Friant-Kern Canal Capacity Restoration Feasibility Study

DRAFT Feasibility Report

SAN JOAQUIN RIVER
RESTORATION PROGRAM

DRAFT -- June 2011

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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List of Abbreviations and Acronyms

AFT	American Farmland Trust
California	State of California
CVHM	Central Valley Hydrological Model
CVP	Central Valley Project
California	State of California
Delta	Sacramento-San Joaquin Delta
DWR	California Department of Water Resources
DMC	Delta-Mendota Canal
EA	Environmental Assessment
ESA	Endangered Species Act
FKC	Friant-Kern Canal
HEC-RAS	Hydrologic Engineering Center River Analysis System
FONSI	Finding of No Significant Impact
FWA	Friant Water Authority
FWCA	Fish and Wildlife Coordination Act
MAF	Million Acre-Feet
MP	Milepost
MW	Megawatts
n-value	Describes the resistance of flow in a given cross section NHPA National Historic Preservation Act
NWR	National Wildlife Refuge
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
Secretary	Secretary of the Interior
Settlement	Stipulation of Settlement in *Natural Resource Defense Council, et al. v. Kirk Rodgers, et al., United States District Court, Eastern District of California, No. CIV. S-88-1658-LKK/GGH*
SJRRP	San Joaquin River Restoration Program
SJRRS Act	Title X, Subtitle A, Public Law 111-11, San Joaquin River Restoration Settlement Act
SJRRP Flows	SJRRP Interim Flows and Restoration Flows
SWP	State Water Project
TAF	Thousand Acre-Feet
U.S.	United States
USGS	U.S. Geological Survey

USJRBSI	Upper San Joaquin River Basin Storage Investigation
USFWS	U.S. Fish and Wildlife Service
WMTF	Water Management Technical Feedback

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Executive Summary

The purpose of this report is to present the results of the Friant-Kern Canal Capacity Restoration Feasibility Study (FKC Feasibility Study) and to document if any of the alternatives developed are feasible and warrant Federal implementation.

The United States Department of the Interior, Bureau of Reclamation, conducted the FKC Feasibility Study consistent with the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (*Principles & Guidelines*) (WRC 1983), and other pertinent Federal and state laws. This report has a companion Draft Environmental Assessment (EA) and Finding of No Significant Impact (FONSI) published under separate cover.

ES-1 Study Area

The Study Area, as shown in Figure ES-1, encompasses the 152-mile Friant-Kern Canal (FKC) and the contract service areas of the 25 Central Valley Project (CVP), Friant Division, long-term water service contractors served by the FKC (FKC Contractors), Table ES-1. The Study Area is located within the counties of Fresno, Tulare, and Kern, which are the top three agricultural producing counties in the nation (USDA 2007). In addition to agricultural production, the lands within the Study Area are used for municipal, industrial, and environmental purposes. The Study Area is represented by Congressional Districts 20, 21, and 22.

ES-2 Problem, Purpose, Need, and Objective

Since completion of construction by Reclamation in 1951, the FKC has lost its ability to convey the capacity for which it was previously designed and constructed by Reclamation. These limitations result in restrictions, at times, of CVP water deliveries to the FKC Contractors. The purpose and need for the FKC Feasibility Study is to analyze the feasibility of restoring the FKC to such capacity as previously designed and constructed by Reclamation. Figure ES-2 and Table ES-1 identify the affected FKC Contractors, the current capacity, and the previously designed and constructed capacity of the FKC. Restoration of the capacity of the FKC is needed to avoid water supply impacts to the FKC Contractors that may result from the Interim Flows and Restoration Flows (SJRRP Flows), provided in the Stipulation of Settlement in *Natural Resources Defense Council, et al., v. Kirk Rodgers, et al.*

Sandbags placed on FKC to restore capacity

The objective of the FKC Feasibility Study is to:

- Improve the water deliveries and reliability of the FKC in order to reduce or avoid water supply impacts on the FKC Contractors that may result from the SJRRP Flows.

ES-3 Study Authority

The FKC Feasibility Study is authorized and funded by Sections 10201 and 10203(a) of Public Law 111-11, the San Joaquin River Restoration Settlement Act (SJRRS Act).

Section 10201:

> "*(a) The Secretary of the Interior (hereafter referred to as the 'Secretary') is authorized and directed to conduct feasibility studies in coordination with appropriate Federal, State, regional, and local authorities on the following improvements and facilities in the Friant Division, Central Valley Project, California:*
>
> *(1) Restoration of the capacity of the Friant-Kern and Madera Canal to such capacity as previously designed and constructed by the Bureau of Reclamation.*
>
> *(2) […]*
>
> *(b) Upon completion of and consistent with the applicable feasibility studies, the Secretary is authorized to construct the improvements and facilities identified in subsection (a) in accordance with applicable Federal and State laws.*
>
> *(c) The costs of implementing this section shall be in accordance with Section 10203, and shall be a nonreimbursable Federal expenditure.*"

Section 10203(a):

> "*(a) The Secretary is authorized and directed to use monies from the fund established under section 10009 to carry out the provisions of section 10201(a)(1), in an amount not to exceed $35,000,000.*"

Initially, Reclamation evaluated the restoration of the capacity of the FKC and Madera Canal jointly. However, due to unique differences in the design and construction of the canals, Reclamation separated the evaluation of the canals. Accordingly, this report evaluates the restoration of the capacity of the FKC.

The Friant Water Authority (FWA) and Madera Chowchilla Water Power Authority agreed to separate the authorized funding as follows: $25,000,000 for the FKC; $10,000,000 for the Madera Canal. Therefore, the FKC Feasibility Study assumes $25,000,000 to restore the capacity of the FKC.

June 1, 2011

N

0 75 150 300 450 600 Miles

Friant-Kern Canal Feasibility Study

SAN JOAQUIN RIVER RESTORATION PROGRAM

Figure ES-1. Study Area

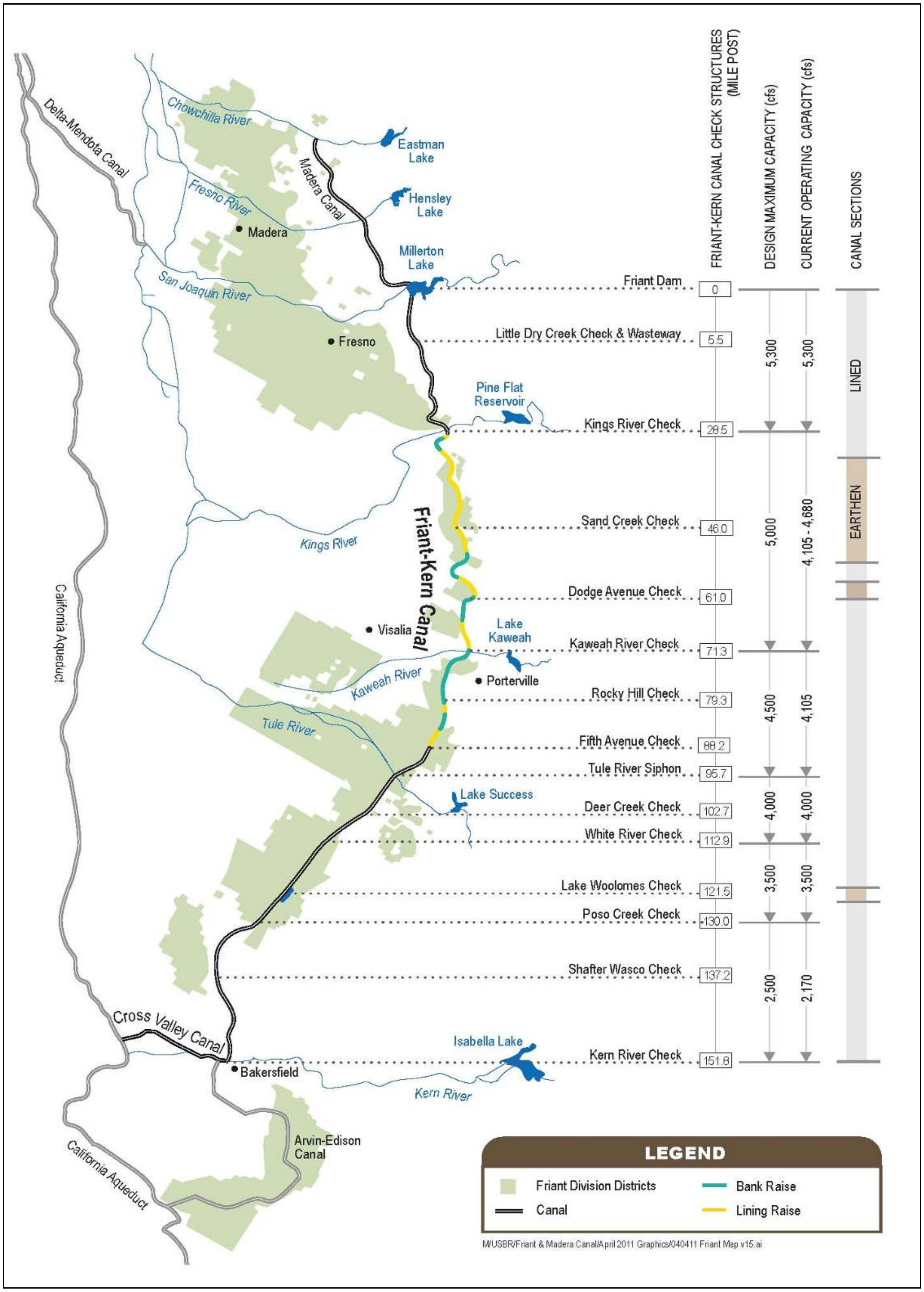

Figure ES-2. Current Capacity vs. Maximum Capacity

Table ES-1. FKC - Current Capacity vs. Maximum Capacity

Reach for Modeling	*Friant-Kern Structures* FRIANT CONTRACTOS	Mile Post	*Current Capacity (cfs)*	*Maximum Capacity (cfs)*
	Friant Dam	**0**		
Reach 1	FRESNO I.D.		5,300	5,300
	CITY OF FRESNO			
	GARFIELD W.D.			
	INTERNATIONAL W.D.			
	Kings River Check	**28.52**		
Reach 2	CITY OF ORANGE COVE		4,680 - 4,105	5,000
	IVANHOE I.D.			
	ORANGE COVE I.D.			
	STONE CORRAL I.D.			
	TULARE I.D.			
	KAWEAH DELTA W.C.D.			
	Kaweah River Check	**71.29**		
	EXETER I.D.		4,105	4,500
	CITY OF LINDSAY			
	LEWIS CREEK W.D.			
	LINDSAY STRATHMORE I.D.			
	LINDMORE I.D.			
	5th Ave Check	**88.22**		
Reach 3	LINDSAY STRATHMORE I.D.			
	LINDMORE I.D.			
	LOWER TULE RIVER I.D.			
	PORTERVILLE I.D.			
	Tule River Check	**95.67**		
	LOWER TULE I.D.		4,000	4,000
	PORTERVILLE I.D.			
	TEA POT DOME W.D.			
	SAUCELITO I.D.			
	TERRA BELLA I.D.			
	Deer Creek Check	**102.69**		
Reach 4	SAUCELITO I.D.			
	TERRA BELLA I.D.			
	DELANO EARLIMART I.D.			
	KERN-TULARE W.D.			
	White River Check	**112.9**		
	DELANO EARLIMART I.D.		3,500	3,500
	SOUTHERN S.J.M.U.D.			
	Poso Creek Check	**130.05**		
Reach 5	SHAFTER WASCO I.D.		2,170	2,500
	Shafter Wasco Check	**137.2**		
Reach 6	ARVIN EDISON W.S.D			
	Kern River Check	**151.8**		

Note: Some contractors span two reaches.

ES-4 Background

In 1942, Reclamation, as part of the CVP, completed construction of Friant Dam on the San Joaquin River, 16 miles northeast of downtown Fresno, California. Friant Dam is a concrete gravity structure, 319 feet high, with a crest length of 3,488 feet. It controls the flows of the San Joaquin River and provides for: downstream releases to meet requirements above Mendota Pool; flood control; conservation storage; SJRRP Flows, diversion into the FKC and Madera Canal; and, the delivery of water to one million acres of agricultural land in Fresno, Kern, Madera, and Tulare Counties. Friant Dam was first used to store water on February 21, 1944. Millerton Lake, the reservoir behind Friant Dam, has a total capacity of 520,500 acre-feet, a surface area of 4,900 acres, and is approximately 15 miles long. It provides for 45 miles of shoreline that varies from gentle slopes near Friant Dam to steep canyon walls further inland, and it allows for various recreational activities, such as boating, fishing, picnicking, and swimming (Reclamation 1994).

Friant Dam Construction

Friant Dam serves the CVP Friant Division long-term contractors through three separate river and canal outlets: the San Joaquin River outlet works, the FKC, and the Madera Canal. The FKC carries water over 151.8 miles in a southerly direction from Millerton Lake to the Kern River, four miles west of Bakersfield. The water is primarily used as supplemental and irrigation supplies in Fresno, Tulare, and Kern Counties. Construction of the FKC began in 1945 and was completed in 1951. Approximately 85 percent of the FKC is concrete lined, with 15percent earth lined. The FKC originally had a maximum capacity of 5,000 cubic feet per second (cfs) that gradually decreased to 2,500 cfs at its terminus in the Kern River (Reclamation 1994). In the late 1970s, Reclamation raised the FKC's concrete lining from the headworks to the Kings River Siphon, increasing the maximum capacity to 5,300 cfs.

Since completion of construction by Reclamation in 1951, the FKC has lost its ability to fully meet its previously designed and constructed capacity, resulting in restriction, at times, on water deliveries to the FKC Contractors. The reduction in capacity is a result of several factors, including original design limitations, subsidence, increased canal roughness, and changes in water delivery patterns.

Settlement and Act

In 1988, a coalition of environmental groups, led by the Natural Resources Defense Council (NRDC) filed a lawsuit, entitled *NRDC, et al., v. Kirk Rodgers, et al.*, challenging the renewal of long-term water service contracts between the United States and the Friant Contractors. On September 13, 2006, after more than 18 years of litigation, the Settling Parties, including NRDC, Friant Water Users Authority, and the U.S. Departments of the Interior and Commerce, agreed on the terms and conditions of the Settlement subsequently approved by the U.S. Eastern District Court of California on October 23, 2006. The SJRRS Act authorizes and directs the Secretary of the Interior (Secretary) to implement the Settlement, which establishes two primary goals:

> **Restoration Goal –** To restore and maintain fish populations in "good condition" in the main stem San Joaquin River below Friant Dam to the confluence of the Merced River, including naturally reproducing and self-sustaining populations of salmon and other fish.
>
> **Water Management Goal –** To reduce or avoid adverse water supply impacts on all of the Friant Division long-term contractors that may result from the SJRRP Flows.

To achieve the Restoration Goal, the Settlement calls for releases of water from Friant Dam to the confluence of the Merced River, a combination of channel and structural modifications along the San Joaquin River below Friant Dam, and reintroduction of Chinook salmon. To achieve the Water Management Goal, Paragraph 16 of the Settlement and Part-III of the SJRRS Act provide for certain activities to be developed and implemented to reduce or avoid adverse water supply impacts on all Friant Division long-term contractors, which includes the FKC Feasibility Study.

Friant Dam and San Joaquin River

ES-5 Public Involvement and Scoping

Reclamation integrated public and agency involvement into the overall planning process for the FKC Feasibility Study, starting in 2008, as part of the bi-monthly public San Joaquin River Restoration Program (SJRRP) Water Management Technical Feedback (WMTF) meetings held in Visalia and Fresno, California. As part of these WMTF meetings, Reclamation presented background information on the FKC Feasibility Study, obtained comments and screened alternatives, and solicited and received public concerns and comments throughout the process.

Friant Dam river outlets

In addition to the public WMTF meetings, starting in 2008, Reclamation held frequent agency coordination meetings with the FWA and conducted several briefings for other local agencies, cooperating agencies, environmental groups, and congressional staff on the development of the FKC Feasibility Study.

ES-6 Study Sponsor

The FWA is the non-Federal sponsor for the FKC Feasibility Study; however, pursuant to Section 10201(c) of the SJRRS Act, the FKC Feasibility Study is funded through non-reimbursable Federal appropriations. The FWA, which operates and maintains the FKC pursuant to Contract No. 8-07-20-X0356, actively participated in the development of the FKC Feasibility Study and supports the recommendations in this report.

ES-7 Problems, Resources, Opportunities, and Constraints

Since completion of construction by Reclamation in 1951, the FKC has lost its ability to fully meet its previously designed and constructed capacity, resulting in restrictions, at times, on water deliveries to the FKC Contractors. The reduction in capacity of the FKC was confirmed by Reclamation as part of this study through the use of a steady-state hydraulic model (FKC HEC-RAS). The FKC HEC-RAS model results are shown as the "Current Capacity" in Figure ES-2 and Table ES-1. In addition, through implementation of the Settlement and the SJRRP Flows, average total system water deliveries from Friant Dam are expected to be reduced by approximately 208

Friant Dam

TAF per year, which is approximately 15 to 19 percent of the deliveries made prior to implementation of the Settlement (Reclamation 2011b). The continued general downward trend of groundwater levels reveals that considerable water supply reliability problems remain. Moreover, it is expected that the continued downward trend in groundwater levels may result in localized areas of impaired groundwater quality, increase risk of subsidence, and may ultimately reduce water use and irrigated acreage in the San Joaquin Valley.

San Joaquin River

Major resources identified for the FKC Feasibility Study include surface water and groundwater resources. The major surface water resources in the Study Area are the San Joaquin River and its tributaries, Friant Dam, Millerton Lake, and the FKC. The San Joaquin Valley Groundwater Basin makes up the southern two-thirds of the 400-mile-long, northwest trending, asymmetric trough of the Central Valley's regional aquifer system (Page 1986). The San Joaquin River Hydrologic Region relies heavily on groundwater. Groundwater makes up approximately 30 percent of this hydrologic region's annual water supply for agricultural and urban uses (DWR 2003).

Opportunities in the Study Area include improvements to water reliability and quality, flood management, and hydropower. Demand for reliable and quality water has always been important; however, coupled with anticipated changes in future supply and demand related to climate change (Reclamation 2011a), reliable sources of quality water will become increasingly more important. The FKC Feasibility Study provides an opportunity to increase water reliability and quality in the Study Area.

Constraints for the FKC Feasibility Study include the designed and constructed maximum capacity of the FKC, current Reclamation Design Standards, and the appropriation ceiling provided in the SJRRS Act. Therefore, the FKC Feasibility Study assumes $25,000,000 to restore the capacity of the FKC.

ES-8 Plan Formulation

The plan formulation process for Federal water resources studies is identified in the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (*Principles & Guidelines*) (WRC 1983) and consists of the following iterative steps:

- Defining water resources problems, needs, and opportunities to be addressed.

- Identifying existing and projected future resources conditions likely to occur in the Study Area.
- Developing planning objectives, constraints, and criteria.
- Identifying and formulating potential alternative plans to meet planning objectives within planning constraints.
- Comparing and evaluating alternative plans.
- Identifying and selecting a plan that best meets planning criteria and maximizes net National Economic Development (NED) benefits.

Plan formulation is a dynamic process with various steps that are iterated one or more times, occur at any step, and sharpen the planning focus or change its emphasis as new data are obtained or as the specification of problems or opportunities changes or becomes more clearly defined (WRC 1983). The FKC Feasibility Study plan formulation and selection process included identifying the no-action future conditions; defining resources, opportunities, and constraints; identifying and formulating alternatives; evaluating alternative plans; reformulating the alternatives; and, selecting a recommended feasible alternative.

Planning Objectives

On the basis of the problems, resources, opportunities, and constraints, the authorization for the FKC Feasibility Study, and other pertinent direction from the public and the FWA, the following FKC Feasibility Study planning objective was developed and guided formulation of the alternatives:

- Improve the water deliveries and reliability of the FKC in order to reduce or avoid water supply impacts on the FKC Contractors that may result from the SJRRP Flows.

FKC downstream of Friant Dam

Planning Constraints and Other Considerations

The *Principles & Guidelines* provide fundamental guidance for the formulation of Federal water resources alternatives. In addition, basic constraints and other considerations specific to the FKC Feasibility Study must be developed and identified. The following is a summary of the constraints and considerations relevant to the FKC Feasibility Study:

Planning Constraints

Planning constraints help guide development of feasibility studies. Some planning constraints are more rigid than others. Examples of more rigid constraints include congressional direction; current applicable laws, regulations, and policies; and physical conditions (e.g., topography, hydrology). Other planning constraints are less restrictive, but are still influential in guiding the process. Several constraints identified for the FKC Feasibility Study are as follows:

- **Study Authorization –** The SJRRS Act authorizes and directs the Secretary to complete a feasibility study on the restoration of the capacity of the FKC, as previously designed and constructed by Reclamation. It further authorizes the Secretary to construct the improvements upon completion of and consistent with the feasibility study, subject to an appropriation limitation that is assumed to be $25,000,000 for the FKC.

- **Laws, Regulations, and Policies –** Numerous laws, regulations, executive orders, and policies were considered, among them the *Principles & Guidelines*, National Environmental Policy Act (NEPA), Fish and Wildlife Coordination Act, the Clean Air Act, Clean Water Act, National Historic Preservation Act, Federal Endangered Species Acts, and Federal Reclamation law, regulations, and policies.

Other Considerations

Other planning considerations were specifically identified to help formulate, evaluate, and compare alternatives:

- Alternatives must incorporate results of agency and public coordination.

- Alternatives must address the planning objective.

- Alternatives must restore the capacity of the FKC, as previously designed and constructed by Reclamation.

- Alternatives must incorporate current Reclamation engineering standards, requirements, and regulations.

- Alternatives must provide for, at a minimum, a 50-year period of performance.

- Alternatives must have a high certainty for achieving intended benefits and cannot significantly depend on long-term actions, past the initial construction period, for success.
- Alternatives cannot increase the capacity of the FKC beyond the capacity previously designed and constructed by Reclamation.
- Alternatives cannot result in adverse effects to existing and future water supplies, hydropower generation, or related water and land resources conditions.
- Alternatives strive to either avoid potential adverse effects to environmental and cultural resources or include features to mitigate unavoidable adverse effects through enhanced designs, construction methods, and/or facilities operations.
- Alternatives may address current subsidence areas, but cannot include provisions for addressing future unknown subsidence areas.

ES-9 No-Action Alternative

The *Principles & Guidelines* require a No-Action Alternative to account for existing facilities, conditions, water and land resources, reasonably foreseeable actions expected to occur in the Study Area, and as a basis of comparison for all other alternatives.

Under the No Action Alternative, SJRRP Flows provided in the Settlement would be implemented; however, Reclamation would not restore the capacity of the FKC, which is not consistent with the Secretary's direction pursuant to the Settlement and SJRRS Act. The FKC would continue to operate at its current capacity-restricted condition, limiting its ability to convey water during periods of peak demand, peak flow, or flood water from Millerton Lake. Water that could not be conveyed by the FKC would be lost, either through evaporation from Millerton Lake or by spilling into the San Joaquin River.

San Joaquin River downstream of Friant Dam

In response, the FKC Contractors may take alternative water supply actions, including increasing groundwater pumping, idling cropland, or water rationing. Under the No Action Alternative, the current capacity-restricted condition of the FKC would limit the FKC Contractors ability to divert water during periods of peak demand or peak flow "for the purpose of reducing or avoiding impacts to water deliveries to all of the

Friant Division long-term contractors caused by the Interim and Restoration Flows," thus limiting the Secretary's ability to achieve the Water Management Goal in the Settlement.

ES-10 Initial Alternatives

Reclamation and the FWA initially identified four alternatives as part of the FKC Feasibility Study. The four initial alternatives are:

- **Alternative 1 –** Restore the Designed Maximum Flows of the FKC at "high priority reaches" identified by the FWA and the calibrated FKC HEC-RAS model.
- **Alternative 2 –** In addition to Alternative 1, restore the remaining deficient reaches identified by the calibrated FKC HEC-RAS model to Designed Normal Flows.
- **Alternative 3 –** Restore the Designed Maximum Flows of the entire FKC as identified by the calibrated FKC HEC-RAS model, applying original Reclamation designed and constructed freeboard standards for the FKC (0.3 feet of freeboard over maximum water surface elevation).

Friant-Kern Canal

- **Alternative 4 –** Restore the Designed Maximum Flows of the entire FKC as identified by the uniformed FKC HEC-RAS, applying current Reclamation freeboard standards (1.15 feet of freeboard over maximum water surface elevation).

Alternatives 1 and 2 would not fully restore the capacity of the FKC, and therefore were eliminated. Alternative 3 would restore the capacity of the FKC; however, not to current Reclamation's Design Standards and was therefore eliminated. Alternative 4 would restore the capacity of the FKC and meet current Reclamation Design Standards, and was therefore selected for further evaluation at the appraisal level.

ES-11 Reformulation of Alternatives

The appraisal level evaluation of Alternative 4 found it would require the restoration of up to 113 miles of the FKC at an estimated cost of $72 million. Due to the appraisal cost estimate exceeding authorized funding, the parties stopped further evaluation and reformulated the FKC Feasibility Study to identify alternatives within authorized funding, with benefits equal to or exceeding costs, and developed the following additional Planning Constraints and Other Considerations for the FKC Feasibility Study:

- Alternatives are not required to restore the entire capacity of the FKC, but must provide benefits equal to or exceeding total costs and within the assumed $25,000,000 in funding.
- Alternatives must prioritize restoration of the FKC from MP 29.14 to 88.22.
- Alternatives must result in an operational increase in capacity of the FKC.

ES-12 Feasibility Alternatives

Accordingly, based on the reformulated Planning Constraints and Other Considerations, the appraisal cost estimates, assumed funding of $25 million, and coordination with the FWA, the following two alternatives were identified and developed for evaluation at the feasibility level.

- **Alternative 5(a)** - Restore the Designed Maximum Flows of the FKC from the Kings River Outlet, MP 29.14, to the Kaweah River Check, MP 71.3, as identified by the uniformed FKC HEC-RAS model and applying current Reclamation Design Standards.
- **Alternative 5(b)** - Restore the Designed Maximum Flows of the FKC from the King River Outlet, MP 29.14, to the 5th Avenue Check, MP 88.2, as identified by the uniformed FKC HEC-RAS model and applying current Reclamation Design Standards.

Alternatives 5(a) and 5(b) are identical, except for Alternative 5(b) also providing for the restoration of the capacity of the FKC from the Kaweah River Check to the 5th Avenue Check. Accordingly, for the purposes of this Alternatives 5(a) and 5(b) are discussed jointly (Alternative 5), noting exceptions when applicable.

Description

Alternative 5 would consist of restoring the capacity of the FKC as previously designed and constructed by Reclamation at the mileposts identified in Table ES-2, including modifications to the Little Dry Creek Wasteway at MP 5.44. Proposed modifications to the FKC under Alternative 5 would include: constructing raised sections of new lining attached to and above the existing concrete and earth lining; raising existing banks; modifying check structures and inlet/outlet structures; removing three timber farm bridges and replacing one with a concrete farm bridge; modifying up to 37 other bridges crossing the canal; and, modification to the Little Dry Creek Wasteway Facility, Table ES-3. There would be no modifications to any of the FKC siphons and construction activities would be limited to the outside slope toes of the canal’s existing embankments, except for roadway travel and mobilization, and would occur over a period of three years.

Lining Raises

Alternative 5 would require raising the FKC's existing concrete and earthen lining, at the locations shown in Table ES-3 to allow for the canal to convey its capacity as previously designed and constructed by Reclamation. Lining raises would vary from a minimum of 1.0 foot to a maximum of 4.0 feet, averaging 1.7 feet vertically and placed in 1-foot increments. Alternative 5 would not include relining the FKC's earthen sections with concrete.

Bank Raises

Alternative 5 would require raising the FKC's banks at select locations to meet Reclamation Design Standards. In the select reaches identified as requiring bank raises, Table ES-3, those raises would vary from a minimum of 1.0 foot to a maximum of 3.0 feet, averaging 1.0 foot, and placed in 1-foot increments.

Bridge Modifications

Alternative 5 would require the removal of up to three timber farm bridges, replacement of the timber bridge at MP 34.13 with a concrete bridge, and the modification of up to 37 other bridges crossing the FKC, as further detailed in Table ES-3. The bridges are owned by private individuals, counties, and the State of California (California).

Bank Raises

Alternative 5 would also include raising the FKC's banks to allow for the conveyance of the canal's maximum capacity. In the limited reaches identified as requiring bank raises, Table ES-3, those raises would vary from a minimum of 1.0 foot to a maximum of 3.0 feet, averaging 1.0 foot, and placed in 1-foot increments.

Feasibility-Level Cost Estimate

Construction activities would be phased over a period of up to 3 years and are estimated as the feasibility-level to cost $24,530,000 for Alternative 5(a) and $39,100,000 for Alternative 5(b). The feasibility-level estimates were completed in accordance with Reclamation's FAC 09-01 and FAC 09-02.

Millerton Lake

Table ES-2. Alternative 5 – Current Capacity vs. Maximum Capacity

Alternative	Mileposts	Distance (miles)	Current Capacity (cfs)	Maximum Capacity (cfs)
5(a) and 5(b)	29.14 to 71.29	42.15	4,500	5,300
5(b)	71.29 to 88.22	16.93	4,105	4,500

Table ES-3. Alternative 5 – Modifications

Alternative	Mileposts		Type of Lining	Lining Raise Length	Bank Raise Length	Bridge Work
	From	To		Miles	Miles	Number of Bridges Potentially Modified
5(a) and 5(b)	5.44	5.44	Little Dry Creek Wasteway	--	--	--
5(a) and 5(b)	29.14	33.87	Concrete	4.73	0.72	2
5(a) and 5(b)	33.89	34.92	Concrete	1.03	0.51	2
5(a) and 5(b)	34.92	35.59	Earthen	0.67	0.11	1
5(a) and 5(b)	35.62	36.30	Earthen	0.68	0.07	1
5(a) and 5(b)	36.33	43.39	Earthen	7.06	--	8
5(a) and 5(b)	43.42	43.95	Earthen	0.53	--	1
5(a) and 5(b)	43.99	45.81	Earthen	1.82	--	1
5(a) and 5(b)	45.89	46.17	Earthen	0.28	--	--
5(a) and 5(b)	46.21	52.98	Earthen	6.77	0.95	1
5(a) and 5(b)	52.98	57.13	Concrete	4.15	1.12	--
5(a) and 5(b)	57.13	62.00	Earthen	4.87	0.31	5
5(a) and 5(b)	62.00	66.47	Concrete	4.47	2.76	--
5(a) and 5(b)	66.52	67.09	Concrete	0.57	--	--
5(a) and 5(b)	67.12	67.95	Concrete	0.83	--	--
5(a) and 5(b)	68.00	69.48	Concrete	1.48	--	1
5(a) and 5(b)	69.54	71.30	Concrete	1.76	0.05	2
5(b)	71.36	73.74	Concrete	2.38	0.45	1
5(b)	73.78	75.19	Concrete	1.41	--	1
5(b)	75.22	77.06	Concrete	1.84	1.19	2
5(b)	77.08	85.56	Concrete	8.48	3.11	5
5(b)	85.58	85.79	Concrete	0.21	0.21	1
5(b)	85.81	86.87	Concrete	1.06	--	2
5(b)	86.89	88.22	Concrete	1.33	--	3
	TOTAL			**58.41**	**11.57**	**40**

Key: -- = not applicable

ES-13 Feasibility Evaluation

The *Principles & Guidelines* establish four accounts to facilitate the evaluation and display of effects of alternatives. These accounts are: National Economic Development (NED), Environmental Quality (EQ), Regional Economic Development (RED), and Other Social Effects (OSE). The only required account is the NED. Other information that is required by law or that will have a material bearing on the decision is included in the other accounts.

EQ, RED, and OSE Accounts

The EQ, RED, and OSE accounts are not estimated to have a material bearing on Alternative 5 and therefore feasibility evaluation of these accounts was not considered necessary by Reclamation.

Net NED Benefits

The objective of the national economic development analysis is to determine the change in net value of the Nation's output of goods and services that would result from implementing the alternative. Beneficial and adverse effects are evaluated in monetary terms and are measured in terms of changes in national income.

NED Benefits

The benefits of Alternative 5 are estimated relative to the No-Action Alternative and are categorized as the:

- Increase in the ability to deliver surface water supplies to lands that may be impacted from implementation of the SJRRP Flows.
- Increase in groundwater levels, reducing pumping costs for lands that may be impacted from implementation of the SJRRP Flows.

Reclamation used a series of operational models, including CalSim, in order to evaluate the change in surface water and groundwater supplies between the No-Action Alternative and Alternative 5. As illustrated in Figures ES-3 and ES-4, the benefit of Alternative 5 is the ability to divert water supplies in wet years and results in an increase in the annual average surface water deliveries to the FKC Contractors of 5,000 to 8,000 acre-feet, without and with Part-III Projects, respectively. The maximum single year increase in deliveries is 56 TAF without Part-III Projects and 113 TAF with Part-III Projects.

San Joaquin River downstream of Friant Dam

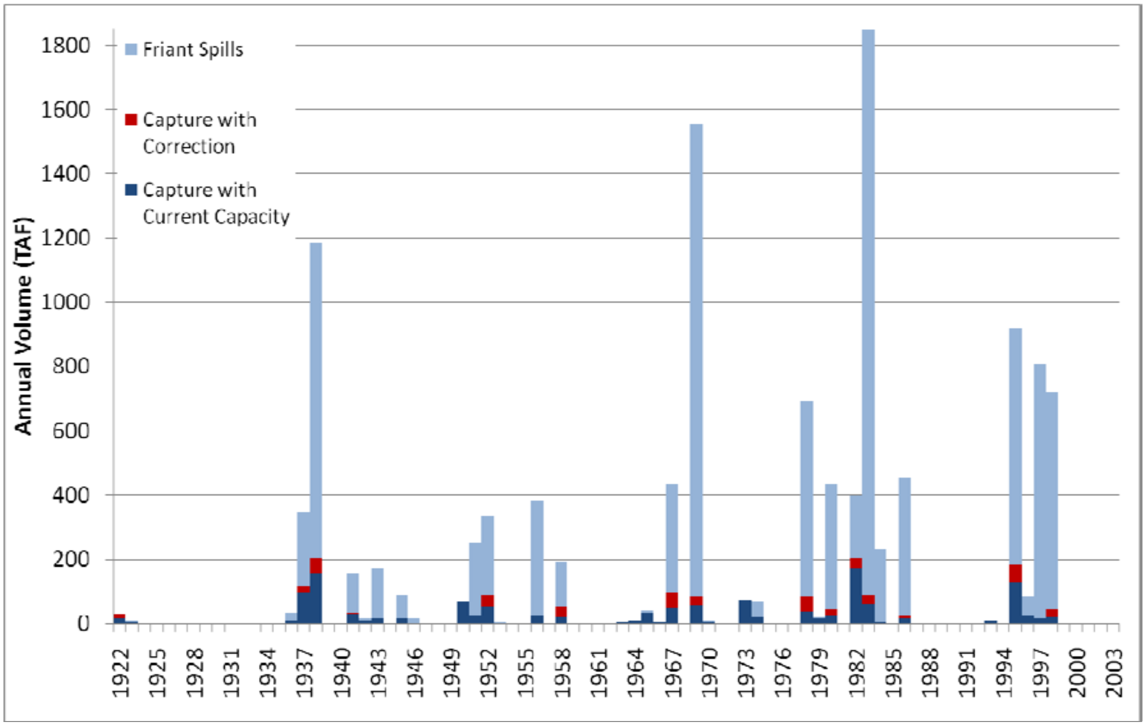

Figure ES-3. Change in Friant Dam Spills without Part-III Projects

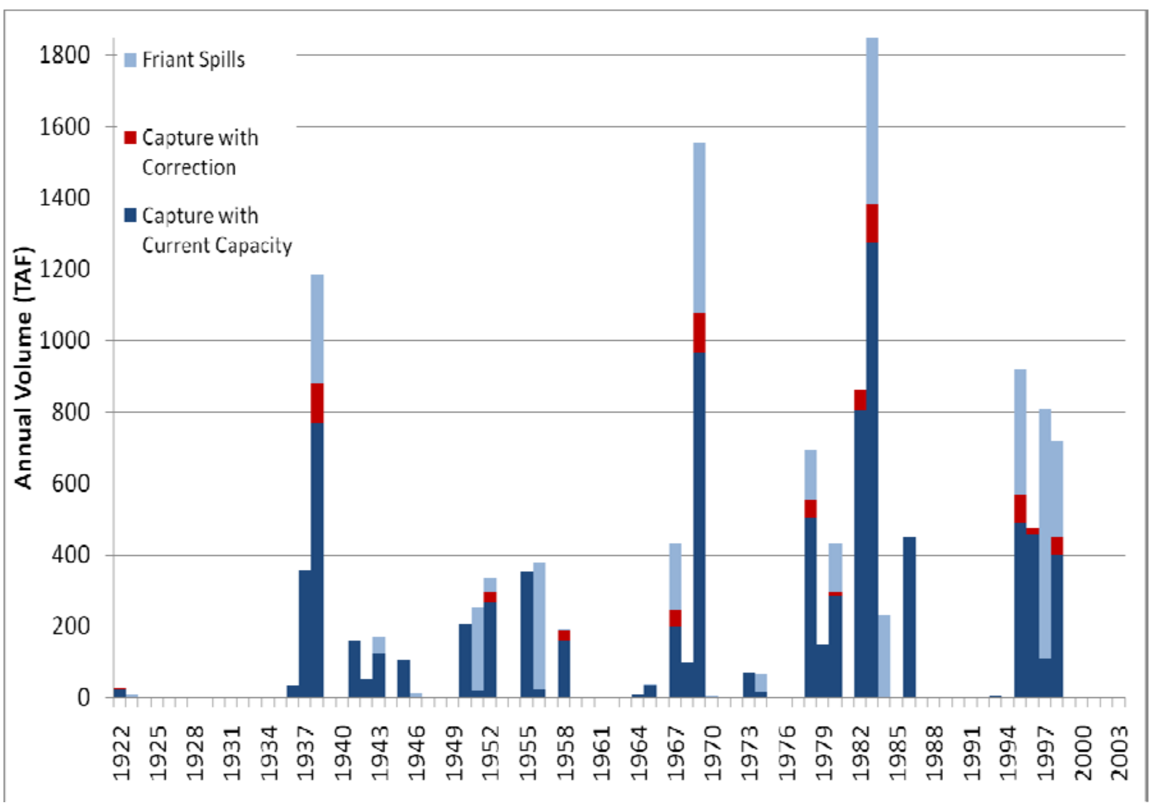

Figure ES-4. Change in Friant Dam Spills with Part-III Projects

Due to the increase in wet year diversions resulting from implementation of Alternative 5, Reclamation completed an analysis to determine the change, if any, in total CVP/State Water Project (SWP) diversions from the Sacramento-San Joaquin Delta (Delta) as a result of Alternative 5. This analysis was carried out by modifying two CalSim simulations developed under the SJRRP for existing operations, with and without Paragraph 16(b) of the Settlement. Table ES-4 provides the changes in mean monthly Delta exports and the percent change in monthly exports as a result of Alternative 5. Based on this analysis, Reclamation does not anticipate a reduction in the CVP/SWP Delta exports as a result of implementing Alternative 5.

Table ES-4. Mean CVP/SWP Monthly Delta Export (1921-2003)

Month	*No Action Alternative (cfs)*	*Alternative 5 with Part-III Projects (cfs)*	*Percent Change*
October	8,607	8,606	0.0%
November	9,007	9,005	0.0%
December	10,090	10,088	0.0%
January	10,661	10,698	0.3%
February	9,240	9,224	-0.2%
March	8,208	8,208	0.0%
April	5,905	5,904	0.0%
May	5,168	5,154	-0.3%
June	6,275	6,276	0.0%
July	8,976	8,975	0.0%
August	8,723	8,722	0.0%
September	9,075	9,032	-0.5%

In order to determine the economic benefits of implementing Alternative 5, Reclamation used output from the operations modeling described above and inputted it into the Central Valley Production Model (CVPM). Since the majority of the water supplies would be delivered during wet periods, when irrigation demand is low, the majority of the developed water supplies are anticipated to be used for groundwater recharge. Accordingly, based on these assumptions CVPM calculates the national economic benefit of implementing Alternative 5 as follows, Table ES-5:

Table ES-5. NED Benefits

Period	*NED Benefits Without Part-III Projects*	*NED Benefits With Part-III Projects*
Annual	$658,000	$1,157,000
50 Years	**$32,900,000**	**$57,850,000**

NED Costs

NED Costs are the opportunity costs of resource use. In cases where financial costs reflect the full economic value of a particular resource to society, they can and should be used to determine NED Costs, which Reclamation determined to be appropriate for Alternative 5. Due to the FKC Feasibility Study being funded through non-reimbursable Federal appropriations, resulting in no interest during construction or repayment costs, and the operation and maintenance cost of the FKC expected to remain the same, Reclamation determined the NED Costs for Alternative 5 to be the total cost of constructing Alternative 5. Accordingly, based on feasibility-level estimates, the NED Costs is as follows for Alternative 5(a) and 5(b), Tables ES-6 and ES-7:

Table ES-6. Alternative 5(a) – Feasibility Cost Estimate

Description	Percentage	Amount
Construction Cost	--	$15,390,000
Mobilization	5%	$769,500
Design Contingencies	10%	$1,615,900
Construction Contingencies	20%	$3,555,000
Non-Contract Costs	15%	$3,199,600
Total Cost		**$24,530,000**

Table ES-7. Alternative 5(b) – Feasibility Cost Estimate

Description	Percentage	Amount
Construction Cost	--	$24,531,654
Mobilization	5%	1,250,000
Design Contingencies	10%	$2,218,346
Construction Contingencies	20%	$6,000,000
Non-Contract Costs	15%	$5,100,000
Total Cost		**$39,100,000**

Net NED Benefits

The *Principles and Guidelines* state that the alternative that reasonably maximizes Net NED benefits, consistent with the Federal objective, is identified as the NED plan. Net NED Benefits are calculated by subtracting NED Costs from NED Benefits. As shown in Table ES-8, the alternative that provides the maximum Net NED Benefits is Alternative 5(a). If the NED Costs for Alternative 5(b) could be reduced to $25,000,000, the assumed funding for the FKC Feasibility Study, Alternative 5(b) would maximize the Net NED Benefits.

Table ES-8. Summary of Net NED Benefits (50 years)

	Alternative 5(a)		Alternative 5(b)	
	Without Part-III	With Part-III	Without Part-III	With Part-III
Total NED Benefit	$32,900,000	$57,850,000	$32,900,000	$57,850,000
Total NED Costs	$24,530,000	$24,530,000	$39,100,000	$39,100,000
Net NED Benefits	**$8,370,000**	**$33,320,000**	**($6,200,000)**	**$18,750,000**

ES-14 Project Feasibility

Feasibility of Alternatives

Feasibility of the alternatives consists of four parts—technical, environmental, economic, and financial. Technical feasibility consists of engineering, operations, and constructability analyses that verify that the alternative can be constructed, operated, and maintained. Environmental feasibility consists of analyses verifying that constructing or operating the alternative will not result in unacceptable environmental consequences to endangered species, cultural, Indian trust, or other resources. Economic feasibility consists of analyses verifying that constructing the project is an economically sound investment of capital (i.e., that the alternative would result in positive net benefits or the alternatives' benefits would exceed the costs). Financial feasibility for the FKC Feasibility Study consists of the non-reimbursable Federal appropriations. The following findings relate to each of these parts of a feasibility determination.

Technical Feasibility

The alternatives are technically feasible, constructible, and can be operated and maintained. The designs and cost estimates for Alternative 5 are at a feasibility-level.

Environmental Feasibility

The alternatives, including the No-Action Alternative, were included in the Draft Environmental Assessment. The environmental impacts were evaluated and mitigated or found to be less than significant. Compliance with the Endangered Species Act (ESA) and the National Historic Preservation Act (NHPA) is ongoing and any findings will be incorporated as necessary.

Economic Feasibility

Based on the economic modeling, Alternative 5(a) is identified to have the largest Net NED Benefits. If the NED Costs for Alternative 5(b) could be reduced to $25,000,000, the assumed funding for the FKC Feasibility Study, Alternative 5(b) would maximize the largest Net NED Benefits.

Financial Feasibility

Alternative 5 is financially feasible, up to the $25,000,000 of assumed funding for the FKC Feasibility Study, as the costs are to be funded through non-reimbursable Federal appropriations. The only limitation is that Federal funds are subject to future appropriations by Congress.

ES-15 Federal Interest

For an alternative to be implementable there must be a Federal interest in the alternative and the alternative must be feasible as defined by the *Principles and Guidelines*. The *Principles and Guidelines* require that Federal actions contribute to the NED. Federal interest in FKC Feasibility Study can be established by the Settlement and SJRRS Act. As stated above, Alternative 5(a) provides positive NED benefits and Alternative 5(b) could provide positive NED benefits if construction costs could be reduced.

ES-16 Conclusions

- Restoration of the capacity of the FKC must prioritize restoration of the canal from the Kings River Siphon outlet to the 5th Avenue Check.

- Based on analyses to date, the alternatives are technically feasible for implementation by the Federal Government.

- Based on analyses to date, the alternatives are environmentally feasible for implementation by the Federal Government.

- Based on analyses to date, Alternative 5(a) is economically feasible for implementation by the Federal Government. In addition, if the NED Costs of Alternative 5(b) could be reduced to $25,000,000, it would also be economically feasible for implementation by the Federal Government.

- Based on analyses to date, Alternative 5 is financially feasible, up to $25,000,000, for implementation by the Federal Government, subject to future appropriations by Congress.

- The No-Action Alternative is inconsistent with the Secretary’s direction pursuant to the Settlement and the SJRRS Act as it does not assist the FKC Contractors in “reducing or avoiding impacts to water deliveries to all of the Friant Division long-term contractors caused by the Interim and Restoration Flows.”

ES-17 Recommendations and Next Steps

The recommendation is to implement Alternative 5(a), or Alternative 5(b) if costs can be reduced to $25,000,000. Based on the findings of this report, the following are the next steps for the FKC Feasibility Study:

- Reclamation will solicit public input on the Draft Feasibility Report and EA. Comments received during the public review period will be considered in development of the Final Feasibility Report and EA.
- Reclamation will complete compliance with the ESA and NHPA.
- Reclamation will complete a Final Feasibility Report, Final Environmental Assessment, and Finding of No Significant Impact and transmit them to the Secretary and Congress.
- Pursuant to Section 10201(b) of the SJRRS Act, the Secretary is authorized to construct the alternative, subject to future appropriations by Congress.

Friant-Kern Canal at maximum capacity

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Chapter 1. Introduction

The purpose of this report is to present the results of the Friant-Kern Canal Capacity Restoration Feasibility Study (FKC Feasibility Study) and to document if any of the alternatives developed are feasible and warrant Federal implementation.

The United States (U.S.) Department of the Interior, Bureau of Reclamation, conducted the FKC Feasibility Study consistent with the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (*Principles & Guidelines*) (WRC 1983), and other pertinent Federal and state laws. This report has a companion Draft Environmental Assessment (EA) and Finding of No Significant Impact (FONSI) published under separate cover.

This chapter identifies the Study Area, describes the FKC Feasibility Study purpose and objectives, summarizes the background, identifies the authority, Study Sponsor, summarizes the public involvement and scoping for the alternatives, and lists other pertinent studies and activities conducted in the Study Area.

1.1 Study Area

The Study Area, as shown in Figure 1, encompasses the 152-mile Friant-Kern Canal (FKC) and the contract service areas of the 25 Central Valley Project (CVP), Friant Division, long-term water service contractors served by the FKC (FKC Contractors), Table 1. The Study Area is located within the counties of Fresno, Tulare, and Kern, which are the top three agricultural producing counties in the nation (USDA 2007). In addition to agricultural production, the lands within the Study Area are used for municipal, industrial, and environmental purposes. The Study Area is represented by Congressional Districts 20, 21, and 22.

1.2 Problem, Purpose, Need, and Objective

Since completion of construction by Reclamation in 1951, the FKC has lost its ability to convey the capacity for which it was previously designed and constructed by Reclamation. These limitations result in restrictions, at times, of CVP water deliveries to the FKC Contractors. The purpose and need for the FKC Feasibility Study is to analyze the feasibility of restoring the FKC to such capacity as previously designed and constructed by Reclamation. Figure 2 and Table 1 identify the affected FKC Contractors, the current capacity, and the previously designed and constructed capacity of the FKC. Restoration of the capacity of the FKC is needed in order to improve water deliveries

Sandbags placed on the FKC to restore capacity

and reliability to the FKC Contractors in order to reduce or avoid water supply impacts that may result from the Interim Flows and Restoration Flows (SJRRP Flows), provided in the Settlement of the lawsuit entitled *Natural Resources Defense Council, et al., v. Kirk Rodgers, et al*.

The objective of the Feasibility Study is to:

- Improve the water deliveries and reliability of the FKC in order to reduce or avoid water supply impacts on the FKC Contractors that may result from the SJRRP Flows.

1.3 Study Authority

The FKC Feasibility Study is authorized and funded by Sections 10201 and 10203(a) of Public Law 111-11, the San Joaquin River Restoration Settlement Act (SJRRS Act).

Section 10201:

> "*(a) The Secretary of the Interior (hereafter referred to as the 'Secretary') is authorized and directed to conduct feasibility studies in coordination with appropriate Federal, State, regional, and local authorities on the following improvements and facilities in the Friant Division, Central Valley Project, California:*
>
> *(1) Restoration of the capacity of the Friant-Kern and Madera Canal to such capacity as previously designed and constructed by the Bureau of Reclamation.*
>
> *(2) […]*
>
> *(b) Upon completion of and consistent with the applicable feasibility studies, the Secretary is authorized to construct the improvements and facilities identified in subsection (a) in accordance with applicable Federal and State laws.*
>
> *(c) The costs of implementing this section shall be in accordance with Section 10203, and shall be a nonreimbursable Federal expenditure.*"

Section 10203(a):

> "*(a) The Secretary is authorized and directed to use monies from the fund established under section 10009 to carry out the provisions of section 10201(a)(1), in an amount not to exceed $35,000,000.*"

Initially, Reclamation evaluated the restoration of the capacity of the FKC and Madera Canal jointly. However, due to unique differences in the design and construction of the canals, Reclamation separated the evaluation of the canals. Accordingly, this report evaluates the restoration of the capacity of the FKC.

The Friant Water Authority (FWA) and Madera Chowchilla Water Power Authority agreed to separate the authorized funding as follows: $25,000,000 for the FKC; $10,000,000 for the Madera Canal. Therefore, the FKC Feasibility Study assumes $25,000,000 to restore the capacity of the FKC.

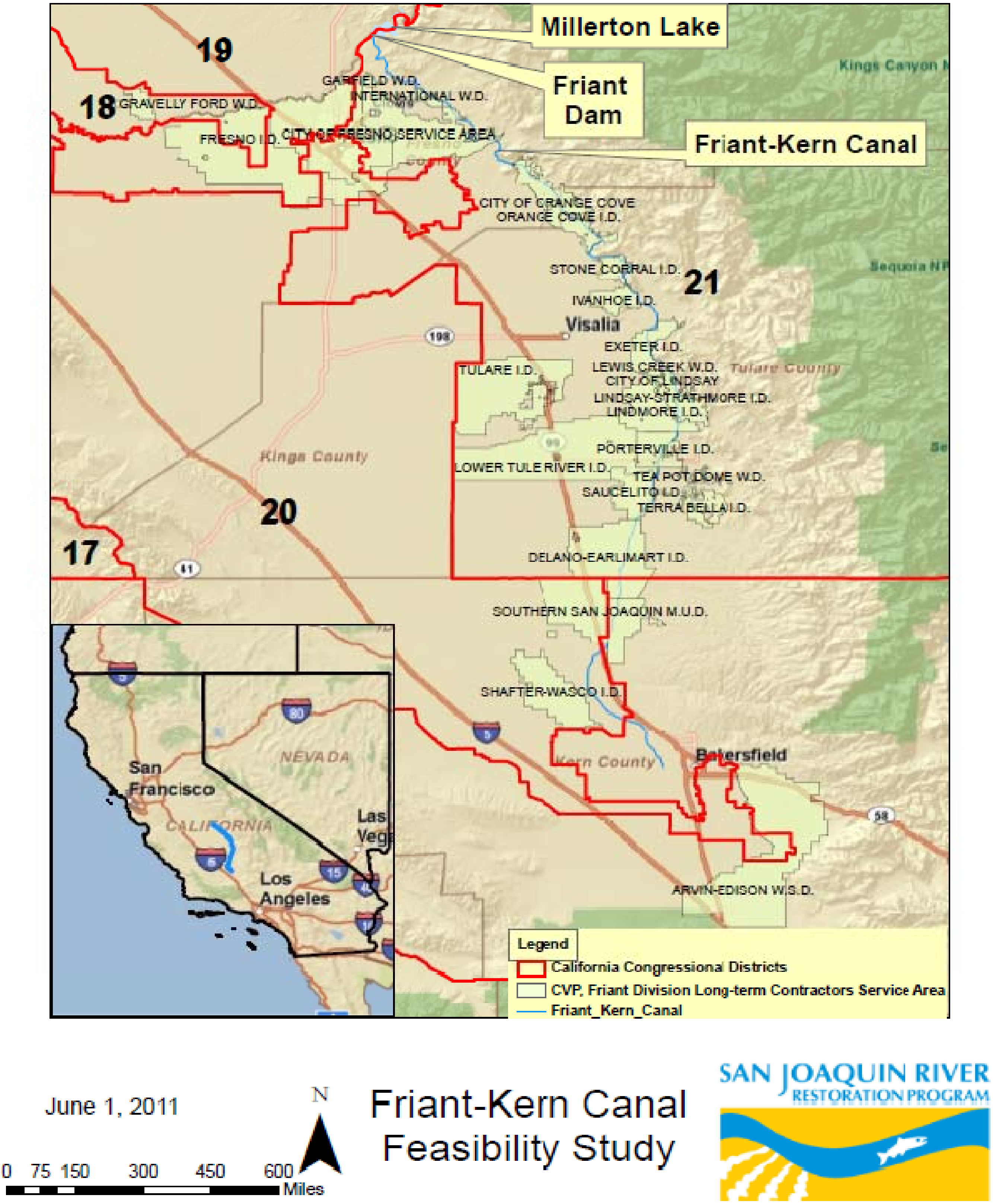


Figure 1. Study Area

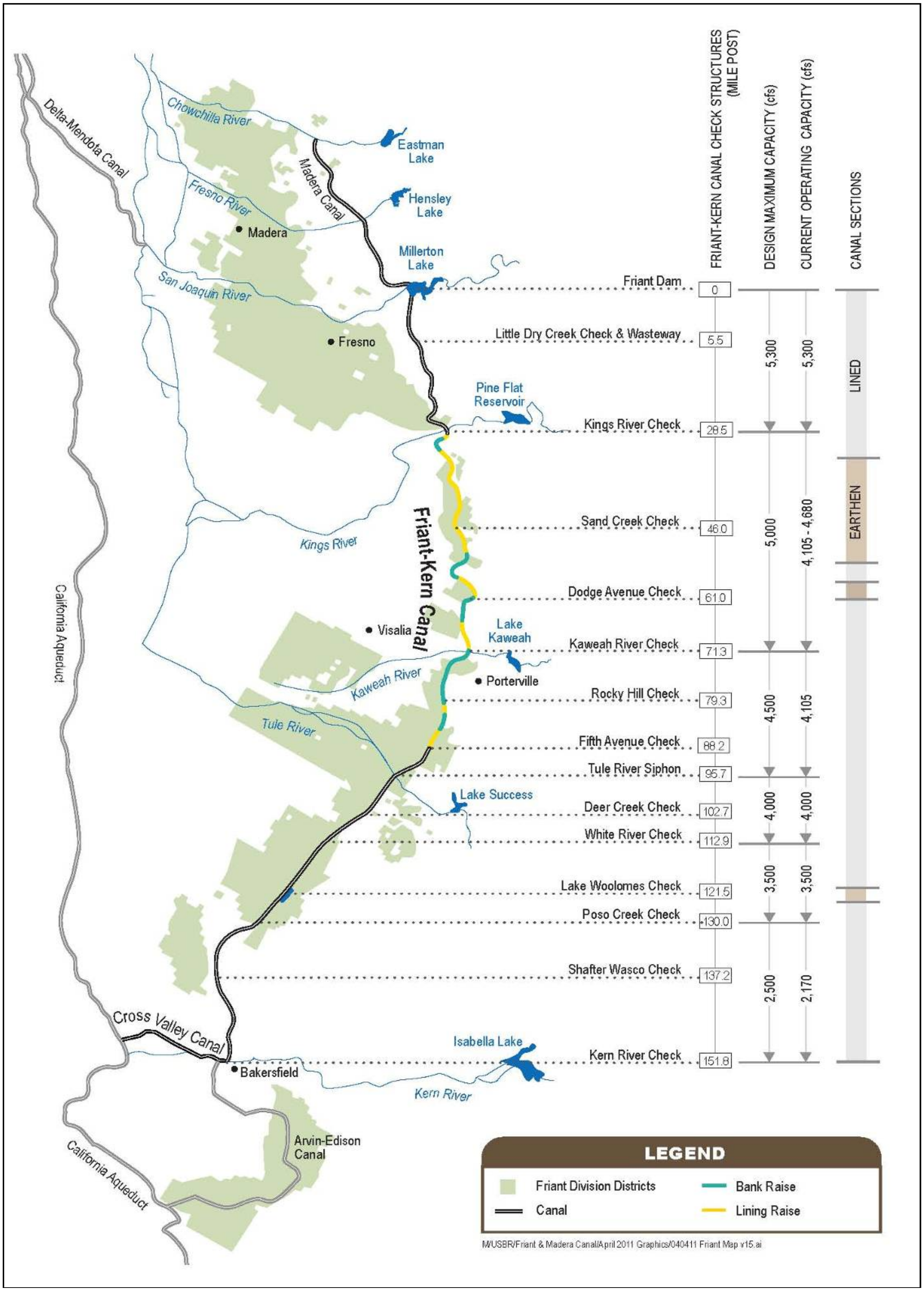


Figure 2. Current Capacity vs. Maximum Capacity

Table 1. Current Capacity vs. Designed Capacity

Reach for Modeling	*Friant-Kern Structures* FRIANT CONTRACTOS	Mile Post	*Current Capacity (cfs)*	*Maximum Capacity (cfs)*
	Friant Dam	**0**		
Reach 1	FRESNO I.D.		5,300	5,300
	CITY OF FRESNO			
	GARFIELD W.D.			
	INTERNATIONAL W.D.			
	Kings River Check	**28.52**		
Reach 2	CITY OF ORANGE COVE		4,680 - 4,105	5,000
	IVANHOE I.D.			
	ORANGE COVE I.D.			
	STONE CORRAL I.D.			
	TULARE I.D.			
	KAWEAH DELTA W.C.D.			
	Kaweah River Check	**71.29**		
	EXETER I.D.		4,105	4,500
	CITY OF LINDSAY			
	LEWIS CREEK W.D.			
	LINDSAY STRATHMORE I.D.			
	LINDMORE I.D.			
	5th Ave Check	**88.22**		
Reach 3	LINDSAY STRATHMORE I.D.			
	LINDMORE I.D.			
	LOWER TULE RIVER I.D.			
	PORTERVILLE I.D.			
	Tule River Check	**95.67**		
	LOWER TULE I.D.		4,000	4,000
	PORTERVILLE I.D.			
	TEA POT DOME W.D.			
	SAUCELITO I.D.			
	TERRA BELLA I.D.			
	Deer Creek Check	**102.69**		
Reach 4	SAUCELITO I.D.			
	TERRA BELLA I.D.			
	DELANO EARLIMART I.D.			
	KERN-TULARE W.D.			
	White River Check	**112.9**		
	DELANO EARLIMART I.D.		3,500	3,500
	SOUTHERN S.J.M.U.D.			
	Poso Creek Check	**130.05**		
Reach 5	SHAFTER WASCO I.D.		2,170	2,500
	Shafter Wasco Check	**137.2**		
Reach 6	ARVIN EDISON W.S.D			
	Kern River Check	**151.8**		

Note: Some contractors span two reaches.

1.4 Background

In 1942, Reclamation, as part of the CVP, completed construction of Friant Dam on the San Joaquin River, 16 miles northeast of downtown Fresno, California. Friant Dam is a concrete gravity structure, 319 feet high, with a crest length of 3,488 feet. It controls the flows of the San Joaquin River and provides for: downstream releases to meet requirements above Mendota Pool; flood control; conservation storage; SJRRP Flows; diversion into the FKC and Madera Canal; and, the delivery of water to one million acres of agricultural land in Fresno, Kern, Madera, and Tulare Counties. Friant Dam was first used to store water on February 21, 1944. Millerton Lake, the reservoir behind Friant Dam, has a total capacity of 520,500 acre-feet, a surface area of 4,900 acres, and is approximately 15 miles long. It provides for 45 miles of shoreline that varies from gentle slopes near Friant Dam to steep canyon walls further inland, and it allows for various recreational activities, such as boating, fishing, picnicking, and swimming (Reclamation 1994).

Friant Dam construction

Friant Dam serves the CVP Friant Division long-term contractors through three separate river and canal outlets: the San Joaquin River outlet works, the FKC, and the Madera Canal. The FKC carries water across 151.8 miles in a southerly direction from Millerton Lake to the Kern River, four miles west of Bakersfield. The water is primarily used as supplemental and irrigation supplies in Fresno, Tulare, and Kern Counties. Construction of the FKC began in 1945 and was completed in 1951. Approximately 85 percent of the FKC is concrete lined, with 15 percent earth lined. The FKC originally had a maximum capacity of 5,000 cfs that gradually decreased to 2,500 cfs at its terminus in the Kern River (Reclamation 1994). In the late 1970s, Reclamation raised the FKC’s concrete lining from the headworks to the Kings River Siphon, increasing the maximum capacity in this reach to 5,300 cfs.

Since completion of construction by Reclamation in 1951, the FKC has lost its ability to fully meet its previously designed and constructed capacity, resulting in restrictions, at times, on water deliveries to the FKC Contractors. The reduction in capacity is a result of several factors, including original design limitations, subsidence, increased canal roughness, and changes in water delivery patterns.

Friant Dam Construction

Settlement and Act

In 1988, a coalition of environmental groups, led by the Natural Resources Defense Council (NRDC) filed a lawsuit, *NRDC, et al., v. Kirk Rodgers, et al.*, challenging the renewal of long-term water service contracts between the United States and the Friant Contractors. On September 13, 2006, after more than 18 years of litigation, the Settling Parties, including NRDC, Friant Water Users Authority, and the U.S. Departments of the Interior and Commerce, agreed on the terms and conditions of the Settlement subsequently approved by the U.S. Eastern District Court of California on October 23, 2006. The SJRRS Act authorizes and directs the Secretary of the Interior (Secretary) to implement the Settlement, that establishes two primary goals:

> **Restoration Goal –** To restore and maintain fish populations in "good condition" in the main stem San Joaquin River below Friant Dam to the confluence of the Merced River, including naturally reproducing and self-sustaining populations of salmon and other fish.
>
> **Water Management Goal –** To reduce or avoid adverse water supply impacts on all of the Friant Division long-term contractors that may result from the SJRRP Flows.

To achieve the Restoration Goal, the Settlement calls for releases of water from Friant Dam to the confluence of the Merced River, a combination of channel and structural modifications along the San Joaquin River below Friant Dam, and reintroduction of Chinook salmon. To achieve the Water Management Goal, Paragraph 16 of the Settlement and Part-III of the SJRRS Act provide for certain activities to be developed and implemented to reduce or avoid adverse water supply impacts on all Friant Division long-term contractors, that includes the FKC Feasibility Study.

San Joaquin River

1.5 Public Involvement and Scoping

Reclamation integrated public and agency involvement into the overall planning process for the FKC Feasibility Study, starting in 2008, as part of the bi-monthly public San Joaquin River Restoration Program (SJRRP) Water Management Technical Feedback (WMTF) meetings held in Visalia and Fresno, California. As part of these WMTF meetings, Reclamation presented background information on the FKC Feasibility Study, obtained comments and screened alternatives, and solicited and received public concerns and comments throughout the process.

In addition to the public WMTF meetings, starting in 2008, Reclamation held frequent coordination meetings with the FWA and conducted several briefings for other local agencies, cooperating agencies, environmental groups, and congressional staff on the development of the FKC Feasibility Study.

1.6 Study Sponsor

The FWA is the non-Federal sponsor for the FKC Feasibility Study; however, pursuant to Section 10201(c) of the SJRRS Act, the FKC Feasibility Study is funded through non-reimbursable Federal appropriations. The FWA, which operates and maintains the FKC pursuant to Contract No. 8-07-20-X0356, actively participated in the development of the FKC Feasibility Study and supports the recommendations in this report.

1.7 Previous Studies and Current Activities in Study Area

The following is a summary of pertinent previous studies and current activities of various Federal, State, and local agencies that directly affect the FKC Feasibility Study.

1960 – Reclamation Technical Memorandum No. 661

In the 1940s and 1950s, Reclamation constructed several large concrete canals and subsequently found they were incapable of conveying the flows specified in the original designs. In response, in the early 1960s, Reclamation conducted a technical investigation, that included investigations of the FKC to determine the cause and published its findings in *Technical Memorandum No. 661 – Analyses and Descriptions of Capacity Tests in Large Concrete-Lined Canals* (Reclamation 1964). A major conclusion from the Technical Memorandum No. 661 was that the basic hydraulic loss formulas used during the design of the large concrete canals required adjustment. Specifically, the original designs for the FKC used a Manning's "n-value" (see Chapter 2 for explanation of "n-value") with a friction coefficient of 0.014 for concrete-lined sections. Results from the Technical Memorandum No. 661 noted the friction coefficient for concrete-lined section ranging from 0.015 to 0.019.

Friant-Kern Canal

1976 Lime Stabilization on FKC – Milepost 60 and 82

Since construction in the late 1940s, the FKC experienced cracking, sliding, and sloughing of the side slopes of the canal in areas of expansive clays in both the concrete-lined and earth-lined portions. In the early 1970s, Reclamation designers decided to remove portions of the FKC's lining, flatten the slopes, and reline the canal using a compacted soil-lime mixture in an attempt to stabilize the slopes. The project added 4 percent (based on dry soil weight) granular quicklime to the soil. Laboratory tests on the compacted soil-lime mixture showed that: (1) soil-lime was about 20 times stronger than the untreated clay; (2) the strength of the soil-lime increases with time; (3) the plasticity index of the natural soil was reduced from 40 to 10 or less after adding the lime; and (4) the compressive strength of the soil-lime was dependent on the compacted density.

1977 Repair – MP 0.00 to 28.5

Between 1977 and 1980, Reclamation authorized, designed, and constructed a lining raise between the FKC headworks, Milepost (MP) 0.00 and the Kings River Check, MP 28.50. This increase was necessitated by an increase in water demand and operational control. Thus, the FKC's initial maximum capacity was increased from 5,000 cfs to 5,300 cfs. The details for this construction can be found in Reclamation specification DC-7295. This work is very similar in nature and design to the proposed canal lining and bank raises detailed in this report.

FWA - Sand Bags/Concrete Lining

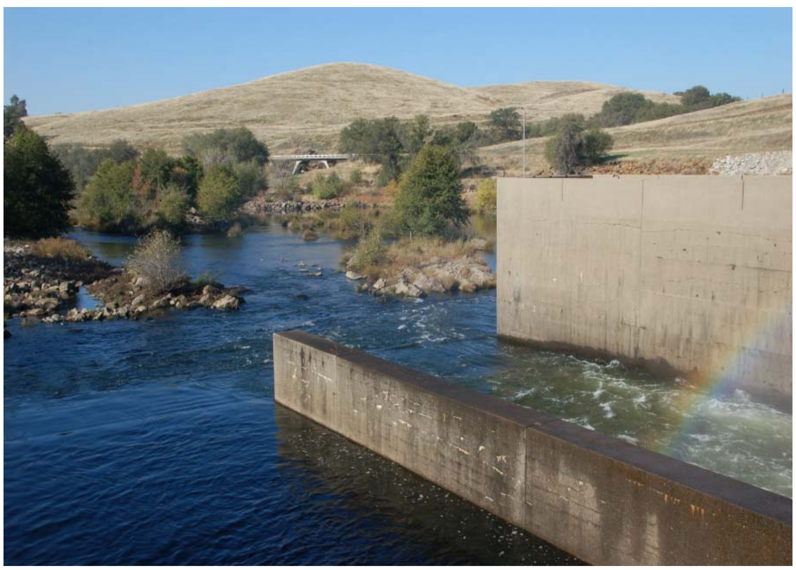
Since 1986, in response to the FKC's original design limitations and subsidence issues, the FWA has been required to periodically place sandbags at select locations on the canal to maintain capacity. Major areas of activity are located downstream of the Kings River siphon outlet, MP 29.14, to MP 30.34. In addition, in response to significant capacity restrictions between MP 75.77 and MP 76.37, the FWA raised the concrete lining in this section in 2002.

Agriculture in the San Joaquin Valley

Upper San Joaquin River Basin Storage Investigation

Reclamation and the California Department of Water Resources (DWR) are continuing the development of the Upper San Joaquin River Basin Storage Investigation (USJRBSI), one of the four ongoing feasibility studies identified in the CALFED Record of Decision. Reclamation was provided feasibility study authority for the USJRBSI through Public Law 108-7, the Omnibus Appropriations Act of 2003, and initiated the study in September 2003, and affirmed in the CALFED Bay-Delta Authorization Act (P.L. 108-361) in 2004. Section 227 of the State's Water Code authorizes DWR to participate in water resources investigations. The USJRBSI encompasses the San Joaquin River watershed upstream from Friant Dam and the portions of the San Joaquin and Tulare Lake hydrologic regions served by the FKC and Madera Canal.

The Settlement resulted in the reformulation of the USJRBSI to incorporate SJRRP Flows into the baseline condition. Primary objectives of the USJRBSI are to increase water supply reliability for agricultural and urban users and enhance flow and temperature conditions in support of the SJRRP along with secondary opportunities for recreation, flood damage reduction, and hydropower benefits. The changing regulatory and institutional landscape has resulted in increasing constraints on Delta exports and has impacted the study schedule and scope. Consequently, Reclamation is reevaluating the project features and operation to adapt the USJRBSI to a reduced Delta export regime and to consider new benefit opportunities. Reclamation and DWR completed: Public Scoping Report, December 2004; Initial Alternatives Information Report, June 2005; and, Plan Formulation Report, October 2008.



Friant Dam outlet works and San Joaquin River

Part-III Projects

Part-III of Title X, Subtitle A of Public Law 111-11, authorizes Reclamation to provide financial assistance to local agencies within the CVP for the planning, design, environmental compliance, and construction of local facilities to bank water underground or recharge groundwater. A project will be eligible if all or a portion of the project is designed to reduce, avoid, or offset the quantity of expected water supply impacts to Friant Division long-term contractors caused by SJRRP Flows in the San Joaquin River released pursuant to the Settlement.

Reclamation completed Guidelines for the Application of Criteria for Financial Assistance for Local Projects under Part-III of Public Law 111-11 (Guidelines) in consultation with Friant Division long-term contractors. The Guidelines provide a framework for obtaining Federal financial assistance for Friant Division groundwater recharge and/or banking projects as authorized by Part-III. Consistent with statutory requirements of Part-III, Office of Management and Budget cost principles and Reclamation policy, the Guidelines address the contents of a complete Planning Report and cost-share agreement.

1.8 Organization of this Report

Chapter 1 provides an overview of the FKC Feasibility Study – Study Area, purpose and objectives, background, authority, Study Sponsor, and other information.

Chapter 2 discusses resources, opportunities, and constraints necessary to formulate viable alternatives to meet the FKC Feasibility Study objective.

Chapter 3 presents the study formulation, planning objectives, planning constraints and other considerations, criteria, No-Action Alternatives, Initial Alternatives evaluation and screening, appraisal evaluation of Alternative 4, reformulation of planning constraints and other considerations, and Reformulated Alternatives.

Chapter 4 presents the feasibility evaluation of the Reformulated Alternatives.

Chapter 5 summarizes the affected environment and potential environmental effects.

Chapter 6 summarizes the consultation and coordination during the course of the FKC Feasibility Study.

Chapter 7 presents the findings, conclusions, recommendations, and next steps resulting from the FKC Feasibility Study.

San Joaquin River

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Chapter 2. Problems, Resources, Opportunities, and Constraints

This chapter discusses the problems, resources, opportunities, and constraints considered in formulating the alternative plans for the FKC Feasibility Study.

2.1 Problems

FKC Capacity Deficiency

Since completion of construction by Reclamation in 1951, the FKC has lost its ability to fully meet its designed and constructed capacity, resulting in restrictions, at times, on water deliveries to the FKC Friant Contractors. The reduction in capacity is a result of several factors, including: original design limitations, subsidence, increased canal roughness, and changes in water delivery patterns.

In order to identify the capacity deficiencies of the FKC, Reclamation met with the FWA to identify known operationally deficient reaches, conducted on site-studies and surveys, and generated a steady-state hydraulic model of the FKC using HEC-RAS (FKC HEC-RAS).

HEC-RAS is a hydraulic model developed by the U.S. Army Corps of Engineers Hydrologic Engineering Center in Davis, California, and incorporates many aspects of hydraulic modeling, including water surface profile computations, bridge hydraulics, one-dimensional steady flow, and unsteady flow simulation. The steady flow water surface profile component of the modeling system is intended for calculating water surface profiles for steady gradually varied flow.

The FKC HEC-RAS model simulates hydraulics of the entire 151-mile FKC from Friant Dam to the Kern River Check, including siphons, checks, and bridges. The FKC geometry represented in the FKC HEC-RAS model is based on original design, as-built, and repair drawings of the canal, FWA's 2007 FKC Structures List, and surveying and bathymetry work conducted in 2009 by Reclamation on select reaches of the canal, Appendix A – *Friant-Kern Canal Hydraulic Modeling Technical Memorandum, August 2010*.

Once the FKC geometry was represented in the FKC HEC-RAS model, FKC operations data from May 12, 2009, were used to calibrate the model. This date was chosen because of the relatively few flow changes in the preceding days, making the flow in the FKC more accurately represent steady state flow conditions. Steady state flow in the FKC is important for calibration because then it can be assumed that water surface elevations in the FKC are a result of the hydraulic characteristics of the FKC, rather than being a result of operations. Therefore, a steady state condition in the FKC makes it possible to confirm the hydraulic parameters used in the FKC HEC-RAS model. Table 2 shows the assumed flows and flow change locations, provided by the FWA, for the calibration.

Table 2: FKC Flows on May 12, 2009

Mileposts	Location	Flow (cfs)
0.0	Head of FKC	4900
9.8	Farm Bridge	4890
19.5	Farm Bridge	4883
29.7	Belmont	4278
39.0	Cove Avenue	4261
46.0	Sand Creek Check	4221
56.9	Farm Bridge	4199
61.0	Dodge Avenue Check	4184
71.3	Kaweah River Siphon and Check	3290
79.3	Rocky Hill Check	3264
88.2	5th Avenue Check	3199
95.7	Tule River Siphon and Check	2937
103.7	Road 208	1816
112.9	White River Siphon and Check	1706
116.9	County Line	1624
121.5	Reservoir Check	1376
130.0	Poso Creek Siphon and Check	1170
133.4	Pipe Crossing	1170
137.2	Shafter-Wasco Check	960
151.8	Kern River Check	960

The major hydraulic factor that can be varied to calibrate a HEC-RAS model is the Manning's "n" roughness coefficient, "n-value." The n-value describes the resistance of flow in a given cross section. *Open Channel Hydraulics* (Chow 1959), contains tables that list the n-values for various types of materials. The n-value for a float finished concrete canal range from 0.013 as a minimum to 0.016 as a maximum, with a normal n-value of 0.015. The n-value for a clean straight and uniform earthen excavated canal range from 0.018 to 0.025, with a normal n-value of 0.022. The FKC HEC-RAS model used an initial n-value of 0.014 for concrete structures (e.g. siphons), 0.015 for the concrete-lined sections, and 0.020 for the earthen lined sections. During the calibration procedure, the n-values for the various FKC reaches and structures, were varied such that the water surface elevations reported on May 12, 2009, at the upstream gage station matched the water surface elevations calculated in the FKC HEC-RAS model. Mean Absolute Error of the calibrated FKC HEC-RAS model at the upstream ends of checks/gates was calculated to be nearly ±0.06 feet. The Federal Emergency Management Agency's guidance suggests an error tolerance of ±0.5 feet, indicating the FKC HEC-RAS model is calibrated within acceptable tolerances.

Table 3 summarizes the Designed Normal Flows and Designed Maximum Flows ("Flows" are synonymous with "Capacity" and are interchangeably used in this report) for the FKC from information obtained from the canal's profile and section drawings, dated December 1937 through March 1950, and subsequent modifications to the canal since construction. Designed Normal Flows are the flows the FKC is designed to routinely convey to make project deliveries. Designed Maximum Flows are the flows the FKC is designed to periodically convey to make project deliveries and for convey seasonal flood flows and runoff.

Table 3. FKC Designed Normal Flows and Designed Maximum Flows

Mileposts	Type of Canal	Designed Normal Flow (cfs)	Designed Maximum Flow (cfs)
0 to 28.45	Concrete	4000	5300
29.15 to 34.94	Concrete	4000	5000
34.94 to 52.98	Earth	4000	5000
52.98 to 57.14	Concrete	4000	5000
57.14 to 61.99	Earth	4000	5000
62.00 to 71.29	Concrete	4000	5000
71.29 to 95.67	Concrete	3500	4500
95.67 to 112.90	Concrete	3000	4000
112.90 to 119.49	Concrete	2500	3500
119.50 to 121.51	Earth	2500	3500
121.54 to 128.69	Concrete	2500	3500
128.69 to 151.60	Concrete	2000	2500

Upon calibration of the FKC HEC-RAS model, a steady flow simulation of the canal was completed under Designed Normal Flows and Designed Maximum Flows. Model outputs indicate that the simulated maximum water surface elevations of the reaches downstream of Milepost (MP) 29.14 to the end of the canal infringe upon Reclamation's Design Standards for freeboard and/or bank elevation requirements, Table 4 and Figures 3, 4, and 5.

Table 4. Reclamation Design Standards for Freeboard and Bank Height

Parameter	Lining or Flow Specifications	Requirements	Approximate Height (feet)
Design Normal Flows Lining Freeboard	Compacted earth lining	0.83 x log(flow rate in cfs) - 1.48	1.51[1]
	Concrete lining	1.15 x log(flow rate in cfs) – 1.85	2.30[1]
Minimum Allowable Lining Freeboard	Compacted earth or concrete lining	Infringement of up to one-half of the normal lining freeboard allowed for maximum flows	1.15[1]
Design Bank Height (above water surface)	Flows between 200 cfs and 800 cfs	1.64 x log(flow rate in cfs) – 1.4	3.36
	Flows greater than 800 cfs	2.02 x log(flow rate in cfs) – 2.5	4.78

Note:
1. Based on flow of 4,000 cfs

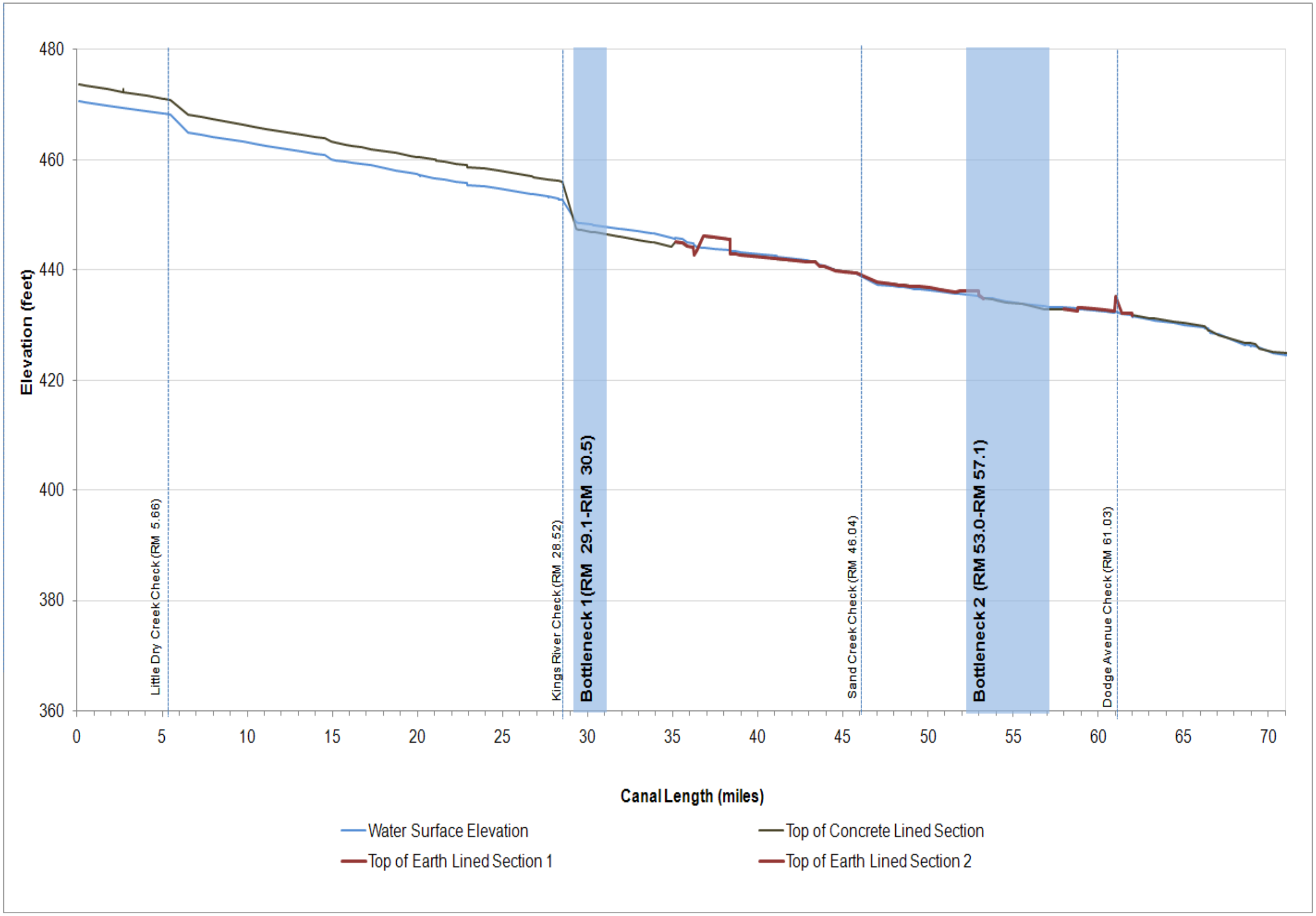


Figure 3: FKC Profile Plot (MP 0-70) under Designed Maximum Flows

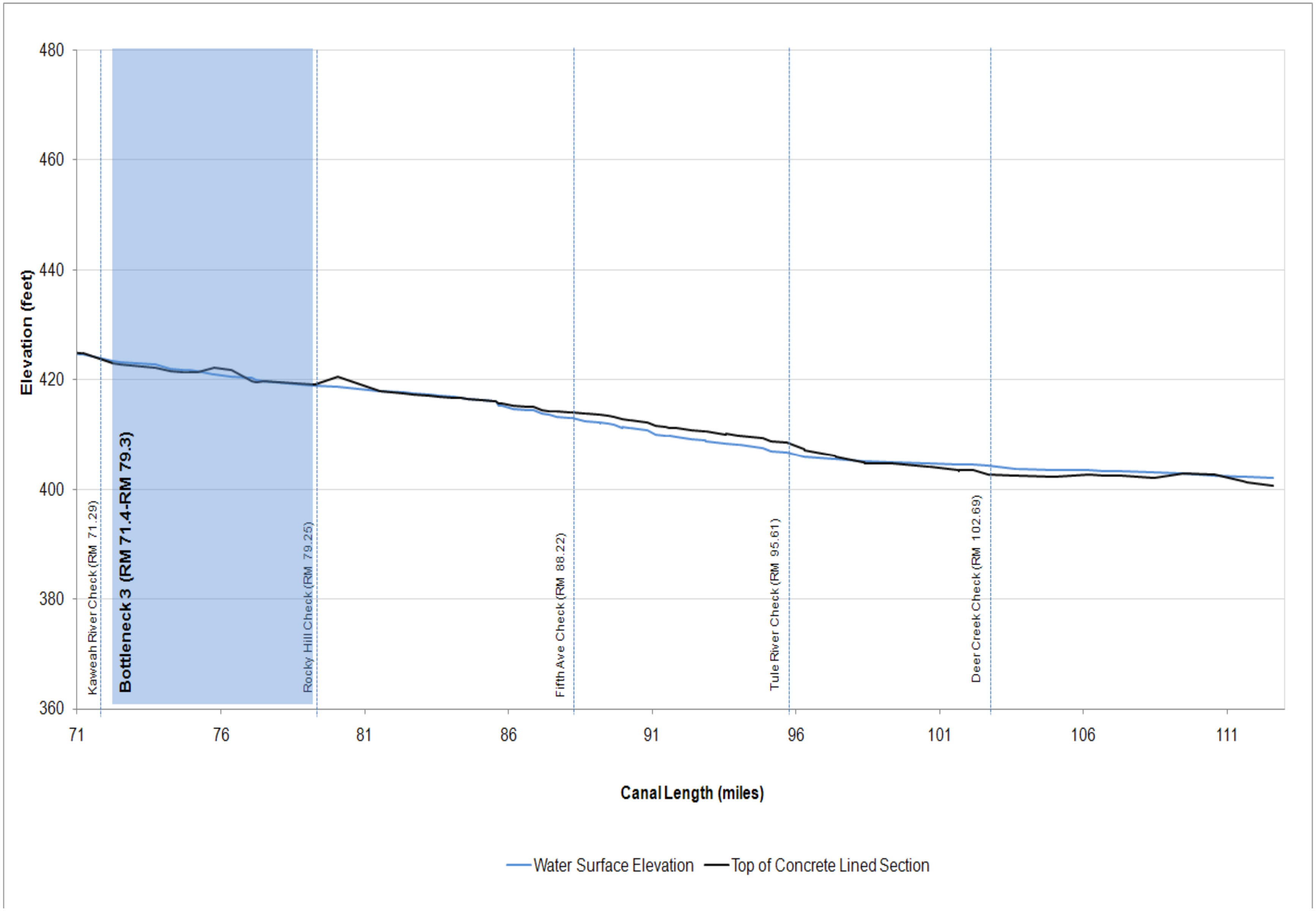


Figure 4: FKC Profile Plot (MP 71-113) under Designed Maximum Flows

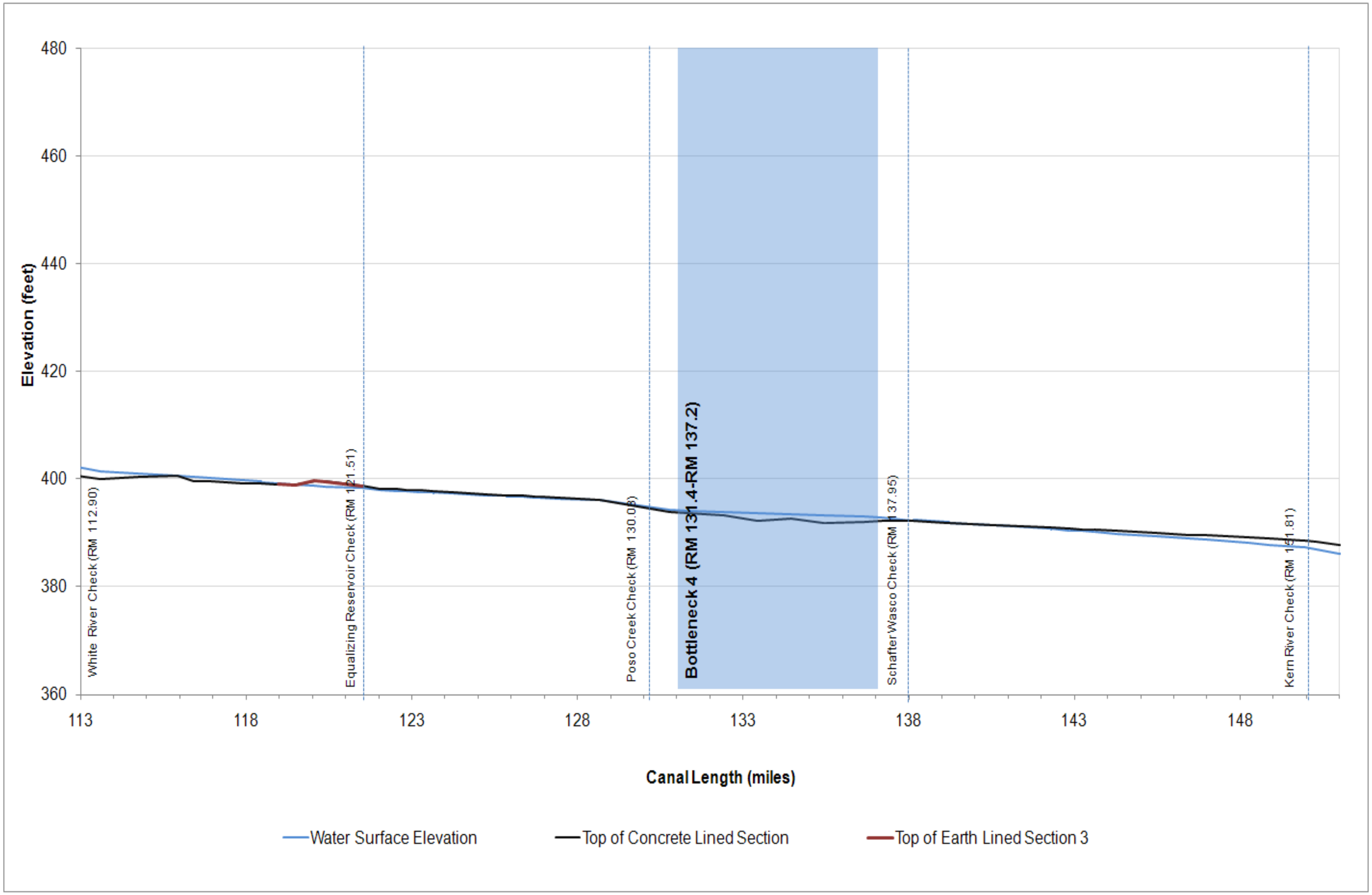


Figure 5: FKC Profile Plot (MP 113-151.8) under Designed Maximum Flows

2.2 Resources

Surface Water

The major surface water resources in the Study Area are the San Joaquin River and its tributaries, Friant Dam, Millerton Lake, FKC, and the Madera Canal. The San Joaquin River is the State of California's (California) second longest river. It originates in the Sierra Nevada mountain range at an elevation of approximately 12,000 feet above mean sea level and carries snowmelt from mountain meadows to the valley floor before turning north and becoming the backbone of tributaries draining into the San Joaquin Valley. Eventually the San Joaquin River discharges to the Sacramento-San Joaquin Delta (Delta) and, ultimately, to the Pacific Ocean through San Francisco Bay.

Millerton Lake, formed by Friant Dam, is the largest reservoir on the San Joaquin River. Inflow to Millerton Lake consists primarily of upper San Joaquin River flows, and is influenced by the operation of several upstream hydropower generation projects and local runoff. Unimpaired runoff from Millerton Lake averages 1,818 thousand acre-feet (TAF), ranging from 362 to 4,642 TAF. Millerton Lake typically fills during late spring and early summer from snowmelt in the upper San Joaquin River watershed. Annual water allocations and release schedules are developed with the intent of obtaining a full reservoir in mid-June and drawing down reservoir storage to minimum levels by the end of September.

Friant Dam diverts water from the San Joaquin River for agricultural and urban deliveries to the Friant Division long-term contractors, and to make releases for Holding Contractors and SJRRP Flows. Reclamation holds most of the water rights on the San Joaquin River, allowing diversion of water at Friant Dam through purchase and exchange agreements with entities holding those rights when the project was developed.

For the CVP, Friant Division, Reclamation employs a two-class system of water contracts. Class 1 contracts total 800 TAF and are based on a firm water supply, and are generally assigned to agricultural and urban water users who have limited access to good quality groundwater. Class 2 contracts total approximately 1,401 TAF and are based on surplus water supply and deliveries are only made when surplus water is available.

In addition, surface water can be provided to the FKC Contractors in accordance with Section 215 of the Reclamation Reform Act of 1982 and Paragraph 16(b) of the Settlement. Section 215 authorizes Reclamation to deliver water that cannot be stored and otherwise would be released in accordance with flood management criteria or unmanaged flood flows. Paragraph 16(b) provides for the delivery of water during wet hydrologic conditions at a cost of $10 per acre-foot, when water is not needed for SJRRP Flows. Delivery of Section 215 water has enabled and delivery of Paragraph 16(b) water will provide for the San Joaquin Valley groundwater to be replenished at higher levels than otherwise could be supported with Class 1 and Class 2 contract deliveries.

Groundwater

The San Joaquin Valley Groundwater Basin, Figure 6, makes up the southern two-thirds of the 400-mile-long, northwest-trending, asymmetric trough of the Central Valley's regional aquifer system (Page 1986). The San Joaquin Valley is bounded to the west by the Coast Ranges, to the south by the San Emigdio and Tehachapi mountains, to the east by the Sierra Nevada, and to the north by the Delta and the Sacramento Valley (DWR 2003).

The San Joaquin River Hydrologic Region relies heavily on groundwater. Groundwater makes up approximately 30 percent of this hydrologic region's annual water supply for agricultural and urban uses (DWR 2003). The San Joaquin River Hydrologic Region consists of surface-water basins that drain into the San Joaquin River system, from the Cosumnes River basin in the north through the southern boundary of the San Joaquin River watershed (DWR 1999). Aquifers in the San Joaquin Valley Groundwater Basin, typically extend to depths of up to 800 feet.

Historically, the Tulare Lake Hydrologic Region has also been heavily reliant on groundwater supplies. The Tulare Lake Hydrologic Region is a closed drainage basin at the south end of the San Joaquin Valley, south of the San Joaquin River watershed. This hydrologic region encompasses surface-water basins that drain to the beds of Kern, Tulare, and Buena Vista lakes (DWR 1999). In the southern portion of the San Joaquin Valley Groundwater Basin the primary aquifer extends 1,000 feet below ground surface (DWR 2003).

The Kings, Westside, Pleasant Valley, Kaweah, Tulare Lake, Tule, and Kern County groundwater sub-basins lie within the southern half of the San Joaquin Valley Groundwater Basin, in the Tulare Lake Hydrologic Region. Groundwater use in this hydrologic region has historically accounted for 41 percent of the total annual water supply within the region and for 35 percent of all groundwater use in California. Groundwater use in this hydrologic region represents approximately 10 percent of the state's total agricultural and urban water use (DWR 1998).

The CVP, Friant Division, was designed and is operated to support conjunctive water management to reduce groundwater overdraft in the eastern San Joaquin Valley. Although the conjunctive water management has been effective, groundwater remains in a state of overdraft in most years. Overdraft in California's groundwater sub-basins has not been comprehensively assessed since 1980; however, as noted in the *San Joaquin Valley Drainage Monitoring Program 2001, District Report*, the 1998 edition of the *California Water Plan Update* reports that three of the sub-basins in the San Joaquin River Hydrologic Region (Chowchilla, Eastern San Joaquin, and Madera) are in a critical condition of overdraft (DWR 2005a). According to the *California Water Plan Update* (DWR 2005b), five sub-basins (Kings, Tulare, Kern County, Kaweah, and Tule) in the Tulare Lake Hydrologic Region are in critical overdraft conditions.

A recent publication from the U.S. Geological Survey (USGS) (Faunt 2009) used the Central Valley Hydrologic Model (CVHM) to simulate cumulative change in groundwater storage in the Central Valley as a whole. The simulation included the hydrologic regions of interest, San Joaquin River and Tulare Lake (which the USGS publication referred to as the “San Joaquin Basin” and “Tulare Lake Basin”), Figure 7. The USGS study’s simulations of annual recharge and discharge between 1962 and 2003 estimated a net loss of 57.7 MAF from aquifer storage in the Central Valley (Faunt 2009).

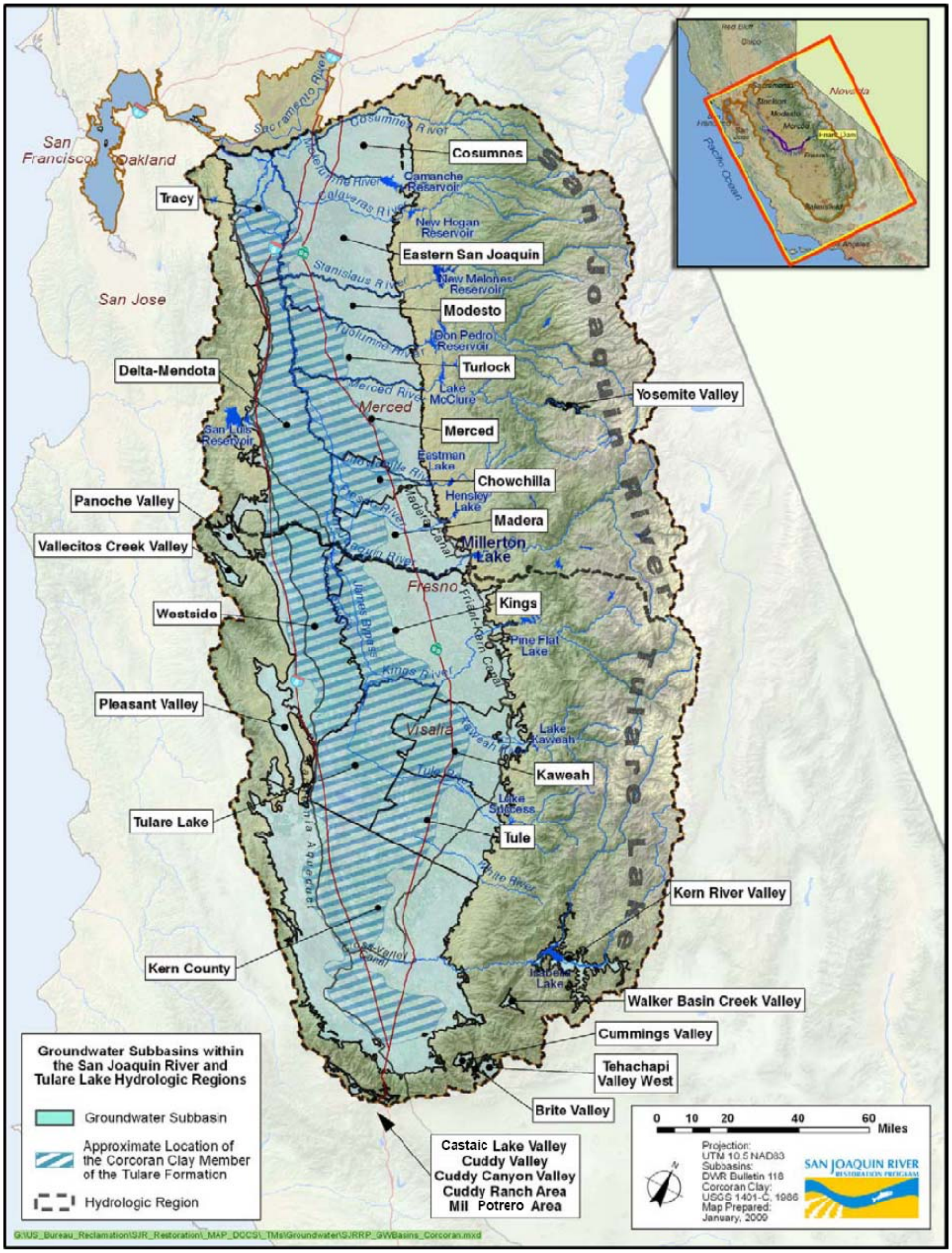
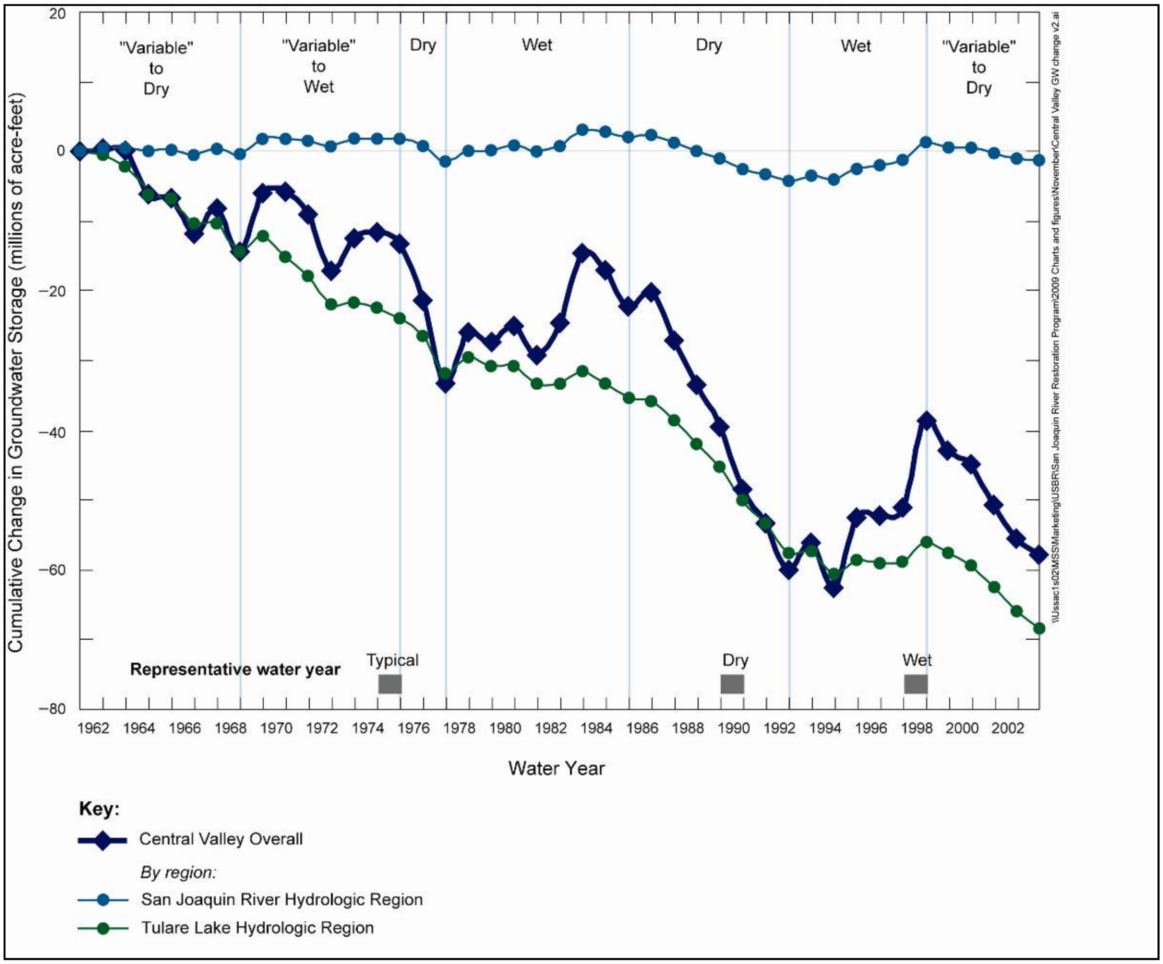


Figure 6. San Joaquin Valley Groundwater Basin and sub-Basins



Source: Faunt 2009

Figure 7. Simulated Cumulative Change in Groundwater Storage

Additionally, through implementation of the Settlement, average total system water deliveries from Friant Dam are expected to be reduced by approximately 208 TAF per year, which is approximately 15 to 19 percent of the deliveries made prior to implementation of the Settlement (Reclamation 2011). The continued general downward trend of groundwater levels reveals that considerable water supply reliability problems remain. Moreover, it is expected that the continued downward trend in groundwater levels may result in localized areas of impaired groundwater quality, increase risk of subsidence, and may ultimately reduce water use and irrigated acreage in the San Joaquin Valley.

Land Use and Agricultural Resources

According to the American Farmland Trust (AFT), California's Great Central Valley is the most threatened major land resource area in the United States. This is based on the market value of agricultural production, development pressure, and land quality issues (AFT 1995). The CVP, Friant Division, contains some of the most productive lands in California, with the Study Area containing the top three agricultural producing counties in the nation (USDA 2007).

The primary land uses in the Study Area are agriculture, urban, and open space. Agriculture accounts for the majority of land use, with urban and open space accounting for only a small percentage of land use in the Study Area. Table 5 shows the acreages of land use by the FKC Contractors, which produce more than 90 varieties of crops.

2.3 Opportunities

Water Reliability

According to the *California Water Plan Updates* (DWR 1994, 1998, 2005, 2009), California is facing one of the most significant water crises in its history. Drought impacts are growing, ecosystems are declining, water quality is diminishing, and climate change is affecting statewide hydrology. Compounding these issues is the variability associated with existing water resources in California, coupled with anticipated changes in future supply and demand related to climate change (Reclamation 2011b).

Precipitation in California is seasonably, temporally, and spatially variable, and climate change is projected to decrease precipitation in the San Joaquin River Basin by 4.2 to 5.3 percent by 2050 (Reclamation 2011b). Urban, agricultural, and environmental water users have variable needs for water quantity, quality, timing, and place of use. The water and flood systems are challenged by too little water to meet needs during droughts and too much water during floods. Water supply availability challenges are greatest during drought years, when environmental and agricultural water are most needed and least available, requiring greater reliance on groundwater; resulting in groundwater overdraft (DWR 2009).

Uncertainty exists for future water supplies in the Study Area because of potential reductions in water conservation space in existing reservoirs due to increasing needs for additional space for flood management purposes. The challenges associated with increasing population, environmental needs, and climate change indicates changing intensities of precipitation patterns and the need for flexible and adaptable water management strategies for the Friant Division long-term contractors in the future.

Critical to the development of current and future water resources plans for the Study Area is the addressing of opportunities to increase the water supply reliability for expanding urban uses, and agricultural and environmental purposes.

Water Quality

Water upstream from Friant Dam is generally soft with low mineral and nutrient concentrations due to the insolubility of granitic soils in the watershed and the river’s granite substrate (SCE 2007). As the San Joaquin River and tributary streams flow from the Sierra Nevada foothills across the eastern valley floor, their mineral concentration increases. Sediment is likely captured behind the many impoundments in this geographic subarea. Water delivered to Friant Contractors from Millerton Lake is representative of water quality conditions at Millerton Lake and the upper San Joaquin River watershed.

Table 5. Existing Land Uses in Study Area

Water District	Land Uses (acres)			
	Agricultural	Open Space	Urban	Total
Arvin-Edison WSD	128,941	220	3,691	132,852
City of Fresno	85,869	0	2,250	88,119
City of Lindsay	415	0	1,113	1,528
City of Orange Cove	286	0	674	960
Delano-Earlimart ID	56,264	0	353	56,617
Exeter ID	14,078	0	1,136	15,214
Fresno ID	187,489	64	60,336	247,889
Garfield WD	1,813	0	0	1,813
International WD	724	0	0	724
Ivanhoe ID	10,983	0	0	10,983
Lewis Creek WD	1,297	0	0	1,297
Lindmore ID	27,483	0	214	27,697
Lindsay-Strathmore ID	15,628	0	492	16,120
Lower Tule River ID	102,159	932	185	103,276
Orange Cove ID	29,163	0	116	29,279
Porterville ID	15,842	0	1,194	17,036
Saucelito ID	19,826	0	0	19,826
Shafter-Wasco ID	36,042	0	2,952	38,994
Southern San Joaquin MUD	56,233	79	5,308	61,620
Stone Corral ID	6,882	0	0	6,882
Tea Pot Dome WD	3,581	0	0	3,581
Terra Bella ID	13,642	0	272	13,914
Tulare ID	69,293	0	4,220	73,513
Total	**883,933**	**1,295**	**84,506**	**969,734**

Source: Draft SJRRP PEIS/R

Key:

WSD = Water Storage District
WD = Water District
ID = Irrigation District.

Water quality in various segments of the Study Area have been a problem for several decades due to low flow and poor quality discharges from agricultural areas, wildlife refuges, and M&I treatment plants. Water quality concerns of particular importance are those related to salinity and drinking water quality. Over time, regulatory requirements for water quality in the Study Area have become more stringent, and the number of locations at which specific water quality objectives are identified and monitored have increased. Accordingly, improvement of water quality conditions in the Study Area is a critically important element in current and future water resources plans.

Flood Management

Flooding in the Study Area poses threats to human life, health, safety, agricultural and urban lands, and environmental habitat. Threats from flooding are caused by many factors, including overtopping or sudden failures of levees, which can cause deep and rapid flooding with little warning, threatening lives, public safety, and property. In addition, expanding urban development in flood-prone areas has increased the public's exposure to the threat of flooding.

Friant Dam is the principal flood damage reduction facility on the San Joaquin River and is operated to maintain combined releases to the San Joaquin River at or below a flow objective of 8,000 cubic feet per-second (cfs). Under certain situations, the FKC and Madera Canal are also used to convey flood water to reduce potential damage. Several flood events in the past few decades have resulted in flows greater than 8,000 cfs downstream from Friant Dam and, in some cases, flood damages resulted. Flood management has been and is a critically important element in the Study Area and, with increasing urban development, it will remain important in future water resources plans.

Hydropower

Hydropower is an important element of power supply in California and the nation. On average, hydropower generation constitutes between 10 to 27 percent of California's annual energy supply, depending on the type of water year. The U.S. receives between 7 and 12 percent of its electricity from hydropower. Due to its ability to rapidly increase and decrease power generation rates, hydropower can be used to support peak power loads in addition to base power loads. As population, industry, and associated infrastructure growth occurs in the future, demands for power would also increase. Over the next 10 years, California's peak demand for electricity is expected to increase almost 30 percent from about 50,000 to 65,000 megawatts (MW). Although some new power generation capacity likely would be developed in California during the next few decades, it is expected that additional new generation capacity would still be required.

The San Joaquin River watershed upstream from Friant Dam is extensively developed for hydroelectric generation. Hydropower is also generated by the Friant Power Authority at the Friant Power Project through releases from Friant Dam to the FKC, Madera Canal, and San Joaquin River. The FKC Powerhouse generates hydroelectricity as water is released through outlets in the left abutment to the FKC, Figure 9. The powerhouse operates at a normal maximum head of 105 feet and has a rated operating capacity of 18.4 MW. The Madera Canal Powerhouse generates hydroelectricity as water is released through outlets in the right abutment to the Madera Canal, Figure 9. The powerhouse operates at a normal maximum head of 126 feet and has a rated operating capacity of 9.8 MW. The River Outlet Powerhouse, located at the base of Friant Dam adjacent to the spillway, generates hydroelectricity as water is released to the San Joaquin River through river outlets, Figure 9. The powerhouse operates at a normal maximum head of 273 feet, has a rated operating capacity of 2.4 MW. Hydropower is an important element in the Study Area, California, and the Nation, and remains important to water resources plans.

Figure 9. Hydropower Generation Facilities at Friant Dam

2.4 Constraints

Designed Normal Flows and Designed Maximum Flows

The FKC was originally designed with two flow rates, termed Normal and Maximum Designed Flows. Designed Normal Flows are the flows the FKC is designed to routinely convey to make project deliveries. The Designed Normal Flows vary from 4,000 cfs at the headworks to 2,000 cfs at the Kern River. Designed Maximum Flows are the flows the FKC is designed to periodically convey to make project deliveries and for convey seasonal flood flows and runoff. The Designed Maximum Flows vary from 5,300 cfs at the headworks to 2,500 cfs at the Kern River. Table 3 provides information obtained from FKC's profile and section drawings, dated December 1937 through March 1950, and modifications since construction, for the FKC's Designed Normal Flow and Designed Maximum Flows.

Reclamation Design Standards

The FKC was constructed by Reclamation in 1945, prior to the development of Reclamation's current Design Standards No. 3, Release No. DS-3-5, dated 1967, and revised in 1994. In the 1950's and 1960's, Reclamation discovered that many of the large concrete canals constructed up to that time were incapable of conveying the flows specified in the original designs. This problem prompted a study on most of the larger canals built to that time, including the FKC. The conclusions and results of this study were document in Reclamation's *Technical Memorandum No. 661 – Analyses and Descriptions of Capacity Tests in Large Concrete-Lined Canals*. Though not referenced, many of the same conclusions and recommendations from Technical Memorandum No. 661 are found in the current version of Reclamation's Design Standards. Included in these recommendations are the current freeboard recommendations for large canals, which are found in both Technical Memorandum No. 661 and Design Standards No. 3. A summary of the freeboard requirements as they relate to the FKC is shown in Table 5. In addition to the two design references above, miscellaneous design details may also be found in Reclamation's *Design of Small Canal Structures*, dated 1978.

Appropriation Ceiling

Pursuant to Section 10203(a) of the SJRRS Act, the Secretary is authorized to and directed to develop solutions within the funding limit of $35,000,000, from the San Joaquin River Restoration Fund, to restore the capacity of the FKC and Madera Canal, consistent with the applicable feasibility studies. The FWA and Madera Chowchilla Water Power Authority agreed to separate the authorized funding as follows: $25,000,000 for the FKC; $10,000,000 for the Madera Canal. Therefore, the FKC Feasibility Study assumes $25,000,000 to restore the capacity of the FKC.

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Chapter 3. Alternatives Formulation

This chapter discusses the alternatives formulation process, planning objectives, planning considerations and other criteria, no action alternative, initial alternatives, appraisal evaluation, and subsequent reformulation of the alternatives.

3.1 Plan Formulation

The plan formulation process for Federal water resources studies is identified in the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (*Principles & Guidelines*) (WRC 1983) and consists of the following iterative steps:

- Defining water resources problems, needs, and opportunities to be addressed.
- Identifying existing and projected future resources conditions likely to occur in the Study Area.
- Developing planning objectives, constraints, and criteria.
- Identifying and formulating potential alternative plans to meet planning objectives within planning constraints.
- Comparing and evaluating alternative plans.
- Identifying and selecting a plan that best meets planning criteria and maximizes net National Economic Development (NED) benefits.

Plan formulation is a dynamic process with various steps that are iterated one or more times, occur at any step, and sharpen the planning focus or change its emphasis as new data are obtained or as the specification of problems or opportunities chanes or becomes more clearly defined (WRC 1983). The FKC Feasibility Study plan formulation and selection process included identifying the without-project future conditions; defining resources, opportunities, and constraints; identifying and formulating alternatives; evaluating alternative plans; reformulating the alternatives; and, selecting a recommended alternative.

3.2 Planning Objectives

On the basis of the problems, resources, opportunities, and constraints identified in Chapter 2, the authorization for the FKC Feasibility Study, and other pertinent direction from the public and the FWA, the following FKC Feasibility Study planning objective was developed and guided formulation of the alternatives:

- Improve the water deliveries and reliability of the FKC in order to reduce or avoid water supply impacts on the FKC Contractors that may result from the SJRRP Flows.

3.3 Planning Constraints and Other Considerations

The *Principles & Guidelines* provide fundamental guidance for the formulation of Federal water resources projects. In addition, basic constraints and other considerations specific to this study must be developed and identified. Following is a summary of the constraints and considerations relevant to the FKC Feasibility Study:

Planning Constraints

Planning constraints help guide development of feasibility studies. Some planning constraints are more rigid than others. Examples of more rigid constraints include congressional direction; current applicable laws, regulations, and policies; and physical conditions (e.g., topography, hydrology). Other planning constraints are less restrictive, but are still influential in guiding the process. Several constraints identified for the FKC Feasibility Study are as follows:

- **Study Authorization** – The SJRRS Act authorizes and directs the Secretary to complete a feasibility study on the restoration of the capacity of the FKC, as previously designed and constructed by Reclamation. It further authorizes the Secretary to construct the improvements upon completion of and consistent with the feasibility study, subject to an appropriation limitation that is assumed to be $25,000,000 for the FKC.

- **Laws, Regulations, and Policies** – Numerous laws, regulations, executive orders, and policies were considered, among them the *Principles & Guidelines*, National Environmental Policy Act (NEPA), Fish and Wildlife Coordination Act, the Clean Air Act, Clean Water Act, National Historic Preservation Act, Federal Endangered Species Acts, and Federal Reclamation law, regulations, and policies.

Other Considerations

Other planning considerations were specifically identified to help formulate, evaluate, and compare alternatives, and later, detailed alternatives:

- Alternatives must incorporate results of agency and public coordination.

- Alternatives must address the planning objective.

- Alternatives must restore the capacity of the FKC, as previously designed and constructed by Reclamation.

- Alternatives must incorporate current Reclamation engineering standards, requirements, and regulations.

- Alternatives must provide for, at a minimum, a 50-year period of performance.

- Alternatives must have a high certainty for achieving intended benefits and cannot significantly depend on long-term actions, past the initial construction period, for success.
- Alternatives cannot increase the capacity of the FKC beyond the capacity previously designed and constructed by Reclamation.
- Alternatives cannot result in adverse effects to existing and future water supplies, hydropower generation, or related water and land resources conditions.
- Alternatives strive to either avoid potential adverse effects to environmental and cultural resources or include features to mitigate unavoidable adverse effects through enhanced designs, construction methods, and/or facilities operations.
- Alternatives may address current subsidence areas, but cannot include provisions for addressing future unknown subsidence areas.

3.4 Criteria

The Federal planning process in the *Principles & Guidelines* also includes four specific criteria for consideration in formulating and evaluating alternatives: (1) completeness, (2) effectiveness, (3) efficiency, and (4) acceptability (WRC 1983), which are defined as follows:

- Completeness is a determination of whether a plan includes all elements necessary to realize planned effects, and the degree that intended benefits of the plan depend on the actions of others.
- Effectiveness is the extent to which an alternative alleviates problems and achieves objectives.
- Efficiency is the measure of how efficiently an alternative alleviates identified problems while realizing specified objectives consistent with protecting the Nation’s environment.
- Acceptability is the workability and viability of a plan with respect to its potential acceptance by other Federal agencies, State and local governments, and public interest groups and individuals.

These criteria and how they apply in helping to compare comprehensive alternative plans are described below and in Chapter 4.

3.3 No Action Alternative

The *Principles & Guidelines* require a No-Action Alternative to account for existing facilities, conditions, water and land resources, reasonably foreseeable actions expected to occur in the Study Area, and as a basis of comparison for all other alternatives.

Under the No Action Alternative, SJRRP Flows provided in the Settlement would be implemented; however, Reclamation would not restore the capacity of the FKC, which is not consistent with the Secretary's direction pursuant to the Settlement or SJRRS Act. The FKC would continue to operate at its current capacity-restricted condition, limiting its ability to convey water during periods of peak demand, peak flow, or flood water from Millerton Lake. Water that could not be conveyed by the FKC would be lost, either through evaporation from Millerton Lake or by spilling into the San Joaquin River. In response, the FKC Contractors may take alternative water supply actions, including increasing groundwater pumping, idling cropland, or water rationing. Under the No Action Alternative, the current capacity-restricted condition of the FKC would limit the FKC Contractors ability to divert water during periods of peak demand or peak flow "for the purpose of reducing or avoiding impacts to water deliveries to all of the Friant Division long-term contractors caused by the Interim and Restoration Flows," thus limiting the Secretary's ability to achieve the Water Management Goal in the Settlement.

3.4 Initial Alternatives

Reclamation and the FWA identified four initial alternatives for restoration of the capacity of the FKC, as previously designed and constructed by Reclamation. The four initial alternatives are:

- **Alternative 1 –** Restore the Designed Maximum Flows of the FKC at "high priority reaches" identified by the FWA and the calibrated FKC HEC-RAS model.

- **Alternative 2 –** In addition to Alternative 1, restore the remaining deficient reaches identified by the calibrated FKC HEC-RAS model to Designed Normal Flows.

- **Alternative 3** - Restore the Designed Maximum Flows of the entire FKC as identified by the calibrated FKC HEC-RAS model, applying original Reclamation designed and constructed freeboard standards for the FKC (0.3 feet of freeboard over maximum water surface elevation).

- **Alternative 4 –** Restore the Designed Maximum Flows of the entire FKC as identified by the uniformed FKC HEC-RAS, applying current Reclamation freeboard standards (1.15 feet of freeboard over maximum water surface elevation).

Alternative 1

Alternative 1 would include modifications to the FKC to achieve the following:

- Restore the Designed Maximum Flows of the FKC at high priority reaches identified by the FWA through its operation of the canal; and,

- Restore the Designed Maximum Flows of the FKC at additional reaches identified by the calibrated FKC HEC-RAS model with the high freeboard and bank deficiencies.

Through the operation of the FKC, the FWA has encountered several reaches of the canal with high capacity deficiencies that have required placement of sandbags, raising the lining, restricting the flow, or accidently overtopping the freeboard. The FKC HEC-RAS model confirmed these high priority reaches and the inability to convey Designed Maximum Flows with sufficient freeboard. The calibrated FKC HEC-RAS model also identified additional reaches of the FKC with freeboard deficiencies similar to the deficiencies found in the FWA identified operationally deficient reaches. These additional reaches are considered equal in priority for capacity restoration and therefore also included in Alternative 1.

Accordingly, Alternative 1 would restore the FKC's Designed Maximum Flows at the locations identified in Appendix B – *Initial Alternatives*, totaling 34 miles. The modifications to the FKC under Alternative 1 include raising the existing concrete or earth lining and bank height on both sides of the canal to return capacity-deficient reaches of the canal to Designed Maximum Flows. In addition, restoring the capacity of the FKC may also require modifications to some of the bridges that cross the canal, drain inlets, check structures, and other minor structures.

Alternative 2

Alternative 2 would include modifications to the FKC to achieve the following:

- In addition to Alternative 1, restore the remaining deficient reaches identified by the calibrated FKC HEC-RAS model to Designed Normal Flows.

The calibrated FKC HEC-RAS model identified additional reaches, outside of the high priority reaches included in Alternative 1, which are unable to convey Designed Normal Flows with sufficient freeboard. Under Alternative 2, these additional reaches would be restored to convey Designed Normal Flows.

Accordingly, Alternative 2 would restore the FKC at the locations identified in Appendix B – *Initial Alternatives*, totaling 55 miles. The modifications to the FKC under Alternative 2 include raising the existing concrete or earth lining and bank height on both sides of the canal to return capacity-deficient reaches of the canal to Designed Normal Flows and Designed Maximum Flows. In addition, restoring the capacity of the FKC may also require modifications to some of the bridges that cross the canal, drain inlets, check structures, and other minor structures.

Alternative 3

Alternative 3 would include modifications to achieve the following:

- **Alternative 3 -** Restore the Designed Maximum Flows of the entire FKC as identified by the calibrated FKC HEC-RAS model, applying original Reclamation designed and constructed freeboard standards for the FKC (0.3 feet of freeboard over maximum water surface elevation).

Under Alternative 3, the entire FKC would be restored to convey Designed Maximum Flows with original Reclamation designed and constructed lining freeboard (0.3 feet) and bank freeboard criteria for the FKC.

Accordingly, Alternative 3 would restore the entire FKC to Designed Maximum Flows at the locations identified in Appendix B – *Initial Alternatives*, totaling 62 miles. The modifications under Alternative 3 include raising the existing concrete or earth lining and bank height on both sides of the canal to return capacity-deficient sections of the canal to design capacities. In addition, restoring the capacity of the FKC may also require modifications to some of the bridges that cross the canal, drain inlets, check structures, and other minor structures.

Alternative 4

Alternative 4 would include modifications to achieve the following:

- Restore the Designed Maximum Flows of the entire FKC as identified by the uniformed FKC HEC-RAS model, applying current Reclamation freeboard standards (1.15 feet of freeboard over maximum water surface elevation).

Alternative 4 is similar to Alternative 3 except for the following:

- The calibrated "n-values" used in the FKC HEC-RAS model were modified to uniformed Mannings "n-values" as follows:
    a. Structures, n=0.014
    b. Concrete lined canal, n=0.016
    c. Earthen canal, n=0.0225

- Current Reclamation Design Standards were used to determine bank and freeboard requirements (1.15 feet of freeboard over maximum water surface elevation).

Figure 8 illustrated the difference between calibrated and normalized "n" values. Generally, the maximum water surface predicted using the normalized Mannings "n" values are higher.

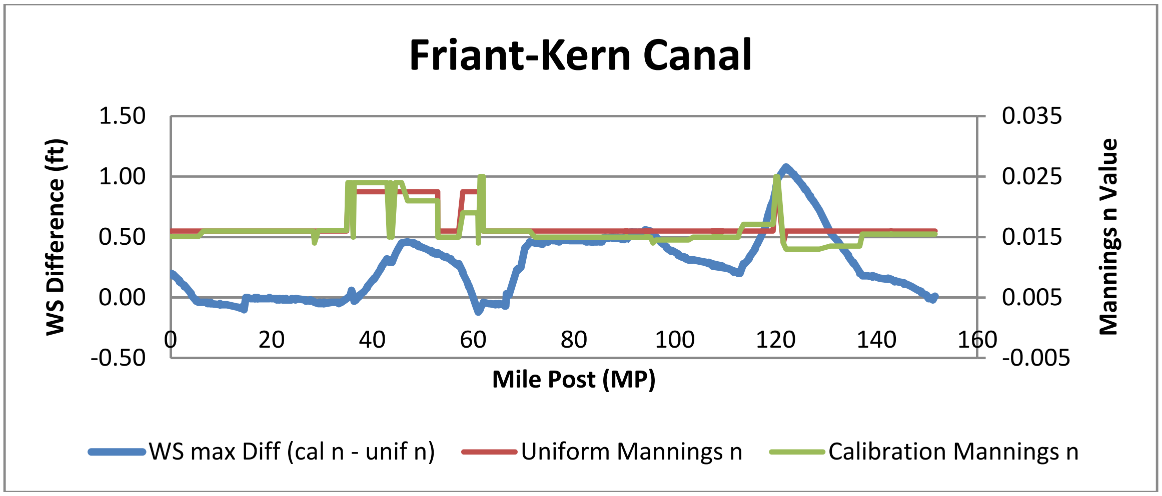

Figure 8. Calibrated vs. Uniformed Manning "n-values"

Under Alternative 4, the entire FKC would be restored to convey Designed Maximum Flows using current Reclamation Design Standards for lining (1.15 feet) and bank freeboard, Table 4. Accordingly, Alternative 4 would restore the entire FKC to Designed Maximum Flows at the locations identified in Appendix B – *Initial Alternatives*, totaling 113 miles. The modifications under Alternative 4 include raising the existing concrete or earth lining and bank height on both sides of the canal to return capacity-deficient sections of the canal to design capacities. In addition, restoring the capacity of the FKC may also require modifications to some of the bridges that cross the canal, drain inlets, check structures, and other minor structures.

3.5 Evaluation, Comparison, and Screening of Initial Alternatives

Alternatives 1 and 2 would only result in the restoration of the capacity at select locations on the FKC and would not fully restore the capacity of the FKC. Therefore, Alternatives 1 and 2 were eliminated from further consideration as they would not fully restore the capacity of the FKC "as previously designed and constructed by Reclamation." Alternative 3 would restore the capacity of the FKC "as previously designed and constructed;" however, it would not meet Reclamation's Design Standards, Table 4, and was therefore eliminated. Alternative 4 would fully restore the capacity of the FKC and meet current Reclamation Design Standards and, as further detailed in Table 6, Alternative 4 was the only selected alternative for further consideration under the FKC Feasibility Study at the appraisal level.

Table 6. Summary Comparison of Alternatives

	Completeness	Effectiveness	Efficiency	Acceptability	Overall Ranking
No Action	It does not address any of the planning objectives, and does not meet the requirements of the Settlement and SJRRS Act.	Water supply and reliability needs will continue to increase and the Secretary will have limited ability to achieve the Water Management Goal	Highly inefficient. Water supply and reliability needs will continue to increase and costs to correct the problem in the future will grow exponentially.	It does not address any of the planning objectives, and does not meet the requirements of the Settlement and SJRRS Act.	*Very Low*
	Very Low	*Very Low*	*Very Low*	*Very Low*	
Alternative 1	Incomplete due to inability to restore the capacity of the entire FKC.	It would only address a portion of the problem and would not maximize opportunities available through restoration of the capacity of the FKC.	Inefficient. Only restores and fixes a portion of the FKC.	Relatively acceptable. Restores the known operationally deficient reaches and addresses a portion of the FKC's problem.	*Low to Moderate*
	Very Low	*Low*	*Low*	*Moderate*	
Alternative 2	Incomplete due to inability to restore the capacity of the entire FKC.	It would only address a portion of the problem and would not maximize the opportunities available through restoration of the capacity of the FKC.	Inefficient. Only restores and fixes a portion of the FKC and restores some sections of the canal to levels not providing any benefit.	Relatively acceptable. Restores the known operationally deficient reaches and addresses a portion of the FKC's problem, but also restores sections with low benefits to the water users.	*Low*
	Very Low	*Low*	*Low*	*Low*	
Alternative 3	Incomplete due to inability to restore the FKC to meet current Reclamation freeboard standards for ensuring proper operation and safety of the canal.	It would address most of the problem with the FKC and would maximize most of the opportunities available through restoration of the capacity of the canal.	Relatively efficient, but does not fully address the problem or maximize opportunities.	Highly acceptable. Restores the known operationally deficient reaches and addresses a portion of the FKC's problem.	*High*
	Low	*Moderate*	*Moderate*	*High*	
Alternative 4	Relatively complete.	It would address all of the FKC problems and maximize the opportunities available through restoration of the capacity of the canal.	Relatively efficient as it fully addresses the problem and maximize opportunities, but at a high cost.	Highly acceptable. Restores the entire capacity of the FKC, but application of current Reclamation freeboard standards and associated costs are a concern of water users.	*High to Very High*
	Very High	*Very High*	*Moderate*	*High*	

3.6 Alternative 4 – Appraisal Evaluation

Alternative 4 would require the restoration of 113 miles of the FKC, between the Kings River Outlet, MP 29.14, and the Kern River, MP 151.8, at an estimated total cost of $72 million, as further detailed in Appendix C – *DRAFT Alternative 4 - Appraisal Evaluation Technical Memorandum.* Due to the appraisal cost estimate exceeding the authorized funding, the parties stopped further evaluation of Alternative 4 and reformulated the FKC Feasibility Study to identify alternatives with benefits equal to or exceeding costs and within authorized funding.

3.7 Reformulation of Planning Constraints and Other Considerations

Significant findings from the appraisal evaluation of Alternative 4 used to reformulate the Planning Constraints and Other Considerations of the FKC Feasibility Study are as follows:

- Alternatives are not required to restore the entire capacity of the FKC, but must provide benefits equal to or exceeding total costs, within the assumed funding for the alternative, $25,000,000.
- Alternatives must prioritize restoration of the FKC from MP 29.14 to 88.22, Reach 2. As illustrated in Figure 9, without first restoring capacity in this reach, there are no benefits realized in the other reaches.
- Alternatives must result in an operational increase in the capacity of the FKC.

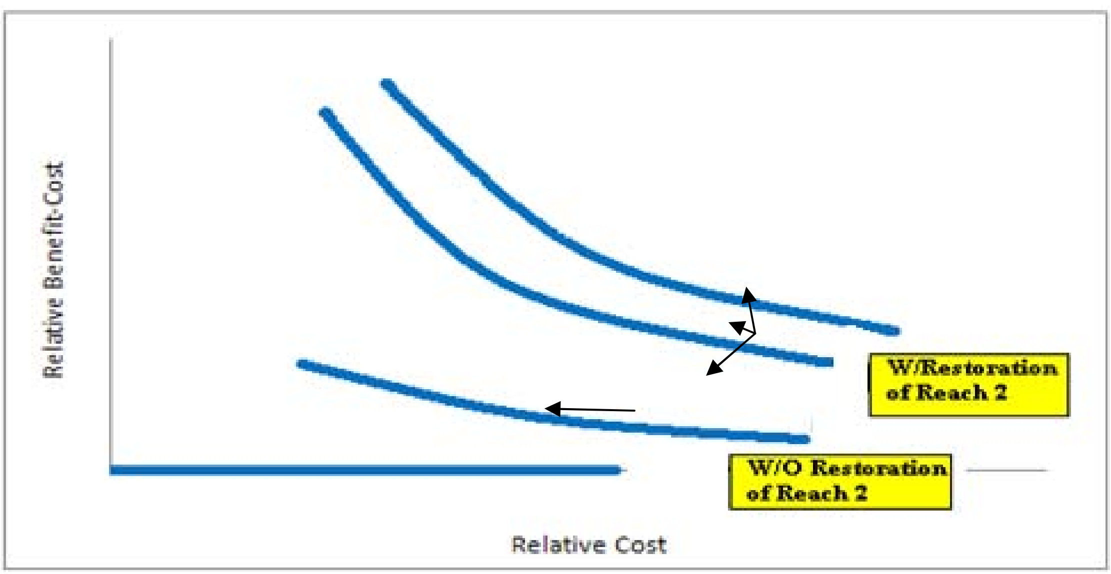

Figure 9. Illustration of with and without Restoration of Reach 2

3.8 Reformulated Alternatives

Accordingly, based on the reformulated Planning Constraints and Other Considerations, the appraisal cost estimates, assumed funding of $25,000,000, and coordination with the FWA, the following two alternatives were identified and developed for evaluation at the feasibility level.

Alternative 5(a)

Restore the Designed Maximum Flows of the FKC from the Kings River Outlet, MP 29.14, to the Kaweah River Check, MP 71.3, as identified by the uniformed FKC HEC-RAS model and applying current Reclamation Design Standards.

Alternative 5(b)

Restore the Designed Maximum Flows of the FKC from the King River Outlet, MP 29.14, to the 5th Avenue Check, MP 88.2, as identified by the uniformed FKC HEC-RAS model and applying current Reclamation Design Standards.

Chapter 4. Feasibility Evaluation

This chapter describes the feasibility level evaluation of Alternatives 5(a) and 5(b), operations and water supply evaluation, *Principles & Guidelines* four account analysis, project feasibility, and recommendation.

4.1 Feasibility Alternatives

Feasibility evaluations are presented for two alternatives:

- Alternative 5(a) – Restoration of the capacity of the FKC from Kings River outlet to the Kaweah River Check.

- Alternative 5(b) - Restoration of the capacity of the FKC from Kings River outlet to the 5th Avenue Check.

Alternatives 5(a) and 5(b) are identical, except for Alternative 5(b) continuing the restoration of the capacity of the FKC from the Kaweah River Check to the 5th Avenue Check. Accordingly, this report discusses Alternatives 5(a) and 5(b) jointly (Alternative 5), noting exceptions when applicable.

Description

Alternative 5 would consist of restoring the capacity of the FKC as previously designed and constructed at the mileposts identified in Table 7, including modifications to the Little Dry Creek Wasteway at MP 5.44. Additional details are provided in Appendix D -- *Alternative 5 - Feasibility Design Technical Memorandum.*

Table 7. Alternative 5 – Current Capacity vs. Maximum Capacity

Alternative	Mileposts	Distance (miles)	Current Capacity (cfs)	Maximum Capacity (cfs)
5(a) and 5(b)	29.14 to 71.29	42.15	4,680-4,105	5,300
5(b)	71.29 to 88.22	16.93	4,105	4,500

The FKC's capacity deficiencies were identified by Reclamation through discussions with the FWA, on-site studies, surveying, and use of the FKC HEC-RAS model, as further discussed previously in Chapter 2. Proposed modifications to the FKC under Alternative 5 would include constructing raised sections of new lining attached to and above the existing concrete and earth lining; raising existing banks; modifying check structures and inlet/outlet structures; removing three timber farm bridges, replacing one timber farm bridge with a concrete farm bridge, and modifying up to 37 other bridges crossing the canal; and, modifying the Little Dry Creek Wasteway Facility at MP 5.44, Table 8. There would be no modifications to any of the FKC siphons and construction activities would be limited to the outside slope toes of the canal's existing embankments, except for roadway travel and mobilization.

Table 8. Alternative 5 Modifications

Alternative	Mileposts		Type of Lining	Lining Raise Length	Bank Raise Length	Bridge Work
	From	To		Miles	Miles	Number of Bridges Potentially Modified
5(a) and 5(b)	5.44	5.44	Little Dry Creek Wasteway	--	--	--
5(a) and 5(b)	29.14	33.87	Concrete	4.73	0.72	2
5(a) and 5(b)	33.89	34.92	Concrete	1.03	0.51	2
5(a) and 5(b)	34.92	35.59	Earthen	0.67	0.11	1
5(a) and 5(b)	35.62	36.30	Earthen	0.68	0.07	1
5(a) and 5(b)	36.33	43.39	Earthen	7.06	--	8
5(a) and 5(b)	43.42	43.95	Earthen	0.53	--	1
5(a) and 5(b)	43.99	45.81	Earthen	1.82	--	1
5(a) and 5(b)	45.89	46.17	Earthen	0.28	--	--
5(a) and 5(b)	46.21	52.98	Earthen	6.77	0.95	1
5(a) and 5(b)	52.98	57.13	Concrete	4.15	1.12	--
5(a) and 5(b)	57.13	62.00	Earthen	4.87	0.31	5
5(a) and 5(b)	62.00	66.47	Concrete	4.47	2.76	--
5(a) and 5(b)	66.52	67.09	Concrete	0.57	--	--
5(a) and 5(b)	67.12	67.95	Concrete	0.83	--	--
5(a) and 5(b)	68.00	69.48	Concrete	1.48	--	1
5(a) and 5(b)	69.54	71.30	Concrete	1.76	0.05	2
5(b)	71.36	73.74	Concrete	2.38	0.45	1
5(b)	73.78	75.19	Concrete	1.41	--	1
5(b)	75.22	77.06	Concrete	1.84	1.19	2
5(b)	77.08	85.56	Concrete	8.48	3.11	5
5(b)	85.58	85.79	Concrete	0.21	0.21	1
5(b)	85.81	86.87	Concrete	1.06	--	2
5(b)	86.89	88.22	Concrete	1.33	--	3
	TOTAL			**58.41**	**11.57**	**40**
	Key: -- = not applicable					

Lining Raises

Alternative 5 would require raising the FKC's existing concrete and earthen lining to allow for the canal to convey its capacity as previously designed and constructed by Reclamation. Lining raises would vary from a minimum of 1.0 foot to a maximum of 4.0 feet, averaging 1.7 feet vertically and placed in 1-foot increments. Alternative 5 would not include relining the FKC's earthen sections with concrete.

Soil Embankment

Lining raises in soil embankment would be accomplished by removing the FKC's existing uncompacted embankment and demolishing and breaking up the existing roadway surfacing on the inside slopes (water side) of the canal with heavy equipment. This excavation would be a minimum 8.0 feet wide in "no-bench" sections and 3.5 feet wide in "bench" sections to accommodate the use of heavy equipment, and approximately 1.0 to 4.0 feet deep. Select embankment backfill material would then be placed and compacted with heavy and hand-held, near existing lining, equipment to reach the required top-of-lining elevation. If in a concrete-lined reach a new concrete lining segment would be formed and placed above and connected to the existing lining, either by modular forming methods or slip-forming methods, to the required top-of-lining height. In earth-lined sections, the "beach-belting" riprap would be placed on the water side slopes, in an excavated or formed void, above the water surface elevations expected to protect the newly raising lining. Then, for both the earthen and concrete reaches, backfill would be placed by heavy equipment to raise the canal bank to the required elevation. Finally, in places where the operation and maintenance (O&M) road, typically the FKC right side, was covered by new lining and embankment fill material, a replacement road of aggregate road base course would be constructed. Any soil material excavated would be temporarily stored on the sides of the FKC and/or in existing spoil piles for use as backfill, or removed from the FKC. Transport of the material would be accomplished using loaders and dump trucks.

Rock Embankment

Embankment and lining raises that would occur in rock embankment, typically on the FKC left side, would be accomplished by excavating the rock with hand-excavation tools (e.g., drills, jackhammers). This excavation would be approximately 3.0 feet wide and 1.0 to 4.0 feet deep. Blasting would not be performed to remove the rock, unless absolutely necessary, to protect the in-place lining material from damage. If in a concrete reach new concrete lining would then be formed and placed, similar to the methods described above. If access to certain areas precludes utilizing the formed and placed method to replace the concrete lining, concrete (shotcrete) will be conveyed through a hose and pneumatically projected onto the bank. In places where the O&M road would be covered by new lining and embankment fill material, a replacement road of aggregate road base course would be constructed. Any rock material excavated would be stored in existing spoil piles for use as backfill or removed from the FKC. Transport of the material would be accomplished using loaders and dump trucks.

Bank Raises

Alternative 5 would require raising the FKC's banks at select locations to meet Reclamation Design Standards. In the select reaches identified as requiring bank raises, those raises would vary from a minimum of 1.0 foot to a maximum of 3.0 feet, mean average of 1.0 foot, and placed in 1-foot increments. Most bank raises would occur in the same reaches where lining raises are required and therefore would be accomplished at the same time.

Bank raises would be accomplished by using heavy equipment (e.g., scraper, loader) to remove any material or roadway surfacing on the top of the FKC's embankment. If required, any lining raises would be constructed as necessary. Heavy equipment would then place reused embankment fill and/or new backfill, as required, to the required bank elevation. Modification of check structures and inlet/outlet structures may require minor internal modifications of existing structures to accommodate increased water surface elevations in the canal. Finally, in places where the O&M road was removed, a replacement road aggregate road base course would be constructed.

Bridge Modifications

Alternative 5 would require the removal of up to three timber farm bridges, replacement of the timber bridge at MP 34.13 with a concrete bridge, and the modification of up to 37 other bridges crossing the FKC, as further detailed in Tables 8 and 9. The bridges are owned by private individuals, counties, and the State of California (California). They are constructed of timber or concrete and, in some cases, also carry utilities, such as electrical, telephone, water, and gas lines. No utilities are expected to be permanently removed as part of the alternatives, though temporary construction-related disruptions may occur.

Farm – Timber Bridges

Alternative 5 would consist of one of two options for replacement or removal of timber bridges that would be submerged by implementation of the action. These options are described below.

- *Option 1* - The timber bridge at MP 34.13 would be replaced with cast-in-place or a precast concrete bridge. If replaced with a cast-in-place, the existing abutments would be removed and new concrete abutments, piers, and roadway would be placed. New concrete abutments would be poured and then the concrete bridge would be delivered by flatbed trailer and positioned in place by a crane. The timber bridges at MP 33.80 and MP 34.91 would not be replaced due to close access to existing alternative bridges. Removal of these two existing timber bridges would be accomplished by dismantling the bridges and removing those sections with a crane located on the FKC embankment. The timber bridges would be recycled or disposed of in a permitted waste facility.

- *Option 2* – All three timber bridges would be removed using the methods described above. The timber bridges would be recycled or disposed of in a permitted waste facility.

Concrete Bridges

Alternative 5 could require the modification of up to 37 concrete bridges. If modifications are found to be necessary, they would be accomplished by strengthening/hardening the bridges to ensure their stability during periods of sustained maximum flows. These modifications could include building parapet walls along the bridge length, adding anchor points from the bridge to the piers/abutments, and/or adding additional weight to the bridge superstructure. During construction, appropriate barricades and signage would be in place to control traffic.

Little Dry Creek Wasteway Modification

Alternative 5 would include modification to the Little Dry Creek Wasteway, located at MP 5.44, to increase the height of the existing wasteway radial gates. The increase in height is required to accommodate higher water surface elevations resulting from wind and wave action in this reach, which is currently overtopping the existing radial gates and flowing into the wasteway channel. Additionally, by restoring the capacity of the FKC, higher water surface elevations are expected to be found at the wasteway. The modification would consist of cleaning and preparing the top of existing radial gates (two), fabricating steel plates to act as splashboard panels off-site, transporting those panels by flatbed truck to the site, hoisting them into position, securing and welding the panels in place on top of the radial gates, and finishing by applying a protective coating.

Construction Considerations

Construction would occur within the existing rights-of-way of Reclamation and Reclamation's Operating Non-Federal Entity, FWA. Only existing infrastructure and rights-of-way would be used for staging areas and haul routes, except for limited on-highway traffic, and no additional land would be needed. Construction staging areas would be located on Reclamation and FWA properties, parts of which are currently being used as staging areas for ongoing O&M activities for the FKC. Most major travel and haul routes would occur on paved roads, with source piles for material being within 30 miles of the construction sites. Access to the local construction sites would occur via paved roads to within 5 miles of those sites. Within 5 miles of the local construction sites, existing paved/unpaved FKC O&M roads would be used during construction. Construction materials, including backfill material and concrete, would be obtained from permitted facilities or existing spoil piles. Surplus materials would be taken off-site to permitted locations for safe storage, use, and/or disposal. No new borrow or disposal sites would be developed as a part of the alternatives. Construction activities would be phased over a period of up to 3 years, Figure 10.

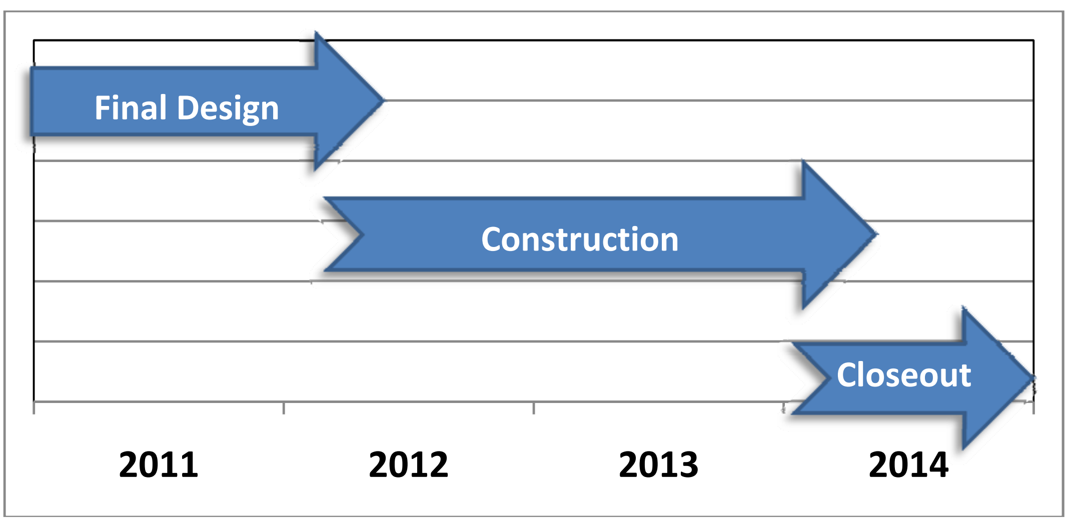

Figure 10. Alternative 5 – Construction Schedule

Table 9. Alternative 5 - Bridges

Alternative	MP	Activity	Clearance (feet)	Class	Material	Notes
5(a) and 5(b)	33.34	Ensure Stability	-0.72	State Hwy	Concrete	State Highway 180
5(a) and 5(b)	33.80	Remove	-0.02	Farm	Timber	Verify need for removal.
5(a) and 5(b)	34.13	Remove/Replace	-0.29	Farm	Timber	Verify need for removal.
5(a) and 5(b)	34.91	Remove	-0.22	Farm	Timber	Verify need for removal.
5(a) and 5(b)	35.16	Ensure Stability	-0.36	County	Concrete	Alta Avenue
5(a) and 5(b)	35.86	Ensure Stability	-0.57	County	Concrete	Jensen Avenue
5(a) and 5(b)	36.78	Ensure Stability	-0.01	County	Concrete	Edgar Avenue
5(a) and 5(b)	36.95	Ensure Stability	-0.88	County	Concrete	Crawford Avenue
5(a) and 5(b)	38.74	Ensure Stability	-0.68	County	Concrete	Central Avenue
5(a) and 5(b)	39.00	Ensure Stability	-0.70	County	Concrete	Cove Avenue
5(a) and 5(b)	40.37	Ensure Stability	-0.65	County	Concrete	American Avenue
5(a) and 5(b)	41.11	Ensure Stability	-0.56	County	Concrete	Anchor Avenue
5(a) and 5(b)	41.75	Ensure Stability	-0.61	County	Concrete	Lincoln Avenue
5(a) and 5(b)	42.90	Ensure Stability	-0.60	County	Concrete	Adams Avenue/Avenue 464
5(a) and 5(b)	43.64	Ensure Stability	-0.41	County	Concrete	Hills Valley Road/Road 120
5(a) and 5(b)	44.59	Ensure Stability	-0.10	County	Concrete	Parlier Avenue/Avenue 452
5(a) and 5(b)	51.63	Ensure Stability	-0.16	County	Concrete	Avenue 416/El Monte Way
5(a) and 5(b)	58.81	Ensure Stability	-0.32	County	Concrete	Avenue 394
5(a) and 5(b)	59.13	Ensure Stability	-0.16	County	Concrete	Road 176
5(a) and 5(b)	59.87	Ensure Stability	-0.30	County	Concrete	Road 180
5(a) and 5(b)	60.50	Ensure Stability	-0.27	County	Concrete	Road 184
5(a) and 5(b)	60.95	Ensure Stability	-0.23	County	Concrete	Dodge Avenue/Avenue 384
5(a) and 5(b)	69.23	Ensure Stability	-0.53	County	Concrete	Road 204

Alternative	MP	Activity	Clearance (feet)	Class	Material	Notes
5(a) and 5(b)	70.28	Ensure Stability	-0.63	County	Concrete	Avenue 328
5(a) and 5(b)	71.18	Ensure Stability	-0.79	County	Concrete	Avenue 322
5(b)	72.25	Ensure Stability	-0.49	State Hwy	Concrete	State Hwy 245/Avenue 314
5(b)	74.71	Ensure Stability	-0.59	County	Concrete	Avenue 300
5(b)	75.77	Ensure Stability	-0.43	County	Concrete	Spruce Avenue/Road 204
5(b)	76.37	Ensure Stability	-1.61	County	Concrete	Marinette Avenue/Avenue 288
5(b)	77.24	Ensure Stability	-0.39	County	Concrete	Wirth Avenue/Avenue 282
5(b)	77.50	Ensure Stability	-0.06	County	Concrete	Exeter Avenue/Avenue 280/Rocky Hill Drive
5(b)	81.56	Ensure Stability	-0.73	County	Concrete	Avenue 256/Sycamore Avenue
5(b)	82.71	Ensure Stability	-0.81	County	Concrete	Avenue 248/Burr Avenue, 20'
5(b)	85.12	Ensure Stability	-2.14	County	Concrete	Avenue 232, Tulare Road
5(b)	85.67	Ensure Stability	-0.67	County	Concrete	Avenue 228/Round Valley Road
5(b)	86.18	Ensure Stability	-0.38	County	Concrete	Avenue 224/Lindmore Avenue
5(b)	86.68	Ensure Stability	-0.13	County	Concrete	Avenue 220/Waddel Avenue/2nd Avenue
5(b)	87.18	Ensure Stability	-0.18	County	Concrete	Avenue 216/Citrus Avenue
5(b)	87.68	Ensure Stability	-0.12	County	Concrete	Avenue 212/El Mirador Hwy
5(b)	88.18	Ensure Stability	-0.15	County	Concrete	Avenue 208/5th Avenue

4.2 FKC Operations Modeling

Reclamation used a series of operational models in order to evaluate the change in surface water and groundwater supplies between the No-Action Alternative and Alternative 5. Reclamation used the output from these operation models to complete the economic analyses included in this report. The following section describes the modeling environment used for surface water and groundwater analyses, the availability of water for delivery, the demand for water, and the ability of the FKC to convey water. Additional details are provided in Appendix E --*Operations and Benefits Analysis Technical Memorandum*.

Surface Water Operations

Reclamation used the water operations model, CalSim, to simulate the change in surface water deliveries between the No Action Alternative and Alternative 5. CalSim is a water supply operations model that simulates the operations of the CVP, including the Friant Division, and the State Water Project. For the CVP, Friant Division, CalSim simulates the month-to-month and year-to-year operation of Millerton Lake, the FKC and Madera Canal, and releases to the San Joaquin River. The model applies the current Class 1, Class 2, and Section 215 contracts over the historical water record, 1922 to 2003.

As represented by the CalSim-II modeling package, the model accounts for water supply conditions in the region in the year 2030. This package contains descriptions of related studies, programs, planning efforts that are assumed to be fully implemented in the future condition, and assumed implementation of Alternative A from the Draft SJRRP Programmatic Environmental Impact Statement/Environmental Impact Report (Draft PEIS/R) (Reclamation 2011). Alternative A for the Draft PEIS/R assumes reoperation at Friant Dam for SJRRP Flows and the potential for recapture of SJRRP Flows in the Restoration Area and in the Delta using existing diversion facilities.

The ability of FKC Contractors to convey water is conditioned on the maximum physical capacity of the FKC, demand, contractual obligations, and the availability of surface water. Accordingly, in order to determine the change in diversions resulting from Alternative 5, Reclamation developed the following set of parameters to simulate the operations of the FKC.

Surface Water Availability

Historically, Friant Dam has spilled water into the San Joaquin River in wet years. Spills at Friant Dam normally occur over periods of a few weeks during the winter and spring, and result from some combination of conditions, including storage evacuations in preparation for high snowmelt conditions, rainfall-dominated inflows that exceed the reservoir’s physical capacity or regulated flood management capacity, a lack of conveyance capacity in the FKC and Madera Canal for delivering the required evacuations, and/or low demand from the Friant Division long-term contractors.

Between 1922 and 2003, 62 spill periods were simulated in CalSim at Friant Dam. Generally, spills only occurred in Wet years (being the wettest 20 percent of years on record at Friant Dam), and Normal-Wet years (being the next wettest 30 percent of years). The annual inflow over the entire simulation period is greater than 2.5 million acre-feet (MAF) for Wet years and greater than 1.45 MAF for Normal-Wet years. The average annual volume of spills for Wet and Normal-Wet years is 700 TAF and 60 TAF, respectively. The largest spill was 2.3 MAF in 1983 with a total of 12.5 MAF of spills over the simulation period from 1921 to 2003.

In order to determine the increase, if any, in surface water availability between the No-Action Alternative and Alternative 5, Reclamation established two criteria. The supplies must be spilled from Friant Dam and must not have been otherwise diverted by water users downstream from Friant Dam.

Conveyance Capacity

The ability of FKC Contractors to capture new supplies depends, in part, on the available conveyance capacity of the FKC. The maximum physical capacity of the FKC is reduced by existing water deliveries, which would have been made in the absence of spill conditions. The modeling tools currently available reflect the general existing operation of Friant Dam and the FKC during spill and non-spill conditions.

While there is existing potential for the FKC to divert a portion of the surface water available, there remains additional surface water supplies that cannot be conveyed under the canal's current capacity. Alternative 5 would expand the ability of the FKC Contractors to capture surface water supplies; however, there remain some events when surface water supplies would not be able to be captured, Figure 11.

The maximum physical capacity of the FKC used for canal operations is limited to the maximum capacity simulated by the calibrated FKC HEC-RAS model, Chapter 2.

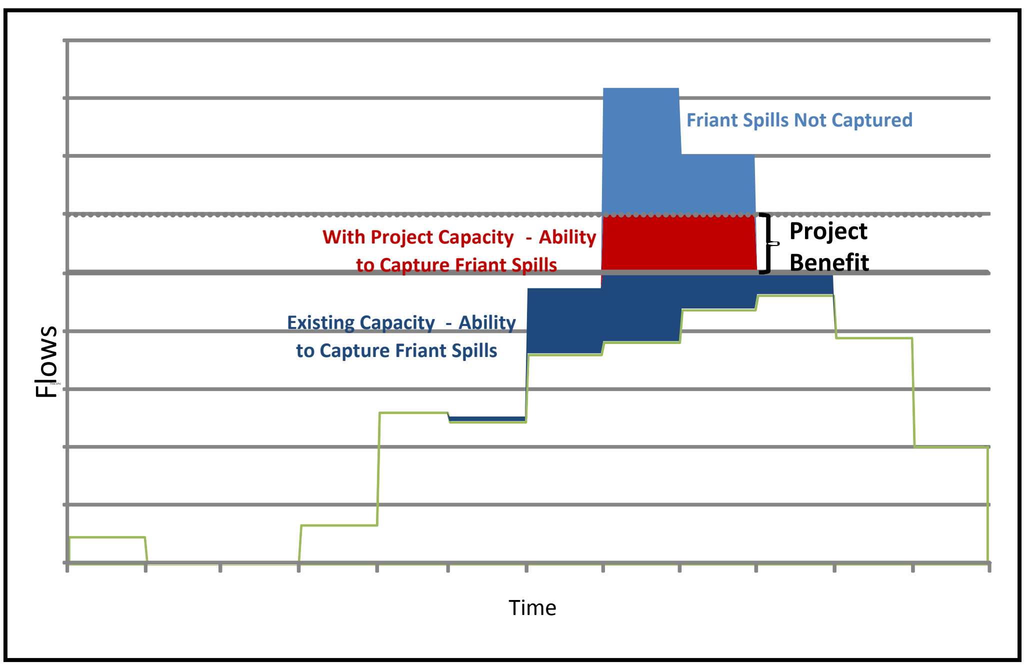

Figure 11. Illustration of Ability to Increase Deliveries

FKC Reaches

CalSim divided the FKC into six reaches, Table 10. The reaches were selected to be consistent with available monthly water diversion data and, where possible, to combine sections of the FKC with similar capacities. This resulted in some of the reaches including multiple design capacities. Based on the assumption that available supplies are first delivered to the furthest, most downstream, demands along the FKC, the conveyance capacities for reaches that include multiple design capacities are given the lower of the two capacities. That is, Reach 2 ranges from 5,000 to 4,500 cfs and is given a capacity of 4,500 cfs, Reach 3 ranges from 4,500 to 4,000 cfs and is given a capacity of 4,000 cfs, and Reach 4 ranges from 4,000 to 3,500 cfs and is given a capacity of 3,500 cfs. In addition, due to Reach 2 being inclusive of both Alternative 5(a) and 5(b), the model output is unable to differentiate any changes in water supply between the two alternatives.

Distribution of Diversions

CalSim incorporates a dynamic representation of the Friant Division's water diversions and operations. Diversions vary from year to year based on variable water supply, and consider the current protocols for providing the Class 1, Class 2, and "Other Water." Other Water includes Class 2 water and Section 215 water. Class 1 (C1) water supply is considered the "firm supply" from the Friant Division and amounts to the first 800 TAF of yield from the San Joaquin River and reservoir storage. Class 2 (C2) deliveries are developed after C1 deliveries are met and are highly variable because of variable hydrology. Deliveries that occur when water is unstorable are also modeled, and referred to as "Other Water". Other Water includes C2 water plus Section 215 water.

Monthly distribution of the annual diversion is based on historical delivery practices of the FKC Contractors and is based on a weighted distribution of Class 1, Class 2, and Section 215 supplies, Table 11.

Demand

Potential surface water supply benefits from Alternative 5 are influenced by the FKC Contractors demand for water. The ability for FKC Contractors to divert water depends on the following:

- Need for the water for agricultural production, municipal and industrial uses, in-lieu projects, groundwater recharge, or groundwater banking (Maximum Historical Deliveries).

- Capacity of facilities to divert and covey water supplies. (Maximum Historical Deliveries).

Availability of other competing water supplies. (Tule River Index).

The Maximum Historical Deliveries are the maximum monthly deliveries of the FKC by reach for the period 1994-through-2005, Table 12. Using monthly deliveries ensures consistency with CalSim, and using the monthly maximum deliveries provides and upper-end estimate of demand of the FKC Contractors. Reclamation considers this assumption to be conservative; however, FWA suggests that implementation of the SJRRP Flows may result in a further increase in demand over the maximum historical deliveries up to the maximum capacity of the FKC.

Table 10. FKC Modeled Reaches

Model Reach	***FKC Reach***	***Friant Contractors***	***Current Capacity (cfs)***	***Maximum Capacity (cfs)***
1	Friant Dam to Kings River Check	FRESNO	5,300	5,300
		CITY OF FRESNO		
		GARFIELD		
		INTERNATIONAL		
2	Kings River Check to Fifth Ave. Check	EXETER	4,680 - 4,105	4,500
		IVANHOE		
		LINDMORE		
		LINDSAY STRATHMORE		
		ORANGE COVE		
		STONE CORRAL		
		TULARE		
		CITY OF LINDSAY		
		CITY OF ORANGE COVE		
		LEWIS CREEK		
3	Fifth Ave. Check to Deer Creek Check	LOWER TULE	4,000	4,000
		PORTERVILLE		
		SAUCELITO		
		TEA POT DOME		
		TERRA BELLA I.D.		
4	Deer Creek Check to Poso Creek Check	DELANO EARLIMART	3,500	3,500
		SOUTHERN S.J.M.U.D.		
5	Poso Creek Check to Shafter-Wasco Check	SHAFTER WASCO	2,170	2,170
6	Shafter-Wasco Check to Kern River Check	ARVIN EDISON	2,170	2,170

Key:
cfs = cubic feet per second
S.J.M.U.D. = San Joaquin Municipal Utility District

Table 11. Distribution of FKC Deliveries by Reach

Reach	Class 1	Class 2	Section 215	Losses
Friant to Kings	9.8%	7.2%	1.9%	19%
Kings to Fifth	24.9%	18.2%	12.5%	39%
Fifth to Deer	20.4%	28.9%	5.2%	10%
Deer to Poso	31.2%	12.0%	31.1%	18%
Poso to Shafter	7.6%	3.8%	14.4%	5%
Shafter to Kern	6.1%	29.9%	34.9%	10%
Total	**100%**	**100%**	**100%**	**100%**

Table 12. FKC Maximum Historical Monthly Deliveries (cfs)

Reach	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Friant to Kings	554	9	23	106	127	274	160	185	436	605	500	449
Kings to Fifth	347	156	215	2,095	1,457	740	541	802	1,054	1,024	1,066	467
Fifth to Deer	421	351	213	73	356	461	656	865	1,146	1,088	1,146	705
Deer to Poso	272	143	42	32	157	354	508	757	891	928	704	493
Poso to Shafter	116	33	17	24	139	175	139	181	768	349	187	102
Shafter to Kern	401	281	212	219	952	889	1,049	1,069	635	808	434	288
Total	***2,110***	***973***	***722***	***2,549***	***3,187***	***2,893***	***3,053***	***3,861***	***4,930***	***4,801***	***4,038***	***2,505***

Key:
cfs = cubic feet per second

The Tule River Index takes into account the wetness of the San Joaquin Valley. Historically, higher precipitation in the San Joaquin Valley results in lower FKC Contractors deliveries. The Tule River, which flows from a lower elevation catchment along the western Sierra Nevada Range, receives little snow fall and therefore serves as an excellent indicator of when the San Joaquin Valley has received heavy precipitation. Historically, in months when inflow into the Tule River exceeds 40 TAF the FKC Contractors temporarily reduce their deliveries. As such, 40 TAF has been incorporated into CalSim as an indicator of periods to temporarily reduce FKC Contractors deliveries.

Daily vs. Monthly Time-Step

Consistent with the monthly time-step used by CalSim, Reclamation used a monthly time-step to simulate the operations of the FKC. Reclamation completed a comparison of the daily and monthly time-steps and found the results to be within ten percent of each other, indicating an acceptable level of tolerance. Figures 12 and 13 illustrate the comparison between the daily and monthly time-steps.

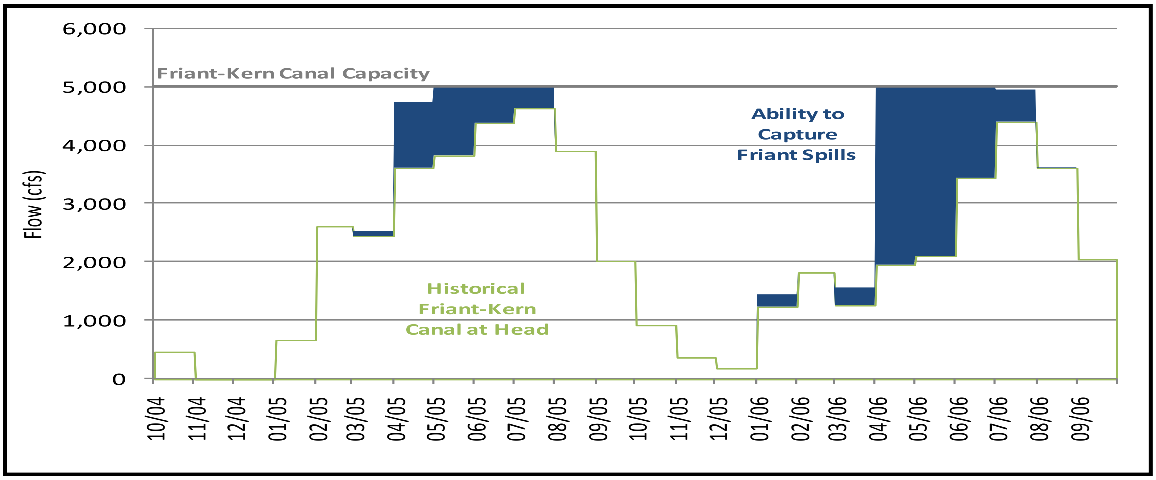

Figure 12. Monthly Time-Step

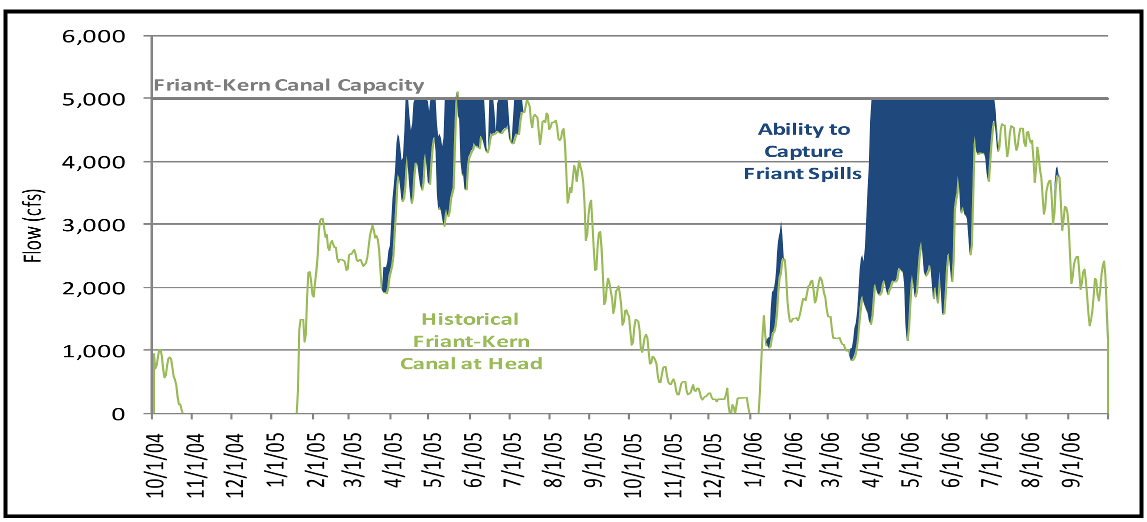

Figure 13. Daily Time-Step

Groundwater Operations

In order to determine the increase in groundwater levels and groundwater pumping between the No-Action Alternative and Alternative 5, Reclamation used two custom tools, developed in Excel, to simulate flow and delivery data from the post-processed CalSim simulations. One regional groundwater tool is based on relationships describing annual groundwater pumping and resulting groundwater level change developed during litigation studies by Dr. Schmidt (2005a, b). A second tool is based on regional aquifer parameters and available groundwater elevation information available from the California Department of Water Resources (DWR) Water Data Library (WDL) and Bulletin 118-03 (DWR 2003, 2010). These tools are not full groundwater models but used a water balance approach based on the CalSim delivery output to produce the regional groundwater description.

Schmidt Tool

The Schmidt Tool identifies the change in groundwater levels in feet per year and groundwater pumping by Friant Division long-term contractors. It is a simplified numerical tool developed by Schmidt (2005b). During litigation of the Settlement, it was used to evaluate changes in groundwater conditions in the Friant Division as part of the regional groundwater analysis. This regional groundwater tool estimates the depth to groundwater within Friant Division long-term contractors service areas according to relationships describing annual groundwater pumping and resulting depth to groundwater. The report completed by Schmidt in 2005 presents the best available data describing the relationship between groundwater pumping and groundwater depth within the Friant Division, as illustrated in Table 13. Relationships between groundwater pumping and groundwater depth within the Friant Division, as developed by Dr. Schmidt, are linear and describe annual aquifer drawdown. To estimate long-term aquifer drawdown for future conditions, annual drawdown within each district region was applied for a 25-year period to correspond to 2030 conditions.

Not all of the Friant Division contractors are represented in the output tables because historical information was not available for each of the contractors from Schmidt (2005b). Groundwater conditions for 15 contractors are represented in the attachment output tables. The remaining Friant Division contractors were considered using the Mass Balance Tool.

Mass Balance Tool

The Mass Balance Tool identifies the change in groundwater levels in feet per year and groundwater pumping by Friant Division long-term contractor. It was used to address potential changes in groundwater conditions within the Friant Division long-term contractors that did not have a Schmidt relationship. The Mass Balance Tool provides a quantitative evaluation of how the groundwater levels could potentially change as a result of a decrease in surface water deliveries using the best available information for these different regions. The Mass Balance Tool involved the development of a spreadsheet model that uses post-processed CalSim data as input to calculate the average change in simulated surface water deliveries from within each district, and to estimate the change in the depth to groundwater within each region by assuming a uniform drainable porosity (specific yield) and a uniform change in depth to groundwater throughout the entire area overlying the basin. As with the Schmidt method, the changes in annual surface water deliveries were assumed to be offset by an increase in groundwater pumping.

Development of this tool involved identifying the groundwater subbasins underlying each of the districts to evaluate the subsurface conditions, and estimating an average uniform specific yield within each district. To evaluate the potential change in groundwater elevation, groundwater data from all groundwater wells within each district that stores data publically on the DWR WDL was downloaded from the website (DWR 2010). The data were evaluated by district to estimate the average existing groundwater-level condition for 2005. Although it is recognized that political boundaries do not control the physical environment, for the purposes of estimating conditions using the Mass Balance Tool, it was necessary to treat each district as a hydraulically closed system.

Table 13. Changes in Groundwater Levels and Groundwater Pumping

District	Change in Groundwater Level (1987-1999, Existing Level) (feet/year)	Change in Groundwater Level (Spring-Run Hydrograph) (feet/year)	Change in Groundwater Pumping (Existing Deliveries) (acre-feet/year)	Change in Groundwater Pumping (Spring-Run Hydrograph) (acre-feet/year)
Chowchilla WD	-3.8	-8.8	93,000	127,000
Madera ID	-2.1	-5.1	153,000	197,000
Fresno ID	-0.9	N/A	N/A	N/A
Garfield WD	-1	N/A	N/A	N/A
International WD	N/A	N/A	N/A	N/A
Orange Cove ID	0.5	-16	41,000	49,000
Ivanhoe ID	-0.9	-3	16,000	19,000
Stone Corral ID	0.2	N/A	9,500	12,000
Tulare ID	-2.9	-8.7	137,000	163,000
Exeter ID	-0.6	-4.7	20,000	25,000
Lindsay-Strathmore ID	0.3	-2	7,000	13,000
Lindmore ID	-1	-7.4	34,000	44,000
Lower Tule River ID	-2.9	-7.9	134,000	181,000
Porterville ID	-0.5	-7.5	23,000	31,000
Teaport Dome WD	0.2	N/A	1,500	3,000
Terra Bella ID	N/A	N/A	12,000	18,000
Saucilito ID	-1.3	-7.5	15,000	24,000
Delano-Earlimart ID	-1	-8.3	26,000	54,000
Southern San Joaquin Municipal Utility District	-2.7	-3.5	49,000	75,000
Shafter Wasco ID	-3.1	-8.8	55,000	70,000
Arvin-Edison WSD	2.1	-14.5	186,000	239,000

Source: Schmidt 2005b.

4.3 Water Supply Evaluation

Based on the above, Reclamation completed a water supply evaluation of Alternative 5, including a supplemental analysis to evaluate the potential effects of groundwater opportunities authorized under Section 10202 of the SJRRS Act (Part-III Projects).

Accordingly, as illustrated in Figure 14 and 15, Alternative 5 would result in an increase in the annual average surface water deliveries to the FKC Contractors of 5,000 acre-feet without Part-III Projects, and 8,000 acre-feet with Part-III Projects, represented in ***red*** as the "Capture with Correction." The maximum single year increase is 56 TAF without Part-III Projects and 113 TAF with Part-III Projects. Since the majority of these water supplies would be delivered during wet periods, when demand to irrigate crops is low, the majority of the developed water supplies are anticipated to be used for groundwater recharge. Additional details are provided in Appendix E -- *Operations and Benefits Analysis Technical Memorandum*.

Sacramento-San Joaquin Delta

Due to the increase in wet year diversions resulting from implementation of Alternative 5, Reclamation completed an analysis to determine the change, if any, in total CVP/State Water Project (SWP) diversions from the Sacramento-San Joaquin Delta (Delta) as a result of Alternative 5. This analysis was carried out by modifying two CalSim simulations developed under the SJRRP for existing operations, with and without Paragraph 16(b) of the Settlement. Table 14 provides the changes in mean monthly Delta exports and the percent change in monthly exports as a result of Alternative 5. Based on this analysis, Reclamation does not anticipate a reduction in the CVP/SWP Delta exports as a result of implementing Alternative 5.

Table 14. Mean CVP/SWP Monthly Delta Export (1921-2003)

Month	No Action Alternative (cfs)	Alternative 4 with Part-III Projects (cfs)	Percent Change
October	8,607	8,606	0.0%
November	9,007	9,005	0.0%
December	10,090	10,088	0.0%
January	10,661	10,698	0.3%
February	9,240	9,224	-0.2%
March	8,208	8,208	0.0%
April	5,905	5,904	0.0%
May	5,168	5,154	-0.3%
June	6,275	6,276	0.0%
July	8,976	8,975	0.0%
August	8,723	8,722	0.0%
September	9,075	9,032	-0.5%

Key:
cfs = cubic feet per second

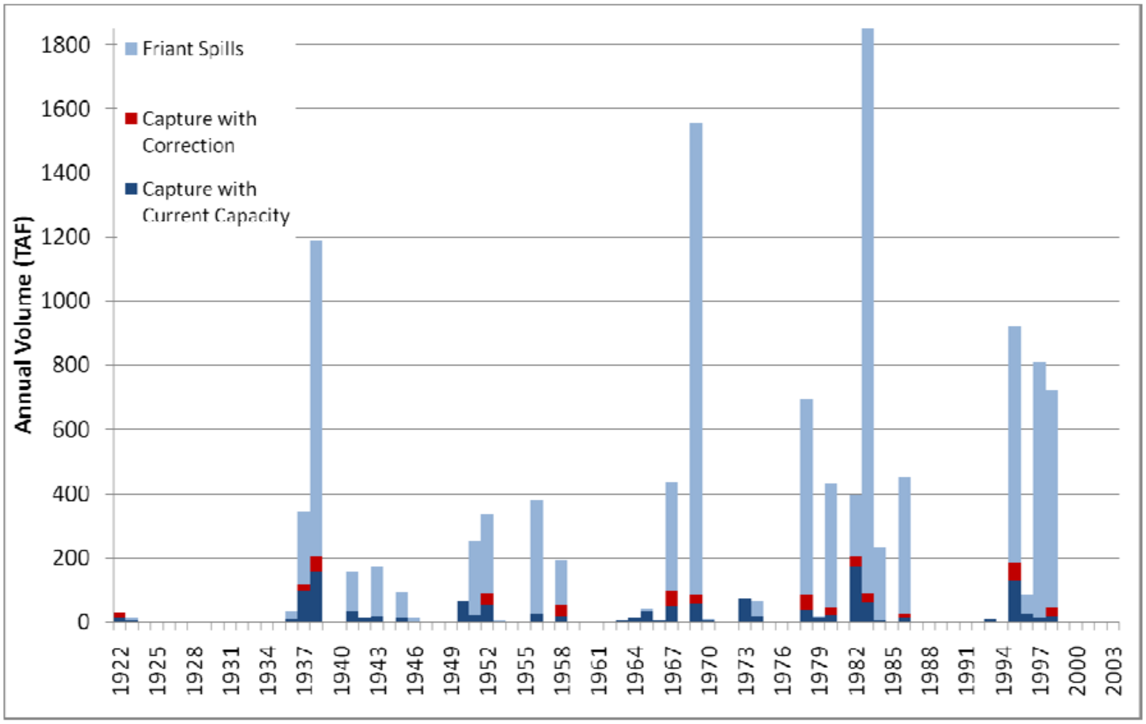

Figure 14. Change in Annual Volume of Captured Spills w/out Part-III Projects

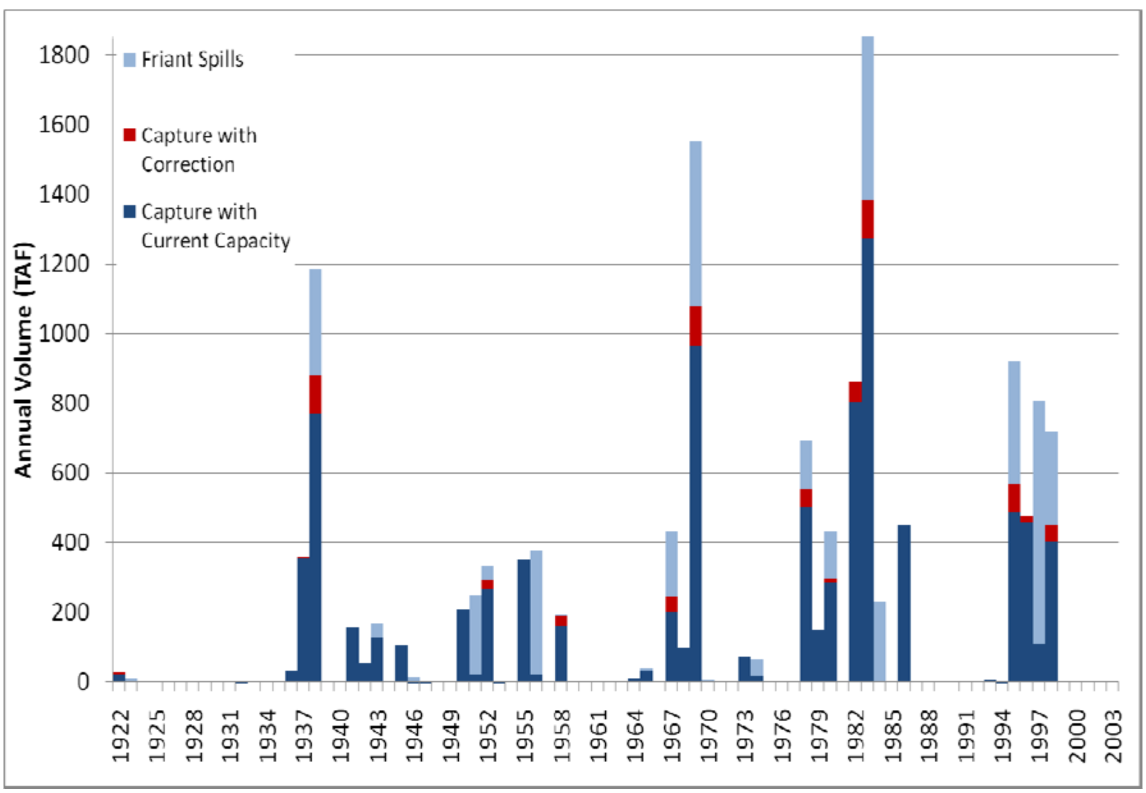

Figure 15. Change in Annual Volume of Captured Spills w/Part-III Projects

4.4 Economic Evaluation

This section describes the methods and models used to address the economic effects associated with restoring conveyance capacity in the FKC. Alternative 5 has the potential to change surface water supply reliability and water costs to agricultural water users within the Friant Division. Changes in surface water deliveries affect agricultural users by altering crop output and production costs. For example, reductions in surface water supply reliability may result in increased temporary crop idling and increased reliance on groundwater resources, among other effects. The reduced net farm income generated through reduced production opportunities and higher production costs would result in direct economic effects to the region.

Reclamation applied the Central Valley Production Model (CVPM) to quantify the direct effects associated with changes in surface water deliveries to Friant long-term contractors resulting from implementation of Alternative 5. As previously described, regional agricultural water deliveries from CalSim were post-processed for the surface water operations modeling, then post-processed again to account for the groundwater modeling. Long-term average surface water deliveries and changes in groundwater pumping lifts are used as inputs to CVPM. Figure 16 illustrates the relationship among the water operations model, the regional groundwater model, and the agricultural economics model. In this analysis, changes in 2030 groundwater pumping lifts among alternative plans are estimated for the Friant Division and incorporated in the CVPM. Key output from the CVPM includes irrigated acres, net revenue, and gross revenue by agricultural production region.

CalSim provides annual surface water deliveries by agricultural production region to the CVPM. In addition, CalSim water deliveries that occur outside of the irrigation season are used in the regional groundwater model to estimate changes in depth to groundwater within the Friant Division. The estimated changes in depth to groundwater are used as inputs in the CVPM and affect the cost of irrigation water supplies to agricultural producers. The potential economic effects of changes in depth to groundwater beyond the Friant Division are not considered in this analysis.

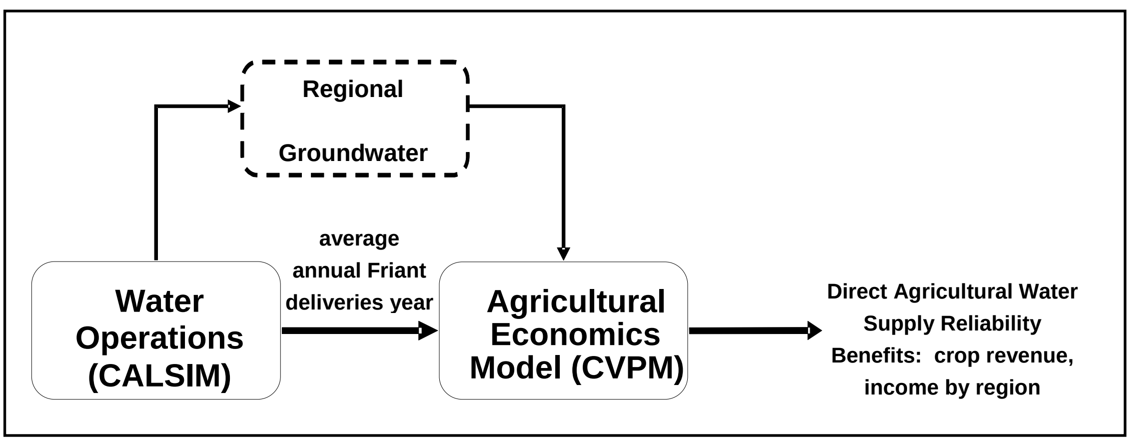

Figure 16. FKC Modeling Diagram

CVPM

CVPM is an economic model that includes irrigated acres, gross revenue, net revenue, and water use by production region. The model assumes that farmers maximize net revenue subject to resource, technical, and market constraints. Farmers sell and buy in competitive markets, and no one farmer can affect or control the price of any commodity. To obtain a market solution, the model's objective function maximizes the sum of producers' surplus (net income) and consumers' surplus (net value of the agricultural products to consumers) subject to the following relationships and restrictions:

1. Linear, increasing marginal cost functions estimated using the technique of positive mathematical programming. These functions incorporate acreage response elasticities that relate changes in crop acreage to changes in expected returns and other information.

2. Commodity demand functions that relate market price to the total quantity produced.

3. Irrigation technology tradeoff functions that describe the tradeoff between applied water and irrigation costs.

4. A variety of constraints involving land and water availability and other legal, physical, and economic limitations.

The model selects those crops, water supplies, and irrigation technology that maximize net revenue subject to the above equations and constraints. From No. 1 above, cost per acre increases as production increases. From No. 2 above, crop price and revenue per acre decline as production increases. No. 3 affects costs and water use through the selection of the least-cost irrigation technology. No. 4 is used to analyze the effects of the project alternatives that change water availability and cost.

Alternative 5

The CVPM divides agricultural production into production regions. To isolate effects of Alternative 5 on the Friant Division, it was necessary to change production regions in the model. The number of CVPM production regions was expanded to distinguish the effects of action alternatives on the Friant Division from the rest of the Central Valley and the recognize differences in resource availability among Friant long-term contractors. The original CVPM model included 22 crop production regions in the Central Valley. For this analysis, the model area was disaggregated into 30 crop production regions. Descriptions of the production regions are provided in Table 15, and the regions added for evaluation of Alternative 5 are also highlighted. In addition, CVPM includes 20 crop categories that represent the wide variety of crops produced in the Central Valley. Table 16 summarizes crop categories and types of crops included in each.

Table 15. CVPM Regions and Descriptions

CVPM Region	Description of Major Water Users
1	CVP Users: Anderson Cottonwood, Clear Creek, Bella Vista, Sacramento River miscellaneous users
2	CVP Users: Corning Canal, Kirkwood, Tehama, Sacramento River miscellaneous users
3	CVP Users: Glenn Colusa ID, Provident, Princeton-Codora, Maxwell, and Colusa Basin Drain MWC
3b	Tehama Colusa Canal Service Area. CVP Users: Orland-Artois WD, most of County of Colusa, Davis, Dunnigan, Glide, Kanawha, La Grande, Westside WD
4	CVP Users: Princeton-Codora-Glenn, Colusa Irrigation Co., Meridian Farm WC, Pelger MWC, Reclamation District 1004, Reclamation District 108, Roberts Ditch, Sartain M.D., Sutter MWC, Swinford Tract IC, Tisdale Irrigation, Sacramento River miscellaneous users
5	Most Feather River Region riparian and appropriative users
6	Sacramento County north of American River. CVP Users: Natomas Central MWC, Sacramento River miscellaneous users, Pleasant Grove-Verona, San Juan Suburban
7	Yolo, Solano counties. CVP Users: Conaway Ranch, Sacramento River Miscellaneous users
8	Delta Regions. CVP Users: Banta-Carbona, West Side, Plainview
9	Sacramento County south of American River, San Joaquin County
10	Delta Mendota Canal. CVP Users: Panoche, Pacheco, Del Puerto, Hospital, Sunflower, West Stanislaus, Mustang, Orestimba, Patterson, Foothill, San Luis WD, Broadview, Eagle Field, Mercy Springs, Pool Exchange Contractors, Schedule water rights
11	Stanislaus River water rights: Modesto ID, Oakdale ID, South San Joaquin ID
12	Turlock ID
13	Merced ID
13A	CVP Users: Madera, Chowchilla, Gravelly Ford
14	CVP Users: Westlands WD
15	Tulare Lake Bed. CVP Users: Fresno Slough, James, Tranquility, Traction Ranch, Laguna, Reclamation. District 1606
16	Eastern Fresno County CVP Users: Friant-Kern Canal. Fresno ID, Garfield, International
17	Hills Valley, Tri-Valley
17A	CVP Users: Friant-Kern Canal Orange Cove
18	County of Fresno, Pixley ID, portion of Rag Gulch, Ducor, County of Tulare
18A	Lower Tule River ID, Tulare ID, Porterville ID, Stone Corral ID
18B	Delano-Earlimart ID
18C	Lindsay-Strathmore ID, Lindmore ID, Exeter ID, Ivanhoe ID, Lewis Creek ID
18D	Saucelito ID, Terra Bella ID, Tea Pot Dome WD
19	Kern County SWP Service Area
20	CVP Users
20A	Southern San Joaquin MUD, Shafter Wasco ID
21	CVP Users: Cross Valley Canal
21A	Arvin Edison WSD

Note: Region 16 was not divided between Friant and non-Friant irrigated land. CVPM results for Region 16 were allocated according to the relative proportion of Friant Division acreage contained in the region.

Key:

CVP = Central Valley Project
IC = Irrigation Company
ID = Irrigation District
MWC = Mutual Water Company
WD = Water District
WSD = Water Service District

Table 16. CVPM Crop Groupings

Category	Proxy Crop[1]	Other Crops[2]	Unit of Measure
Grain	Wheat	Barley, oats	Tons
Rice	Rice	----	Tons
Cotton	Upland cotton	Pima cotton	Bales
Sugar beets	Sugar beets	----	Tons
Corn	Corn silage	Other corn	Tons
Dry beans	Dry beans	Lima beans	Tons
Safflower	Safflower	----	Tons
Alfalfa	Alfalfa hay	Alfalfa seed, clover	Tons
Pasture	Irrigated pasture	----	Acres
Other field	Sudan grass	Sunflower, other misc. field and seed Crops	Tons
Processing tomatoes	Processing tomatoes	----	Tons
Fresh tomatoes	Fresh tomatoes	----	Tons
Cucumbers/Cantaloupe	Cantaloupe	Honeydew, watermelon, squash, cucumbers	Tons
Onions/Garlic	Dry onions	Dry and fresh onions, garlic	Tons
Potatoes	White potatoes	Other potatoes	Tons
Other truck	Broccoli	Carrots, cauliflower, lettuce, peas, spinach, peppers, asparagus, sweet potatoes, other truck vegetables	Tons
Almonds/Pistachios	Almonds	Pistachios	Tons
Other deciduous	English walnuts	Peaches, walnuts, nectarines, pears, cherries, apples	Tons
Subtropical	Oranges	Citrus, avocadoes, olives, figs, misc. subtropical	Tons
Vines	Wine grapes	Raisins, table grapes	Tons

Notes:
[1] Production costs, yields, and prices for this crop used in the CVPM.
[2] Acreage data for these crops summed with the proxy crop.
Key:
CVPM = Central Valley Production Model

Groundwater Supply

Within the CVPM calibration, groundwater availability by production region is estimated as the residual between crop irrigation demands and surface water availability. This estimation is primarily the result of limited information regarding groundwater availability within each region. During the estimation stage of the model, groundwater availability is generally assumed to be the same as the estimated volumes during the calibration stage. However, in some cases it is necessary to increase groundwater availability during the estimation stage for some regions to promote model solvability. For this study, groundwater availability was set at a level such that it did not impose a binding constraint within the model for any of the regions. This results in groundwater providing a complete buffer against reductions in surface water supply. As a result, the model will generally only idle acres if the cost of accessing groundwater is too high to generate positive net returns to crop production. The assumption is that groundwater will become too expensive for agricultural production before groundwater is fully exhausted.

Groundwater Costs

The cost of groundwater is determined in the CVPM model according to the pump lift requirement. The model assigns a unit cost that accounts for the cost to lift 1 acre-foot of water by 1 foot. The unit cost includes the estimated power cost based on 70-percent pump efficiency and the amortized capital cost of well construction. Previously, the unit cost within the model was set at $0.26 (1.02 x $0.18/kWh/.70 = $0.26) for all production regions. For this study, a unit cost of $0.35 was applied to groundwater pumping in the Friant Division regions of the model to account for an average pump efficiency of 53.5 percent, as determined by experts in the Settlement litigation documents (NRDC 2006). The unit cost of $0.26 was unchanged for all crop production regions outside of the Friant Division regions. This analysis assumes that the capital costs to pump groundwater are unaffected by changes in depth to groundwater.

Depth to Groundwater

As described above, depth to groundwater within each of the Friant Division production regions was estimated according to relationships describing annual groundwater pumping and resulting depth to groundwater developed by Dr. Schmidt (2005a and b) (Reclamation 2011). The analysis assumed that changes in surface water deliveries are fully offset by changes in groundwater withdrawals as agricultural producers seek to satisfy crop water requirements. The groundwater depth estimates were included as inputs in the CVPM, Table 17.

Table 17. Depth to Groundwater by CVPM Region (feet)

CVPM Region	Current Depth	Without Part-III Projects		With Part-III Projects	
		No-Action	Alternative 5	No-Action	Alternative 5
13A	150	249	248	230	228
16A	85	85	85	85	85
17A	44	126	123	59	53
18A	124	196	194	155	152
18B	180	225	222	173	169
18C	71	101	100	77	75
18D	165	194	193	169	166
20A	231	313	312	296	294
21A	410	409	403	294	284

Surface Water Deliveries

CVPM requires distinctions between agricultural and municipal and industrial (M&I) deliveries for the Friant Division, among Friant Division long-term contractors, and to other SWP/CVP delivery areas included in the CalSim modeling. CVPM agricultural water delivery input was developed based on the CalSim analysis showing no changes in deliveries to existing South of Delta (SOD) contractors as a result of implementation of Alternative 5. Under this assumption, the CalSim results from the non-project simulations represent the water deliveries to the non-Friant areas under Alternative 5. The Friant Division results would be the CalSim results post-processed to add the appropriate potential returns for the alternative as in the groundwater analysis.

The CVPM results for each simulation are split into three areas:

- NOD – North of Delta
- SOD – South of Delta except Friant area
- Friant Area– Friant Contract Service Area

The Friant Area results are selected and post-processed using the same basic assumptions and procedures as in the groundwater section. These are:

- Compute the reduction in project deliveries for each reach.
- Select the appropriate return volume for the analysis.
- Allocate the return between the reaches based on their total contract reduction percentage.
- Add this volume to the appropriate CalSim volume, assigning 30 percent to surface delivery and 70 percent to groundwater recharge.

The final composite set of CVPM inputs is then used in the CVPM and IMPLAN modeling.

4.5 Feasibility Level Analysis

The *Principles & Guidelines* establish four accounts to facilitate the evaluation and display of effects of alternatives. These accounts are: National Economic Development (NED), Environmental Quality (EQ), Regional Economic Development (RED), and Other Social Effects (OSE). The only required account is the NED. Other information that is required by law or that will have a material bearing on the decision is included in the other accounts.

Environmental Quality Account and Other Social Effects Account

The “environmental quality” account is a means of displaying and integrating into water resources planning that information on the effects of alternatives on significant EQ resources and attributes of NEPA human environment, as defined in 40 Code of

Federal Regulations 1507.14, that is essential to a reasoned choice among alternatives. Significant means likely to have a material bearing on the decision making process.

The "other social effects" account is a means of displaying and integrating into water resource planning information on alternatives effects from perspectives that are not reflected in the other three accounts. The categories of effects in the OSE account include the following: urban and community impacts; life, health, and safety factors; displacement; long-term productivity; and energy requirements and energy conservation.

A thorough evaluation of the EQ and OSE accounts was performed as part of the FKC Feasibility Study's environmental documentation process, and no significant effects were identified that would have a material bearing on the decision making process. Accordingly, feasibility level evaluation of these two accounts was considered unnecessary.

Regional Economic Development Account

The purpose of the Regional Economic Development Account (RED) is to register changes in the distribution of regional economic activity that will result from alternatives. Two measures of the effects on regional economies used in the account are regional income and regional employment. For Alternative 5, the RED assesses and compares the alternatives effects within Fresno, Tulare, and Kern Counties. It is anticipated that Alternative 5 would generate a minimal amount of economic activity during the construction period and thereafter. However, as provided in Appendix E -- *Operations and Benefits Analysis Technical Memorandum*, the change in crop production from implementation of Alternative 5 is anticipated to be minimal, with most of the benefit coming from increased groundwater levels. Accordingly, feasibility level evaluation of this account was considered unnecessary.

National Economic Development Account

The objective of the national economic development analysis is to determine the change in net value of the Nation's output of goods and services that would result from implementing the alternative. Beneficial and adverse effects are evaluated in monetary terms and are measured in terms of changes in national income.

NED Benefits

NED may include net benefits to the following categories: M&I water supply, agriculture, urban flood damage reduction, power (hydropower), transportation (inland navigation and deep draft navigation), recreation, commercial fishing, unemployed or underemployed labor resources, and other direct benefits. For analysis of Alternative 5, NED benefits result from agriculture production. The benefits of Alternative 5 are estimated relative to the No-Action Alternative and are categorized as follows:

- Increase in the ability to deliver surface water supplies to lands that may be impacted from implementation of the SJRRP Flows.

- Increase in groundwater levels, reducing pumping costs for lands that may be impacted from implementation of the SJRRP Flows.

The economic benefit to the nation can be calculated as the difference between the Total Social Value for the No-Action Alternative and Alternative 5, Table 18. Total Social Value is the sum of producer and consumer surplus. Producer surplus is the net benefits to agricultural producers as measured by profit. Consumer surplus is the net value of the agricultural products to consumers. Accordingly, as provided in Table 18, the economic benefit (Total Social Value) of implementing Alternative 5 without Part-III Projects is estimated to be $658,000 per year, with a total benefit of $32,900,000 over the 50-year performance period. With Part-III Projects the benefit of Alternative 5 is estimated to be $1,157,000 per year, with a total benefit of $57,850,000 over the 50-year performance period.

Table 18. Alternative 5 - Economic Results

All CVPM Regions	Without Part-III Projects			With Part-III Projects		
	No-Action	Alternative 5	Change	No-Action	Alternative 5	Change
Gross Revenue (1,000$)	$19,350,807	$19,350,828	$21	$19,351,317	$19,351,369	$52
Net Revenue (1,000$)	$3,015,176	$3,015,805	$628	$3,028,167	$3,029,273	$1,105
Consumer Surplus (1,000$)	$3,011,356	$3,011,386	$30	$3,011,969	$3,012,020	$52
Total Social Value (1,000$)	***$6,026,532***	***$6,027,190***	***$658***	***$6,040,136***	***$6,041,293***	***$1,157***

NED Costs

The alternatives require the use of various resources. NED Costs are the opportunity costs of resource use. Opportunity costs are a measure of the highest valued alternative use that would be foregone as a result of using a particular resource. Both public and private uses of the various resources required in an alternative should be considered when evaluating NED Costs.

NED Costs are the opportunity, or economic, costs of resources used in a project alternative. Financial or accounting costs are a measure of the actual cash outlays made to acquire the resources necessary to implement the alternatives. In cases where financial costs reflect the full economic value of a particular resource to society, they can and should be used to determine NED Costs, which was determined by Reclamation to be appropriate for the alternatives in this report.

Due to the FKC Feasibility Study being funded through non-reimbursable Federal appropriations, resulting in no interest during construction or repayment costs, and the operation and maintenance cost of the FKC expected by the parties to remain the same, , Reclamation determined the NED Costs for Alternative 5 to be the total cost of constructing the Alternative 5. Accordingly, the NED Cost, based on feasibility-level estimates, for Alternative 5(a) is expected to be $24,530,000 and Alternative 5(b) is expected to be $39,100,000, Tables 19 and 20. The feasibility-level estimates were completed in accordance with Reclamation's FAC 09-01 and FAC 09-02.

Table 19. Alternative 5(a) – Feasibility Cost Estimate

Description	*Percentage*	*Amount*
Construction Cost	--	$15,390,000
Mobilization	5%	$769,500
Design Contingencies	10%	$1,615,900
Construction Contingencies	20%	$3,555,000
Non-Contract Costs	15%	$3,199,600
Total Cost		**$24,530,000**

Table 20. Alternative 5(b) – Feasibility Cost Estimate

Description	*Percentage*	*Amount*
Construction Cost	--	$24,531,654
Mobilization	5%	1,250,000
Design Contingencies	10%	$2,218,346
Construction Contingencies	20%	$6,000,000
Non-Contract Costs	15%	$5,100,000
Total Cost		**$39,100,000**

Net NED Benefits

The *Principles and Guidelines* state that the alternative that reasonably maximizes new NED benefits, consistent with the Federal objective, is identified as the NED plan. Net NED Benefits are calculated by subtracting NED Costs from NED Benefits. As shown in Table 21, the alternative that provides the maximum Net NED Benefits is Alternative 5(a). If the NED Costs for Alternative 5(b) could be reduced to $25,000,000, the assumed funding for the FKC Feasibility Study, Alternative 5(b) would maximize the Net NED Benefits.

Table 21. Alternative 5 - Net NED Benefits (50 years)

	Alternative 5(a)		*Alternative 5(b)*	
	Without Part-III	*With Part-III*	*Without Part-III*	*With Part-III*
Total NED Benefits	$32,900,000	$57,850,000	$32,900,000	$57,850,000
Total NED Costs	$24,530,000	$24,530,000	$39,100,000	$39,100,000
Net NED Benefits	**$8,370,000**	**$33,320,000**	**($6,200,000)**	**$18,750,000**

Chapter 5. Affected Environment

Potential environmental effects of the recommended alternatives considered in this feasibility study are presented in Table 22. This table includes a summary of resources areas and a synopsis of potential impacts to these resources on the human environment.

Table 22: Summary of Environmental Effects

<table>
<tr><th>Resource Area</th><th>Authority</th><th>Potential Impacts</th></tr>
<tr><td>Air Quality</td><td>Clean Air Act (42 USC Section 176 et seq.)</td><td>Air quality impacts are below regulated thresholds and will not require mitigation. Temporary and short-term air quality impacts, generally from dust and emissions from construction equipment, could occur from construction of the alternatives. Air quality constituents of concern that may be generated by the recommended alternative include volatile organic compounds (VOCs), oxides of nitrogen (NO_x), particulate matter at both 10 microns and 2.5 microns (PM_{10} and $PM_{2.5}$, respectively), and carbon monoxide (CO). Below are estimated emissions from the recommended alternative in relation to the Federal and Local (San Joaquin Valley Air Pollution Control District) thresholds:
<table>
<tr><th>Constituent</th><th>Federal Threshold*</th><th>Local Threshold*</th><th>Estimated Project Emissions*</th></tr>
<tr><td>VOCs</td><td>50</td><td>10</td><td>0.17</td></tr>
<tr><td>NO_x</td><td>50</td><td>10</td><td>6.23</td></tr>
<tr><td>PM_{10}</td><td>100</td><td>15</td><td>3.07</td></tr>
<tr><td>$PM_{2.5}$</td><td>100</td><td>--</td><td>3.07</td></tr>
<tr><td>CO</td><td>100</td><td>--</td><td>3.98</td></tr>
<tr><td colspan="4">* All quantities shown in tons per year</td></tr>
</table>
</td></tr>
<tr><td>Biological Resources</td><td>Endangered Species Act (16 USC Section 1531 et seq.)

Fish and Wildlife Coordination Act (16 USC Section 651 et seq.)

Migratory Bird Treaty Act (16 USC Section 703 et seq.)

Executive Order 11990-Protection of Wetlands</td><td>Migratory Bird Treaty Act (MBTA) species or habitats may be impacted by the project. The canal is lined mainly by agricultural fields and some grasslands that could house MBTA species. The 40 bridge structures along the canal provide nesting habitat for MBTA species. Through coordination with the U.S. Fish and Wildlife Service (USFWS), impacts would be mitigable.

Vernal pool species and associated critical habitats are mapped adjacent to the FKC. Construction activities have the potential to disturb vernal pool critical habitat via direct impacts (ground disturbance on outside toe of levee) and indirect impacts (noise, dust). There is approximately 10 linear miles of mapped vernal pool species or critical habitats along the FKC. Through coordination with USFWS, impacts would be mitigable.

Elderberry shrubs, which have the potential to have endangered Valley Elderberry Longhorn Beetles (VELB) have been observed near the alternatives area. These shrubs occur only intermittently along the canal. Through coordination with USFWS, impacts would be mitigable.

Observations of Kern brook lamprey (an ESA Species of Concern) and San Joaquin kit fox have occurred along the Friant-Kern Canal. Through coordination with USFWS, impacts would be mitigable.</td></tr>
<tr><td>Historic Properties and Cultural Resources</td><td>National Historic Preservation Act (16 USC Section 470 et seq.)</td><td>The eligibility status of the FKC and its associated features, as determined under the National Register of Historic Places criterion, is being assessed and developed. An assessment of potentially impacted cultural resources will occur once eligibility determinations are concluded and consultation with the California State Historic Preservation Office is completed.</td></tr>
</table>

Resource Area	***Authority***	***Potential Impacts***
Indian Trust Assets	Executive Order 13751, Consultation and Coordination with Indian Tribal Governments, (63 CFR 96) Government-to-Government Relations with Native American Tribal Governments, Memorandum signed by President Clinton -1994 (CFR, Vol. 59, No. 85) Secretarial Orders No. 3175, 3206, and 3215	The alternatives will not impact Indian Trust Assets (ITA) as the nearest ITA is a Public Domain allotment approximately two miles northeast of the alternatives. As no impacts will occur to ITA, no mitigation is required.
Environmental Justice and Socioeconomics	Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations	Short-term impacts associated with the alternatives construction would not have an adverse effect on minority or economically disadvantaged populations. Short-term impacts from the alternatives may also provide a temporary increase in construction-related jobs and expenditures. Long-term impacts from the alternatives would be largely beneficial, by maintaining or increasing the economic viability of irrigation agricultural resources in the region, thus helping support disadvantaged populations that rely on agricultural-related employment. As impacts from the alternatives are largely beneficial, no mitigation is required.
Global Climate Change	CEQ Memorandum of February 18, 2010: Draft NEPA Guidance on Consideration of the Effects of Climate Change and Greenhouse Gas Emissions	Construction of the alternatives would involve short-term and temporary impacts from the release of emissions from construction equipment of approximately 851 metric tons of carbon dioxide. This is significantly below the annual reporting threshold for greenhouse gas emissions of 25,000 metric tons per year. As climate change impacts are well below reportable thresholds, no mitigation is required.
Water Resources: Floodplains, Groundwater, Water Supplies, and Water Quality	Clean Water Act (16 USC Section 703 et seq.) Executive Order 11988 – Floodplain Management	<u>Floodplains:</u> The recommended alternatives would occur within existing facilities and no floodplains would be impacted. No mitigation is required. <u>Groundwater:</u> The recommended alternative would not involve additional groundwater pumping and could reduce some need for groundwater supplies as a result of the implementation of the SJRRP. No mitigation is required. <u>Water Supplies:</u> The alternatives would not generate a new supply of water but would improve the reliability of water supply deliveries. No mitigation is required. <u>Water Quality:</u> Construction of the alternatives would involve best management practices to avoid or minimize construction-related impacts on water quality. The restoration of the capacity of the FKC may reduce the need for higher-salinity groundwater pumping and thus, improving surface water quality. No mitigation is required.

Chapter 6. Consultation and Coordination

This chapter summarizes the consultation and coordination efforts conducted in preparation of this report. Public involvement is summarized, as well as consultation activities with Federal and local agencies.

6.1 Public Involvement

Reclamation integrated agency consultation and involvement into the overall planning process starting in 2008, as part of the SJRRP bi-monthly public Water Management Technical Feedback (WMTF) meetings in Visalia and Fresno, California. As part of these WMTF meetings, Reclamation presented information on background, scoping, alternatives identification and screening, and solicited and received public concerns and comments on the FKC Feasibility Study throughout the process.

In addition to the public WMTF meetings, beginning in 2008, Reclamation has held frequent coordination meetings with the FWA and conducted several briefings for other local agencies, cooperating agencies, environmental groups, and congressional staff on the development of the FKC Feasibility Study.

6.2 Agency Coordination

The USFWS was closely coordinated with during the preparation of this study. The Service actively participated in the development of the environmental documents and this report. A key element of these coordination activities is the Fish and Wildlife Coordination Act (FWCA) report and Section 7 consultation.

Fish and Wildlife Coordination

In accordance with 48 Stat. 401, as amended; 16 U.S.C. 661 et seq., the Service prepared a Draft FWCA report for the FKC Feasibility Study, dated May 5, 2011. The FWCA requires Federal agencies proposing water resource development project or involved in issuant of related permits or licenses to consult with the Service and provide equal consideration to the conservation, rehabilitation, and enhancement of fish and wildlife resources with other project purposes.

Section 7 consultation

Reclamation is preparing a Biological Assessment for the selected alternatives. The Biological Assessment evaluates potential effects of the alternative to Federally listed threatened and endangered species indentified on initial species lists received from the USFWS.

Indian Trust Assets and Native American Consultation

Reclamation reviewed the location of Native American rancherias, reservations, and public domain allotments in relation to each the selected alternatives. No Native American lands were found to be in conflict with any of the alternatives. The nearest

Indian Trust Asset is a Public Domain allotment approximately 2 miles NE of the selected alternatives location.

National Historic Preservation Act/State Historic Preservation Officer Consultation

As the lead Federal agency, Reclamation has determined that any of the alternatives constitutes an undertaking subject to Section 106 of the National Historic Preservation Act of 1966, as amended. Reclamation is delineating the area of potential effect (APE) for cultural resources and initiating consultation with the State Historic Preservation Officer (SHPO) pursuant to implementing regulations (36 Code of Federal Regulations 800) for Section 106. As appropriate, the Section 106 process will be coordinated with planning and review procedures required under NEPA. Reclamation will consult with the California SHPO during final design to delineate the APE and identify other consulting parties in the Section 106 process. Once the APE and consulting parties have been established, Section 106 efforts will focus on the identification of historic properties and the assessment and resolution of any adverse effects to those properties to be affected by the selected alternatives.

Chapter 7. Findings and Conclusions

Reclamation conducted the FKC Feasibility Study consistent with the *Principles and Guidelines* and other pertinent Federal and State laws. This report has a companion Draft Environmental Assessment (EA) and Finding of No Significant Impact (FONSI) published under separate cover. This chapter summarizes the major findings and conclusions of the FKC Feasibility Study.

7.1 Findings

Net NED Benefits

The *Principles and Guidelines* state that the alternative that reasonably maximizes Net NED benefits, consistent with the Federal objective, is identified as the NED plan. Net NED Benefits are calculated by subtracting NED Costs from NED Benefits. As shown in the below table, Table 21, the alternative that provides the maximum Net NED Benefits is Alternative 5(a). If the NED Costs for Alternative 5(b) could be reduced to $25,000,000, the assumed funding for the FKC Feasibility Study, Alternative 5(b) would maximize the Net NED Benefits.

Table 21. Alternative 5 - Net NED Benefits (50 years)

	Alternative 5(a)		Alternative 5(b)	
	Without Part-III	With Part-III	Without Part-III	With Part-III
Total NED Benefit	$32,900,000	$57,850,000	$32,900,000	$57,850,000
Total NED Costs	$24,530,000	$24,530,000	$39,100,000	$39,100,000
Net NED Benefits	**$8,370,000**	**$33,320,000**	**($6,200,000)**	**$18,750,000**

Other Accounts

The other accounts provided in the *Principles and Guidelines* are not estimated to have a material bearing on the alternatives.

Federal Interest

For an alternative to be implementable there must be a Federal interest in the alternative and the alternative must be feasible as defined by the *Principles and Guidelines*. The *Principles and Guidelines* require that Federal actions contribute to the NED. Federal interest in FKC Feasibility Study can be established by the Settlement and SJRRS Act. As stated above, Alternative 5(a) provides positive NED benefits and Alternative 5(b) could provide positive NED benefits with Part-III Project and if construction costs could be reduced to $25,000,000.

Feasibility of Alternatives

Feasibility of the alternatives consists of four parts—technical, environmental, economic, and financial. Technical feasibility consists of engineering, operations, and constructability analyses that verify that the alternative can be constructed, operated, and maintained. Environmental feasibility consists of analyses verifying that constructing or operating the alternative will not result in unacceptable environmental consequences to endangered species, cultural, Indian trust, or other resources. Economic feasibility consists of analyses verifying that constructing the project is an economically sound investment of capital (i.e., that the alternative would result in positive net benefits or the alternatives' benefits would exceed the costs). Financial feasibility for the FKC Feasibility Study consists of the non-reimbursable Federal appropriations. The following findings relate to each of these parts of a feasibility determination.

Technical Feasibility

The alternatives are technically feasible, constructible, and can be operated and maintained. The designs and cost estimates for Alternative 5 are at a feasibility-level.

Environmental Feasibility

The alternatives, including the No-Action Alternative, were included in the Draft Environmental Assessment. The environmental impacts were evaluated and mitigated or found to be less than significant. Compliance with the Endangered Species Act (ESA) and the National Historic Preservation Act (NHPA) is ongoing and any findings will be incorporated as necessary.

Economic Feasibility

Based on the economic modeling, Alternative 5(a) is identified to have the largest Net NED Benefits. If the NED Costs for Alternative 5(b) could be reduced to $25,000,000, the assumed funding for the FKC Feasibility Study, Alternative 5(b) would maximize the largest Net NED Benefits.

Financial Feasibility

Alternative 5 is financially feasible, up to the $25,000,000 of assumed funding for the FKC Feasibility Study, as the costs are to be funded through non-reimbursable Federal appropriations. The only limitation is that Federal funds are subject to future appropriations by Congress.

7.2 Conclusions

- Restoration of the capacity of the FKC must prioritize restoration of the canal from the Kings River Siphon outlet to the 5th Avenue Check.

- Based on analyses to date, the alternatives are technically feasible for implementation by the Federal Government.

- Based on analyses to date, the alternatives are environmentally feasible for implementation by the Federal Government.

- Based on analyses to date, Alternative 5(a) is economically feasible for implementation by the Federal Government. In addition, if the NED Costs of

Alternative 5(b) could be reduced to $25,000,000, it would also be economically feasible for implementation by the Federal Government.

- Based on analyses to date, Alternative 5 is financially feasible, up to $25,000,000, for implementation by the Federal Government, subject to future appropriations by Congress.

- The No-Action Alternative is inconsistent with the Secretary’s direction pursuant to the Settlement and the SJRRS Act as it does not assist the FKC Contractors in “reducing or avoiding impacts to water deliveries to all of the Friant Division long-term contractors caused by the Interim and Restoration Flows.”

7.3 Recommendations and Next Steps

The recommendation is to implement Alternative 5(a), or Alternative 5(b) if costs can be reduced to $25,000,000. Based on the findings of this report, the following are the next steps for the FKC Feasibility Study:

- Reclamation will solicit public input on the Draft Feasibility Report and EA. Comments received during the public review period will be considered in development of the Final Feasibility Report and EA.

- Reclamation will complete compliance with the ESA and NHPA.

- Reclamation will complete a Final Feasibility Report, Final Environmental Assessment, and Finding of No Significant Impact and transmit them to the Secretary and Congress.

- Pursuant to Section 10201(b) of the SJRRS Act, the Secretary is authorized to construct the alternative, subject to future appropriations by Congress.

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