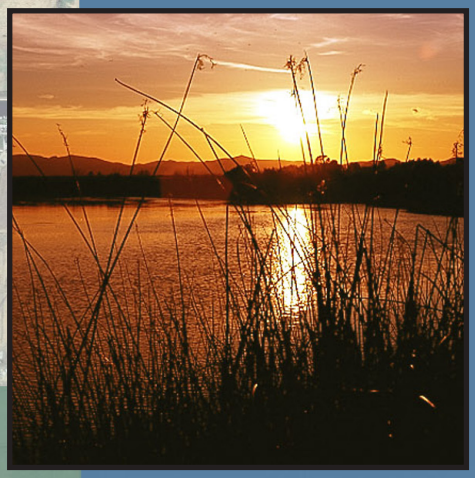

Contra Costa Water District
Proposition 1E Grant Proposal
Attachment 7

Economic Analysis - Flood Damage Reduction Costs and Benefits

1 of 2

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

ATTACHMENT 7 –
ECONOMIC ANALYSIS – FLOOD DAMAGE REDUCTION

Proposal	Page
Contra Costa Canal Levee Elimination and Flood Protection Project	7-1

This attachment describes the flood damage reduction benefits provided by the Contra Costa Canal Levee Elimination and Flood Protection Project. In accordance with the PSP, the following details are provided for the proposed project:

- ✓ Description of the project and its relationship to other projects in the proposal
- ✓ Narrative discussion of the projects expected flood reduction benefits, including:
  - o Estimates of historical flood damage
  - o Estimate of with and without-project conditions
  - o Methods used to estimate with and without-project conditions
  - o Description of the distribution of local, regional, and statewide benefits
  - o Identification of beneficiaries
  - o When benefits will be received
  - o Uncertainty of benefits
  - o Description of any adverse effects
- ✓ Narrative discussion that describes, qualifies and supports values entered in the tables
- ✓ Narrative description of the project's economic costs
- ✓ Cost details for the project
- ✓ If possible, quantified estimates of economic flood damage reduction benefits using Table 12 as applicable
- ✓ Documentation to support information presented for projects

The following sections present a quantitative and qualitative analysis of project costs and flood damage reduction benefits. Tables 10 through 13 are included at the end of this section.

Overview and Project Linkages

Contra Costa Water District's (CCWD) Canal Levee Elimination and Flood Protection Project (Project) is needed to reduce the flood risk currently posed by the Contra Costa Canal (the Canal). At least seven square miles are currently at risk of flooding if the Canal levees fail, including housing developments, roads, working farms and a tidal marsh restoration project. The full Project will replace four miles of the unlined portion of the Canal with a pipeline and eliminate eight miles of aging embankments. Phase 5 of the Project is the portion of the full Project evaluated in this grant; Phase 5 includes installing a flood isolation structure near the mouth of the Canal (Rock Slough Intake), installing 4,000 feet pipeline and

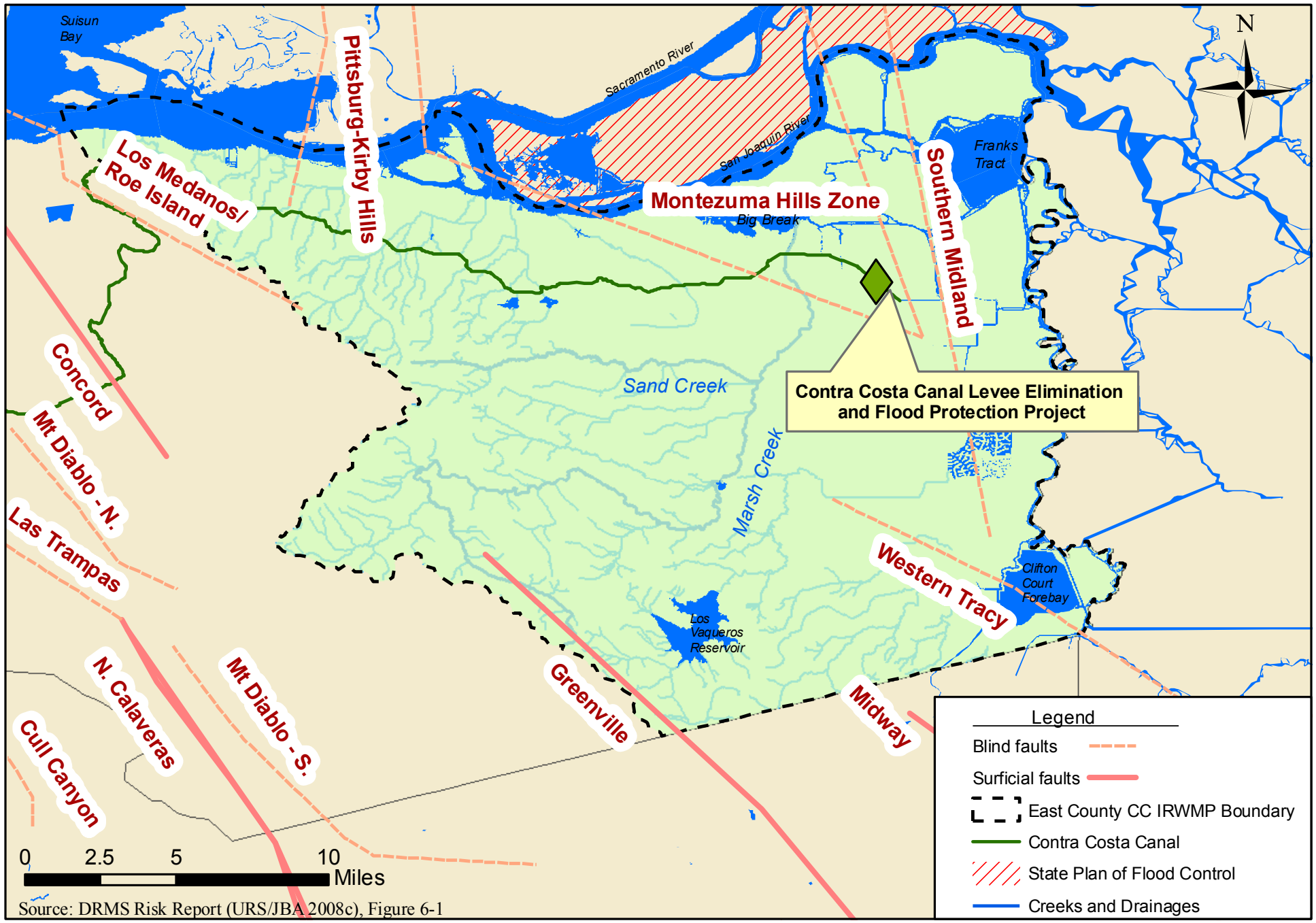
eliminating approximately 8,000 feet of levees. Phase 5 will enable CCWD to remotely isolate the Canal from the San Joaquin-Sacramento River Delta in the event of a levee breach. Other benefits of the Project include improving source water quality by preventing intrusion of saline groundwater, improving public safety by eliminating the drowning risk of the open water Canal, and improving CCWD's water supply reliability.

The Canal was developed as part of the Central Valley Project in the 1930s. The Canal is an integral part of the water delivery system for CCWD. Prior to the completion of Los Vaqueros Reservoir in 1997, the Canal supplied nearly 100 percent of the water to CCWD's service area. Since the completion of the Los Vaqueros Reservoir, the Canal transports approximately 30 percent of the annual water diverted by CCWD and is needed to supply CCWD's service area when the reservoir is being filled. Without the use of the Canal, the reservoir must release more water to meet demand and the time to refill the reservoir increases substantially, leading to an overall decrease in water supply reliability.

According to a 1997 CCWD report on seismic risk and reliability of CCWD's complete distribution system, the unlined portion of the Canal was one of the least reliable portions of the system due to potential soil liquefaction and power outages at Pump Plant #1. The Los Vaqueros Reservoir and new intake facilities are more reliable than the Canal, and consequently, encasing the Canal has been part of CCWD's long-term capital improvements program.

The Canal levees are in poor condition; they are not designed to provide flood protection and are not seismically sound. The Canal levees are unconsolidated dredging spoils from the original construction. A geotechnical report done in 2000 indicated that the static factor of safety along the Canal was 1.2, at least 10 percent less than the recommended short-term static factor of safety and at least 25 percent less than the recommended long-term static factor of safety. The static factor of safety decreases as water level in the Canal increases, indicating high risk of failure associated with high tides in wet conditions. This finding has been confirmed by field experience when levees often slough and slump after high water events or extended rain (e.g., this occurred in 1996, 1997, 1998, 2006, 2009). The historical geotechnical investigations of the Canal system have indicated that the levees in the unlined portion of the Canal and the foundation are highly prone to liquefaction in the event of an earthquake (Seismic Reliability Improvements Project 1997, Geotechnical Engineering Report Intake Channel Levees Contra Costa Canal 2000, Geotechnical Engineering Investigation Contra Costa Water District Canal Replacement Project 2007).

Figure 7-1 on the following page shows the location of the Project in relation to active faults in the area. Figure 7-2 illustrates the potential impact associated with failure of northern and southern Canal levees following a major seismic event. As shown in Figure 7-2, failure of the Canal levees due to a storm or seismic event could inundate many acres of adjacent land, including 540 homes, working farms, an active gas well, and the Department of Water Resources' (DWR's) Dutch Slough Tidal Marsh Restoration Project (an ecosystem restoration project). In addition, 680 homes that are currently surrounded by levees would be isolated. The Canal levees are not engineered for flood protection, but are simple earthen berms. As a result, once a failure begins, it is likely that the remaining berms would experience washout, and the result could be catastrophic.



Source: DRMS Risk Report (URS/JBA 2008c), Figure 6-1

Figure 7-1: Regional Map

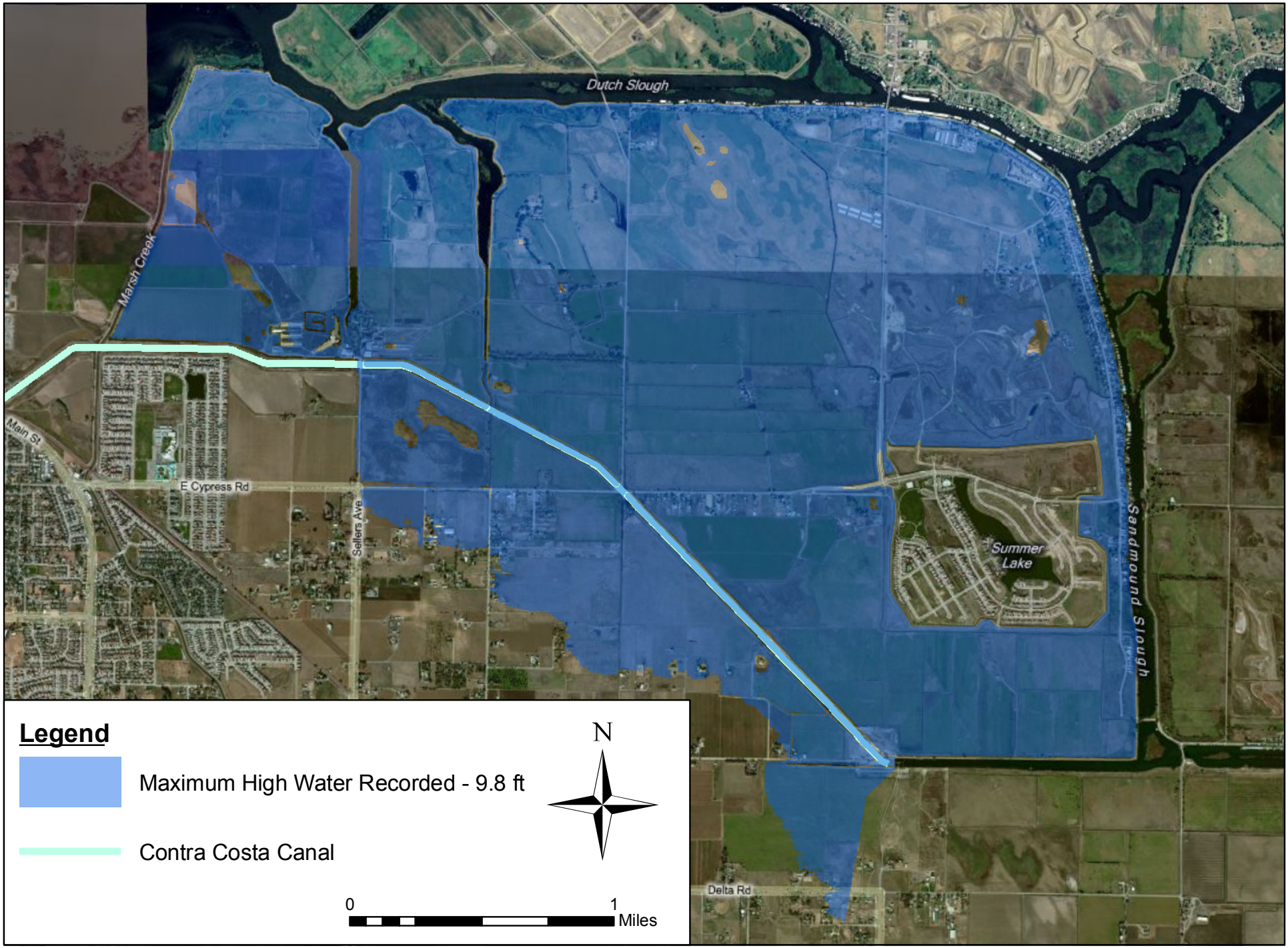


Figure 7-2: Potential Inundation Resulting from Canal Levee Failure

In addition to the property damage resulting from a levee failure, such a failure would result in loss of the Canal as a critical water supply facility for CCWD for an extended period of time. It is currently unknown how the levees would be repaired, as there would be extremely limited access following such an event. Repair and cleanup efforts would likely require several months to a year before the Canal could be repaired and service restored.

Loss of the Canal would disrupt water supply to CCWD's service area and substantially increase the cost of delivering water. In addition, the City of Brentwood currently relies on the Canal for delivery of 100 percent of its Delta supply. Catastrophic levee failure and loss of the Canal would force CCWD to find an alternate approach to delivering Brentwood's supply. This would likely result in an interruption of supply to the City of Brentwood for a period of months, during which alternate delivery arrangements would be made.

Encasing the Canal in a pipe will reduce flood risk to adjacent properties, improve water quality delivered to customers, decrease operating costs (power and treatment), decrease CO2 emissions, and increase emergency water supply availability. Until the entire Canal can be encased, the flood isolation structure at the head of the Canal will minimize the flood risk to the adjacent properties, and the extent of the pipeline constructed through this Project will provide water quality, operational, water supply and public safety benefits.

It is important to note that Phase 5 submitted in this proposal, and evaluated in this Attachment, reflects a key portion of the full Project (including the installation of a flow isolation structure), but not the entire 21,000 feet of anticipated pipeline installation to replace all of the existing Canal. To evaluate benefits, we estimated (as feasible) the value of the benefits for the full Project (because the benefits accrue from the full Project being completed), and then attributed a portion of those aggregate benefits to the specific portion of the Project that would be developed under Phase 5. At $20 M, Phase 5 represents 20.8 percent of the full $96 M Project budget; therefore, we assigned 20.8 percent of the overall water supply, water quality, and other Project benefits to this specific portion of the Project. Because Phase 5 includes installation of the flow isolation structure, all avoided flood damages from the full Project will be achieved through implementation of this component.

A summary of all benefits and costs of the Project are provided in Table 7-1. Flood damage reduction benefits are discussed in the remainder of this attachment. Project costs and water supply benefits are described in Attachment 8, and water quality and other benefits are described in Attachment 9. In several instances, the water supply and water quality benefits are highly inter-woven, and could have been placed in either of the Attachments; however we have been careful to avoid double counting. Several of the most important benefits could not be reliably quantified or monetized.

Table 7-1. Benefit-Cost Analysis Overview

	Present Value
Costs – Total Capital and O&M	$16,847,000
Monetizable Benefits	
Flood Damage Reduction	
Avoided property damage and road inundation	$33,867,000
Avoided costs associated with water supply	$3,015,000
Avoided levee repair costs	$7,553,000
Avoided lost water revenues	$140,000
Water Supply Benefits (Attachment 8)	$11,624,000
Water Quality and Other Benefits (Attachment 9)	$18,824,000
Total Monetized Benefits	$75,024,000
Qualitative Benefit or Cost	**Qualitative indicator***
Water Supply Benefits (Attachment 8)	
Improved Operational Flexibility for Contra Costa Water District	++
Water Quality and Other Benefits (Attachment 9)	+

O&M = Operations and Maintenance
* Direction and magnitude of effect on net benefits:
+ = Likely to increase net benefits relative to quantified estimates.
++ = Likely to increase net benefits significantly.
– = Likely to decrease benefits.
– – = Likely to decrease net benefits significantly.
U = Uncertain, could be + or –.

Economic Costs

Capital costs for Phase 5 of the Project amount to $20,000,000 (2009 USD), to be expended between 2011 and 2013. Once the pipeline is in place and operational (beginning 2014), $50,000 per year is anticipated to be required for routine maintenance. Over the 100-year anticipated lifetime of the pipeline, the present value costs amount to approximately $16,847,000, as shown in Table 10 at the conclusion of this section.

Estimates of Historical Flood Damage

Detailed information on historical damages incurred is currently unavailable, and the total value of residential and other properties and assets in the areas facing flood risks in the event of levee failure

along the Canal is currently unknown. However, historic levee slumping and overtopping events provide some insight into the extent and magnitude of potential damages.

In 1996 through 1997, multiple major levee slumping and overtopping events were observed at the western end of the Canal near Pumping Plant #1. At the time of these events, 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. The repairs took approximately two weeks (see attached photos). Flood damage to adjacent properties was limited 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 long-term investment was needed to prevent a complete failure of the reach. The greatest risk associated with the 1996-1997 levee damage at that location was sewage from the Ironhouse Sanitation District flowing into the Canal from an adjacent property where the sewage was land applied. This section of Canal (from Pump Plant #1 to Marsh Creek) was encased in 2009; encasing that portion of the Canal cost $13M (construction cost only, 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 CCWD over $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 the Contra Costa County for their role in emergency assistance or any repairs to adjacent properties.

The following paragraphs present estimated impacts associate with a levee failure following an earthquake of magnitude 6.7 or greater in the Delta Region. Failure of northern or southern levees could occur in such an event, and failure of either levee system would cause inundation and property damage. The damages described below assume failure of the northern levees.

Estimates of Damage Following Seismic Activity – Without Project Condition

As shown in the preceding figure, the Canal is located in a seismically active zone, with the South Midland Fault running through the Project site. The Concord/Green Valley Fault is the closest surface fault, and the Hayward Fault is an active fault adjacent to the Canal. The likelihood of seismic activity affecting the Canal is high. According to the Delta Risk Management Strategy (2009), a major earthquake of magnitude 6.7 or greater in the vicinity of the Delta Region has a 62 percent probability of occurring sometime within the 30-year period from 2003 and 2032, or an annual probability of 2.07 percent (0.62 / 30). Although the likelihood of any individual Delta fault experiencing a 6.7 magnitude earthquake is much smaller, we have evaluated the potential flood damages caused by a 6.7 magnitude earthquake (or greater) in the Delta Region. For the purposes of this analysis, this represents the upper bound for potential damages.

Based on modeling performed by CCWD and the DRMS study, it is estimated that, in the event of an earthquake of magnitude 6.7 or greater in the Delta Region, there is a 70 percent chance that the Canal levees (northern and/or southern) would fail.[1] As described previously, the Canal levees are not engineered levees, but rather earthen embankments not designed for flood protection or to withstand strong seismic activity. Should slumping or levee failure occur in a single location, remaining

[1]Liquefaction assumptions based on modeling performed by CCWD for a 6.7 magnitude earthquake on the Concord fault with an associated peak ground acceleration (PGA) of 0.375g or greater. An earthquake of similar magnitude and PGA along another Delta fault line would be expected to generate similar damage.

embankments proximate to the initial failure location would likely wash out, creating a situation in which loss of levees results in a washout condition which causes further levee failure. This would result in extensive loss of levees and inundation to a significant area, as shown in the preceding figure.

Under this scenario, cleanup efforts would be extremely difficult, and cleanup costs would be significant. It is currently unknown how the area would be accessed to repair the Canal levees and restore the Canal to service. Access to the area would be available via Cypress Road, and vehicles may be able to travel along the remaining levees; however, these levees are narrow (~8 feet wide) and not designed to carry vehicular travel, so the feasibility of this option is unclear. A complete pump out operation may be needed prior to initiating levee repairs.

In summary, the following damages would be expected to result from failure of the northern Canal levees following a 6.7 magnitude earthquake (or greater) in the Delta Region:

- **Residential property damage.** There are approximately 540 homes adjacent to the Canal that are located in low-lying areas and are unprotected by levees. These homes have an average value of approximately $280,000 per home (total of approximately $151.2 M), and are likely to be inundated in the event of a failure of the northern levees. We have conservatively estimated that, in the event of a 6.7 magnitude earthquake (or greater) in the Delta Region, 85 percent of these homes would be completely inundated, with damages to each property totaling 90-100 percent of the home value. This equates to potential damage of $115.7 M in the event of levee failure ($151.2 M * 0.85 * 0.9). In addition, the Summer Lakes Housing Development is located within the inundation area, though surrounded by levees. The development includes 628 homes, valued at approximately $300,000 each, for a total value of approximately $188.4 M. Assuming a 5 – 10 percent chance of failure of the Summer Lakes Housing Development levees following the earthquake, approximately 10 percent of the value would be damaged. This equates to $942,000 in damages in the event of a levee failure ($188 M * 0.05 * 0.10). Together, these properties represent a total at-risk residential property value of approximately $116.6 M. Assuming the probability of a magnitude 6.7 earthquake in the Delta Region is 2.07 percent per year, and assuming a 70 percent likelihood of levee failure under that condition, this translates to an annual benefit of approximately $1,677,000 in avoided damages each year ($116.6 M * 0.0207 * 0.70).

- **Agricultural property damage.** 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. The total value of the land is valued at a much higher rate since it has been rezoned for residential development. Assuming the land value to be approximately $10,000 per acre, the total estimated value of this land is approximately $10,300,000 (1,030 * $10,000). Annual revenues are estimated to be approximately $618,000 (1,030 * $600). In the event of a 6.7 magnitude earthquake (or greater) in the Delta Region, all of this agricultural land would be inundated. Assuming damages equal to 90 percent of the property value plus one hundred percent of lost revenues, this corresponds to $9,888,000 of at-risk agricultural land value (0.9 * $10,300,000 + 618,000). Assuming an annual probability of 2.07 percent that a magnitude 6.7 earthquake will strike the Delta Region, and assuming a 70 percent likelihood of levee failure under that condition, this translates to an annual benefit of approximately $143,000 in avoided damages each year $9,888,000 * 0.0207 * 0.70).

- **Dutch Slough property damage.** 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 2009 value of $26.9 M. Assuming 50 percent of the land value would be lost in the event of inundation, this corresponds to $13.45 M ($2009) of Dutch Slough property value at risk. Assuming the annual probability of a 6.7 magnitude earthquake (or greater) striking the Delta Region is 2.07 percent per year, and assuming a 70 percent likelihood of levee failure under that condition, this translates to an annual benefit of approximately $195,000 in avoided damages each year ($13.45 M * 0.0207 * 0.70).

- **Road inundation.** The following table summarizes the road inundation that would be expected to occur following levee failure. As shown in this table, the total cost associated with road inundation is approximately $665,000. Assuming the annual probability of a 6.7 magnitude earthquake (or greater) striking the Delta Region is 2.07 percent per year, and assuming a 70 percent likelihood of levee failure under that condition, this translates to an annual benefit of approximately $10,000 in avoided damages each year ($664,813 * 0.0207 * 0.70).

Table 7-2: Road Inundation Assumptions

Road	Miles Inundated	Category	Unit Cost ($/Mile Inundated)[1]	Total Cost
BETHEL ISLAND RD	1.5	Major	$100,000	$154,000
BROADWAY	0.2	Unsealed	$10,000	$1,500
DUTCH SLOUGH RD	0.4	Minor	$30,000	$11,000
CYPRESS AND EAST CYPRESS RD	2.0	Major	$100,000	$196,000
JERSEY ISLAND RD	1.5	Major	$30,000	$44,000
KNIGHTSEN AVE	0.2	Minor	$30,000	$7,000
TULE LN	0.03	Minor	$30,000	$1,000
COW POKE LN	0.3	Unsealed	$10,000	$3,000
FRANKLIN RD	0.1	Unsealed	$10,000	$1,000
WELLS RD	1.3	Minor	$10,000	$13,000
CACTUS LN	0.03	Minor	$10,000	$300
DELTA RD	0.3	Minor	$10,000	$3,000
MARINER RD	0.1	Minor	$10,000	$800
SANDMOUND BLVD	2.2	Major	$100,000	$224,000
SELLERS AVE	0.5	Minor	$10,000	$5,000
TOTAL	10.6			$665,000

1. Cost per mile based on assumptions in DWR's FRAM model.

- **Cleanup and levee breach repair.** As described previously, cleanup and levee repairs would be extremely difficult. It is likely that cleanup would be similar to that required following the Jones Tract levee failure in June of 2004. In that emergency event, Lower Jones Tract was flooded

following a breach in the West Levee of Upper Jones Tract. This resulted in approximately 19 square miles of inundation; failure of the northern Canal levees would cause approximately 6.2 square miles of inundation. The cleanup effort required approximately 6 months: following the levee failure on June 3, 2004, raising the levee at Trapper Slough was completed on June 8, 2004; breach closure and protection of interior levee slopes were completed on June 30, 2004; and dewatering was completed on December 18, 2004. The entire cleanup cost was approximately $90 million. It is anticipated that the timeline and costs associated with cleanup of inundation following levee failure from the unlined Canal would be similar, if not worse, to those experienced following the Jones Tract failure. For the purposes of this analysis, the cost associated with cleanup and repair of the damaged Canal levees has been estimated as $29.4 M, calculated by reducing the Jones Tract cleanup cost in proportion to the land mass inundated ($90 M * 6.2 square miles / 19 square miles). This translates to an annual avoided cost of approximately $426,000 per year ($29.4 M * 0.0207 * 0.70).

- **Damage to Rock Slough Fish Screen.** In the event of levee failure, the Rock Slough Fish Screen would experience uncontrolled flow. CCWD estimates damages to the Rock Slough Fish Screen at approximately $2 M. This translates to an annual avoided cost of approximately $29,000 per year ($2 M * 0.0207 * 0.70).

- **Lost Water Sales.** Several of CCWD's Delta water customers, including the City of Brentwood, are entirely dependent upon the Canal for conveyance of their supplies. In the event of catastrophic failure of the Canal levees, supply to these customers would be interrupted until alternative supply arrangements could be made. As described above, cleanup and repair following such an event would be extremely difficult, and would be expected to require several months. It is assumed that an alternative supply arrangement would be developed to serve the City of Brentwood and other Canal customers while the cleanup and repair was underway. However, CCWD estimates that it would take at least two months before alternative supply arrangements could be made. As a result, the City of Brentwood and other Canal customers would be unable to take Delta supplies for at least two months. CCWD currently receives approximately $3.5 M per year from the city of Brentwood and from raw water sales provided exclusively by the Canal. Assuming supply to these customers was interrupted for a period of two months before alternative arrangements could be made, that would equate to lost water sales of approximately $583,000. This translates to an annual avoided cost of $8,000 per year ($583,000 * 0.0207 * 0.70).

- **Additional Water Distribution Cost.** In the event of levee failure, CCWD would be required to depend on its alternate intakes to meet the supply needs otherwise met through the Canal. Supplying water via these alternate intakes is significantly more energy-intensive than supply water from the Canal. The costs associated with pumping costs are estimated to be $1.4 M per year. Assuming the annual probability of a 6.7 magnitude earthquake (or greater) striking the Delta Region is approximately 2.07 percent per year, and assuming a 70 percent likelihood of levee failure under that condition, this translates to an annual benefit of approximately $20,000 in avoided damages each year ($1.4 M * 0.0207 * 0.70).

- **Replacing Service to Canal Users.** The cost of replacing water service to the City of Brentwood in the event of levee failure is estimated to be $1,122,180 per year. The City of Brentwood receives the majority of its supply directly from the Canal (~6,340 ac-ft/yr @ $433/ac-ft); substituting that water with water from Los Vaqueros Reservoir is more expensive ($610/ac-ft).

Assuming a 2.07 percent chance of a 6.7 magnitude earthquake (or greater) in the Delta Region each year, and assuming a 70 percent likelihood of levee failure under that condition, this translates to an annual benefit of approximately $16,000 in avoided damages each year ($1,122,180* 0.0207 * 0.70).

- **Reduced Storage and Recovery.** In the event of the Canal levee failure, it would be difficult to refill the reservoir, leading to a long term deficit in water stored in the reservoir. Typically, the Canal is used to serve all CCWD customers while Los Vaqueros Reservoir is being filled by diversions at the other intakes (Old River and Middle River Intakes); if the Canal is out of service, the reservoir would not be filled because the other intakes would be needed to meet demands directly. Depending on Delta water quality, loss of the Canal could result in a storage deficit between 13,000 and 61,000 AF. At $500/AF, this corresponds to a cost of $6.5M -$30.5M. Conservatively assuming $10 M, and assuming the annual probability of a 6.7 magnitude earthquake (or greater) striking the Delta Region is approximately 2.07 percent per year, with a 70 percent likelihood of levee failure under that condition, this translates to an annual benefit of approximately $145,000 in avoided damages each year ($10 M * 0.0207 * 0.70).

The following table summarizes the avoided costs associated with Project implementation.

Table 7-3: Summary of Avoided Costs

Description (a)	Expected Damage Without Project (b)	Expected Annual Damage Without Project (c)	Present Value of Future Benefits (d)
		*(b) * 0.0207 * 0.70*	*(c) * present value coefficient*
Residential property damage			
540 homes in inundation area	$115,668,000	$1,677,000	$27,861,000
Summer Lakes Homes	$942,000	$14,000	$227,000
Ag property damage	$9,888,000	$143,000	$2,381,000
Dutch Slough Damage	$13,450,000	$195,000	$3,239,000
Road inundation	$665,000	$10,000	$160,000
Cleanup and levee breach repair	$29,368,000	$426,000	$7,072,000
Damage to Rock Slough Fish Screen	$2,000,000	$29,000	$482,000
Lost water sales	$583,000	$8,000	$140,000
Additional Water Distribution Cost	$1,400,000	$20,000	$337,000
Replacing Raw Supply to Canal Users	$1,122,000	$16,000	$270,000
Reduced Storage and Recovery	$10,000,000	$145,000	$2,408,000
TOTAL	***$185,087,000***	***$2,682,000***	***$44,576,000***

1. Present value coefficient = 16.618 (assumes 6 percent discount rate and 100-year project life).

In total, avoided damages to residential, agricultural, and Dutch Slough properties, combined with avoided costs associated with road inundation, are expected to total $140.6 M, or $2,038,000 per year, for a total present value of $33,867,000. Avoided costs related to water distribution, replacing raw water service, and loss of water storage are expected to total $12.5 M, or $181,000 per year, for a

present value of $3,015,000. Avoided costs associated with levee repair and damage to the Rock Slough Fish Screen are expected to total approximately $31.4 M, which equates to $455,000 per year (present value of $7.6 M). Avoided costs associated with lost water sales total $583,000, which equates to $8,000 per year, or $140,000 in present value benefits over the life of the Project. Together, these avoided costs total approximately $185,087,000, which equals $216,000 per year. As shown in Tables 12 and 13 at the end of this document, these benefits are expected to total approximately $44,576,000 in avoided flood damages over the 100-year life of the Project.

Expected Flood Reduction Benefits With Project

The pipeline has been designed to withstand an earthquake of 6.7M along the Concord fault with an associated peak ground acceleration of 0.375g (DMC Geotechnical Report 2007). Presumably, in the event of an earthquake of magnitude 6.7 or less, the above-mentioned property and water operations would be protected. The flood isolation structure included in this proposal would enable the Canal to be isolated from the Delta, limiting the amount of water that could reach the surrounding properties in the event of a failure.

The flood isolation structure provides a transition from the Canal into the pipeline and will be the point of hydraulic isolation between the Delta the unlined Canal. Currently, in the event of a Canal berm breach water will flow uncontrolled from the Delta through Rock Slough and into the Canal. The Isolation Structure will rapidly shut isolate the Canal and prevent water from flowing through the breach and flooding adjacent land. The structure will be constructed from the existing Rock Trash Rack to the upstream inlet of the pipeline, near the new Rock Slough Fish Screen, and includes remote monitoring of water level and a remote controlled, automatically actuated slide gate at the pipeline inlet. In response to excessive flows through the Isolation Structure or report of a breach of the Canal, CCWD will initiate closure of the valve to prevent continued uncontrolled flows within approximately 15 minutes.

In the event of a Canal failure, the flood isolation structure would also allow for easier repairs to the Canal or pipe so that the disruption to the water supply could be minimized. In the event of a much larger earthquake or PGA, the pipeline could fail leading to a disruption in water operations but flooding risks would still be minimized by the flood isolation structure.

Project Beneficiaries and Distribution of Benefits

This Project will benefit stakeholders at the local, regional, and state level, as is summarized in Table 7-4. This Project not only benefits CCWD but also many state and federal interests. The completion of the legislatively mandated (SBX7-1 Section 85085) Dutch Slough Tidal Marsh Restoration Project is dependent on the encasement of the Canal adjacent to the Dutch Slough Restoration site. This will provide appreciable ecological benefits to the Delta and all statewide stakeholders with an interest in the Delta's health.

Table 7-4. Project Beneficiaries Summary

Local	Regional	*Statewide*
CCWD and its retail customers: Clayton, Clyde, Concord, Martinez (portion), Pacheco, Pleasant Hill (portion), Port Costa, Walnut Creek (portion) Residents living in lands adjacent to the existing Canal	Contra Costa Water District's wholesale customers, especially those relying on raw water (all of which relies on the Canal): Antioch, Brentwood, Golden State Water Company (Bay Point), Diablo Water District, Martinez, Pittsburg	Department of Water Resources State Water Project, Central Valley Project, fisheries, and general ecologic well-being

Timing of Benefits

Construction of the new pipeline will be completed in 2013 and will come online in 2014. For this analysis, a 100-year useful project life is assumed, thus benefits and costs are calculated through 2113 (100 years after the Project comes online).

Uncertainty of Benefits and Adverse Effects

This analysis of costs and benefits is based on available data and some assumptions. As a result, there may be some omissions, uncertainties, and possible biases. In most cases, omissions lead to a downward bias in benefits: the Project is expected to be much more beneficial than the subset of benefits that can be monetized would indicate. Several of these issues are listed in Table 7-5.

Table 7-5. Omissions, Biases, and Uncertainties, and Their Effect on the Project

Benefit or Cost Category	Likely Impact on Net Benefits*	*Comment*
Probability of seismic activity	U	Assumptions have been based on an approximate annual risk of a magnitude 6.7 earthquake (or greater) occurring in the Delta Region of 2.07 percent per year, based on the 2009 Delta Risk Management Strategy. Should the actual probability of major earthquake occurring be greater, the potential damages would similarly increase.
Flood damages	U	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.

*Direction and magnitude of effect on net benefits:
+ = Likely to increase net benefits relative to quantified estimates.
++ = Likely to increase net benefits significantly.
– = Likely to decrease benefits.
– – = Likely to decrease net benefits significantly.
U = Uncertain, could be + or –.

Documentation Supporting Benefits

The following references were used to develop the cost and benefit analyses described in this section:

- Personal communication with Marie Valmores and Maureen Martin, Contra Costa Water District (3/16/2011, 3/24/2011, 3/29/2011, 4/6/2011)
- Personal communication with Mark Seedall, Contra Costa Water District (3/29/2011, 4/6/2011)
- Seismic Reliability Improvements Project, 1997
- Geotechnical Engineering Report Intake Channel Levees Contra Costa Canal, 2000
- Engineering Investigation Contra Costa Water District Canal Replacement Project, 2007
- Delta Risk Management Study Reports (http://www.water.ca.gov/floodmgmt/dsmo/sab/drmsp/docs/drms_execsum_ph1_final_low.pdf, http://www.water.ca.gov/floodmgmt/dsmo/ sab/drmsp/docs/Seismology_TM.pdf, http://www.water.ca.gov/floodmgmt/dsmo/ sab/drmsp/docs/Risk_Report_Section_6_Final.pdf)

Economic Benefit Tables

Capital costs for the Project amount to $16,847,000 in present value terms, as shown in Table 10. This includes initial spending starting in 2011 and continuing through the end of 2013. The project lifetime is expected to be 100 years, and annual maintenance costs of $50,000 per year are anticipated once the Project is completed, beginning in 2014 to conduct routines maintenance and cleaning operations, as well as maintenance of the flow isolation structure.

Because this is a seismic retrofit project, Table 11 does not apply.

Flood damages were estimated using present value analysis. As described above, because the Project will address the risk of catastrophic failure of Canal embankments unrelated to hydrology, the Project's loss-probability curve has only a single data point, and the area under the curve cannot be integrated to determine the EAD. Table 12 presents the results of the present value analysis. Based on this analysis, using a project life of 100 years and a 6 percent discount rate, the present value of expected flood damage reduction benefits is estimated to be $44,576,000. All of these benefits are attributable to this Project.

Table 10: Annual Costs
Contra Costa Canal Levee Elimination and Flood Protection Project

	Initial Costs	Operations and Maintenance Costs [1]						Discounting Calculations	
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
YEAR	Grand Total Cost	Admin.	Ops.	Maint.	Replace.	Other	Total Costs (a) +…+ (f)	Discount Factor	Discounted Costs (g) x (h)
2009							$0	1.00	$0
2010							$0	0.94	$0
2011	$265,000						$265,000	0.89	$235,849
2012	$6,746,650						$6,746,650	0.84	$5,664,617
2013	$12,988,350						$12,988,350	0.79	$10,287,990
2014				$50,000			$50,000	0.75	$37,363
2015				$50,000			$50,000	0.70	$35,248
2016				$50,000			$50,000	0.67	$33,253
2017				$50,000			$50,000	0.63	$31,371
2018				$50,000			$50,000	0.59	$29,595
2019				$50,000			$50,000	0.56	$27,920
2020				$50,000			$50,000	0.53	$26,339
2021				$50,000			$50,000	0.50	$24,848
2022				$50,000			$50,000	0.47	$23,442
2023				$50,000			$50,000	0.44	$22,115
2024				$50,000			$50,000	0.42	$20,863
2025				$50,000			$50,000	0.39	$19,682
2026				$50,000			$50,000	0.37	$18,568
2027				$50,000			$50,000	0.35	$17,517
2028				$50,000			$50,000	0.33	$16,526
2029				$50,000			$50,000	0.31	$15,590
2030				$50,000			$50,000	0.29	$14,708
2031				$50,000			$50,000	0.28	$13,875
2032				$50,000			$50,000	0.26	$13,090
2033				$50,000			$50,000	0.25	$12,349
2034				$50,000			$50,000	0.23	$11,650
2035				$50,000			$50,000	0.22	$10,991
2036				$50,000			$50,000	0.21	$10,368
2037				$50,000			$50,000	0.20	$9,782
2038				$50,000			$50,000	0.18	$9,228
2039				$50,000			$50,000	0.17	$8,706
2040				$50,000			$50,000	0.16	$8,213
2041				$50,000			$50,000	0.15	$7,748
2042				$50,000			$50,000	0.15	$7,309
2043				$50,000			$50,000	0.14	$6,896

Table 10: Annual Costs
Contra Costa Canal Levee Elimination and Flood Protection Project

	Initial Costs	Operations and Maintenance Costs [1]						Discounting Calculations	
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
YEAR	Grand Total Cost	Admin.	Ops.	Maint.	Replace.	Other	Total Costs (a) +…+ (f)	Discount Factor	Discounted Costs (g) x (h)
2044				$50,000			$50,000	0.13	$6,505
2045				$50,000			$50,000	0.12	$6,137
2046				$50,000			$50,000	0.12	$5,790
2047				$50,000			$50,000	0.11	$5,462
2048				$50,000			$50,000	0.10	$5,153
2049				$50,000			$50,000	0.10	$4,861
2050				$50,000			$50,000	0.09	$4,586
2051				$50,000			$50,000	0.09	$4,326
2052				$50,000			$50,000	0.08	$4,081
2053				$50,000			$50,000	0.08	$3,850
2054				$50,000			$50,000	0.07	$3,633
2055				$50,000			$50,000	0.07	$3,427
2056				$50,000			$50,000	0.06	$3,233
2057				$50,000			$50,000	0.06	$3,050
2058				$50,000			$50,000	0.06	$2,877
2059				$50,000			$50,000	0.05	$2,714
2060				$50,000			$50,000	0.05	$2,561
2061				$50,000			$50,000	0.048	$2,416
2062				$50,000			$50,000	0.046	$2,279
2063				$50,000			$50,000	0.043	$2,150
2064				$50,000			$50,000	0.041	$2,028
2065				$50,000			$50,000	0.038	$1,914
2066				$50,000			$50,000	0.036	$1,805
2067				$50,000			$50,000	0.034	$1,703
2068				$50,000			$50,000	0.032	$1,607
2069				$50,000			$50,000	0.030	$1,516
2070				$50,000			$50,000	0.029	$1,430
2071				$50,000			$50,000	0.027	$1,349
2072				$50,000			$50,000	0.025	$1,273
2073				$50,000			$50,000	0.024	$1,201
2074				$50,000			$50,000	0.023	$1,133
2075				$50,000			$50,000	0.021	$1,069
2076				$50,000			$50,000	0.020	$1,008
2077				$50,000			$50,000	0.019	$951
2078				$50,000			$50,000	0.018	$897
2079				$50,000			$50,000	0.017	$846

Table 10: Annual Costs
Contra Costa Canal Levee Elimination and Flood Protection Project

	Initial Costs	Operations and Maintenance Costs [1]						Discounting Calculations	
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
YEAR	Grand Total Cost	Admin.	Ops.	Maint.	Replace.	Other	Total Costs (a) +…+ (f)	Discount Factor	Discounted Costs (g) x (h)
2080				$50,000			$50,000	0.016	$798
2081				$50,000			$50,000	0.015	$753
2082				$50,000			$50,000	0.014	$711
2083				$50,000			$50,000	0.013	$670
2084				$50,000			$50,000	0.013	$632
2085				$50,000			$50,000	0.012	$597
2086				$50,000			$50,000	0.011	$563
2087				$50,000			$50,000	0.011	$531
2088				$50,000			$50,000	0.010	$501
2089				$50,000			$50,000	0.009	$473
2090				$50,000			$50,000	0.009	$446
2091				$50,000			$50,000	0.008	$421
2092				$50,000			$50,000	0.008	$397
2093				$50,000			$50,000	0.007	$374
2094				$50,000			$50,000	0.007	$353
2095				$50,000			$50,000	0.007	$333
2096				$50,000			$50,000	0.006	$314
2097				$50,000			$50,000	0.006	$297
2098				$50,000			$50,000	0.006	$280
2099				$50,000			$50,000	0.005	$264
2100				$50,000			$50,000	0.005	$249
2101				$50,000			$50,000	0.005	$235
2102				$50,000			$50,000	0.004	$222
2103				$50,000			$50,000	0.004	$209
2104				$50,000			$50,000	0.004	$197
2105				$50,000			$50,000	0.004	$186
2106				$50,000			$50,000	0.004	$176
2107				$50,000			$50,000	0.003	$166
2108				$50,000			$50,000	0.003	$156
2109				$50,000			$50,000	0.003	$147
2110				$50,000			$50,000	0.003	$139
2111				$50,000			$50,000	0.003	$131
2112				$50,000			$50,000	0.002	$124
2113				$50,000			$50,000	0.002	$117
Project Life	100 Years							…	
Total Present Value of Discounted Costs (Sum of Column (i))									**$16,846,589**

Table 10: Annual Costs
Contra Costa Canal Levee Elimination and Flood Protection Project

	Initial Costs	Operations and Maintenance Costs [1]						Discounting Calculations	
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
YEAR	Grand Total Cost	Admin.	Ops.	Maint.	Replace.	Other	Total Costs (a) +…+ (f)	Discount Factor	Discounted Costs (g) x (h)
Transfer to Table 20, column (c), Exhibit F: Proposal Costs and Benefits Summaries									

Comments:
Annual maintenance includes regular right-of-way maintenance, periodic cleaning, and maintenance of the flow control structure. All costs are in 2009 dollars.

Table 11: Annual Table 11 – Event Damage
Contra Costa Canal Levee Elimination and Flood Protection Project

NOT APPLICABLE

Table 12 - Present Value of Expected Annual Damage Benefits
Contra Costa Canal Levee Elimination and Flood Protection Project

(a)	Expected Annual Damage Without Project (1)		$2,682,474
(b)	Expected Annual Damage With Project (1)		$0
(c)	Expected Annual Damage Benefit	(a) – (b)	$2,682,474
(d)	Present Value Coefficient (2)		16.618
(e)	**Present Value of Future Benefits**	**(c) x (d)**	**$44,576,131**
	Transfer to column (e), Table 20: Proposal Costs and Benefits Summaries.		

(1) This program assumes no population growth thus EAD will be constant over analysis period.
(2) 6 percent discount rate; 100-year analysis period.

Table 13 - Present Value of Expected Annual Damage Benefits
Contra Costa Canal Levee Elimination and Flood Protection Project

Variables	Without Project	With Project
Earthquake magnitude which causes structural failure	5.8	>6.7
Estimated probability of seismic event causing structural failure	>70%	0.00
Potential inundation damage	**$185,086,747**	**$0**

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Supporting Information:

Photos of 1998 Levee Repairs

12/27/96 CANAL SLIPPAGE
FACING SW

12/27/96 CANAL
LEVEE SLIPPAGE
FACING NE

12/31/97 1045 HRS.

1045 HRS 12/31/97

7/9/98

7/9/98

Supporting Information:

- **Seismic Reliability Analysis Information**- The following documents supporting the seismic reliability analysis have been submitted on CD and uploaded to BMS along with this application (Att7_SWF_DReduc_2of2):
    - Seismic Reliability Improvements Project, 1997
    - Geotechnical Engineering Report Intake Channel Levees Contra Costa Canal, 2000
    - Geotechnical Engineering Investigation Contra Costa Water District Canal Replacement Project, 2007