RECLAMATION
Managing Water in the West

Feasibility Report
Appendix C– Economics Evaluation

Friant-Kern Canal Middle Reach Capacity Correction Project Feasibility Study

November 2019

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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Abbreviations and Acronyms

CalSim II	California Water Resources Simulation Model
CEC	California Energy Commission
cfs	cubic feet per second
CVP	Central Valley Project
CWC	California Water Commission
DCR	Delivery Capability Report
DWR	California Department of Water Resources
FKC	Friant-Kern Canal
FWA	Friant Water Authority
Project	Friant-Kern Canal Middle Reach Subsidence and Capacity Correction Project
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
SGMA	Sustainable Groundwater Management Act
SJRRP	San Joaquin River Restoration Program
SJRRS	San Joaquin River Restoration Settlement
SWP	State Water Project
TAF	thousand acre-feet
TM	technical memorandum
URF	Unreleased Restoration Flows
USACE	U.S. Army Corps of Engineers
WDR Calculation	Water Delivery Reduction Calculation
WRIMS	Water Resources Integrated Modeling System

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Chapter 1 Introduction

This document presents information on modeling and analysis processes and results performed in support of the Feasibility Report prepared for the Friant-Kern Canal (FKC) Middle Reach Capacity Correction Project (Project). The purpose of the Project is to restore the conveyance capacity of the FKC Middle Reach to such capacity as previously designed and constructed by Reclamation, as provided for in the San Joaquin River Resonation Settlement Act (Public Law 111-11, Title X, Part III(a)(1). The FKC Middle Reach Capacity Correction Project Feasibility Study (Study) is being developed by the Friant Water Authority (FWA) in coordination with the U.S. Department of the Interior, Bureau of Reclamation (Reclamation). The purpose of the Study is to provide an evaluation and recommendation of alternatives that can be implemented restore the designed and constructed delivery capability and reliability of water supply.

Appendix Purpose

A suite of models and other tools was used to develop information needed to analyze the effects of the Alternatives on different resource areas in the Feasibility Study. This Economics Evaluation Appendix documents the models, tools, assumptions, and associated analysis procedures used to develop this information. It also presents detailed results and discussion to assist in interpreting the results. The overall analysis process encompasses FKC operations and economic benefits.

This Modeling Appendix is organized as follows:

Chapter 1 Introduction – provides an overview of the Modeling and Economics Evaluation Appendix.

Chapter 2 Evaluation Methods – provides an overview of the variables that affect the benefits analysis.

Chapter 3 Modeling and Analysis Process – provides an overview of the modeling analysis tools and inputs and outputs for each.

Chapter 4 Evaluation Tools – discusses operations modeling tools and assumptions.

Chapter 5 References – contains sources of information used to prepare the appendix.

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Chapter 2
Evaluation Methods

Evaluating the benefits of the Alternatives requires the consideration of three variables that will change over the 100-year planning horizon. These include water supply availability at Friant Dam, the delivery capability of the FKC in response to future subsidence, and the economic value of water over the project life. The quantification of physical effects and calculation of monetary benefits of Alternatives multiple-step process, that included the following:

- Estimate water supply available at Friant Dam
- Determine canal capacity in response to future subsidence
- Quantify water deliveries affected by reduced canal capacity
- Reschedule affected supplies in Millerton Lake to the extent possible
- Quantify and value lost water supply based on current and future water values

Water Supply Availability at Friant Dam

The California Water Resources Simulation Model (CalSim II) model was used to estimate water deliveries from Friant Dam to Friant Division long-term contractors over an 82-year simulation period based on historical hydrologic data for water years 1922 through 2003. The CalSim II model simulates the operation of Millerton Lake to meet a variety of objectives, including the release of flows to the San Joaquin River for water rights and San Joaquin River Restoration Settlement (SJRRS) Restoration Flows, diversion to the San Joaquin River and Friant-Kern and Madera canals for delivery of water under Friant Division Class 1 and Class 2 contracts and also Section 215/other contracts and obligations, and flood operations. Simulated diversions to the Friant-Kern and Madera canals are based on CalSim-estimated water supply allocations under the various contract types, as applied to typical diversion patterns into the canals based on historical data. Only the capacity at the headworks of the canal is considered in the operation of the CalSim II model, meaning the diversions assume no conveyance capacity restrictions due to design deficiencies or subsidence.

Implementation of the San Joaquin River Restoration Settlement (SJRRS) is expected to reduce deliveries from Friant Dam by approximately 200 thousand acre-feet (TAF) per year. Implementation of the SJRRS is progressing more slowly than planned due to unforeseen conditions and funding limitations. As of calendar year 2018, the release of full Restoration Flows is not possible due to downstream channel capacity constraints. As a result, Unreleased Restoration Flows (URF) have been made available to the Friant Division long-term contractors. The availability of URFs will decrease as channel improvements enable greater releases of

Restoration Flows. It is anticipated that implementation of projects that would enable the release of full the full volume of Restoration Flows no later than 2025.

Figure 2-1 presents the results of a CalSim II simulation that represents the delivery capability of the Friant Division under the 2018 level of implementation of the SJRRS using historical hydrology, not including recapture or recirculation measures that could reduce water shortages to Friant Contractors resulting from the release of Restoration Flows or implementation of projects authorized in Part III of the SJRRS Act. This evaluation is based on limiting releases from Friant Dam to the 2018 existing channel capacity, as applied to year-type hydrographs included in Exhibit B of the SJRRS. Figure 2-1 also presents the results of full implementation of SJRRS using historical hydrology, not including recapture and recirculation measures that could reduce water shortages to Friant Division long-term contractors resulting from the release of Restoration Flows or implementation of projects authorized in Part III of the SJRRS Act.

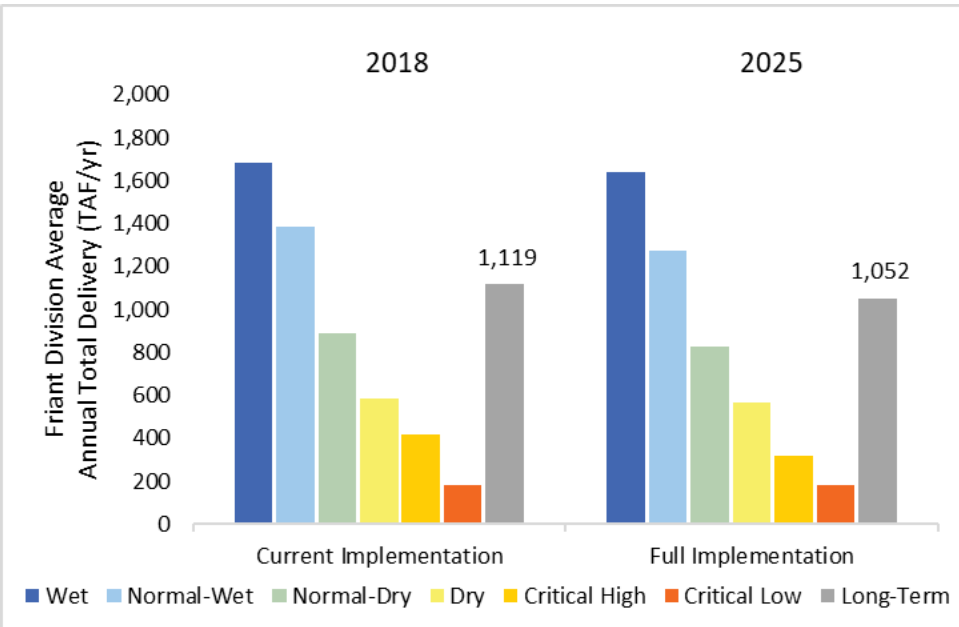

Figure 2-1. Friant Division Delivery Capability with San Joaquin River Restoration Settlement Implementation

Water Deliveries Affected by Subsidence

The water delivery capability through the Middle Reach of the FKC is controlled by the amount of regional subsidence that has occurred. Even with the implementation of SGMA, regional subsidence is expected to continue and decrease the capacity of the FKC. Analysis by Thomas Harter & Co. modeled the potential for subsidence along the FKC for various future pumping scenarios and hydrology. The subsidence for each of these scenarios is projected for every year until 2070. For additional information on the subsidence scenarios were developed and the assumptions used to develop the subsidence groupings used in this analysis refer to Appendix A Initial Alternative Formulation Attachment A1b1. The groundwater model results indicate that the greatest amount of future land subsidence is projected occur between 2017 (first year of groundwater model simulation) and 2030, with additional subsidence occurring to 2040 when actions to achieve SGMA requirements would be fully implemented, and additional subsidence occurring to 2070 as a result of 'residual' subsidence of subsurface formations. Figure 2-2 shows the subsidence profiles that were used to determine the canal capacity using the hydraulic model.

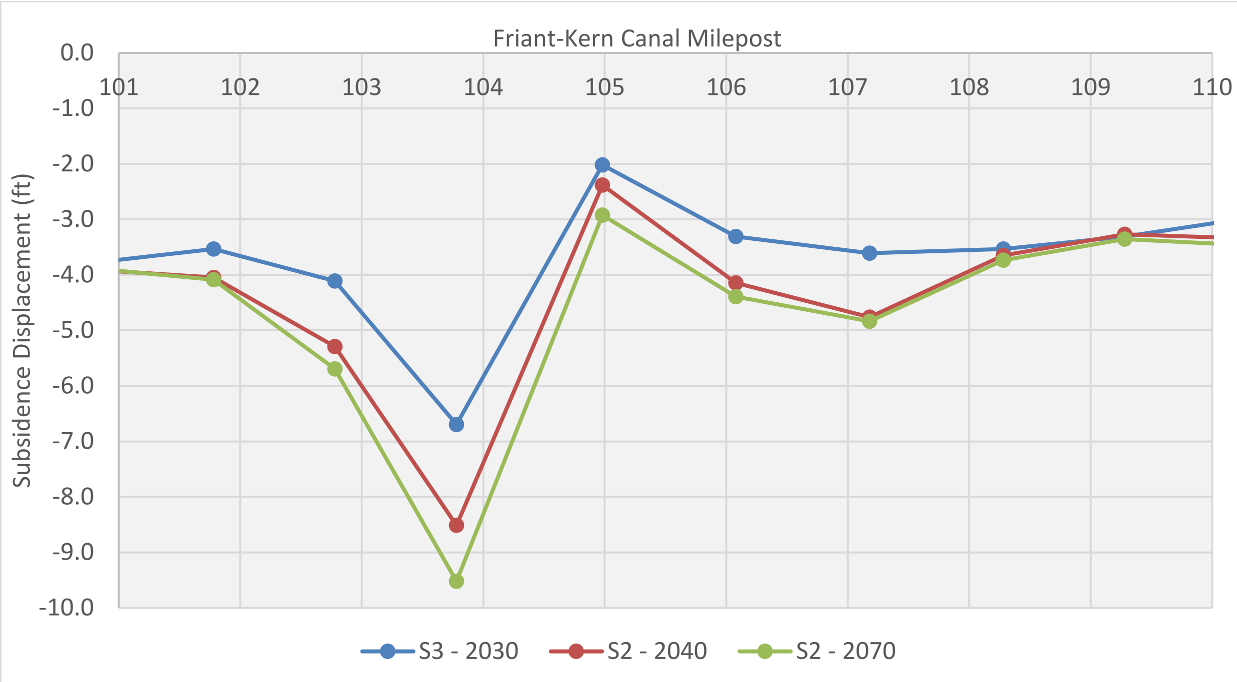

Figure 2-2. Future Subsidence Profiles

These subsidence profiles were applied in the HEC-RAS hydraulic model of the FKC to determine the maximum flow capacity through the most restricted section of the FKC, an area near milepost 104 also known as the chokepoint. For more discussion on the FKC HEC-RAS model development and assumptions refer to Appendix A Initial Alternative Formulation Attachment A1a1 HEC-RAS Modeling Technical Memorandum (TM). The maximum flow capacity is the flow at which water can pass through the most severely affected section of the FKC while maintaining the design freeboard of 2 feet from the water surface to the top of the existing concrete liner. Figure 2-3 shows the modeled capacity and modeled peak subsidence displacement of the FKC chokepoint from the 2018 conditions to 2070 conditions.

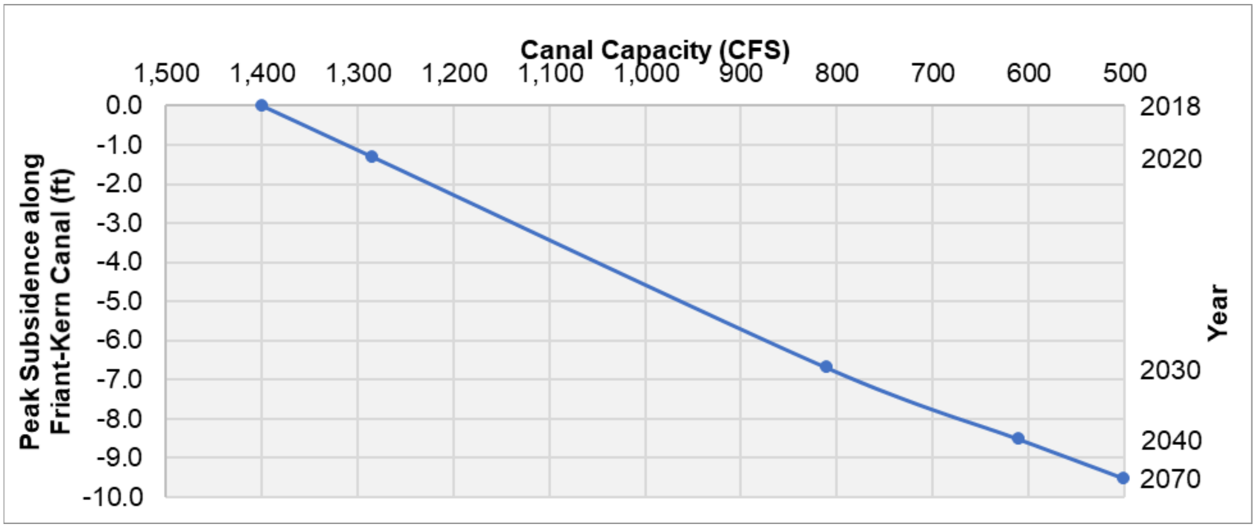

Figure 2-3. Minimum Capacity in the Middle Reach of the Friant-Kern Canal Capacity Under Future Subsidence Scenarios

The maximum modeled flow capacity provides a look at the instantaneous peak flows that can pass through the subsided section of the FKC. While tools like CalSim II provide a look at monthly volume delivery capability using historical hydrology, to understand the volume of deliveries that could potentially be affected the daily flows are necessary. A look at historical deliveries from 2000 through 2017 reveal patterns of irrigation delivery that peaks mid-week and can be considerably less on weekends. Using this historical data and adjusting to account for the weekly shifts in delivery, annual patterns were developed for each San Joaquin River Index year-type. The pattern consists of each day of the month representing a percent of the total monthly delivery volume. This pattern was applied to distribute monthly Class 1, Class 2, RWA/215 volumes from the CalSim II runs to determine daily volume and flow requirements in the FKC. Figure 2-4 shows the example delivery patterns for June for each San Joaquin River Index year-type.

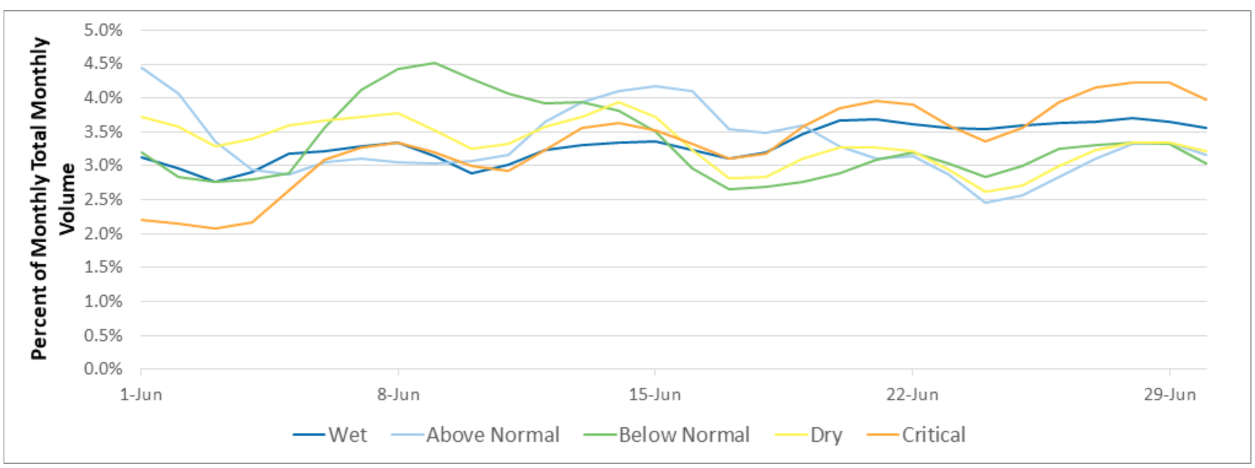

Figure 2-4. Daily Delivery Pattern for all Year-types Applied to Delivery to Downstream Districts

These delivery patterns were used to distribute monthly flows for the entire CalSim II record for historical hydrology from 1922 through 2003 daily. The daily deliveries to Friant Division long-term contractors, with turnouts located south of the chokepoint, is then compared to the maximum flow capacity. Any daily deliveries in excess of the assumed maximum flow capacity is considered affected by the reduced canal capacity. Figure 2-5 shows a sample year of the daily delivery distribution with the modeled 2018 maximum canal capacity of 1,400 cfs and identifies the affected deliveries.

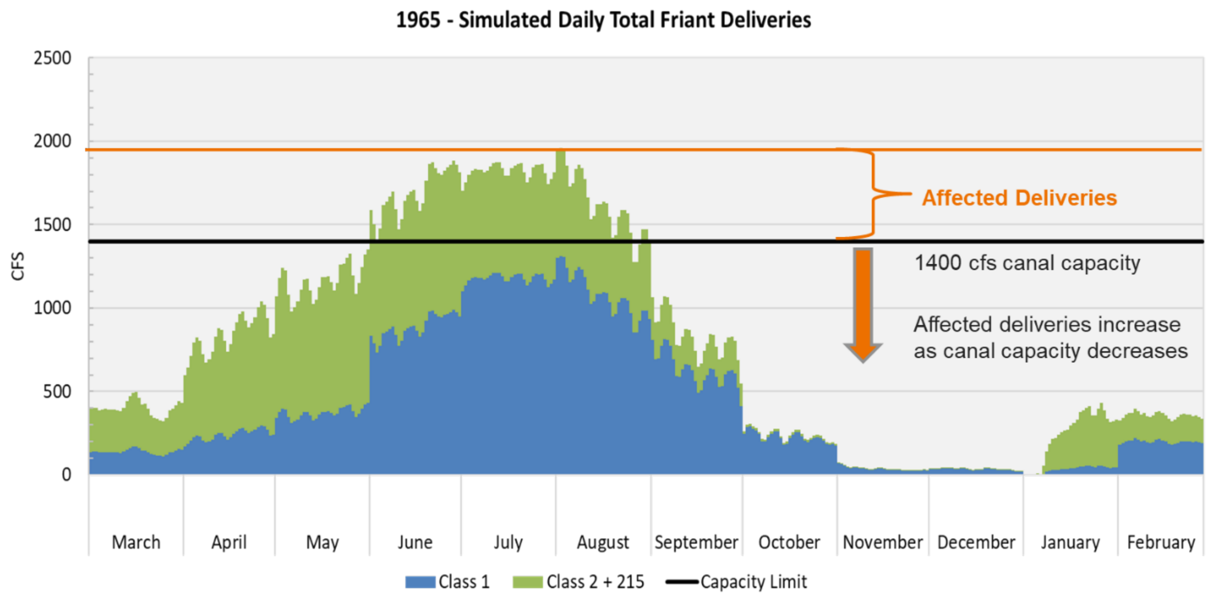

Figure 2-5. Simulated Daily Total Friant Deliveries Below Chokepoint

The simulated Friant deliveries below the chokepoint are determined for each water year-type, and the weighted long-term average. As the hydrology is expected to decrease the average annual deliveries to the Friant Division long-term contractors, subsidence will continue to decrease the conveyance capacity of the FKC further reducing the average annual deliveries. Table 2-1 presents the results of modeled flow capacity, from the FKC HEC-RAS model and the total expected annual affected water deliveries. Figure 2-6 shows the change in average annual deliveries to the Friant Division long-term contractors below the chokepoint as the variables change.

Table 2-1. Modeled Friant-Kern Canal Capacity and Average Annual Affected Water Supplies

Year	Estimated Minimum Capacity (cfs)	Average Annual Affected Water Supply (AF/yr)
2018	1,400	27,083
2030	810	102,651
2040	610	149,346
2070	500	179,746

Source: Information is from the WDR Calculation described in Appendix C-Economics Evaluation
Key:
AF/yr = acre feet per year
cfs = cubic feet per second

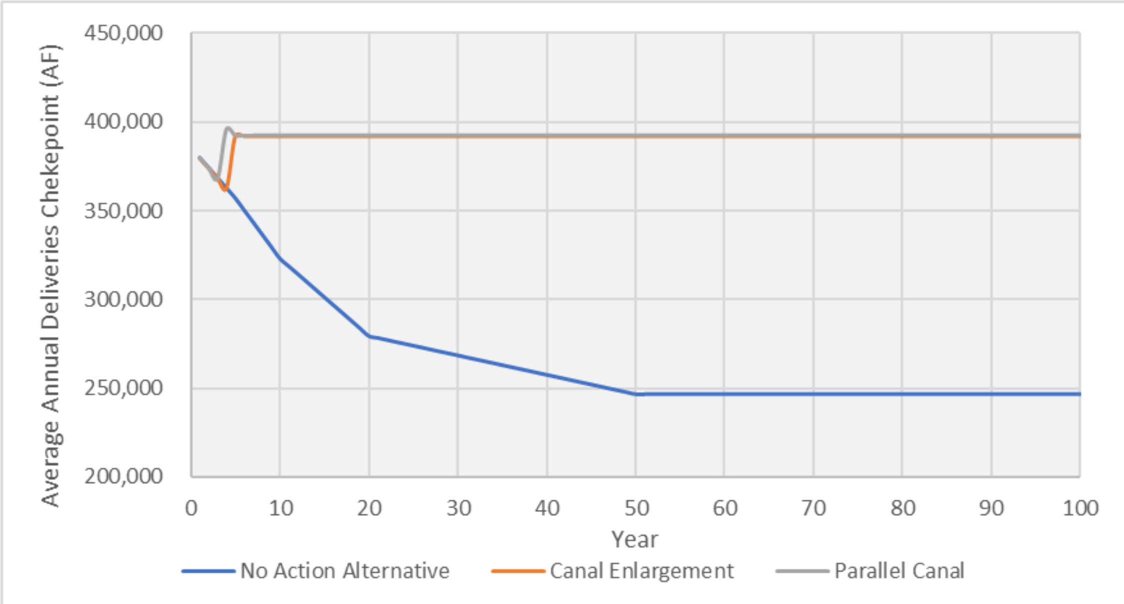

Figure 2-6. Average Annual Deliveries for No-Action and Alternatives

Potential Actions to Minimize Delivery Reductions of Affected Water Supplies

To quantify the total water supply benefits of the Alternatives the affected deliveries must be accounted for. There are three management options for affected water deliveries, including rescheduling in Millerton Lake, increased groundwater pumping, or loss of water to the San Joaquin River.

Rescheduled Water Deliveries

It is reasonable to expect the Friant Division long-term contractors that experience water delivery effects as a result of reduced FKC capacity would take some measures to minimize resulting water delivery shortages. The potential for rescheduling affected water supplies was evaluated by considering the following factors:

- Water demands for affected Friant Division contractor that would be served by non-Friant Division water supplies (local surface water, groundwater, or other supplies)
- Available storage capacity in Millerton Lake
- Available capacity in the FKC to convey rescheduled water supplies.

Water Deliveries that can be rescheduled would continue to be limited on the capacity in the FKC. Figure 2-7 shows the total irrigation demand assumption for affected districts used in the Millerton Lake rescheduling analysis, compared to a sample year of CVP surface water deliveries, and the potential demand for additional surface water.

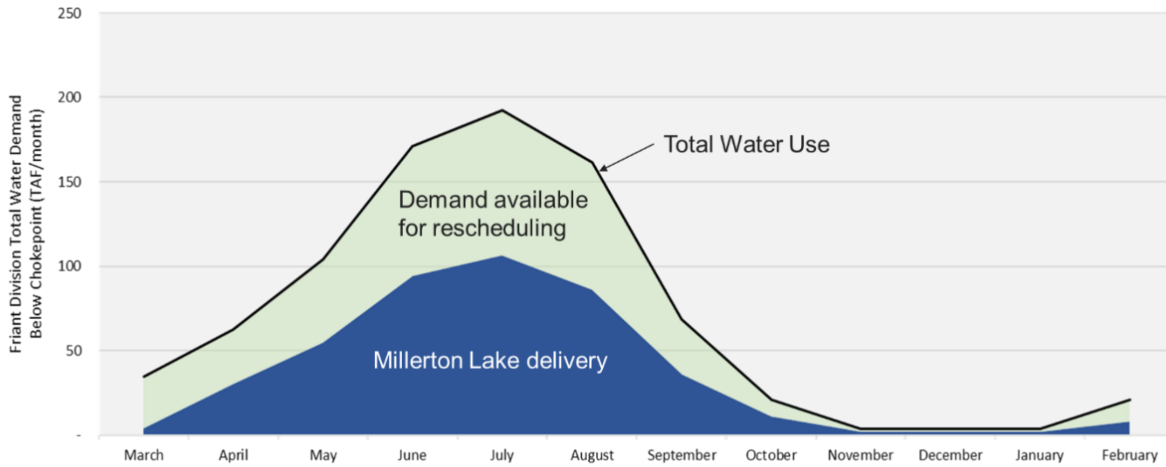

Figure 2-7. Demand Assumption for Affected Friant Division Long-term Contractors

The potential to reschedule affected Friant Division water deliveries in Millerton Lake was simulated by creating an account to track the storage of affected water supplies. Water in the rescheduled water account would be the first water subject to spill to assure that all existing obligations for the operation of Friant Dam would continue under existing priorities. Water would be diverted from the reschedule water storage account to the FKC in months when demand that would be served by other supplies is available, as constrained by available conveyance capacity in the FKC. Water would remain in the rescheduled storage account, including into successive years, until the account is evacuated, or flood releases are made from Friant Dam to the San Joaquin River. It is assumed that the rescheduled supplies would result in a shift of groundwater pumping and local surface water supply use. This approach is considered to be conservative in the estimate of project benefits because it represents the maximum opportunity for rescheduling. Actual opportunity for rescheduling may be less due to several factors, including forecasting uncertainty and the ability of Friant Division long-term contractors to adjust local water uses. The economic analysis assumes that rescheduling of affected water deliveries could be accomplished at no additional cost.

Using the total irrigation demand pattern described above and the modeled affected deliveries a relationship was derived to show the average annual reschedule opportunity for the expected average annual affected water supply. As well as the percent of the affected water supply that can be rescheduled for the expected average annual affected water supply. These relationships if no water is to be stored in groundwater banks is shown in Figure 2-8. For full implementation of the SJRRS the peak expected ability to reschedule affected water supplies is approximately 45 percent.

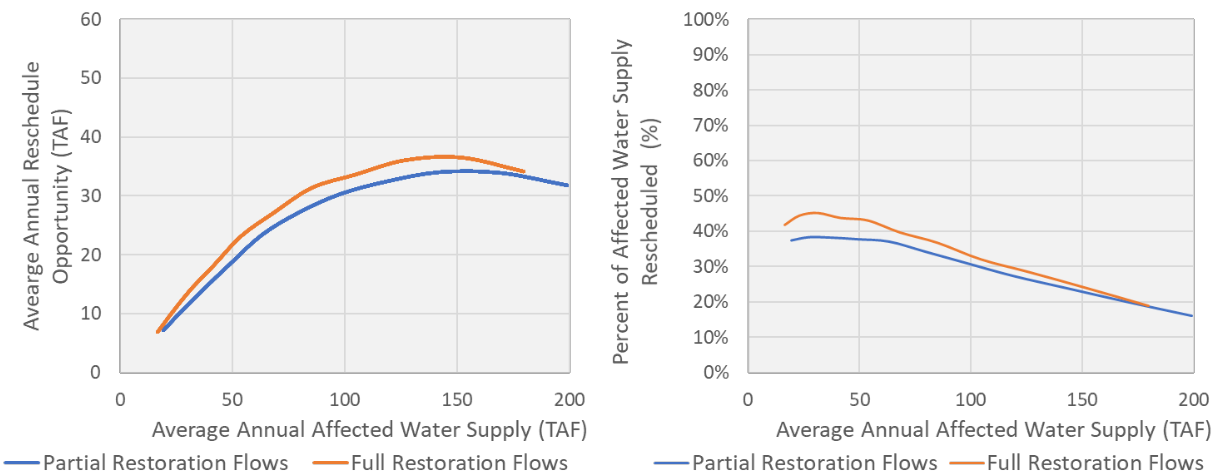

Figure 2-8. Relationships of Average Annual Volume and Percentage of Affected Water Supply Rescheduled for Average Annual Affected Water Supply

Reduced Deliveries to Friant Division long-term contractors

Affected water supplies that could not be rescheduled in Millerton Lake would be lost as flood releases from Friant Dam to the San Joaquin River and represents a loss of water supply to affected Friant Division long-term contractors.

Water Valuation

The value of water over is expected to change over the 100-year planning horizon of the Project. For the Project there are two sets of valuations that are changing, power costs and the valuation of water in the Eastern San Joaquin Valley. The value of surface water in the eastern San Joaquin Valley will change over time in response to changes in water supply availability, particularly in response to the implementation of SGMA because groundwater use will be limited by sustainable yield. In 2015, the California Water Commission (CWC) prepared estimates the value applied water for consumptive use in California under current operational requirements and projected future values with SGMA implementation. The CWC identifies post-SGMA values as 2045 because SGMA requires full state-wide implementation no later than 2045. The entire Friant Division of the CVP overlies groundwater basins that are designated as “high priority basins” which require SGMA compliance no later than 2040. The CWC classified current unit values of water as those for 2030 conditions. Both the 2030 and 2045 values (applicable in 2040 in the Project Area) provided by the CWC in 2015 were escalated to a 2018 price level using the U.S. Bureau of Economic Analysis GDP Deflator, and are shown in Table 2-4.

Table 2-4 Projected Value of Water in the Eastern San Joaquin Valley

Water Year Type	# of Years	2030 Condition $/AF of CU 2015 Price Level	2030 Condition $/AF of CU 2018 Price Level	2045 Condition $/AF of CU 2015 Price Level	2045 Condition $/AF of CU 2018 Price Level
Wet	24	$200	$211	$256	$271
Above-Normal	16	$251	$265	$321	$339
Below-Normal	13	$261	$276	$481	$508
Dry	13	$278	$294	$512	$541
Critical	16	$324	$342	$1,105	$1,168
Weighted Average		$256	$271	$511	$540

Source: Table 5-5 WSIP Technical Reference - Unit Values of Water
Key:
AF = acre feet
CU = Consumptive Use

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Chapter 3 Modeling and Analysis Process

The economics evaluation undertook a comprehensive analysis of the alternatives using a series of sequentially applied models and tools. This economics analysis included water availability analysis, reservoir operations, canal operations, and economic benefits. The economics evaluation analysis began with water operations of the existing conditions for Millerton Lake and implementation of the SJRRP. These operations results and the existing delivery capability of the FKC were carried through an assessment of the affected water deliveries. Millerton Lake reoperation was evaluated to determine the ability to reschedule affected water supplies. The economic benefits of the Alternatives were evaluated over a 100-year planning horizon. Each modeling process component used to evaluate the operations and effects of each alternative is described in this Modeling Appendix.

A suite of models and related tools was used to evaluate the range of alternatives as well as to quantify the resulting water supply delivery increases. This suite of models and tools includes the following:

- **CalSim II** – The CalSim II model is a specific application of the Water Resources Integrated Modeling System (WRIMS) to simulate Central Valley water operations. The CalSim II model simulates Central Valley Project (CVP) and State Water Project (SWP) operations, including reservoir storages, river and canal flows, and project deliveries, including an operational representation of Friant Dam and Millerton Lake with the SJRRP. The baseline CalSim II model used for this analysis is the Delivery Capability Report (DCR) 2015 developed by California Department of Water Resources (DWR) and is the most current version of the model available at the time this report was prepared. The DCR 2015 CalSim II model was simulated using currently-estimated maximum Restoration Flow releases from Friant Dam, as constrained by current downstream channel capacity. Output from CalSim II to support the analysis in this feasibly study included Class 1, Class 2, and Section 215/Other water deliveries to the Friant-Kern and Madera canals. This output was used as input to the Water Delivery Reduction Calculation described below. Millerton Lake inflows, outflows, and losses from the CalSim II model are used in the Reservoir Rescheduling Tool described below.

- **HEC-RAS 5.0.4** – A hydraulic model developed by the U.S Army Corp of Engineers (USACE) Hydraulic 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. A previously-developed HEC-RAS model of the FKC was updated using survey information collected during the summer of 2018 in support of the Middle Reach Subsidence and Capacity Correction Project to reflect the existing canal profile throughout its entire length. The FKC HEC-RAS model includes definition of top of existing concrete liner, canal sections, siphons, bridges, turnouts, and other appurtenant structures. The FKC HEC-RAS model was operated at various flows, at 100 cubic feet per second (cfs) increments, to determine the resulting water surface profile. The model applied a water surface depth of 14 feet at the Lake Woollomes Check Structure to represent existing canal operational objectives. The results of model simulations were reviewed to identify canal capacity with 2 feet of freeboard, which is considered the basis to define current operational capacity. A similar process was used to update the model for potential future subsidence and determining the estimated future capacity of the FKC. A more detailed description of the HEC-RAS model development and application is provided in the Initial Alternatives Report Attachment A1a1 HEC-RAS Modeling TM.

- **Water Delivery Reduction Calculation –** The Water Delivery Reduction Calculation (WDR Calculation) tool was used to determine the daily deliveries and affected deliveries to Friant-Division long-term contractors downstream of the FKC subsidence area chokepoint near milepost 104. The tool was used to quantify affected water deliveries because of reduced capacity of the FKC. The development and application of this tool is described in Chapter 4 of this appendix.

- **Reservoir Rescheduling Tool –** The Reservoir Rescheduling Tool was used to determine the portion of affected deliveries that could be rescheduled under a variety of hydrologic conditions. The development and application of this tool is described in Chapter 4 of this appendix.

- **Benefits Horizon Analysis –** To determine the monetary benefits of restored water delivery capability for each alternative over the life of the project. This tool considers the changes in affected deliveries, changes canal capacity, changes in water valuation, ability to reschedule affected water deliveries in Millerton Lake, and near future additional groundwater pumping. The development and application of this tool is described in Chapter 4 of this appendix.

Figure 3-1 shows the interaction between the major modeling tools and the outputs and information used to support the evaluations in this Feasibility Study.

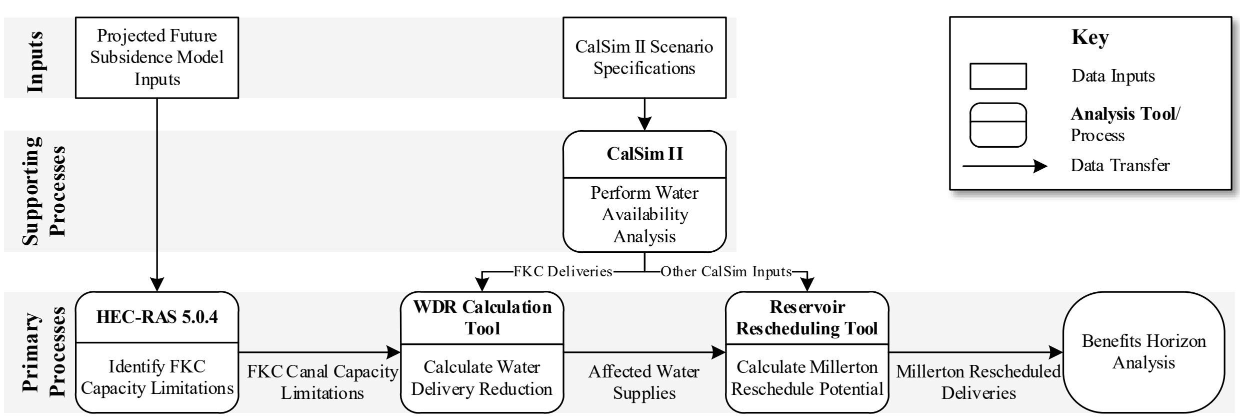

Figure 3-1. Modeling Processes for Economics Evaluation

Chapter 4
Evaluation Tools

The evaluation tools described in this chapter were developed using a combination of historical and simulated data for the purpose of feasibility level analysis. The tools are used to quantify comparative economic effects of changes in water delivery among Alternatives. These outputs do not reflect a prediction of specific project operations or allocation of economic affects to individual Friant Division long-term contractors.

Water Delivery Reduction Calculation

The WDR Calculation tool is a post-processing tool developed using Microsoft Excel to read in the CalSim II simulated operations output as well as take the calculated FKC capacities from FKC HEC-RAS to determine the long-term effect of the reduced capacity due to subsidence compared to the design capacity of the FKC. The WDR Calculation tool was used to determine the daily deliveries and affected deliveries to Friant-Division long-term contractors downstream of the FKC subsidence area chokepoint near milepost 104. The tool was used to quantify affected water deliveries as a result of reduced capacity of the FKC.

Model Description

The WDR Calculation tool uses several steps to take the CalSim II simulated deliveries of Class 1, Class 2, and RWA/215 to the FKC to determine the long-term average annual affected water supply deliveries. These steps include:

1. Determine historical daily FKC delivery pattern
2. Calculate individual Friant Division long-term contractor demands
3. Calculate the monthly demand below the subsidence area
4. Calculate the daily deliveries affected by reduced capacity
5. Calculate the average annual deliveries affected by reduced capacity

Determine Historical Daily FKC Delivery Pattern

Using historical daily releases from Friant Dam to the FKC for the period of 2000 – 2017 the daily delivery pattern for each San Joaquin Valley Index water year type was determined. To capture the weekly variance in demand caused by long-standing irrigation practices, the delivery pattern was normalized to create a year-type averaged accounting year, this sets each day of the month at the same day of the week in the historic record. This prevents the daily delivery pattern being smoothed because of an offset in the day of the week when averaged with different years. Each day in the delivery pattern represents a percentage of the total monthly delivery volume that is delivered on a given day.

Calculate Individual Friant Division Long-term Contractor Demands

The WDR Calculation uses the CalSim II monthly releases of Class 1, Class 2, and RWA/215 to the FKC combined with the Class 1 and Class 2 contract percentages to determine the monthly deliveries to each Friant-Division long-term contractor.

Calculate the Monthly Demand Below the Subsidence Area

Using the individual Friant-Division long-term contractor demands calculated above, the demands are aggregated for the districts below the subsided area. The Friant-Division long-term contractors assumed to be affected include Saucelito Irrigation District, Delano-Earlimart Irrigation District, Southern San Joaquin Municipal Utility District, Kern-Tulare Water District, Shafter Wasco Irrigation District, and Arvin-Edison Water Storage District.

Calculate the Daily Deliveries Affected by Reduced Capacity

Using the daily delivery patterns calculated above, the monthly CalSim II deliveries to the affected Friant Division long-term contractors was disaggregated into daily Class 1, Class 2, and RWA/215 deliveries and converted to cfs. The sum of daily flows that would be required to meet demand below the subsided area is then compared to the modeled flow limit from FKC HEC-RAS to determine the daily flows that could not be conveyed due to reduced capacity.

Calculate the Affected Monthly Delivery Volume

The calculated affected daily delivery for the entire CalSim II record is aggregated to determine the affected monthly delivery volumes. This set of outputs from the WDR Calculation is entered to the Reservoir Rescheduling tool.

Calculate Affected Deliveries to Individual Friant Division Long-term Contractors

The affected deliveries to individual Friant Division long-term contractors was calculated using the average annual affected delivery for Class 1 and Class 2 contracts and apportioning the percentage of affected deliveries based on contract amounts. The output from this analysis was used in combination with average groundwater depths in each affected Friant Division contactor district to calculate a weighted average groundwater pumping.

Model Assumptions

The WDR Calculation assumes deliveries to Friant-Division long-term contractors are delivered proportionally to their Class 1 and Class 2 contract percentages, and other water supplies (RWA, 215, or other flood flows) are delivered proportional to Class 2 contract percentages. The exception is Saucelito Irrigation District which has 2 FKC turnouts located above the subsided area and 2 FKC turnouts below. It is assumed 50 percent of Saucelito Irrigation District's deliveries of Class 1, Class 2, and RWA/215 are delivered below the chokepoint area and are subject to reduction because of subsidence.

The affected deliveries were divided among the Friant-Division long-term contractors below the subsidence area in proportion to their Class 1 and Class 2 contract amounts. The analysis does not assume land use changes or shifts in irrigation practices in the Friant Division.

Reservoir Rescheduling Tool

The Reservoir Rescheduling Tool is a post-processing tool developed using Microsoft Excel that uses information from the WDR Calculation to estimate the maximum amount of affected water supply that could be rescheduled in Millerton Lake without adversely affecting flood control requirements.

Model Description

The Reservoir Rescheduling Tool uses several steps to determine the maximum annual volume that could be reschedule in Millerton Lake. This is done using the following steps:

1. Calculate the demand for rescheduled surface water
2. Develop Baseline Reservoir Model to replicate CalSim II Storage calculations
3. Simulate Rescheduling of Affected Water Deliveries in Millerton Lake
4. Calculate the additional Millerton Lake Spill

Calculate the Demand for Rescheduling Surface Water

To calculate the demand for rescheduling surface water the total water demand pattern for the affected water deliveries to the affected Friant Division long-term contractors was determined. The total irrigation demand was estimated using the total irrigated acreage and cropping patterns and evapotranspiration requirements. The total irrigation demand was divided by the monthly Class 1 delivery pattern for each of the affected Friant Division long-term contractors to develop a total irrigation delivery pattern, as illustrated by the total demand pattern in Figure 2-1. This delivery pattern was compared to the CalSim II deliveries to determine the additional water demand that would not be met by deliveries from Millerton Lake. The additional water demand was compared to Millerton deliveries and canal capacity to establish the demand for rescheduled water that could be conveyed through the FKC.

Develop Baseline Reservoir Model

To develop the Microsoft Excel based Baseline Reservoir Model, Millerton Lake inflows and outflows from CalSim II were used over the historical hydrologic period. The inflows include flows from the main stem of the San Joaquin River and flows from Fine Gold Creek. The outflows include releases to the San Joaquin River, flood flows to the San Joaquin River, releases for snowmelt to the San Joaquin River, and evaporation. Canal outflows include Class 1, Class 2, RWA/215, flood flows and canal losses to both the FKC and Madera Canal. To ensure that all inflows and outflows from CalSim II were accounted for correctly in the reservoir model the end of month storage from the Baseline Reservoir Model were confirmed to equal the Millerton Lake modeled storage from CalSim II.

Simulate Rescheduling of Affected Water Deliveries in Millerton Lake

To calculate the ability to reschedule water, the Baseline Reservoir Model was expanded to include Rescheduled Water Accounts for the management of affected Class 1, Class 2, and RWA/215 water supplies. On the monthly time step the previous month’s affected Class 1, Class 2, RWA/215 water supply is added to Rescheduled Water Accounts. As noted above demands for rescheduled water were developed based on canal capacity constraints. If there is a demand for rescheduled supplies, water is delivered from the Class 1 Rescheduled Water Account until it is exhausted. If there is remaining demand water is then delivered from the Class 2 Rescheduled Water Account until this account is exhausted, and any remaining demand is then delivered from the RWA/215 Rescheduled Water Account. Millerton Lake Storage is recalculated at the end of each monthly operation.

Calculate the Additional Millerton Lake Spill

When inflow to Millerton Lake causes storage levels to encroach into flood control space, water is released to the San Joaquin River first from the RWA/215 Rescheduled Water Account, second from the Class 2 Rescheduled Water Account, and then the Class 1 Rescheduled Water Account until all three are exhausted, or the required flood space is developed in Millerton Lake. The Period Ending Millerton Storage is calculated with spills to determine the monthly storage with reoperation for the rescheduling. This is compared to the Baseline Reservoir Model Storage to ensure that Millerton Reservoir is not drawn down more than the Baseline Reservoir Model, which would indicate an error in the reoperation.

Model Assumptions

The Reservoir Rescheduling Tool assumes a total delivery pattern for the Friant Division long-term contractors that are affected by the reduced capacity of the FKC. The pattern for the total irrigation demand is assumed to follow the Class 1 delivery pattern as described in CalSim II. The tool assumes that the total irrigation demand that is not met from Millerton Lake could be rescheduled as follows:

- Local supplies would be used in-lieu of Millerton Lake supplies that could not be delivered because of FKC capacity constraints.
- The delivery of rescheduled Millerton Lake supplies would not reduce the availability of local water supplies.

These assumptions result in a conservative, or maximum estimate, of rescheduling opportunities.

The monthly Rescheduled Water Demand is not divided into Class 1, Class 2, or RWA/215 but is represented as a total monthly demand. As described above deliveries from Rescheduled Water Accounts would prioritize Class 1 water supplies before delivery of Class 2 supplies or RWA/215 supplies, and delivery from the three accounts would have a lower priority than current contract year Class 1 and Class 2 water supplies. This approach is consistent with the operational priorities of the FKC.

Benefits Horizon Analysis

The Benefits Horizon Analysis evaluates the project benefits over a planning horizon of 100 years. The planning horizon includes expected changes in water allocations to Friant Division long-term contractors (water available at Millerton Lake), the delivery affects as adjusted by rescheduling because of future land subsidence and expected changes in water values. The economic value of reduced water supply was calculated for the No Action Alternative. For the Alternatives the reduction in water supply and that would result from impacts during construction and future subsidence after the FKC is modified to the objective capacity. To estimate the benefits of Alternatives, the value of water delivery reductions was estimated for the No Action Alternative and Alternatives. Benefits of the Alternatives are based on the value of avoided delivery reductions, or net difference, in comparison to the No Action Alternative. Computations are made for each year and the net present value of benefits is computed using the Federal discount rate.

Model Assumptions

The Benefits Horizon Analysis includes the following assumptions:

- Future land subsidence will occur in the No Action Alternative and Alternatives at the same rate. It is assumed that the future land subsidence will have the same effect on canal capacity for all Alternatives.
- Construction for each Alternative would begin in 2021, with full capacity realized in the contract year 2024.
- The 100-year planning horizon would extend from 2021 to 2120.
- The Federal discount rate used in the analysis is 2.75 percent.
- The value of water is held constant beginning for the planning horizon at the $271 per acre-foot as shown in Table 2-4 for the 2030 condition.
- Annual reductions in water delivery resulting from canal capacity reduction were interpolated from simulations of future subsidence in 2020, 2025, 2030, 2040 and 2070
- The cost of energy was linearly interpolated based on information provided by CEC for the years 2015, 2020, and 2024.

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