level (MCL). Although compliance with these standards does not often dictate statewide water operations, there are times when CVP/SWP reservoirs must make releases specifically to meet these water quality objectives.

There are three sources of salinity and contamination in the Canal: 1) seawater intrusion from the ocean into the Delta, 2) groundwater intrusion from an elevated water table adjacent to the Canal, and agricultural return flow from adjacent farms and ranches. Salinity in the Canal from seawater is naturally variable due to the variation in hydrologic conditions and tidal forcing. When freshwater outflow from the Delta dominates, water in the Canal is relatively fresh because the river flow is sufficient to keep seawater downstream of the Delta. Conversely, when there is low freshwater outflow from the Delta, water in the Canal is relatively salty because seawater is able to mix upstream in the Delta. Salinity from the other two sources, groundwater and agricultural return flow, are largely due to human activities and will be eliminated by implementing the Project. Eliminating the two "human-derived" sources of salt will improve water quality in the Canal and will, in turn, improve SWP/CVP operations to provide a water supply benefit. Specifically, implementing the Project would improve water quality, or decrease salinity, by approximately 15% on average. The methodology for determining this reduction is described below.

Because compliance with the regulatory standards is measured at PP1 (at the downstream end of the unlined Canal), degradation incurred along the unlined portion of the Canal from groundwater intrusion and agricultural runoff can result in increased releases from CVP/SWP reservoirs. Historical land use practices adjacent to the unlined Canal, such as land disposal of sewage, agricultural drainage, and cattle grazing, have resulted in significant water quality degradation in the unlined Canal. Implementing the Project will eliminate salinity intrusion from groundwater and direct agricultural runoff thereby decreasing the salinity at Pumping Plant 1 and decreasing the amount of water CVP/SWP need to release from upstream reservoirs to meet the water quality standards.

To calculate the water savings associated with improving water quality at the compliance point, CCWD ran the 'G'-model[7] using the same water quality timeseries as was input into the daily operations model for the other water supply calculations. Implementing the Project would improve water quality, or decrease salinity, by approximately 15%. The G-model output indicated the amount of outflow that would be saved by the improvements to meet the 150 and 250 chloride standards. Daily chloride concentrations from 1999 through 2007 measured by CCWD at Rock Slough were examined to determine the number of days the water quality savings could have been realized. This period was chosen because it captures the data available before the implementation of Segment 1 of the Project which began in 2007. According to the historical record during this period, implementing the Project could have improved the water quality on average 16 days per year to meet the 150 mg/L chloride standard at Rock Slough for an average savings of 14,000 AFY. On average, water quality at Rock Slough would have improved 11 days per year to meet the 250 mg/L chloride standard for an average water savings of 2,593 AFY. Combined, based on historical conditions, implementing the Project would save between 2,000 AFY and 24,000 AFY depending on the water year type. Over the eight-year period of analysis, the average potential water savings was 17,000 AFY.

Table 7-8: Expected Annual Water Supply Benefit to SWP / CVP Operations

	150 standard			250 standard			
Water Year	Amount of Water Saved to Meet Standard by Implementing Project [AF/d]	Maximum Number of Days Per Year Where Water Quality Savings Could be Realized	Amount of Water Could be Saved [AFY]	Amount of Water Saved to Meet Standard by Implementing Project [AF/d]	Maximum Number of Days Per Year Where Water Quality Savings Could be Realized	Amount of Water Could be Saved [AFY]	Maximum Total Water Saved [AFY]
1999	936	20	18,720	244	16	3,904	22,624
2000	936	14	13,104	244	13	3,172	16,276
2001	936	20	18,720	244	23	5,612	24,332
2002	936	13	12,168	244	33	8,052	20,220
2003	936	28	26,208	244	0	0	26,208
2004	936	20	18,720	244	0	0	18,720
2005	936	7	6,552	244	0	0	6,552
2006	936	2	1,872	244	0	0	1,872
Average		**16**	**14,508**		**11**	**2,593**	**17,101**

[7] Gmodel - *Accounting for Antecedent Conditions in Seawater Intrusion Modeling – Applications for the San Francisco Bay-Delta.* Richard Denton, 1993. Hydraulic Engineering, Volume 1, ASCE, pp. 448-453.

WS3: Statewide Water Supply Benefits during 'OMR' Regulations – 5,700 AFY

Conflicts between the need to divert water from the Delta and the legal requirements to protect endangered species can result in pumping restrictions that severely limit the quantity of Delta water allowed to be withdrawn in a given year. The Central Valley Project and State Water Project are subject to flow restrictions from January through June each year to protect endangered species such as Delta smelt. One of these restrictions limits the amount of exporting by regulating flow in Old and Middle Rivers (a.k.a. OMR). CCWD maintains four intakes in the Delta; Mallard Slough Intake, Rock Slough Intake (Pumping Plant 1), Old River Intake and Middle River Intake. Implementation of the Project will improve water quality at Pumping Plant 1 which in turn will enable CCWD to use Pumping Plant 1 more often to meet a greater portion of customer demand that was previously met by using other intakes and releases from the Los Vaqueros Reservoir. CCWD would be able to shift diversions from our Old and Middle River Intakes to Pumping Plant 1, thereby providing CVP/SWP more operational flexibility during that critical regulatory window and possibly increasing the amount of water available for export while complying with OMR regulations.

To calculate the potential water supply benefit to the CVP/SWP during the OMR regulatory period, the CCWD daily operations model[8] was run simulating conditions with the Project implemented and without the Project. The model was run using hydrologic input from January 1999 through November 2007. This end date was chosen because construction of Segment 1 of the Project started in November 2007. The total diversions at CCWD's Old and Middle River intakes from January through June were tabulated with and without project. As is shown in Table 7-9 below, implementing the Project would shift approximately 5,700 AFY on average away from CCWD's Old and Middle River intakes from January through June each year. There are many factors that influence CVP/SWP operations so the federal and state water projects may not be able to increase diversions by the same amount that CCWD is able to reduce Old and Middle River diversions every year but implementing the Project would at least reduce constraints on CVP/SWP operations every year.

Table 7-9: Expected Annual Water Supply Benefit to SWP / CVP Resulting from OMR Compliance

	CCWD Old River Pumping Jan – Jun [AFY]	CCWD Middle River Pumping Jan – Jun [AFY]	Total CCWD Pumping Jan – Jun [AFY]
Without Project	17,578	7,605	25,183
With Project	14,044	5,431	19,475
CVP/SWP Supply Benefit During OMR Restrictions	**3,534**	**2,174**	**5,708**

Facilities, Policies and Actions Required to Obtain Water Supply Benefits

In order to achieve the benefits described herein, all of the following project components must be constructed. Project components include:

[8] Contra Costa Water District Daily Operations Model (WRSEL based linear program). Los Vaqueros Expansion Model Documentation. Technical Memorandum. MBK Engineers. November 3, 2010.

- Installation of the flood isolation structure
- Completion of pipe installation
- Completion of Dutch Slough Tidal Marsh Restoration Project

Potential Adverse Effects
No adverse water supply effects are projected to result from project implementation.

Without-Project Conditions
Without the Project, water supply to the city of Brentwood and all of CCWD's service area would continue to be at risk of interruption in the event of a major Canal failure (approximately a 2% risk of major failure in any given year). The city of Brentwood currently relies on the Canal to meet over 78% of annual demands. In addition, an average of 340 AFY of supply from Los Vaqueros Reservoir that could otherwise be stored for future use would need to be released to meet downstream water quality goals. Without the Project, SWP and CVP upstream reservoirs will continue to release up to 17,000 AFY of water which could otherwise be stored for future use to meet water quality standards at Pumping Plant No. 1. The SWP and CVP would also continue to be tightly constrained during the OMR regulatory period and potentially losing up to 5,700 AFY that could be available for export.

Water Quality Benefits

Background
Water quality is an ongoing challenge facing East County water suppliers. Delta water quality is highly variable depending upon the season, the water year, and the intake location. During dry years and seasons Delta supplies contain high concentrations of total dissolved solids (TDS), chloride and bromide. Total organic carbon (TOC) concentrations in Delta supplies are also highly variable, with increases generally corresponding to periods of increased runoff. The Los Vaqueros Reservoir, which is owned and operated by CCWD, is used to improve the water quality delivered to CCWD's customers. Currently, water is pumped into Los Vaqueros during spring and early summer months when Delta water quality is good. During the late summer and fall, when Delta water quality is poor, Delta supplies are blended with the high quality water stored in Los Vaqueros Reservoir to improve the water quality delivered to CCWD's untreated and treated water customers.

The quality of Delta water is also dependent on maintenance of the Delta levee system as well as land and water management activities throughout the Delta and its larger watershed. Failure of the Delta levee system due to flooding or seismic events could dramatically increase levels of chloride, bromide, and TOC, and potentially render the water supply unusable for municipal or agricultural purposes. Similarly, changes in Delta land-use and water management practices, including many identified by CALFED, could increase levels of undesirable constituents at East County intake locations.

The proposed Project will encase a portion of the Canal, improving drinking water quality for 500,000 people in Contra Costa County by decreasing the amount of saline groundwater intrusion or stormwater into the Canal. This will reduce the concentrations of total dissolved solids (TDS), chloride, bromide and other constituents in CCWD's source water.

Expected Benefits and Methods Used to Develop Estimates

This Project is expected to yield the following water quality benefits:

WQ1: Reduced Levels of DBPs in Drinking Water

WQ2: Decreased Agricultural Runoff from Adjacent Fields
- Decreased turbidity, salinity and nutrients associated with runoff

WQ3: Decreased Risk in Fecal Borne Pathogens Transported into the Canal

WQ4: Decreased Turbidity and Associated Solids Handling Requirements

Estimated benefits and methods for developing these estimates are provided below.

WQ1: Reduced Levels of DBPs in Drinking Water

The primary water quality benefit expected from this Project is a reduction in disinfection byproduct formation, and associated public health protection. Implementing the Project will reduce bromide concentrations at PP1 by 15% on average. Figure 7-3 below shows the increase in bromide concentration that occurs as water travels down the unlined canal; this increase in bromide concentration is due to groundwater intrusion. Groundwater beneath the Ironhouse Sanitary District (ISD) properties immediately adjacent to Segment 1 of the Canal has bromide concentrations regularly exceeding 5 mg/L[9]which is more than ten times greater than the concentration measured in surface water. Similarly, the bromide concentration on the Dutch Slough Properties adjacent to Segments 2 through 4 of the Canal can exceed 3 mg/L[10]. The lower panel of Figure 7-4 shows that by implementing the Project, bromide concentrations could be reduced between 0% and 60%, with an annual average reduction of 15%.

Bromide in the source water is transformed into bromate during ozonation at CCWD's Randall Bold Treatment Plant. Bromate is suspected of contributing to kidney and thyroid cancer in humans. The state and federal MCL for bromate is 10 µg/L. Bromate concentration in CCWD service area has exceeded 10 µg/L in the past, with a maximum of 12 µg/L recorded in 2005. Since 2008, Segment 1 of the Project was implemented limiting the groundwater flux of bromide from ISD's property and the treatment process at Randall Bold Water Treatment Plant was modified to limit bromate concentrations in the service area to less than 5 µg/L.

As bromate is presumed to have a linear no-threshold dose-response relationship, the only risk-free level of exposure to bromate is zero. Thus, any Project that reduces the potential level of bromate in drinking water provides a positive reduction in risk of cancer to those who drink that water.[11]
The bromate model of Ozekin and Amy determines bromate formation based on ozone dose, bromide, DOC, and pH as follows:[12]

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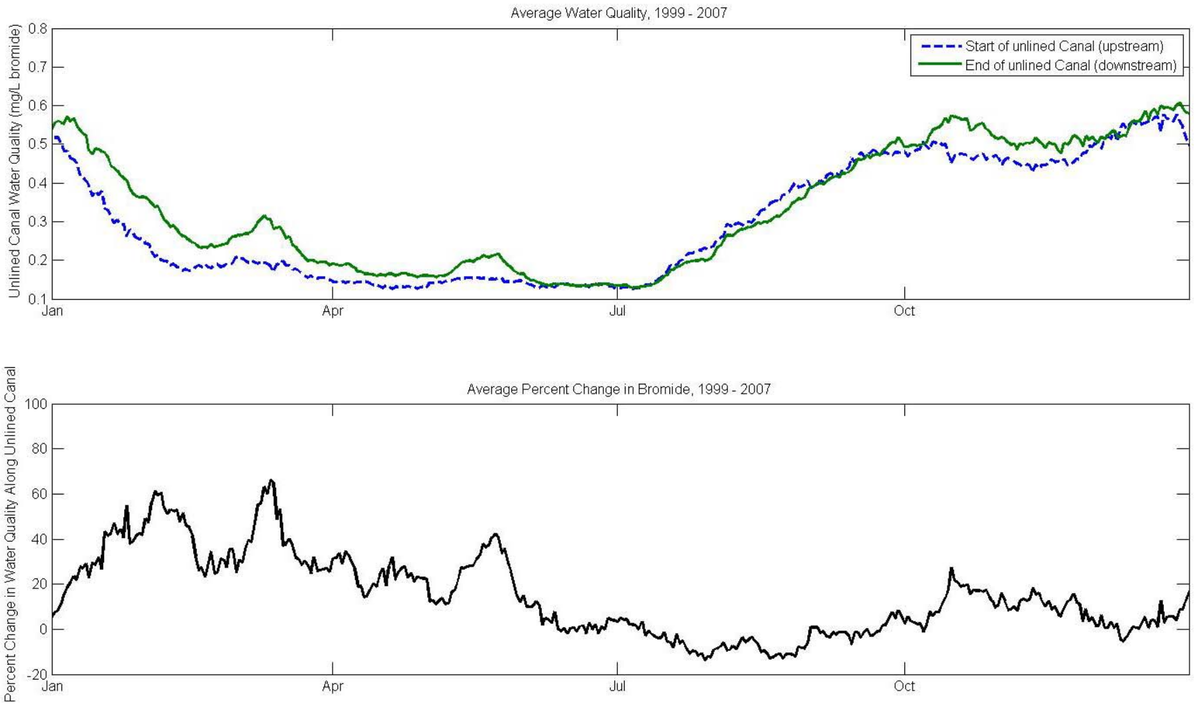
[9] Beneficial Use Impact Study, Final Report Ironhouse Sanitary District, Oakley, California. Prepared by HydroFocus. December 2003
Dutch Slough Restoration Area First and Second Quarters 2012. Semi Annual Groundwater Monitoring Report. Prepared by HydroFocus October 2012.
[U]S EPA Toxicological Review of Bromate(CAS No. 15541-45-4), In Support of Summary Information on the Integrated Risk Information System (IRIS), March 2001, Section 6. http://www.epa.gov/iris/toxreviews/1002tr.pdf#page=40
[12] Amy, G.L., M. Siddiqui, K. Ozekin, H.W. Zhu, and C. Wang, (1998). Empirically Based Models for Predicting Chlorination and Ozonation By-Product: Haloacetic Acids, Chloral Hydrate, and Bromate. EPA Report CX 819579. USEPA Office of Groundwater and Drinking Water: Cincinnati, OH, 1998.

Figure 7-4: Influence of Groundwater Intrusion on Canal Bromide Concentration



$$BrO^3 = 1.63 \times 10\text{-}6 * TOC^{-1.26} * pH^{5.82} * (O_3 \text{ dose})^{1.57} * Br^{0.73} * time^{0.28}$$

with BrO3 in ug/L, TOC in mg/L, O_3 in mg/L, Br in ug/L, and contact time in minutes. The 2005 CALFED Bay Area Water Quality and Supply Reliability Program (BAWQ&SRP) assessed bromate formation at CCWD's water treatment plants.[13] Page C-29 of the BAWQ&SRP report presents long-term average water quality concentrations for CCWD source water at Rock Slough. Long-term average TOC and bromide concentrations presented in this report are approximately 3.0 mg/L and 0.35 mg/L, respectively. Based on conversations with CCWD staff, long-term average pH in water treatment plant influent is approximately 7.2. The BAWQ&SRP also estimated water treatment conditions at Randall Bold water treatment plant. Based on this report (page D-13), ozone dose is approximately 1 mg/L and contact time is approximately 11 min. Bromate production would therefore be calculated as 5.6 ug/L as follows:

$$BrO^3 = 1.63 \times 10\text{-}6 * (3.0 \text{ mg/L TOC})^{-1.26} * (\text{pH of } 7.2)^{5.82} * (O_3 \text{ dose of 1 mg/L})^{1.57} * (\text{Br of 350 ug/L})^{0.73} * (11 \text{ min})^{0.28}$$

Reducing bromide by 15% would reduce bromate formation to 4.99 ug/L (11.2% percent), as follows:

$$BrO^3 = 1.63 \times 10\text{-}6 * (3.0 \text{ mg/L TOC})^{-1.26} * (\text{pH of } 7.2)^{5.82} * (O_3 \text{ dose of 1 mg/L})^{1.57} * (\text{Br of } 350 * 0.85 \text{ ug/L})^{0.73} * (11 \text{ min})^{0.28}$$

The drinking water unit cancer risk for bromate is equal to $2 * 10^{-5}$ per µg/L; for water at the MCL concentration of 10 µg/L, this corresponds to 2 in 10,000, or 2 x 10-4 per ug/L (US EPA, 2011). The

[13] Bay Area Water Quality & Supply Reliability Program. CALFED Bay Delta Program. May 2005.

relationship between bromate risk and concentration is linear, so risk at 5.6 ug/L (as calculated above) equals 56% of the risk at the MCL, or 1.1×10^{-4} per ug/L. Multiplying this risk level by the number of households served (178,571) and the average number of people per household in the area (3.1) provides the estimate of the excess lifetime cancer cases expected under baseline: 61. This Project will reduce bromate levels by approximately 11.2% on average to 4.99 ug/L. This corresponds to an excess lifetime cancer cases expected under the with-Project condition of 54 ($0.98 * 10^{-4} * 178{,}571 * 3.1$). This translates to a reduction in excess lifetime cancer cases of 7 fewer cancer cases per 70-year lifetime compared to baseline, or an average of 0.1 cases avoided each year.

WQ2: Decreased Agricultural Runoff

A previous study[14] of the Canal found that a single point source of agricultural discharge contributes up to 17 mg/L of total dissolved solids to the Canal. The study also found that non-point source runoff from adjacent farms also causes a spike in Canal salinity and other constituents during the early stages of a storm event. There is an initial flushing of the fields as water carries salts, suspended sediment and cattle manure that have accumulated during the dry season that corresponds to the observed spike in salinity. After the initial flushing period, runoff from the farms is generally better quality. There are approximately 600 acres that are irrigated for cattle grazing adjacent to the Canal. Implementing the Project would eliminate non-point sources of agricultural return flow and improve water quality in the Canal.

WQ3: Decreased Risk in Fecal Borne Pathogens Transported into the Canal

Cattle access to streams has been shown to lead to a four-fold increase in total Kjehldahl nitrogen, a five-fold increase in total phosphorous, an eleven-fold increase in total suspended solids and turbidity, and a 36-fold increase in E. coli bacteria in water supplies15. As noted above, approximately 600 acres adjacent to the Canal are currently used for cattle grazing. Figure 7-6 below shows cattle in the Rock Slough Extension adjacent to the mouth of the unlined Canal. Continuous cattle grazing adjacent to the Canal can increase the fecal contamination and turbidity of the Canal. Pathogens associated with fecal contamination can be transported into the Canal via surface water runoff and groundwater seepage. Implementing the Project will reduce nutrients, turbidity and fecal contamination (E. coli, Cryptosporidium, and total coliform) in the Canal. The local reduction in nutrients may help reduce algae growth throughout CCWD's raw water system, improving treatability and reducing treatment costs. The reduction in turbidity would also help reduce treatment costs by reducing the amount of coagulant added, decreasing the frequency that the filtration bed materials need to be replaced, and decreasing the amount of solid waste generated.

[14] Rock Slough Technical Memorandum Evaluating Veale Tract Discharge. FlowScience. December 19, 2003.

[15] Unrestricted cattle access to streams and water quality in till landscape of the Midwest. Philippe Vidon, Marie Campbell, Mark Gray. Agricultural Water Management. V 94, Is3, pp 322-330. March 2008.

Figure 7-6: Photo Illustrating Cattle in Rock Slough Extension Adjacent to Canal

WQ4: Decreased Turbidity and Associated Solids Handling Requirements

Implementing the Project would result in an approximately four-fold reduction in turbidity during the beginning of rain events and the beginning of irrigation return flow, approximately 14 days per year total. CCWD has found that turbidity accounts for roughly 25% of the solid waste that must disposed and that alum added as a coagulant accounts for the remaining 75%. Table 7-10 below shows the solids composition at Randall-Bold treatment plant in 2008 and 2009. Assuming that turbidity during those 14 days accounts for approximately 4 percent of the total solids attributable to turbidity (14/365), turbidity during those 14 days would account for approximately one percent of CCWD's total solids handling (0.04*0.25). A four-fold reduction in turbidity during those 14 days would therefore result in an overall 0.8 percent reduction in total solids handling requirements for CCWD (0.01*0.8).

Table 7-10 Solids Concentration and Removal Rate At Randall Bold Treatment Plant

Month (FY09)	Total Million Gallons Treated	Average RB Influent Turbidity (NTU)	Total Alum Dose (lbs)	Settled Turbidity (NTU)	Average Sedimentation Basin Solids Removed (lbs/month)	lbs/month from Alum	lbs/month from Turbidity	% from alum	% from turbidity
Jul-08	808	14.7	210,322	1.1	211,700	92,542	119,158	44%	56%
Aug-08	825	6.7	181,804	1.0	130,900	79,994	50,906	61%	39%
Sep-08	887	4.4	297,456	0.7	166,900	130,880	36,020	78%	22%
Oct-08	816	3.8	270,518	0.6	147,300	119,028	28,272	81%	19%
Nov-08	488	2.9	166,619	0.4	86,600	73,312	13,288	85%	15%
Dec-08	317	2.9	114,326	0.5	58,500	50,303	8,197	86%	14%
Jan-09	413	3.1	175,471	0.6	88,400	77,207	11,193	87%	13%
Feb-09	257	5.7	110,646	0.8	62,200	48,684	13,516	78%	22%
Mar-09	427	10	190,208	1.1	124,800	83,692	41,108	67%	33%
Apr-09	571	6.4	193,288	0.9	119,300	85,047	34,253	71%	29%
May-09	697	7.6	248,016	1.0	159,000	109,127	49,873	69%	31%
Jun-09	787	6	394,525	0.9	217,300	173,591	43,709	80%	20%
Average	608	6	212767	1	131075	93617	37458	74%	26%

Facilities, Policies and Actions Required to Obtain Water Quality Benefits

In order to achieve the benefits described herein, all of the following project components must be constructed. Project components include:

- Installation of the flood isolation structure
- Completion of pipe installation
- Completion of Dutch Slough Tidal Marsh Restoration Project

Potential Adverse Effects

No adverse water quality effects are projected to result from project implementation.

Without-Project Conditions

Without the Project, historic salinity levels would be expected to continue to rise as climate change and sea level rise exacerbates saline intrusion in the groundwater basin. Completion of the Dutch Slough Tidal Marsh Restoration Project prior to the completion of the Project would also increase the degradation in the Canal including the amount of bromide that seeps into the Canal from groundwater. As such, disinfection byproducts and electrical conductivity would also be expected to increase over time. In addition, cattle would continue to wade in the Canal, exacerbating berm erosion, increasing risk of failure and associated flooding, and degrading water quality for 500,000 end users.

Environmental Benefits

Background

Ecosystem restoration and habitat protection are linked to protecting the water quality and water supply reliability in East County. Protecting Delta water quality protects source water for the region and improves ecosystem habitat for the Delta's aquatic species while also protecting them from the harmful impacts of degraded water quality. Promoting the recovery of the Delta's endangered fish species improves water supply reliability by reducing regulatory conflicts between the legal requirements to protect endangered species and project operations to divert water from the Delta and. Tidal wetland and riparian restoration projects can sometimes create habitat for endangered species while at the same time reducing the amount of polluted runoff flowing into the Delta – a win for water quality, endangered species, and water supply reliability.

The Project will protect natural resources of the Delta and promote habitat restoration for sensitive species. Although construction of the full Project is not complete, the mitigation for the full Project is complete. CCWD purchased 47 acres of wetland and 98 acres of upland habitat as mitigation for the full Project. These lands provide habitat for species of concern such as Delta smelt, longfin smelt and the giant garter snake. Completion of the full Project will also promote the completion of the Department of Water Resources' (DWR's) Dutch Slough Tidal Marsh Restoration Project. DWR's Dutch Slough Tidal Marsh Restoration Project will restore a tidal wetland just to the north of the Project. The Project is a critical early action to improve the ecosystem health of the Sacramento-San Joaquin Delta. Completion of DWR's Dutch Slough Tidal Marsh Restoration Project is legislatively mandated (SBX7-1 Section 85085) and dependent on the construction of 11,000 ft of the pipeline adjacent to the Dutch Slough project site.

Expected Benefits and Methods Used to Develop Estimates

This Project is expected to yield the following environmental benefits:

ENV1: Enabled Completion of Dutch Slough Tidal Marsh Restoration Project
ENV2: Reduction in Herbicide Treatment of Unlined Canal

Estimated benefits and methods for developing these estimates are provided below.

ENV1: Enabled Completion of Dutch Slough Tidal Marsh Restoration Project

Encasing the unlined Canal is a critical step for the completion of DWR's Dutch Slough Tidal Marsh Restoration Project, a tidal wetland restoration site just north of the Canal. DWR's Dutch Slough Tidal Marsh Restoration Project cannot move forward as planned until the Canal is replaced by a pipeline through this area. As specified in Mitigation term 3.1.1-5 of the Dutch Slough EIR Mitigation Monitoring and Reporting Program, "To avoid potential negative impacts to water quality within the Canal from groundwater intrusion, breaching of the Dutch Slough project site will not commence until encasement of the Canal south of the site is complete."

DWR's Dutch Slough Tidal Marsh Restoration Project, in the City of Oakley, is situated at a location and elevation which offer the only opportunity for an immediate and major tidal marsh restoration and research program in the western Delta. The 1,200 acre site is currently is the process of restoring over six miles of shoreline and a mosaic of tidal, riparian, and upland habitats. The resulting restored habitats will provide enhanced western Delta habitat for fish and wildlife. The unique site topography which is relatively unsubsided provides for immediate restoration of intertidal dendritic channels favored by native fish including threatened spring run Chinook salmon, endangered winter run Chinook salmon, and Sacramento splittail. The habitat restoration in the upland sites will allow for the development of riparian forest and shaded riverine habitats.

DWR's Dutch Slough Tidal Marsh Restoration Project is expected to provide important benefits to the larger Delta ecosystem. Numerous planning processes, including the Delta Vision Strategic Plan, the CALFED Ecosystem Restoration Plan, and the Bay Delta Conservation Plan, have identified restoring tidal marsh as integral to restoring the health of the Bay-Delta Ecosystem.

Encasing the unlined Canal is a critical step for the completion of DWR's Dutch Slough Tidal Marsh Restoration Project, a tidal wetland restoration site just north of the Canal. DWR's Dutch Slough Tidal Marsh Restoration Project cannot move forward as planned until the Canal is replaced by a pipeline through this area. As specified in Mitigation term 3.1.1-5 of the Dutch Slough EIR Mitigation Monitoring and Reporting Program, "To avoid potential negative impacts to water quality within the Canal from groundwater intrusion, breaching of the Dutch Slough project site will not commence until encasement of the Canal south of the site is complete."

It has been assumed that the full value of the Dutch Slough Project will be realized approximately five years following completion of the pipeline, or in 2023. Without available funding to support replacement of the unlined Canal, the Dutch Slough Project would face substantial delays. It is assumed that, without expeditious completion of the proposed Project, the Dutch Slough project would not be implemented until 2033[16], which represents a ten-year delay. As such, implementation of the proposed Project would prevent a ten-year delay of environmental benefits posed by the Dutch Slough Tidal Marsh Restoration Project.

ENV2: Reduction in Herbicide Treatment of Unlined Canal

Figure 7-5 above shows the excessive amount of submerged aquatic vegetation that grows along the Canal. The vegetation can become so dense that it becomes difficult to operate the rakes on the Rock Slough Fish screen and restricts water flow through the Canal such that the pumps at PP1 cannot maintain a sufficient head and shut down to avoid cavitation. CCWD currently has a permit to treat submerged aquatic vegetation in the Canal using Sonar. The US Fish and Wildlife Service (USFWS) has approved CCWD to apply the herbicide Sonar annually at 20 ug/L in the Canal. Encasement of the unlined canal would eliminate photosynthetic plant growth, and thereby eliminate the need for this herbicide application.

Facilities, Policies and Actions Required to Environmental Benefits

In order to achieve the benefits described herein, all of the following project components must be constructed. Project components include:

- Installation of the flood isolation structure

[16] CCWD assumes that the Canal must be replaced before DWR implements the Tidal Restoration Project. Proposition 1E Round 2 is the last known grant funding opportunity that CCWD is aware of that is of sufficient size to allow the District to fully pipe the area adjacent to the Dutch Slough Tidal Restoration Project. It is assumed that if CCWD does not obtain Proposition 1E Round 2 grant funding to support work adjacent to the Dutch Slough Tidal Restoration Project, the Dutch Slough Tidal Marsh Restoration would be delayed from 2018 to 2028 (ten years) and the new Dutch Slough wetlands would not be successfully completed until 2033.

- Completion of pipe installation
- Implementation of Dutch Slough Tidal Marsh Restoration Project

Potential Adverse Effects

Temporary construction impacts to environmental resources are expected from pipeline construction. All environmental impacts will be fully mitigated.

Without-Project Conditions

Without the Project, DWR's Dutch Slough Tidal Marsh Restoration Project would not be able to proceed and 1,200 acres of tidal marsh habitat would not be restored. CCWD would continue to apply the herbicide Sonar annually at 20 ug/L in the Canal.

Energy Benefits

Background

The vast majority of CCWD's greenhouse gas (GHG) emissions are from indirect electricity purchases. These emissions account for approximately 90% of all CCWD GHG emissions. Mobile combustion accounts for approximately 8% of remaining emissions district wide, with the remainder of emissions (<2%) from stationary combustion of natural gas in district buildings. CCWD purchases power from Pacific Gas & Electric (PG&E) and Modesto Irrigation District (MID). The energy portfolio of each of these companies varies. Emissions factors associated with each of these power sources were obtained from California Climate Registry and are listed in Table 7-11.

Table 7-11: Emissions By Energy Supplier (lbs / MWh)[17]

	Energy Supplier	
Pollutant	**MID**	**PG&E**
SO2	0.0392	0.0032
NOx	0.1276	0.0788
CO2	942.88	444.64
CH4	0.01824	0.00053
N2O	0.00194	0.00005

Expected Benefits and Methods Used to Develop Estimates

This Project is expected to yield the following energy-related benefits:

ERG1: Energy Reduction
ERG2: Greenhouse Gas Emission Reduction

Estimated benefits and methods for developing these estimates are provided below.

[17] http://www.theclimateregistry.org/resources/protocols/general-reporting-protocol/

ERG1: Energy Reduction

As mentioned above, CCWD operates four Delta intakes as well as the Los Vaqueros Reservoir. Each intake and the reservoir utilize a different combination of power suppliers depending on a variety of factors including water rights, location, power scheduling, time of day of use, etc. Implementing the Project will alter CCWD's operations by shifting more pumping to Pumping Plant 1 away from Old and Middle River Intakes, and requiring fewer releases from Los Vaqueros Reservoir. These changes in operations will reduce CCWD's overall energy requirements and consequently reduce greenhouse gas emissions associated with raw water operations.

To calculate the energy reduction that would be achieved by implementing the Project, the daily operations model was run from 1999 through 2007 as described above in the water supply section[18]. Modeling results are attached. CCWD estimates that the energy savings derived from pipeline-related improvements to water quality will amount to 490 MWH per year.

ERG2: Greenhouse Gas Emission Reduction

The energy savings described above will generate a 460,000 pound-per-year reduction in CO_2 emissions. Table 7-12 below shows the reduction in emissions of CO_2 as well as other GHGs.

Table 7-12: GHG Emissions With- and Without-Project

	Average Power Use CVP All Intakes MWh/yr	Average Power Use MID All Intakes MWh/yr	Average Power Use PG&E All Intake MWh/yr	Total CO2 Emissions [lbs/yr]	Total SO2 Emissions [lbs/yr]	Total NOx Emissions [lbs/yr]	Total CH4 Emissions [lbs/yr]	Total N2O Emissions [lbs/yr]
Without Encasement	19,325	10,093	8,377	13,241,573	422	1,948	189	20
With Encasement	19,324	9,605	8,376	12,781,105	403	1,886	180	19
Reduction in Energy & Greenhouse Gas Emissions	**1**	**488**	**1**	**460,468**	**19**	**62**	**9**	**1**

Facilities, Policies and Actions Required to Obtain Energy Benefits

In order to achieve the benefits described herein, all of the following project components must be constructed. Project components include:

- Installation of the flood isolation structure
- Completion of pipe installation
- Completion of Dutch Slough Tidal Marsh Restoration Project
- Completion of pipe installation

[18] Contra Costa Water District Daily Operations Model (WRSEL based linear program). Los Vaqueros Expansion Model Documentation. Technical Memorandum. MBK Engineers. November 3, 2010.

Potential Adverse Effects

Only temporary, construction-related energy impacts are projected to result from project implementation. All impacts will be fully mitigated.

Without-Project Conditions

Without the Project, CCWD will continue to require an additional 490 MWH per year, and will produce an additional 460 thousand pounds of CO_2 equivalents, for raw water operations and conveyance.

Other Benefits

Background

Currently, the open Canal presents a risk for drowning or other accidents. This is of particular concern because the area is being developed rapidly for residential use, with up to 8,000 homes planned for the area and 25,000 residents. Enclosing the Canal will completely eliminate this risk.

Expected Benefits and Methods Used to Develop Estimates

This Project is expected to yield the following other benefits:

OTH1: Reduced Security Risk

Estimated benefits and methods for developing these estimates are provided below.

OTH1: Reduced Drowning Risk

According to CCWD's records, there have been a total of 70 drownings in the Canal since 1942 (70 drownings over 69 years). The accuracy of older records is uncertain, but records kept since 1972 indicate a total of at least 24 drownings have occurred in recent history (24 drownings over 39 years). This past history indicates a risk of at least 24 fatalities in 39 years, and possibly as many as 70 fatalities in 69 years. To be conservative, we have applied an average risk of 62 percent (24 / 39) that a drowning will occur in any given year. Enclosing the Canal in a pipeline will eliminate this risk.

In addition, the open Canal presents a security risk. To offset this risk, CCWD currently patrols the Canal. Replacing the open Canal with a pipeline will greatly reduce the need to patrol the Canal.

Facilities, Policies and Actions Required to Obtain Energy Benefits

In order to achieve the benefits described herein, all of the following project components must be constructed. Project components include:

- Installation of the flood isolation structure
- Completion of pipe installation

Potential Adverse Effects

No adverse public health and safety-related impacts are expected to result from project implementation.

Without-Project Conditions

Without the Project, average annual risk of drowning will remain at 62 percent.

Uncertainty of Benefits

The following uncertainties could potentially affect the projected benefits described herein.

Table 7-13: Uncertainty of Benefits

Uncertainty	Description	Potential Impact on Benefits
Probability of Canal Failure	Future flood probability assumed to be similar to historical flooding, based on flood frequency curves developed by the U.S. Army Corps of Engineers at nearby gage stations to determine the return interval of water surface levels during events when there was historical damage.	Climate change predicts an increase in occurrence of extreme precipitation events; this would increase annual probability of failure.
Flood damages	Fairly conservative assumptions were used to estimate the value of the combined assets at risk, the probability of levee failure over the coming 100 years, and the extent of damage in the event of a breach. Whether these assumptions lead to an over- or under-estimate of expected damages is unknown.	Under- or over-estimate of groundwater recharge rates could result in an under- or over-estimate of projected flood damage reduction benefits.
Reduced cancer risk from reduced bromate concentrations	The amount by which bromide in source waters will be reduced, and the amount of bromate reduction realized in tap waters, is uncertain. There also are uncertainties regarding the quantified cancer risk assessment and valuation of the avoided cases using VSL. In addition, there may be other DBP reductions associated with the improved source water quality that are omitted from the benefits analysis.	Under- or over-estimate of groundwater recharge rates could result in an under- or over-estimate of projected water quality benefits.

Annual Project Physical Benefits

The following tables present the annual project benefits for each of the different physical benefits claimed for the Contra Costa Canal Flood Protection and Levee Elimination Project. These tables are modeled after Table 7 of the PSP.

Quantified Annual Benefit FD1: Residential and Commercial Structure and Content Damage

Table 7-1a – Annual Project Physical Benefits			
Project Name: Contra Costa Canal Levee Elimination and Flood Protection Project			
Type of Benefit Claimed: FD1: Average Number of Residential Structures Protected from Flooding Per Year			
Measure of Benefit Claimed (Name of Units): Number of Structures Per Year			
Additional Information About this Measure: Average annual benefit calculated as shown in Table 7-1b below.			
(a)	(b)	(c)	(d)
	Physical Benefits		
Year	Without Project	With Project	Change Resulting from Project (b) – (c)
2018-2117	170	32	138
Last Year of Project Life			
Comments: This benefit is only realized in the event of a flood. To calculate the average annual benefit, the degree of benefit for four hydrologic events was assessed, as shown in Table 7-1b. In actuality, the benefit would either not be realized (if no flooding occurs), or a greater benefit than that shown here would be achieved (dependent on the severity of flooding and difference between with- and without-Project conditions).			

Table 7-1b – Example Calculation of Expected Annual Damage												
Hydrologic Event	Event Exceed. Prob.	Number of Structures Damaged if Flood Structures Fail	Probability Structural Failure		Expected Event Damage		Interval Prob.	Average Damage in Interval		Average Damage in Interval times Interval Probability	
			w/o	w/	w/o	w/		w/o	w/	w/o	w/
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(i)	(j)	(k)	(l)	(m)
25-year	0.04	6,169	0.33	0	2,036	0					
50-year	0.02	6,189	0.75	0	4,642	0	0.02	3,339	0	67	0
100-year	0.01	6,259	0.85	0	5,320	0	0.01	4,981	0	50	0
500-year	0.002	7,971	1	1	7,971	7,971	0.008	6,646	3,986	53	32
Expected Annual Damages, Without and With Project										170	32

Quantified Annual Benefit FD2: Loss of Agricultural Land Production

Table 7-2a – Annual Project Physical Benefits			
Project Name: Contra Costa Canal Levee Elimination and Flood Protection Project			
Type of Benefit Claimed: FD2: Acres of Farmland Inundated			
Measure of Benefit Claimed (Name of Units): Acres Inundated per Year			
Additional Information About this Measure: Average annual benefit calculated as shown in Table 7-1b below.			
(a)	(b)	(c)	(d)
	Physical Benefits		
Year	Without Project	With Project	Change Resulting from Project (b) – (c)
2018-2117	18	4	14
Last Year of Project Life			
Comments: This benefit is only realized in the event of a flood. To calculate the average annual benefit, the degree of benefit for four hydrologic events was assessed, as shown in Table 7-2b. In actuality, the benefit would either not be realized (if no flooding occurs), or a greater benefit than that shown here would be achieved (dependent on the severity of flooding and difference between with- and without-Project conditions).			

Table 7-2b – Example Calculation of Expected Annual Damage											
Hydrologic Event	Event Exceed. Prob.	Acres Inundated if Flood Structures Fail	Probability Structural Failure		Expected Event Damage		Interval Prob.	Average Damage in Interval		Average Damage in Interval times Interval Probability	
			w/o	w/	w/o	w/		w/o	w/	w/o	w/
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(i)	(a)	(b)	(c)	(d)
25-year	0.04	257	0.33	0	85	0					
50-year	0.02	561	0.75	0	421	0	0.02	253	0	5	0
100-year	0.01	872	0.85	0	741	0	0.01	581	0	6	0
500-year	0.002	1,030	1	1	1,030	1,030	0.008	886	515	7	4
Expected Annual Damages, Without and With Project										18	4

Quantified Annual Benefit FD3: Loss of Gas Production

Table 7-3a – Annual Project Physical Benefits			
Project Name: Contra Costa Canal Levee Elimination and Flood Protection Project			
Type of Benefit Claimed: FD3: Loss of Gas Production			
Measure of Benefit Claimed (Name of Units): Acres Inundated per Year			
Additional Information About this Measure: Average annual benefit calculated as shown in Table 7-1b below.			
(a)	(b)	(c)	(d)
	Physical Benefits		
Year	Without Project	With Project	Change Resulting from Project (b) – (c)
2018-2117	764	121	644
Last Year of Project Life			
Comments: This benefit is only realized in the event of a flood. To calculate the average annual benefit, the degree of benefit for four hydrologic events was assessed, as shown in Table 7-3b. In actuality, the benefit would either not be realized (if no flooding occurs), or a greater benefit than that shown here would be achieved (dependent on the severity of flooding and difference between with- and without-Project conditions).			

Table 7-3b – Example Calculation of Expected Annual Damage											
Hydrologic Event	Event Exceed. Prob.	Gas Production Lost if Flood Structures Fail	Probability Structural Failure		Expected Event Damage		Interval Prob.	Average Damage in Interval		Average Damage in Interval times Interval Probability	
			w/o	w/	w/o	w/		w/o	w/	w/o	w/
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(i)	(j)	(k)	(l)	(m)
25-year	0.04	22,596	0.33	0	7,457	0					
50-year	0.02	30,128	0.75	0	22,596	0	0.02	15,026	0	301	0
100-year	0.01	30,128	0.85	0	25,609	0	0.01	24,102	0	241	0
500-year	0.002	30,128	1	1	30,128	30,128	0.008	27,868	15,064	223	121
Expected Annual Damages, Without and With Project										764	121

Quantified Annual Benefit FD4: Damage to Dutch Slough Property

Table 7-4a – Annual Project Physical Benefits			
Project Name: Contra Costa Canal Levee Elimination and Flood Protection Project			
Type of Benefit Claimed: FD4: Acres of Dutch Slough Property Inundated			
Measure of Benefit Claimed (Name of Units): Acres Inundated per Year			
Additional Information About this Measure: Average annual benefit calculated as shown in Table 7-1b below.			
(a)	(b)	(c)	(d)
	Physical Benefits		
Year	Without Project	With Project	Change Resulting from Project (b) – (c)
2018-2117	31	5	27
Last Year of Project Life			

Comments: This benefit is only realized in the event of a flood. To calculate the average annual benefit, the degree of benefit for four hydrologic events was assessed, as shown in Table 7-4b. In actuality, the benefit would either not be realized (if no flooding occurs), or a greater benefit than that shown here would be achieved (dependent on the severity of flooding and difference between with- and without-Project conditions).

Table 7-4b – Example Calculation of Expected Annual Damage

Hydrologic Event	Event Exceed. Prob.	Acres Inundated if Flood Structures Fail	Probability Structural Failure		Expected Event Damage		Interval Prob.	Average Damage in Interval		Average Damage in Interval times Interval Probability	
			w/o	w/	w/o	w/		w/o	w/	w/o	w/
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(i)	(j)	(k)	(l)	(m)
25-year	0.04	1,200	0.33	0	396	0					
50-year	0.02	1,200	0.75	0	900	0	0.02	648	0	13	0
100-year	0.01	1,200	0.85	0	1,020	0	0.01	960	0	10	0
500-year	0.002	1,200	1	1	1,200	1,200	0.008	1,110	600	9	5
Expected Annual Damages, Without and With Project										31	5

Quantified Annual Benefit FD5: Road Inundation

Table 7-5a – Annual Project Physical Benefits Project Name: Contra Costa Canal Levee Elimination and Flood Protection Project			
Type of Benefit Claimed: FD5: Roads Inundated			
Measure of Benefit Claimed (Name of Units): Miles Inundated per Year			
Additional Information About this Measure: Average annual benefit calculated as shown in Table below.			
(a)	(b)	(c)	(d)
	Physical Benefits		
Year	Without Project	With Project	Change Resulting from Project (b) – (c)
2018-2117	1	0	1
Last Year of Project Life			
Comments: This benefit is only realized in the event of a flood. To calculate the average annual benefit, the degree of benefit for four hydrologic events was assessed, as shown in Table 7-5b. In actuality, the benefit would either not be realized (if no flooding occurs), or a greater benefit than that shown here would be achieved (dependent on the severity of flooding and difference between with- and without-Project conditions).			

Table 7-5b – Example Calculation of Expected Annual Damage											
Hydrologic Event	Event Exceed. Prob.	Miles Inundated if Flood Structures Fail	Probability Structural Failure		Expected Event Damage		Interval Prob.	Average Damage in Interval		Average Damage in Interval times Interval Probability	
			w/o	w/	w/o	w/		w/o	w/	w/o	w/
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(i)	(j)	(k)	(l)	(m)
25-year	0.04	23	0.33	0	8	0					
50-year	0.02	28	0.75	0	21	0	0.02	14	0	0	0
100-year	0.01	37	0.85	0	31	0	0.01	26	0	0	0
500-year	0.002	43	1	1	43	43	0.008	37	22	0	0
Expected Annual Damages, Without and With Project										1	0

Quantified Annual Benefit FD6: Emergency Response Requirements

Table 7-6a – Annual Project Physical Benefits Project Name: Contra Costa Canal Levee Elimination and Flood Protection Project			
Type of Benefit Claimed: FD6: Time to Respond to a 50' Levee Breach			
Measure of Benefit Claimed (Name of Units): Days per Year			
Additional Information About this Measure: Average annual benefit calculated as shown in Table below.			
(a)	(b)	(c)	(d)
	Physical Benefits		
Year	Without Project	With Project	Change Resulting from Project (b) – (c)
2018-2117	1	0	0
Last Year of Project Life			
Comments: This benefit is only realized in the event of a flood. To calculate the average annual benefit, the degree of benefit for four hydrologic events was assessed, as shown in Table 7-6b. In actuality, the benefit would either not be realized (if no flooding occurs), or a greater benefit than that shown here would be achieved (dependent on the severity of flooding and difference between with- and without-Project conditions).			

Table 7-6b – Example Calculation of Expected Annual Damage											
Hydrologic Event	Event Exceed. Prob.	Days Required to Respond to a 50' Breach if Flood Structures Fail	Probability Structural Failure		Expected Event Damage		Interval Prob.	Average Damage in Interval		Average Damage in Interval times Interval Probability	
			w/o	w/	w/o	w/		w/o	w/	w/o	w/
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(i)	(j)	(k)	(l)	(m)
25-year	0.04	20	0.33	0	7	0					
50-year	0.02	20	0.75	0	15	0	0.02	11	0	0	0
100-year	0.01	20	0.85	0	17	0	0.01	16	0	0	0
500-year	0.002	20	1	1	20	20	0.008	19	10	0	0
Expected Annual Damages, Without and With Project										1	0

Quantified Annual Benefit FD7: Supply Replacement Needs

Table 7-7a – Annual Project Physical Benefits			
Project Name: Contra Costa Canal Levee Elimination and Flood Protection Project			
Type of Benefit Claimed: FD7: Supply Replacement Needs			
Measure of Benefit Claimed (Name of Units): Average AFY			
Additional Information About this Measure: Average annual benefit calculated as shown in Table below.			
(a)	(b)	(c)	(d)
	Physical Benefits		
Year	Without Project	With Project	Change Resulting from Project (b) – (c)
2018-2117	122	19	103
Last Year of Project Life			
Comments: This benefit is only realized in the event of a flood. To calculate the average annual benefit, the degree of benefit for four hydrologic events was assessed, as shown in Table 7-7b. In actuality, the benefit would either not be realized (if no flooding occurs), or a greater benefit than that shown here would be achieved (dependent on the severity of flooding and difference between with- and without-Project conditions).			

Table 7-7b – Example Calculation of Expected Annual Damage											
Hydrologic Event	Event Exceed. Prob.	Supply Replacement Needed if Flood Structures Fail	Probability Structural Failure		Expected Event Damage		Interval Prob.	Average Damage in Interval		Average Damage in Interval times Interval Probability	
			w/o	w/	w/o	w/		w/o	w/	w/o	w/
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(i)	(j)	(k)	(l)	(m)
25-year	0.04	4,658	0.33	0	1,537	0					
50-year	0.02	4,658	0.75	0	3,494	0	0.02	2,515	0	50	0
100-year	0.01	4,658	0.85	0	3,959	0	0.01	3,726	0	37	0
500-year	0.002	4,658	1	1	4,658	4,658	0.008	4,309	2,329	34	19

Quantified Annual Benefit WS1: Increase in emergency water supply available for CCWD customers and partners

Table 7-8 – Annual Project Physical Benefits Project Name: Contra Costa Canal Levee Elimination and Flood Protection Project			
Type of Benefit Claimed: WS1: Increase in Emergency Supply			
Measure of Benefit Claimed (Name of Units): Average AFY			
Additional Information About this Measure: Benefit realized in all years.			
(a)	(b)	(c)	(d)
	Physical Benefits		
Year	Without Project	With Project	Change Resulting from Project (b) – (c)
2018-2117	0	400	400
Last Year of Project Life			
Comments:			

Quantified Annual Benefit WS2: CVP/SWP water savings from upstream reservoirs that would otherwise be released to meet state water quality regulations as measured at the downstream end of the Canal

Table 7-9 – Annual Project Physical Benefits Project Name: Contra Costa Canal Levee Elimination and Flood Protection Project			
Type of Benefit Claimed: WS2: Reduced Salinity-Driven CVP/SWP Releases / CVP/SWP Water Conserved			
Measure of Benefit Claimed (Name of Units): Average AFY			
Additional Information About this Measure: Benefit realized in all years.			
(a)	(b)	(c)	(d)
	Physical Benefits		
Year	Without Project	With Project	Change Resulting from Project (b) – (c)
2018-2117	0	17,000	17,000
Last Year of Project Life			
Comments:			

Quantified Annual Benefit WS3: CVP/SWP operational flexibility when regulations limit Old and Middle River flows

Table 7-10 – Annual Project Physical Benefits Project Name: Contra Costa Canal Levee Elimination and Flood Protection Project			
Type of Benefit Claimed: WS3: Reduced CVP/SWP Releases due to OMR Restrictions			
Measure of Benefit Claimed (Name of Units): Average AFY			
Additional Information About this Measure: Benefit realized in all years.			
(a)	(b)	(c)	(d)
	Physical Benefits		
Year	Without Project	With Project	Change Resulting from Project (b) – (c)
2018-2117	0	5,700	5,700
Last Year of Project Life			
Comments:			

Quantified Annual Benefit WQ1: Reduced Levels of DBPs in Drinking Water

Table 7-11 – Annual Project Physical Benefits Project Name: Contra Costa Canal Levee Elimination and Flood Protection Project			
Type of Benefit Claimed: WQ1: Reduced Levels of DBPs in Drinking Water			
Measure of Benefit Claimed (Name of Units): Reduction in Excess Bromate-Related Cancer Cases/Year			
Additional Information About this Measure: Benefit realized in all years.			
(a)	(b)	(c)	(d)
	Physical Benefits		
Year	Without Project	With Project	Change Resulting from Project (b) – (c)
2018-2117	0	0.1	0.1
Last Year of Project Life			
Comments:			

Quantified Annual Benefit WQ2: Decreased Agricultural Runoff from Adjacent Fields (not monetized)
Not quantified

Quantified Annual Benefit WQ3: Decreased Risk in Fecal Borne Pathogens Transported into the Canal
Not quantified

Quantified Annual Benefit WQ4: Decreased Turbidity and Associated Solids Handling Requirements

Table 7-12 – Annual Project Physical Benefits Project Name: Contra Costa Canal Levee Elimination and Flood Protection Project			
Type of Benefit Claimed: WQ4: Reduced Solids Handling Needs			
Measure of Benefit Claimed (Name of Units): Percent Reduction in Annual Solids Handling Requirements			
Additional Information About this Measure: Benefit realized in all years.			
(a)	(b)	(c)	(d)
	Physical Benefits		
Year	Without Project	With Project	Change Resulting from Project (b) – (c)
2018-2117	0	0.8%	0.8%
Last Year of Project Life			
Comments:			

Quantified Annual Benefit ENV1: Enabled Completion of Dutch Slough Tidal Marsh Restoration Project

Table 7-13 – Annual Project Physical Benefits Project Name: Contra Costa Canal Levee Elimination and Flood Protection Project			
Type of Benefit Claimed: ENV1: Years by Which Dutch Slough Restoration Could be Accelerated			
Measure of Benefit Claimed (Name of Units): Years			
Additional Information About this Measure: Benefit realized in all years.			
(a)	(b)	(c)	(d)
	Physical Benefits		
Year	Without Project	With Project	Change Resulting from Project
2023	0	10	10
Last Year of Project Life			
Comments:			

Quantified Annual Benefit ENV2: Reduction in Herbicide Treatment of Unlined Canal

Table 7-14 – Annual Project Physical Benefits Project Name: Contra Costa Canal Levee Elimination and Flood Protection Project			
Type of Benefit Claimed: ENV2: Reduction in Herbicide Use			
Measure of Benefit Claimed (Name of Units): ug/L			
Additional Information About this Measure: Benefit realized in all years.			
(a)	(b)	(c)	(d)
	Physical Benefits		
Year	Without Project	With Project	Change Resulting from Project (b) – (c)
2018-2117	20	0	20
Last Year of Project Life			
Comments:			

Quantified Annual Benefit ERG1: Energy Reduction

Table 7-15 – Annual Project Physical Benefits Project Name: Contra Costa Canal Levee Elimination and Flood Protection Project			
Type of Benefit Claimed: ERG1: Reduction in Energy Use			
Measure of Benefit Claimed (Name of Units): MWH			
Additional Information About this Measure: Benefit realized in all years.			
(a)	(b)	(c)	(d)
	Physical Benefits		
Year	Without Project	With Project	Change Resulting from Project (b) – (c)
2018-2117	0	490	490
Last Year of Project Life			
Comments:			

Quantified Annual Benefit ERG2: Greenhouse Gas Emission Reduction

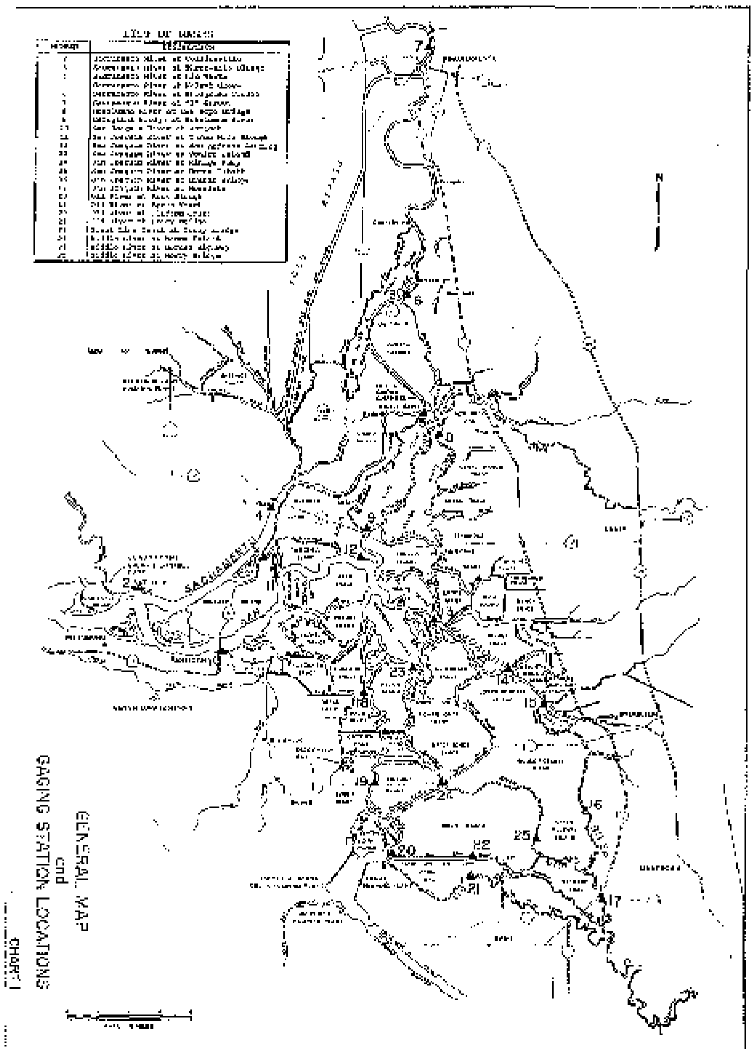
Table 7-15 – Annual Project Physical Benefits Project Name: Contra Costa Canal Levee Elimination and Flood Protection Project			
Type of Benefit Claimed: ERG2: Reduction in CO2 Equivalent Emissions			
Measure of Benefit Claimed (Name of Units): Pounds per Year			
Additional Information About this Measure: Benefit realized in all years.			
(a)	(b)	(c)	(d)
	Physical Benefits		
Year	Without Project	With Project	Change Resulting from Project (b) – (c)
2018-2117	0	460,000	460,000
Last Year of Project Life			
Comments:			

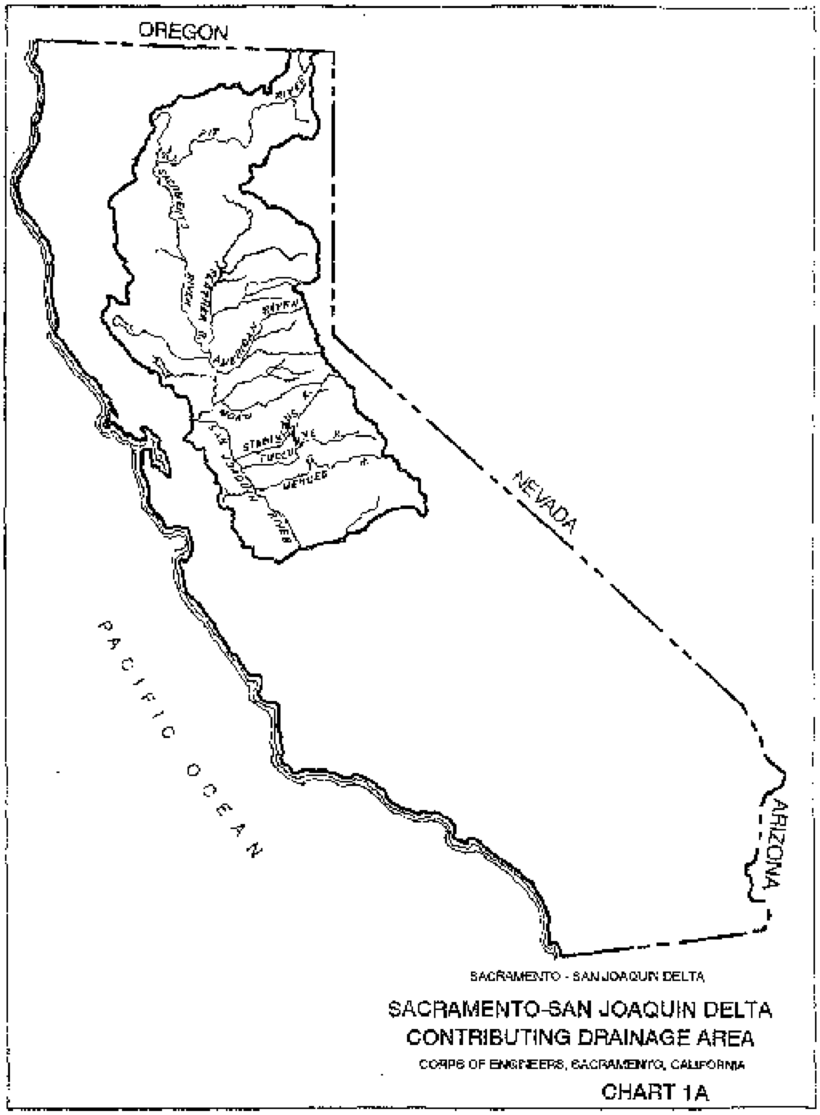
Quantified Annual Benefit OTH1: Reduced Security Risk

Table 7-16 – Annual Project Physical Benefits Project Name: Contra Costa Canal Levee Elimination and Flood Protection Project			
Type of Benefit Claimed: OTH1: Reduction in Annual Risk of Canal Drownings			
Measure of Benefit Claimed (Name of Units): % Reduction in Annual Risk			
Additional Information About this Measure: Benefit realized in all years.			
(a)	(b)	(c)	(d)
	Physical Benefits		
Year	Without Project	With Project	Change Resulting from Project (b) – (c)
2018-2117	0%	62%	62%
Last Year of Project Life			
Comments:			

Appendix 1

U.S. Army Corps of Engineers Flood Frequency Curves for River Gages in the Vicinity of the Project


GENERAL MAP
and
GAGING STATION LOCATIONS
CHART 1
SACRAMENTO
N


OREGON
NEVADA
ARIZONA
PACIFIC OCEAN
SACRAMENTO - SAN JOAQUIN DELTA
SACRAMENTO-SAN JOAQUIN DELTA
CONTRIBUTING DRAINAGE AREA
CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA
CHART 1A

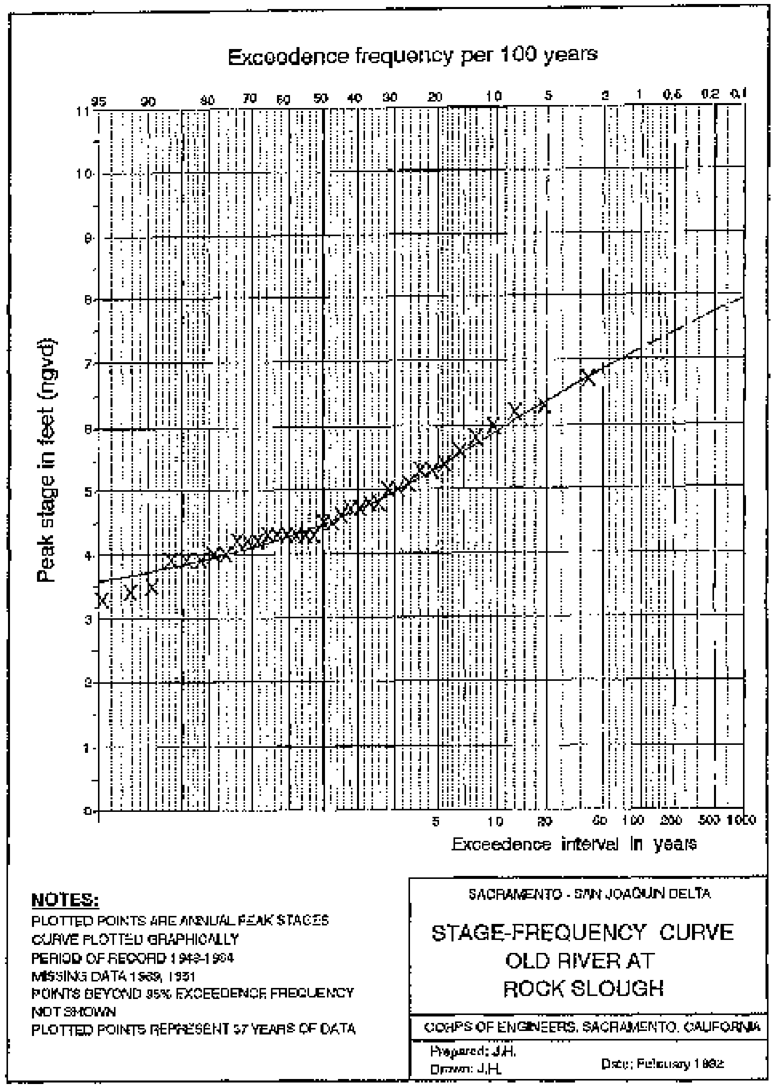
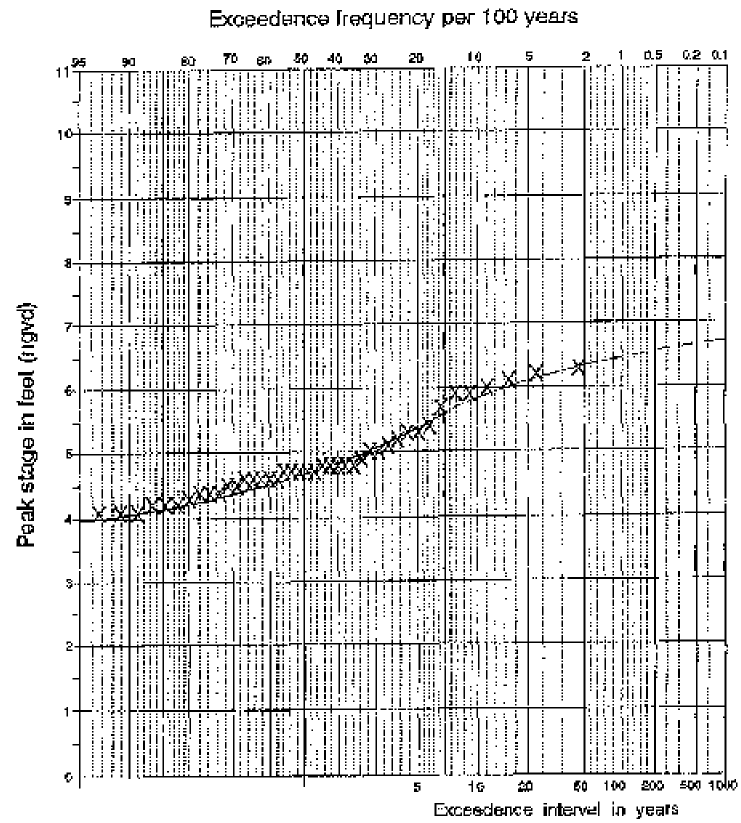

Exceedence frequency per 100 years
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
Peak stage in feet (ngvd)
0
1
2
3
4
5
6
7
8
9
10
11
5
10
20
50
100
200
500
1000
Exceedence interval in years
NOTES:
PLOTTED POINTS ARE ANNUAL PEAK STAGES
CURVE PLOTTED GRAPHICALLY
PERIOD OF RECORD
MISSING DATA
POINTS BEYOND 95% EXCEEDENCE FREQUENCY NOT SHOWN
PLOTTED POINTS REPRESENT 57 YEARS OF DATA
SACRAMENTO - SAN JOAQUIN DELTA
STAGE-FREQUENCY CURVE
OLD RIVER AT
ROCK SLOUGH
CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA
Prepared: J.H.
Drawn: J.H.
Date: February 1992

CHART 18



NOTES:
PLOTTED POINTS ARE ANNUAL PEAK STAGES
CURVE PLOTTED GRAPHICALLY
PERIOD OF RECORD 1946-1988
POINTS BEYOND 95% EXCEEDENCE FREQUENCY NOT SHOWN

SACRAMENTO - SAN JOAQUIN DELTA

STAGE FREQUENCY CURVE
SAN JOAQUIN RIVER AT ANTIOCH

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: J.H.
Drawn: J.H.
Date: February 1992

CHART 10

Appendix 2

Conceptual Cost Estimate to Repair 50 ft Canal Failure Similar to 1998 Failure

Conceptual Cost Estimate		
Repair 50' Breech Section of the Contra Costa Canal, Oakley, CA		
Initial Response and Condition Assessment		$10,000
	Mobilize; Perform emergency response and assessment of canal; Verify canal berm repair criteria. Duration: 3 days.	
Canal Isolation (Cofferdam)		$100,000
	Material procurement; Installation of cofferdam. Duration: 5 days.	
	Assumptions: - Hydrosack/sandbag cofferdam system	
Canal Berm Repair		$200,000
	Material hauling from borrow source; stockpile at site; material handling and placement for canal repair. Duration: 7 days.	
	Assumptions: - Typical Canal Berm Section (above adjacent ground): 600 square feet - Volume 50' Breech Section: 1,110 cubic yards (say 1,200 cubic yards)	
Return to Service		$50,000
	Site restoration; Removal of Cofferdam. Duration: 5 days.	
Miscellaneous		$40,000
	Contract Administration; Permits; Field Testing Services.	
Subtotal		***$400,000***
Contingency: 20%		$80,000
Subtotal		***$480,000***
Contractor Overhead, Insurance, Profit: 20%		$96,000
	Includes Emergency Response Premium (24/7 Work)	
Total		**$576,000**