Upper San Joaquin River Basin Storage Investigation

Initial Alternatives Information Report

Water Operations Technical Appendix

A Study By:

RECLAMATION
Managing Water in the West

California Department of Water Resources

In Coordination With:

CALFED BAY-DELTA PROGRAM

Prepared By:

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UPPER SAN JOAQUIN RIVER BASIN STORAGE INVESTIGATION

Initial Alternatives Information Report

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ABBREVIATIONS AND ACRONYMS

CALFED	CALFED Bay-Delta Program
Corps	U.S. Army Corps of Engineers
CVP	Central Valley Project
Delta	Sacramento and San Joaquin rivers delta
DMC	Delta-Mendota Canal
DWR	California Department of Water Resources
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
Exchange Contractors	San Joaquin River Exchange Contractors
FR	Feasibility Report
FWUA	Friant Water Users Authority
IAIR	Initial Alternatives Information Report
Investigation	Upper San Joaquin River Basin Storage Investigation
M&I	municipal and industrial
NRDC	Natural Resources Defense Council
P&G	Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies
PFR	Plan Formulation Report
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
ROD	Record of Decision
SOD	south-of-Delta
SWP	State Water Project
TA	Technical Appendix
TAF	thousand acre-feet

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CHAPTER 1. INTRODUCTION

This document is the **Water Operations Technical Appendix** (TA) to the Initial Alternatives Information Report (IAIR) for the Upper San Joaquin River Basin Storage Investigation (Investigation). The Investigation is one of five surface water storage studies recommended in the CALFED Bay-Delta Program (CALFED) Programmatic Environmental Impact Statement/Report (PEIS/R) Record of Decision (ROD) of August 2000. It is being performed by the U.S. Department of the Interior, Bureau of Reclamation (Reclamation), and the California Department of Water Resources (DWR). The Investigation is a feasibility study evaluating alternatives to develop water supplies from the San Joaquin River that could contribute to the restoration of, and improve water quality in, the San Joaquin River, and enhance conjunctive management and exchanges to provide high-quality water to urban areas.

The Investigation is being prepared in two phases. Phase 1, which included preliminary screening of initial storage sites, was completed in October 2003. Initially, 17 surface water storage sites were considered, of which 6 were retained for further analysis. Phase 2 began in January 2004 with formal initiation of environmental review processes consistent with Federal and State of California (State) regulations, and will continue through completion of all study requirements. The Investigation will culminate in a Feasibility Report (FR) and supporting environmental documents consistent with the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G) (WRC, 1983), Reclamation directives, DWR guidance, and applicable environmental laws. Reclamation and DWR are coordinating the Investigation with the California Bay-Delta Public Advisory Committee (BDPAC), which provides advice to the Secretary of the United States Department of the Interior (Secretary) regarding the implementation of the CALFED Program, and the California Bay-Delta Authority (CBDA), which provides general oversight and coordination of all CALFED activities.

To facilitate coordination with other agencies and related ongoing studies, preparation of the FR will include two interim planning documents: an Initial Alternatives Information Report (IAIR) and a subsequent Plan Formulation Report (PFR). The IAIR describes without-project conditions and water resources problems and needs; defines study objectives and constraints; screens surface water storage measures; describes groundwater storage measures development; and identifies preliminary water operations rules and scenarios. Retained storage measures and preliminary water operations scenarios will be included in initial alternatives. This IAIR will be used as an initial component of the FR. The PFR will present the results of initial alternatives evaluation, identify refinements of the alternatives, and define a set of final alternatives. A Draft FR will evaluate and compare the final alternatives and identify a recommended plan. A Draft Environmental Impact Statement (EIS) and Environmental Impact Report (EIR) will be included with the Draft FR. Following public review and comment, a final FR/EIS/EIR will be prepared.

STUDY AREA

The study area emphasis for the Investigation encompasses the San Joaquin River watershed upstream of Friant Dam, the San Joaquin River from Friant Dam to the Sacramento-San Joaquin Delta (Delta), and the portions of the San Joaquin and Tulare Lake hydrologic regions served by the Friant-Kern and Madera canals, as highlighted in **Figure 1-1**. The study area includes all potential storage sites under consideration, the region served by the Friant Division of the Central Valley Project (CVP), the eastern San Joaquin Valley groundwater basins, and the portion of the San Joaquin River most directly affected by the operation of Friant Dam. The study area includes a primary study area and an extended study area. The primary study area for evaluations presented in this TA includes the locations of all potential surface water storage sites under consideration.

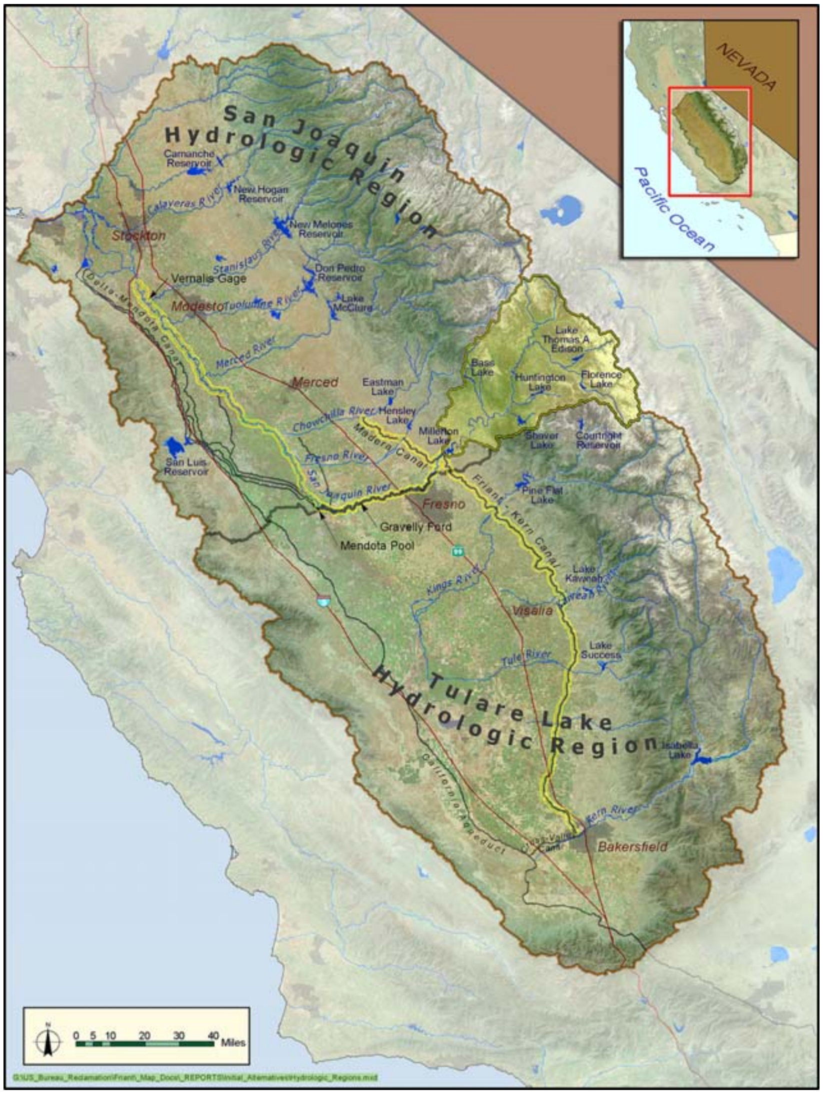

FIGURE 1-1.
UPPER SAN JOAQUIN RIVER BASIN STORAGE INVESTIGATION
STUDY AREA EMPHASIS

SURFACE WATER STORAGE MEASURES CONSIDERED IN THE IAIR

Six potential sites for developing a new surface reservoir or enlarging an existing reservoir were retained from Phase 1 of the Investigation for further consideration in the Investigation. Each site could be configured at various storage sizes, with each configuration identified as a measure. The six surface water storage sites retained from Phase 1 include:

- **Raise Friant Dam.** Enlarging Millerton Lake by raising Friant Dam up to 140 feet.
- **Temperance Flat Reservoir.** Constructing Temperance Flat dam and reservoir at one of three potential dam sites on the San Joaquin River, between Friant and Kerckhoff dams, at River Mile (RM) 274, RM 279, or RM 286.
- **Fine Gold Reservoir.** Constructing a dam and reservoir on Fine Gold Creek to store water diverted from the San Joaquin River or pumped from Millerton Lake.
- **Yokohl Valley Reservoir.** Constructing a dam and reservoir in Yokohl Valley to store water conveyed from Millerton Lake by the Friant-Kern Canal and pumped into the reservoir.

Most of the surface water storage measures retained from Phase 1 would result in a net loss in power generation. In March 2004, Reclamation and DWR held a series of scoping meetings to initiate development of an EIS/EIR. During scoping, power utilities that own and operate hydropower projects in the upper San Joaquin River basin raised concerns about impacts of lost power generation and the ability of retained measures to develop adequate replacement power. These hydropower stakeholders suggested five additional potential reservoir sites that could store water supplies from the upper San Joaquin River without adversely affecting existing hydropower facility operations.

Suggested storage measures include **RM 315 Reservoir** on the San Joaquin River between Redinger Lake and Mammoth Pool, and **Granite Project** (Granite Creek and Graveyard Meadow reservoirs) and **Jackass-Chiquito Project** (Jackass and Chiquito reservoirs) on tributaries to the San Joaquin River upstream of Mammoth Pool. The scoping comments also suggested combining these upstream storage measures with a gravity diversion tunnel from Kerckhoff Lake to a Fine Gold Reservoir.

The locations of the six surface water storage sites retained from Phase 1 and sites suggested during scoping are shown in **Figure 1-2.** This TA presents design and cost information on various configurations of the six surface water storage sites retained from Phase 1. Costs of surface water storage measures suggested during scoping were obtained from previous reports prepared by others, as cited in the IAIR, and are not included in this TA.

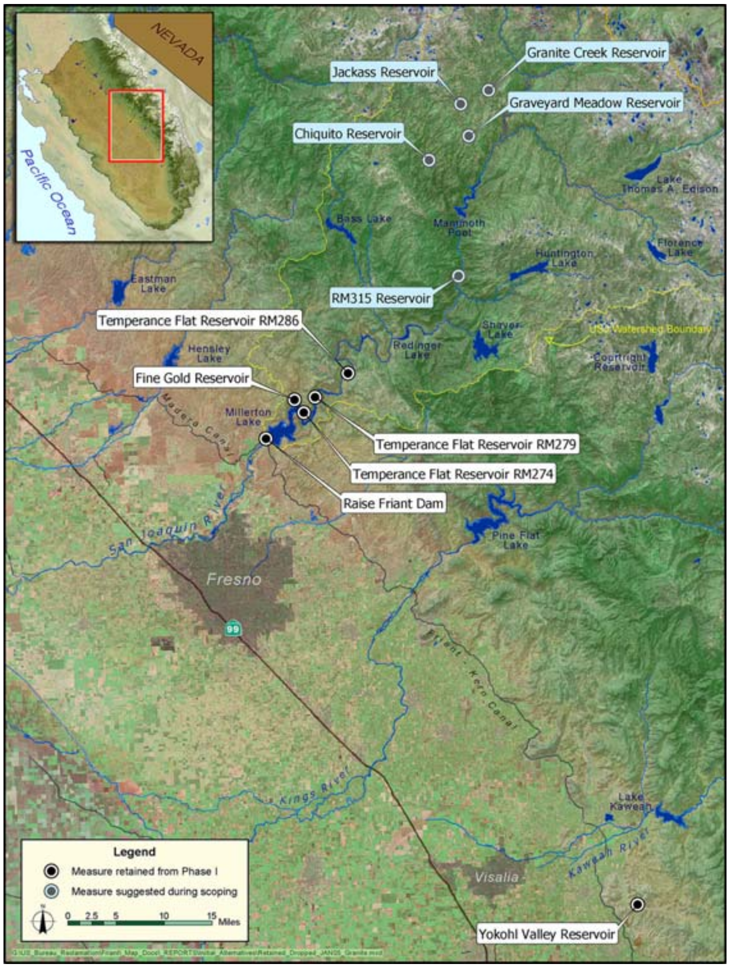

FIGURE 1-2.
SURFACE WATER STORAGE SITES RETAINED FROM PHASE 1 AND SUGGESTED DURING SCOPING

SUMMARY OF PHASE 1 HYDROLOGIC MODELING

The main purposes of Phase 1 hydrologic modeling were to estimate the new water supply yield available and to determine if yield changes with use.

Surface storage sites retained for further analysis from initial screening were evaluated in the CALSIM model to estimate the water supply that the option could provide. For each surface storage option, single-purpose evaluations were performed for multiple reservoir sizes. Model simulations were done to identify the quantity of water that could be available for each Investigation purpose if the additional water supply created by new storage were operated solely to meet that purpose. The single-purpose analyses did not include any changes to the current flood storage rules.

The single-purpose analyses addressed the three purposes of the Investigation – river restoration, water quality, and water supply reliability. Each single-purpose evaluation included a generalized operation of the expanded reservoir to specifically address one project purpose.

Operations for one purpose also can contribute to other purposes and address other opportunities. For example, releases to the San Joaquin River for river restoration also would contribute to improved water quality in the river.

Phase 1 modeling included a constraint to keep average annual canal deliveries the same by water year type as in the benchmark simulation. In contrast, the initial alternatives stage of modeling was refined to allow for a different approach to managing existing contracts, including the ability to shift supplies from wet years to dry years.

Phase 1 modeling did not examine downstream effects of additional storage. Modeling performed in the present initial alternatives stage begins to estimate the range of effects new storage might have on Friant Dam operations, the Friant Service area, San Joaquin River operations, San Joaquin River water quality, Sacramento-San Joaquin Delta (Delta) conditions, and south-of-Delta (SOD) conditions. Further information on hydrologic modeling performed in Phase 1 is documented in the October 2003 Hydrologic Model Development and Application TA to the Phase 1 Investigation Report.

OBJECTIVES OF THIS TECHNICAL APPENDIX

This TA to the IAIR describes the modeling approach and methodology that will be used during the plan formulation stage of the Investigation for evaluating storage options and potential water supply use. Initial operational scenarios have been evaluated for several methods of operating the water supply provided by additional storage. Water operations simulations were performed using a screening model developed specifically for the initial alternatives stage evaluation. The screening model is a spreadsheet simulation model that represents the operations of Friant Dam and Mendota Pool. Further description of the screening model is contained in **Chapter 4**. This evaluation does not provide detailed comparative results for the storage options regarding water use accomplishments; instead, it presents an initial methodology to 1) explore various ways new water supply might be allocated to develop allocation strategies, and 2) identify the range of parameters, issues, scenarios, and effects that will be evaluated further at the plan formulation stage in the future.

ORGANIZATION OF THIS TECHNICAL APPENDIX

This introductory chapter explains the purpose and objective of the Water Operations TA, describes the study area, presents an overview of the hydrologic modeling from Phase 1 of the Investigation, and gives the organization of the document. **Chapter 2** discusses the context of water operations and model development in the initial alternatives stage of the Investigation. **Chapter 3** describes examples of project operations that were used to develop an evaluation tool and illustrate the range of assumptions that will be required during the plan formulation stage of the Investigation. **Chapter 4** briefly describes the analytical tools used for this initial alternatives stage of the Investigation. **Chapter 5** describes next steps for the water operations component of the Investigation. **Chapter 6** lists the document preparers, and **Chapter 7** contains sources used in preparing this TA.

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CHAPTER 2. WATER OPERATIONS SCREENING MODEL DEVELOPMENT

The Phase 1 hydrologic evaluation of surface storage options applied the CALSIM model to estimate preliminary water supply accomplishments associated with single-purpose operating objectives. CALSIM, a monthly water resources planning model, simulates Central Valley Project (CVP) and State Water Project (SWP) operations for a specified level of development through optimization techniques. The geographic coverage includes the Sacramento and San Joaquin valleys, Tulare Lake Basin, upper Trinity River, and areas in Southern California receiving CVP and SWP waters. Phase 1 analyses included several simplifying assumptions for the operation of a storage measure, including an assumption that historically-derived without-project condition water deliveries to the CVP Friant Division service area would be preserved. Although the prior analysis was acceptable for reaching the conclusions developed in Phase 1, continued hydrologic analysis will require additional refinements related to operation of the storage options and the effects of those operations.

During the initial alternatives stage of the Investigation, outreach occurred with several representatives of Reclamation and water user groups that could be affected by changed operations of Friant facilities. These representatives assisted in identifying operational issues and concerns that may be associated with storage measures and the range of potential water use objectives. The outreach confirmed the need to develop a screening model that could quickly be adapted and revised to evalute alternative operations and water allocation decisions. The screening model evolved as participants gained understanding of the interdependencies between water supply, reservoir storage, river releases, and canal releases. The screening model was developed for use in the IAIR analysis to aid in establishing operational rules and mathematical algorithms, and performing preliminary simulations. During the plan formulation stage, operations rules and algorithms developed using the screening model will be incorporated into CALSIM to support more comprehensive analyses of alternatives. Ultimately, the goal of plan formulation stage modeling will be to evaluate project accomplishments and effects with a model that can depict practicable and feasible operations, with consideration given to the several physical and institutional characteristics of the system, including the contractual water supply of the Friant Division.

The first step in developing initial operations scenarios was to identify feasible modes of operation for a reservoir system that does not currently exist. It is recognized that the purpose of the Investigation is to identify how incremental storage can contribute to existing and additional uses without reallocating current water supplies. One of the first challenges in model development was identifying operations that could support Investigation objectives while preserving long-term average canal supplies that have historically been delivered.

Various scenarios for water use were identified and evaluated, ranging from river supply for restoration and water quality to canal supply scenarios. The scenarios differ from those developed in Phase 1. In each scenario, the allocation of water supply for various uses is calculated dynamically (i.e. from year-to-year) without attempting to maintain historically derived (year-to-year) canal deliveries. Assumptions were required to define volumes and patterns of releases to the river.

River release patterns in this analysis were used solely for the purpose of model development and are not based on any restoration or water quality improvement plans. The purpose of modeling at the initial alternatives stage is to identify how the hydrologic analysis in the plan formulation stage will be performed. The scenarios described in this TA and their assumptions provided an adequate range of water uses to test the functionality of operational decisions within the model. One outcome of operating new storage will be additional, controlled releases to the river and/or canals. This is considered a direct accomplishment because it would occur as a result of explicit operational objectives. In addition, water quality in the San Joaquin River could change under certain circumstances. In this TA, water quality change in the San Joaquin River is grouped with the direct accomplishments.

The second step in the initial alternatives modeling effort was to identify system-wide hydrologic effects caused by a change in Friant Division operations. System-wide effects of increased storage are those hydrologic parameters that are incidentally affected by project operations. Examples of effects include the following:

- Change in Delta-Mendota Canal (DMC) deliveries to the Exchange Contractors
- Change in San Joaquin River flow above Merced River
- Change in New Melones Reservoir operations
- Change in other San Joaquin River tributary operations
- Change in Delta inflow from San Joaquin River
- Change in upstream-of-Delta CVP/SWP reservoir operations
- Change in CVP/SWP deliveries, upstream-of-Delta and SOD
- Changes in Sacramento River inflow to Delta, and Delta outflow

During this initial alternatives stage of evaluation, effects of the initial water operations scenarios are described primarily qualitatively. Quantification of the effects will be included in analysis during the plan formulation stage that will incorporate water supply operations logic developed for the screening model into CALSIM. CALSIM will be used to identify system-wide effects of changed operations of the Friant Division after implementation of several modifications that will be included in hydrologic analysis during the plan formulation stage.

OPERATIONAL COMPONENTS

The purpose of the Investigation is to identify how additional storage could develop and manage water supplies to contribute to restoration and improve water quality of the San Joaquin River, and facilitate additional conjunctive management and exchanges that provide higher quality water to urban areas. The amount of water that could be developed by adding storage is the amount of water that currently escapes the control of the Friant system. This volume of water is the amount of released to the San Joaquin River in excess of releases to satisfy downstream riparian and contractual obligations. Additional storage, in combination with operational objectives, would increase regulation of the water supply at Friant Dam and reduce the frequency and quantity of releases to the river that are “uncontrolled.”

The CVP Friant Division generally operates as an isolated single-reservoir system. Millerton Lake is operated as an annual reservoir. Each contract year (from March to the following February), all the available water supply, which varies annually, is allocated to various water demands such as canal deliveries and the requirements for San Joaquin River water rights and contractual obligations. Water supply for contractual deliveries is determined with an assumption that by the end of September, Millerton Lake storage is fully depleted to the level at which Friant-Kern Canal deliveries can still physically occur. Active storage typically remains in Millerton Lake after September as contractors often defer some of their deliveries because they have until the end of February to use their allocated supplies.

Model parameters that could influence operational objectives include those influencing demand, such as contract deliveries and downstream requirements, and parameters influencing reservoir storage levels, such as flood control requirements and carryover targets.

Contract Deliveries

The CVP Friant Division is operated to support conjunctive water management in areas experiencing groundwater overdraft in the eastern San Joaquin Valley. To support conjunctive use, Reclamation employs a two-class system of water allocation: Class 1 and Class 2 contracts. **Figure 2-1** shows the locations of the Friant Division contractors and lists the acreage for each contractor and **Table 2-1** lists Friant Division contract amounts for each contractor.

Class 1 contracts, which are based on a firm water supply, are generally assigned to municipal and industrial (M&I) and agricultural water users with limited access to good quality groundwater. These lands primarily include uphill areas planted with citrus or deciduous fruit. Under current project operations, the first 800 thousand acre-feet (TAF) of annual water supply are delivered under Class 1 contracts.

Class 2 water, as a supplemental supply for agricultural use or for groundwater recharge, is delivered to areas experiencing groundwater overdraft. Class 2 contractors typically have access to good quality groundwater supplies and can continue to operate during periods of surface water deficiency by using groundwater. Many Class 2 contractors are in areas with high groundwater recharge capability and they operate dedicated groundwater recharge facilities. The total Friant Division Class 2 contract amount is approximately1,400 TAF.

In addition to Class 1 and Class 2 water deliveries, Reclamation is authorized by Section 215 of the Reclamation Reform Act of 1982 to deliver unstorable irrigation water, or Section 215 water, that would otherwise be released due to flood control criteria. The delivery of Section 215 water enables groundwater replenishment at levels higher than Class 1 and Class 2 contract deliveries would otherwise support in the southern San Joaquin Valley. Section 215 water is available to any water agency that has the ability to accept deliveries during flood operation periods. Reclamation provides Section 215 water to long-term Friant water contractors first.

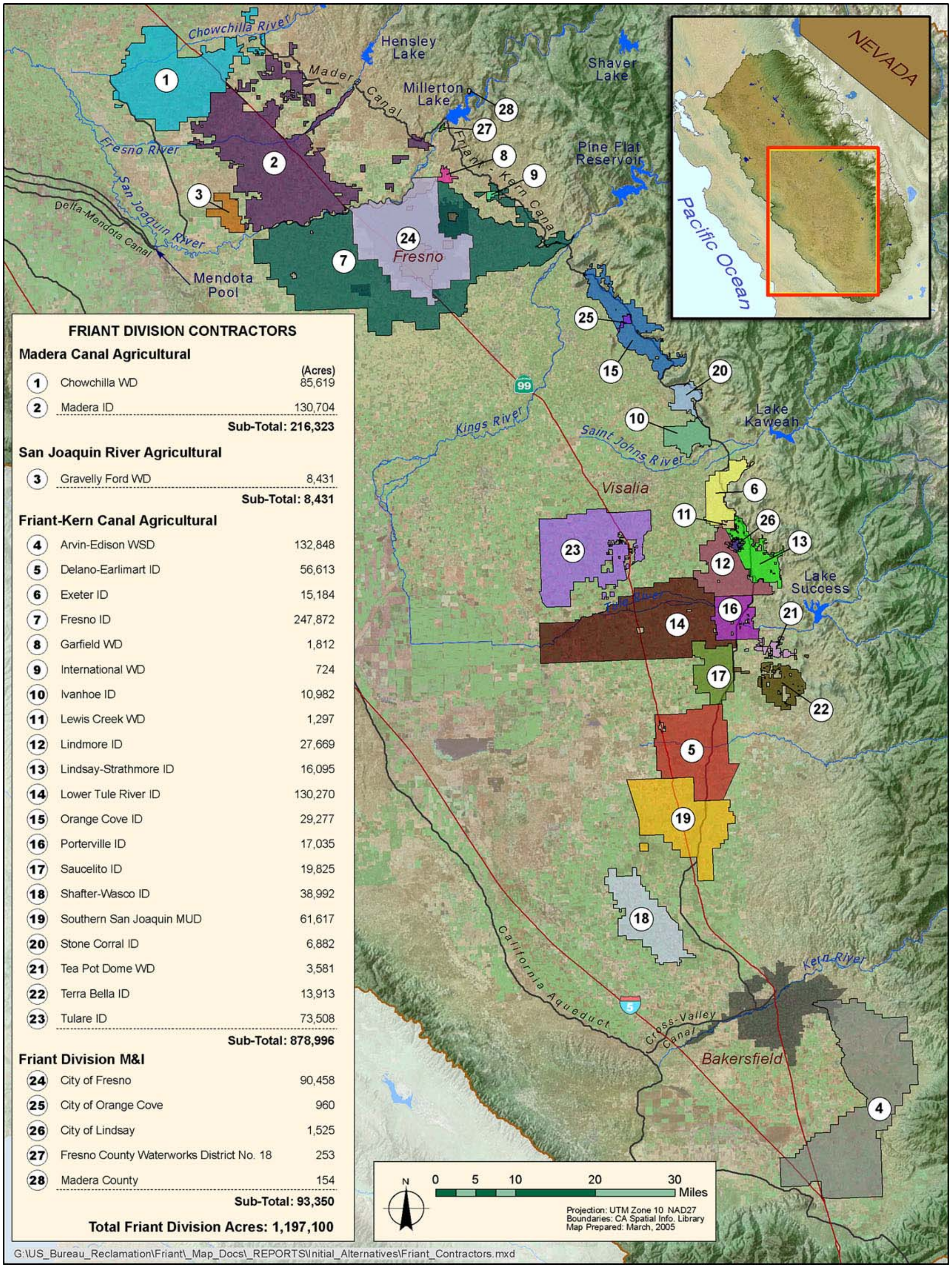

FIGURE 2-1.
FRIANT DIVISION CONTRACTORS

TABLE 2-1.
FRIANT DIVISION LONG-TERM CONTRACTS

CONTRACT TYPE/CONTRACTOR	Class 1	Class 2	Cross-Valley
Madera Canal Agricultural			
Chowchilla WD	55,000	160,000	
Madera ID	85,000	186,000	
Total Madera Canal Agricultural	**140,000**	**346,000**	
San Joaquin River Agricultural			
Gravelly Ford WD	0	14,000	
Friant-Kern Canal Agricultural			
Arvin-Edison WSD	40,000	311,675	
Delano-Earlimart ID	108,800	74,500	
Exeter ID	11,500	19,000	
Fresno ID	0	75,000	
Garfield WD	3,500	0	
International WD	1,200	0	
Ivanhoe ID	7,700	7,900	
Lewis Creek WD	1,450	0	
Lindmore ID	33,000	22,000	
Lindsay-Strathmore ID	27,500	0	
Lower Tule River ID	61,200	238,000	
Orange Cove ID	39,200	0	
Porterville ID	16,000	30,000	
Saucelito ID	21,200	32,800	
Shafter-Wasco ID	50,000	39,600	
Southern San Joaquin MUD	97,000	50,000	
Stone Corral ID	10,000	0	
Tea Pot Dome WD	7,500	0	
Terra Bella ID	29,000	0	
Tulare ID	30,000	141,000	
Total Friant-Kern Canal Agricultural	**595,750**	**1,041,475**	
Total Friant Division Agricultural	**735,750**	**1,401,475**	
Friant Division M&I			
City of Fresno	60,000		
City of Orange Cove	1,400		
City of Lindsay	2,500		
Fresno County Water Works District No. 18	150		
Madera County	200		
Total Friant Division M&I	**64,250**		
Total Friant Division Contracts	**800,000**	**1,401,475**	
Cross-Valley Canal Exchange			
Fresno County			3,000
Tulare County			5,308
Hills Valley ID			3,346
Kern-Tulare WD			40,000
Lower Tule River ID			31,102
Pixley ID			31,102
Rag Gulch WD			13,300
Tri-Valley WD			1,142
Total Cross-Valley Canal Exchange			**128,300**

Key:
ID – Irrigation District; M&I – municipal and industrial; MUD – Municipal Utility District
WD – Water District; WSD – Water Storage District

Source: Friant Water Users Authority Informational Report

The water operations screening model depicts the allocation and delivery process of the Friant Division. Annual water deliveries for the Friant Division are determined in March of each year and updated monthly through June. The allocation is estimated by summing the total water available from storage and inflow and subtracting requirements and losses. The remainder is the water available for delivery. Section 215 supply is available when uncontrolled releases from Friant Dam would otherwise occur.

As storage is increased in the initial water operations screening model scenarios (described in **Chapter 3**), a greater amount of available reservoir space is available to regulate large inflows, resulting in fewer occurrences of uncontrolled releases to the San Joaquin River. The delivery allocation logic for the current Friant system is applied in the screening model for all evaluations presented in this TA. Increasing storage volume results in shifting water deliveries from Section 215 supply to Class 1 and Class 2 supplies, with most increases identified in Class 2. During the plan formulation stage, the method of allocating supply among the contract types may be revised.

Prescribed River Releases

For the existing system, other than in flood control operations, releases from Friant Dam to the San Joaquin River are limited to the amounts necessary to maintain diversions by riparian and contractor users below Friant Dam at a location near Gravelly Ford. Water diverted to the fish hatchery below Friant Dam and returned to the river contributes to the water rights releases. Review of historical operation records provided guidance in estimating the minimum downstream release used for the model of without-project conditions. From an analysis of the record (1990 to 1994) for periods when no flood control releases were made, an annual release of 116.7 TAF was estimated to be the current minimum release necessary to meet downstream diversions (including seepage).

The screening model incorporates the historical minimum river release (116.7 TAF) as a requirement to be met prior to any other allocation of water. In the screening model supplemental releases to the river, as assumed for the river release scenarios, occur above these minimum flow levels. These supplemental releases are defined by volume (varying by availability of water) and by seasonal pattern. Supplemental releases can be simulated in the model for various forms of downstream objective, such as a river restoration release or a water quality release.

Flood Control Operation

Friant Dam and Millerton Lake are operated for flood control in accordance with rules and regulations prescribed by the Code of Federal Regulations Title 33 Part 208.11, the Field Working Agreement for CVP dams and reservoirs, and the Flood Control Manual. Two types of flood control space exist in Millerton Lake: rainflood space and conditional space.

The screening model used in the present initial alternatives stage employs a monthly timestep process to mimic the result of flood control operations. In actual practice, flood control operations are determined daily. During the conditional space time period (modeled February through June), an algorithm is used to simulate management of flood volumes over the entire period. The release necessary to operate within the conditional flood control space is determined for each month between February and May. This is done by forecasting the quantity of water anticipated to be spilled by the end of June. The forecast requires estimating the available water supply, project deliveries, lake evaporation, and minimum river releases through the end of June.

The water supply forecast uses foresight to predict the amount of Millerton inflow that will occur through the end of June. Deliveries, evaporation, and minimum river releases through the end of June are estimated. Using the water supply forecast, delivery forecast, current storage, and end-of-June full reservoir storage target, the projected volume of spill through the end of June is computed. The projected spill volume is then distributed on a release schedule that is consistent with historical reservoir flood control operation. Releases of large projected spills are spread out over several months to avoid releasing large flows late in the season, while the release of small projected spill volumes is deferred until their release is necessary in May or June. The flood control release for a given month is the greater of computed rainflood release or conditional space release.

The water operations analysis assumes the same overarching flood control requirements as currently applied to the existing Friant system. For instance, during the rainflood period up to 170 TAF of space is required for either the existing reservoir or for an enlarged reservoir. Hydrologic analysis tools for the plan formulation stage will be capable of evaluating alternative flood control objectives and requirements.

Carryover Storage Objective

As described above, the existing Friant system is generally operated for an annual water supply; carryover of one year's water supply to the next is not an operational practice or objective. This method of operation maximizes water delivery by drawing the reservoir down to maximize the capture of future inflows. However, the annual method of operation has little ability to stabilize water deliveries from one year to the next.

With increased storage, it may be desirable to create a stabilizing effect on water supply for both canal deliveries and river releases. The screening model allows a carryover storage target to be defined based on the available water supply. Functionally, the model logic can limit the amount of supplemental release made in a year (i.e., an abundant water supply year following a wet period) to the advantage of releases in a following year. In effect, the new controlled water supply developed through additional storage can be stretched over a longer duration of time.

KEY OPERATIONAL OBJECTIVES AND DECISIONS

The Phase 1 hydrologic analysis identified three categories of beneficial use for which additional storage in the upper San Joaquin River basin could provide benefits:

- Water supply reliability — increasing Friant Division canal deliveries.
- Water quality — providing releases from Friant Dam to Mendota Pool to improve water quality of the San Joaquin River by improving the quality of source water used by the San Joaquin River Exchange Contractors (Exchange Contractors) and other water users at Mendota Pool.
- River restoration — providing releases from Friant Dam to Mendota Pool for San Joaquin River restoration from Gravelly Ford to Mendota Pool.

These three categories of beneficial use continue to be the focus for formulating water operations scenarios for which the benefits of storage will be evaluated in the plan formulation stage of the Investigation. At Friant Dam, the key decision for operations is whether additional supply will be used for 1) additional canal releases, or 2) additional controlled river releases. However, the benefits of storage also could be divided between these two fundamental objectives.

For the purposes of the IAIR, detail on assumptions for needs of the river (e.g., a restoration flow pattern or year-to-year sustainable flow) was not critical to completing this stage of work. More important was identifying and developing a tool that could evaluate alternative assumptions for river needs when that information is more fully identified during the plan formulation stage of the Investigation. Operational scenarios described in **Chapter 3** illustrate the breadth of alternatives that can be evaluated for the PFR, and also illustrate some of the accomplishments and constraints associated with additional storage.

A second level of decision occurs downstream from Friant Dam regarding the disposition of river releases. If water reaches the Mendota Pool, can it be used as a water supply to Mendota Pool diverters, or must it be bypassed to points downstream? The disposition of the river releases is critical to examining the effects of new storage, particularly the effects to water quality in the San Joaquin River and to the SOD CVP water supply.

Figure 2-2 shows the San Joaquin River downstream from Friant Dam and highlights features referenced in this TA (e.g., Gravelly Ford, Mendota Pool, Vernalis gage).

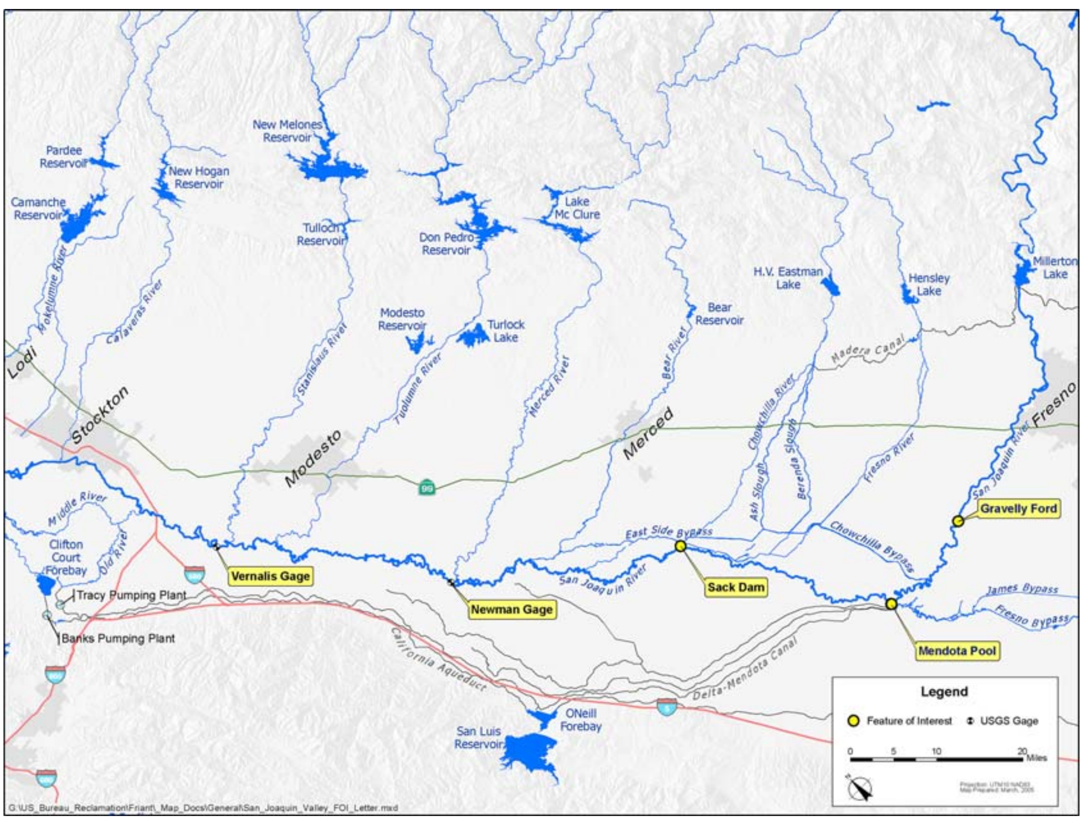

FIGURE 2-2.
SAN JOAQUIN RIVER DOWNSTREAM FROM FRIANT DAM

ANALYTICAL APPROACH

Developing the screening model and formulating operational scenarios was an iterative exercise. As basic operational decisions were identified and incorporated into the model, increasingly refined forms of assumptions needed to be addressed. For example, if water is to be released to the river (or delivered to the canals), should the water be parceled across several years or released as quickly as possible? Additionally, fundamental questions arose for the manner in which the level of existing water deliveries could be maintained. As revisions were made to the model, the operational scenarios also changed as an attempt was made to provide preliminary results that would illustrate the range of operations (and operational objectives) that may be evaluated in the plan formulation stage. The screening model incorporates functionality that can evaluate many of the alternate methods of managing the existing storage at Friant Dam and additional storage being considered in the study area.

The presentation of results from initial operating scenarios in **Chapter 3** illustrates the operational considerations that will be included in the formulation of alternatives and the hydrologic metrics that will be evaluated. Water operations analyses in the PFR also will address water supply allocation operations through systematic procedures and protocols that respond to realistic water supply parameters known in real-time operations.

The screening model is capable of exploring operating scenarios addressing the following:

- Alternative carryover targets affecting the year-to-year delivery of new water supply to the canals or river
- Allocation of water supply to competing beneficial uses such as agricultural water supply or increased river flow
- Alternative patterns of releasing new water supply to the river
- Alternative patterns of delivering new water supply to the canals
- Alternative storage allocations for flood control
- Alternative bypass requirements (if any) for water reaching Mendota Pool

Quantitative results are presented for the benefits of each initial operational scenario, and qualitatively for system-wide effects. As analysis for the PFR advances, some of the effects identified and qualitatively assessed may be deemed minor or insignificant.

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CHAPTER 3. INITIAL WATER OPERATIONS SCENARIOS

This chapter explains the scenarios evaluated and results derived from screening model analysis of the scenarios. Several initial operational scenarios were developed to illustrate the range of assumptions needed for plan formulation stage analysis. Generally, results fall into two categories: 1) benefits that derive from explicit operational objectives, and 2) system-wide effects that incidentally occur. Water quality benefits to the San Joaquin River attributed to each of the scenarios was not been estimated because the necessary water quality modeling tool was not fully developed at the time the evaluations were completed. The CALSIM model will be enhanced during preparation of the PFR to evaluate water quality effects. Results should be viewed only as a preview of the forms of information that will become available in the PFR.

FORMULATION OF INITIAL WATER OPERATIONS SCENARIOS

Operational scenarios were defined and evaluated during preparation of the IAIR to aid in developing evaluation tools and to guide further development and evaluation of initial alternatives. Several operational scenarios were developed to illustrate a range of potential allocation strategies for the water supply developed by new storage. The objectives in formulating initial scenarios was to illustrate water allocation and management decisions, identify assumptions needed to describe water demands (e.g., restoration requirements), demonstrate an approach for year-to-year management of water supplies (carryover), and illustrate interdependencies between water management decisions.

All operational scenarios were developed and evaluated using a common set of assumptions regarding existing institutional conditions. These include the current contract and allocation structure for Class 1, Class 2, and Section 215 supplies, existing flood control rules, and existing minimum downstream riparian and contractual requirements (116.7 TAF). For scenarios that would release new water supplies to the San Joaquin River, a methodology was developed to maintain existing long-term basin supplies. New water supply available for river release was identified by comparing long-term average canal deliveries with new storage to the without-project canal deliveries. This approach can shift water deliveries from year to year, but does not result in reallocating existing supplies from Friant water users. All operations scenarios assume 1,400 TAF additional storage capacity at Millerton Lake.

Operations scenarios were grouped into two themes, as summarized in **Table 3-1**. Four scenarios were developed that would provide water supply for river uses and two scenarios were developed that would provide water supply for canal uses. Operational scenarios are described in the following sections.

TABLE 3-1.
INITIAL WATER OPERATIONS SCENARIOS

San Joaquin River Supply Scenarios	
Scenario 1	Allocate new supply for San Joaquin River restoration, with Mendota Pool diversions
Scenario 2	Allocate new supply for San Joaquin River restoration, with Mendota Pool bypass flow
Scenario 3	Allocate new supply for San Joaquin River restoration, constant annual allocation
Scenario 4	Allocate new supply to improve San Joaquin River water quality
Canal Supply Scenarios	
Scenario 5	Allocate new supply for canal delivery
Scenario 6	Allocate new supply for canal delivery emphasizing multiyear reliability

Several common operational characteristics and constraints are assumed for each of the operations scenarios. The operational characteristics and constraints were applied to assure that the estimate of new water supplies developed from new storage could be attributed to storage only, and would not also require the a change in water allocation or flood management rules. Operational characteristics and constraints applied to all evaluations presented in this TA include:

- **Existing contracts and allocation procedures –** The current Class 1, Class 2, and Section 215 contract and allocation structure is assumed to continue with the addition of storage. The only difference is that additional storage provides a larger water supply to be allocated in some years.
- **Existing flood control operations –** Current flood control requirements (e.g., reserved reservoir space) of the existing Friant system continue to be required for a larger reservoir system.
- **Existing minimum Friant downstream release –** Current minimum riparian and contractual requirements (116.7 TAF) will continue to be met.
- **Maintaining existing long-term basin supplies –** The year-to-year or year-type replication of historical canal deliveries is no longer assumed to be fixed in the model. However, historical long-term average canal deliveries are maintained. This represents no reallocation of existing supplies from Friant water users.
- **Enlargement of storage** – Each scenario assumes upper San Joaquin River basin storage will be enlarged by 1,400 TAF. The screening model simplifies this assumption by representing additional storage as an enlarged Millerton Lake (total storage of 1,920 TAF).

DESCRIPTION OF WATER OPERATIONS SCENARIOS

The six operational scenarios and their operational objectives are described in this section. Four scenarios were developed for the management of water supply developed by new storage for release to the San Joaquin River for restoration or water quality. Two scenarios were developed to illustrate the effect that additional storage could have on the delivery of water supply to the Friant Division.

Scenario 1 – Allocate New Supply for River Restoration with Mendota Pool Diversions

This scenario would allocate new water supply for additional releases to the San Joaquin River in excess of those required for existing riparian and contractual uses. The approach used to allocate additional water supplies for river releases is shown in **Figure 3-1**. Similar to the approach used in Phase 1, the monthly pattern for releases of additional supply from Friant Dam was based on distribution of natural flow of the San Joaquin River at Friant. Alternative patterns for distribution of supplemental releases may be described in restoration plans developed by others.

The annual allocation in this scenario is based on total annual water supply availabile with no provision for carryover storage other than the current minimum operating level of 130 TAF in Millerton Lake. Supplemental releases to the river would be made in all years, increasing in volume as water supply increases in wetter years. This water supply allocation approach may not result in a reliable annual water supply to support restoration of the San Joaquin River because little or no new supply would be available in dry years.

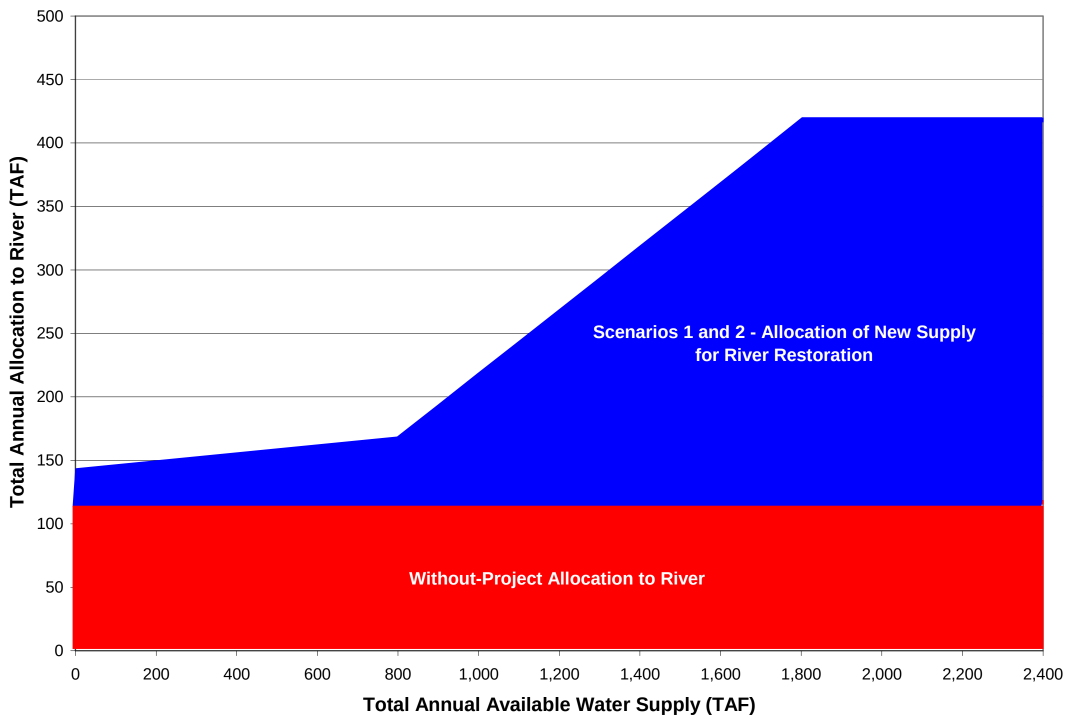

FIGURE 3-1.
SCENARIOS 1 AND 2 ALLOCATION RULES

In Scenario 1, supplemental releases made from Friant Dam to the San Joaquin River that reach Mendota Pool (after additional seepage losses) would be available for diversion at Mendota Pool. The screening model identifies the quantity of water that would be considered a new supply at Mendota Pool, thereby reducing the amount of water that would be delivered to Mendota Pool from the DMC. The effects to the remainder of the CVP or SWP were not evaluated, however any change that occurs would be considered an effect of releasing new supply from Friant Dam.

A model is being developed that will facilitate evaluation of changes to San Joaquin River water quality due to altering the source water to Mendota Pool. During the plan formulation stage, this tool will be applied and the potential benefits to water quality will be determined.

Scenario 2 – Allocate New Supply for River Restoration and Bypass Mendota Pool

Scenario 2 is a variation of Scenario 1, with only a change to the route of water downstream of Gravelly Ford. Similar to Scenario 1, supplemental water would be released to the San Joaquin River based on the water allocation and pattern assumptions described above, with no provision for carryover storage, other than the current minimum operating level of 130 TAF in Millerton Lake. In Scenario 2, it was assumed that the released water would not be available to offset deliveries from the DMC but would continue downstream of Mendota Pool. No site-specific assumptions were made regarding the manner in which water would flow past Mendota Pool and measures to allow bypass have not been considered.

Scenario 3 – Allocate New Supply for River Restoration with Constant Annual Allocation and Mendota Pool Diversions

In Scenario 3, a constant amount of new water supply would be released to the San Joaquin River each year. In the case of a 1,400 TAF reservoir, the long-term average new water supply would be about 175 TAF/year. To facilitate an annual supplemental water demand, a variable carryover storage target approach was used to assure that 175 TAF would be available for river release each year. The approach for allocating annual water supplies for river release for Scenario 3 is shown in **Figure 3-2** and the carryover storage target is shown in **Figure 3-3**. In Scenario 3, supplemental releases made from Friant Dam to the San Joaquin River that reach Mendota Pool would be available for diversion at Mendota Pool. The use of carryover storage in Scenario 3 has the effect of reducing the average annual new water supply resulting from new storage, as compared to a scenario where all water supplies are allocated each year (Scenarios 1 and 2). The carried-over water would be available in dry years, thereby increasing dry year water supplies.

FIGURE 3-2.
SCENARIO 3 ALLOCATION RULES

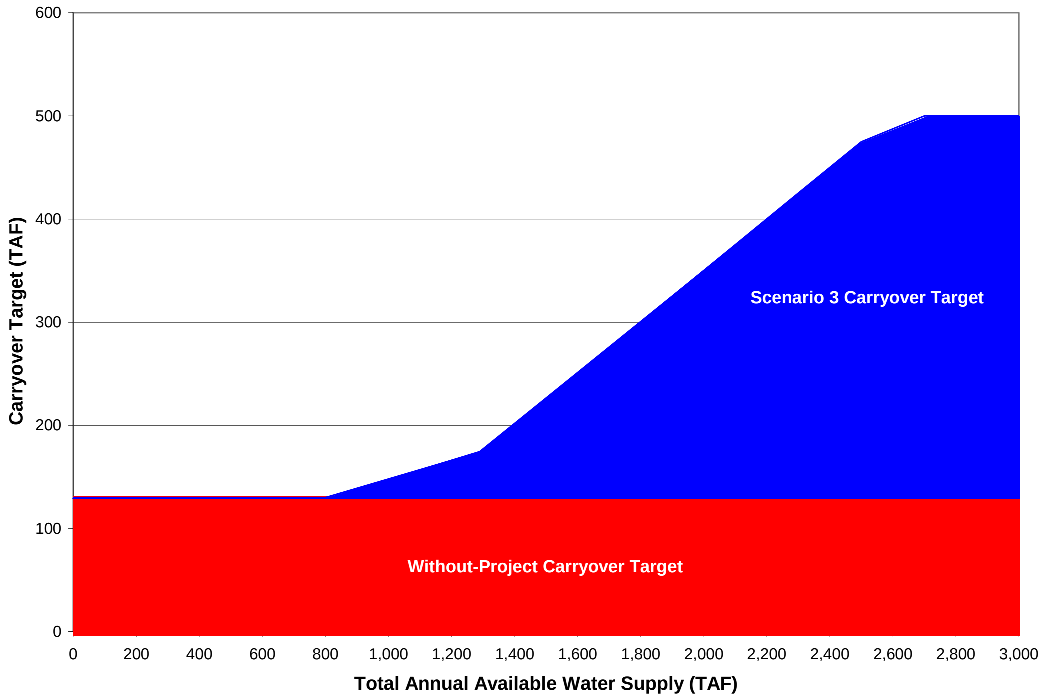

FIGURE 3-3.
SCENARIO 3 END-OF-SEPTEMBER CARRYOVER STORAGE TARGET

Scenario 4 – Allocate New Supply for River Water Quality Enhancement

Scenario 4 was developed to assess how water supplies from new storage could be released from Friant Dam specifically to improve San Joaquin River water quality. Carryover and allocation rules were used to emphasize the availability of new water supply in dry and below-normal years, when water quality problems are prevalent, as shown in **Figures 3-4** and **3-5**.

It should be noted that water quality responses have not been estimated because the model has not yet been developed. In dry years, water supply allocation for water quality would be low because of the limited availability of water supplies. A relatively low allocation in wet years was established based on an assumption that water quality problems are relatively minor in years when significant water supplies are available to the San Joaquin River from multiple tributary streams. By combining the allocation and carryover target rules, wet year water supplies are held in storage for use in subsequent years.

For this analysis, it is assumed that the monthly pattern of release of any volume of water quality allocation occurs evenly during the June through September period (irrigation pattern and presumed water quality concern season). This pattern may be revised as additional information is developed regarding water quality enhancement goals.

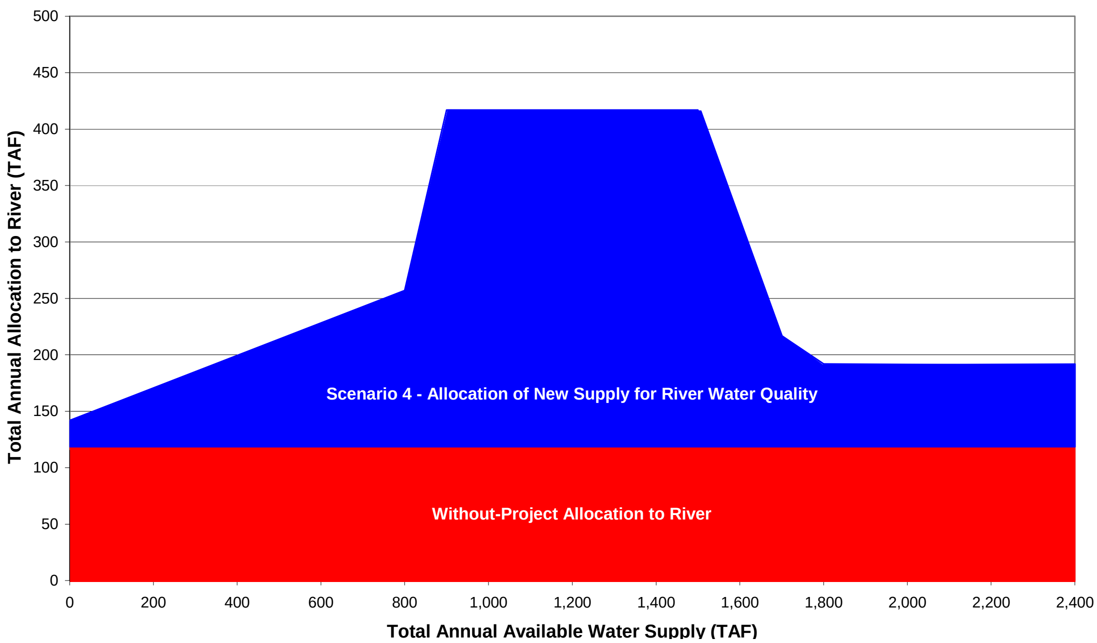

FIGURE 3-4.
SCENARIO 4 ALLOCATION RULES

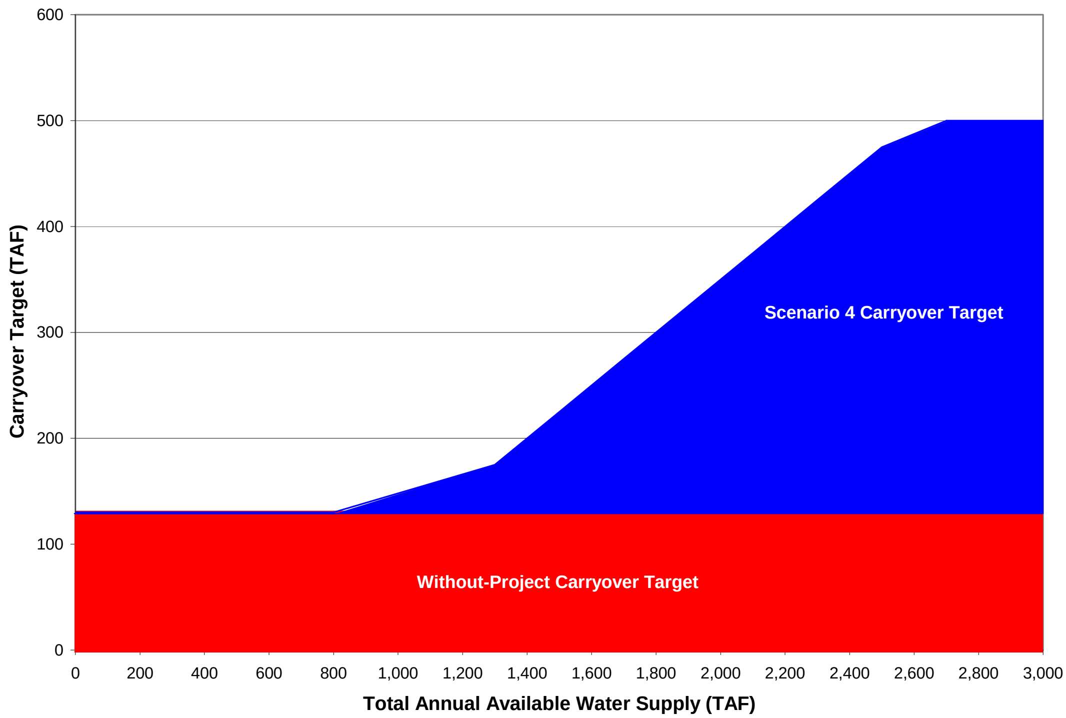

FIGURE 3-5.
SCENARIO 4 END-OF-SEPTEMBER CARRYOVER STORAGE TARGET

Scenario 5 – Allocate New Supply for Canal Delivery

This scenario represents an operation for which all new water supply would be allocated to the Friant-Kern and Madera canals. The only difference in operation between this scenario and the existing Friant system operation is that greater storage would be available to regulate inflows to Millerton Lake. The existing annual water supply allocation procedure for Friant Dam is assumed, which establishes water deliveries based on the annual full drawdown of Millerton Lake. This operational objective would maximize the delivery of water supplies, only constrained by physical and contractual limitations inherent in current Friant contract deliveries.

Scenario 6 – Allocate New Supply for Canal Delivery Emphasizing Multiyear Reliability

This scenario is a variation of Scenario 5, but managed to provide additional deliveries for longer duration, particularly during drier years. This is accomplished by applying a carryover storage target in the annual water delivery allocation procedure. **Figure 3-6** shows how the carryover storage target would be raised for this scenario as available water supplies increase. The use of carryover storage in this scenario would have a minimal effect on Class 1 deliveries during dry years because the carryover target was set to current minimum operating storage levels for years when the total available supply is less than 800 TAF. During normal and wet years, however, additional water supply allocation would be less than in Scenario 5 because a portion of the water supply would be held in storage for use in subsequent years. As a result, the average annual new water supply resulting from new storage is less when carryover storage is in place, as compared to a scenario where all water supplies are allocated each year. The water carried-over would be available in dry years, thereby increasing dry year water supplies.

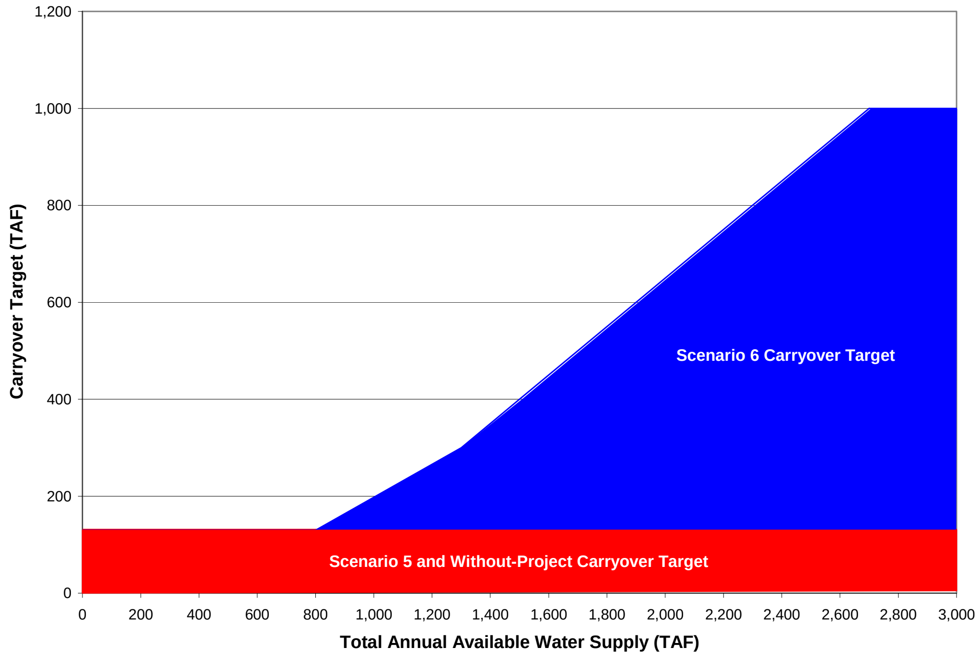

FIGURE 3-6.
SCENARIOS 5 AND 6 END-OF-SEPTEMBER CARRYOVER TARGETS

RESULTS FROM WATER OPERATIONS SCENARIOS

The six operational scenarios described above were developed and evaluated using a screening tool based on the CALSIM model. Although the primary purpose of the analysis performed for the IAIR was identifying key decisions and assumptions to be included in the plan formulation stage of analysis, results also were developed and are presented in this section. As the Investigation proceeds, the CALSIM model will be modified to include multiple purpose operations rules to support evaluation of the initial alternatives.

Preliminary results summarized in **Table 3-2** provide a preview of the general magnitude of results that could be expected when alternatives are more thoroughly defined and analyzed. Quantifiable results were limited to parameters that were explicitly modeled, such as canal and river releases and potential changes to Mendota Pool deliveries from the DMC. Other parameters, such as groundwater changes and CVP/SWP delivery changes, were not explicitly modeled for the IAIR and are described qualitatively. Analyses and results presented in this section illustrate the range of water supply effects in relation to the different operational objectives represented in the scenarios. The initial operations scenarios and preliminary results are informational only and are not intended to represent the final set of operations rules or project accomplishments.

As described above, Scenarios 1 through 4 were designed to provide additional controlled releases to the San Joaquin River for restoration and water quality uses. Minor changes in canal diversions for these scenarios result from the modeling assumption to maintain average historical canal diversions, consistent with the planning constraint described in the IAIR. These scenarios result in relatively minor differences in average river releases, but differ significantly in their ability to sustain releases over a series of years. Scenarios 3 and 4, which apply carryover rules to assure water supplies are available for release during dry years, result in lower average annual releases to the San Joaquin River than Scenarios 1 and 2, which do not include carryover provisions.

Scenario 5 results show that operating an additional 1,400 TAF of new storage under current water allocation rules could increase water deliveries by an average of about 165 TAF/year with a corresponding decrease in current flood control river releases. Comparing Scenarios 5 and 6 shows that increasing carryover storage in Millerton Lake would increase dry year water supplies but would reduce available active storage space, reduce the annual new water supply, and result in more flood control releases. For example, the average annual new water supply developed by Scenario 6, which includes carryover storage, would be about 25 percent lower than in Scenario

The results for many of the other parameters shown in **Table 3-2** are described qualitatively by scenario. Some of these parameters will be quantified during PFR analysis as the logic of the screening model is incorporated into CALSIM along with other refinements and enhancements. Upon completion of the refinements, system-wide reactions to changes in Friant operation can be modeled. Also, the number of parameters described in **Table 3-2** may increase as modeling continues during the plan formulation stage of analysis. Modeling tools are still to be developed, and results from these tools may elevate or diminish the importance or significance of certain parameters.

Generally, simple averaging of results from long-term water operations is not sufficient to describe the accomplishments of a scenario or the differences between scenarios. Therefore, additional detailed results from the six scenarios are provided in the following sections. Detailed results include graphical displays of chronological time-series information, annual results rank-ordered into a frequency of occurrence, and annual results data by chronological sequence. These results are presented for effects on canal deliveries, releases to the San Joaquin River, and Mendota Pool operations for each operating scenario, followed by qualitative discussions about other parameters of interest.

TABLE 3-2.
PRELIMINARY RESULTS FROM INITIAL OPERATIONS SCENARIOS

	Operations Scenario[1] Difference from Without-Project Results (TAF)[2]					
	1	**2**	**3**	**4**	**5**	**6**
Operations Scenario Criteria						
Operating Objective	San Joaquin River Restoration			SJR Water Quality	Canal Delivery	
	Diversions at Mendota Pool	Flow past Mendota Pool	Diversions at Mendota Pool	Diversions at Mendota Pool	Increase Annual Delivery	Increase Multiyear Reliability
Annual Water Supply Allocation	Variable		Constant	Variable		
Reservoir Carryover Storage Rule	Existing[3]		Prop. to Supply[4]		Existing[3]	Prop. to Supply[4]
Change in Friant Operations						
Total Canal Diversion	-1	-1	-1	0	+165	+128
Friant Class 1 Delivery[5]	-3	-3	-16	-12	+11	+34
Friant Class 2 Delivery[6]	+116	+116	+127	+119	+261	+187
Section 215 Delivery[7]	-114	-114	-112	-107	-107	-92
Friant Dedicated Release to SJR	+194	+194	+175	+161	0	0
Friant Spills to SJR	-198	-198	-183	-172	-174	-148
Total Friant Release to SJR	-4	-4	-8	-11	-174	-148
Change in San Joaquin River Flow and Operations						
SJR Flow to Mendota Pool	-44	-44	-51	-19	-162	-137
DMC Flow to Mendota Pool	-72	+45	-61	-97	+43	+39
SJR Flow Upstream from Merced River	-116	+1	-112	-117	-119	-98
Groundwater Recharge from Gravelly Ford to Merced River	Increase				Minor decrease from reduction in flood flow	
SJR Flood Flow at Vernalis	Decrease in all scenarios					
SJR Flow at Vernalis (non-flood periods)	No change	Potential increase	No change			
Effect on April/May SJR Flow w/o VAMP	Potential decrease	Potential decrease or increase	Potential decrease			

Key:
DMC – Delta-Mendota Canal
MP – Mendota Pool
SJR – San Joaquin River
TAF – thousand acre-feet
TDS – total dissolved solids
VAMP – Vernalis Adaptive Management Plan
w/o – without

Notes:
1 All operational scenarios assume existing contracts, existing flood control operations, existing Friant minimum downstream riparian and contractual requirements (116.7 TAF), no reallocation of existing supplies, and 1,400 TAF additional storage.
2 Results and scenarios are preliminary and will change in the future.
3 The existing end-of-September carry over target is 130 TAF.
4 End-of-September carryover target increased above existing target in proportion to supply when supply exceeds 800 TAF.
5 Class 1 contracts are based on a firm water supply and represent the first 800 TAF of annual water supply delivered. These contracts are generally assigned to M&I and agricultural water users who have limited access to good-quality groundwater.
6 Class 2 water is a supplemental supply and is delivered directly for agricultural use or for groundwater recharge, generally in areas that experience groundwater overdraft. Class 2 contractors typically have access to good-quality groundwater supplies and can use groundwater during periods of surface water deficiency.
7 Section 215 water is defined under Section 215 of the Reclamation Reform Act of 1982 as unstorable irrigation water to be released due to flood control criteria or unmanaged flood flows.

Operations Scenarios Effects on Canal Deliveries

As described previously, Friant Division deliveries occur under a two-category system of Class 1 and Class 2 contracts, with water also delivered under Section 215 provisions. This section presents results of canal deliveries for each of the six scenarios. In Scenarios 1 through 4, the operational objective was to supplement releases to the San Joaquin River; but not to diminish the existing water supply accomplishments of the existing project. In contrast, Scenarios 5 and 6 were operated specifically to increase deliveries to the Friant Division Annual Friant Division, while maintaining the existing requirements for Friant releases to the San Joaquin River.

Scenarios 1 and 2

Allocation of supplemental releases in Scenarios 1 and 2 is established so that average annual canal deliveries are consistent with without-project condition deliveries. **Figure 3-7** shows the exceedence (rank-ordered annual quantity over the entire simulation period) of total annual canal deliveries for Scenarios 2 and 3 and without-project conditions. Although annual average is the same as without-project conditions, as indicated in **Table 3-2**, a slight decrease in deliveries occurs during wetter years and a slight increase in deliveries occurs during above and below normal years.

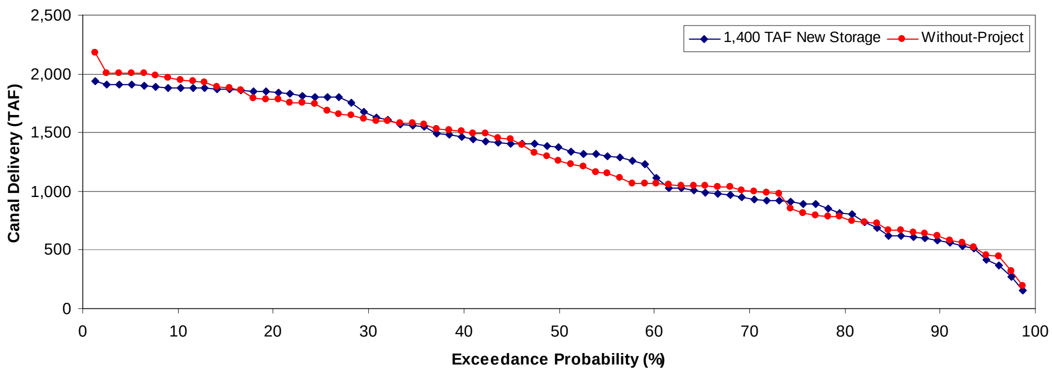

FIGURE 3-7.
TOTAL CANAL DELIVERY RESULTS FOR SCENARIOS 2 AND 3

Scenario 3

The allocation of supplemental release of 175 TAF per year in Scenario 3 was established so that average annual canal deliveries would be consistent with without-project condition deliveries for the addition of 1,400 TAF storage capacity. **Figure 3-8** shows the exceedence of total annual canal deliveries for Scenario 3 and without-project conditions. Due to operational challenges in providing carryover water through multiple-year droughts, a decrease in canal deliveries would occur in drier years, as illustrated in a decrease in Class 1 deliveries during drier years.

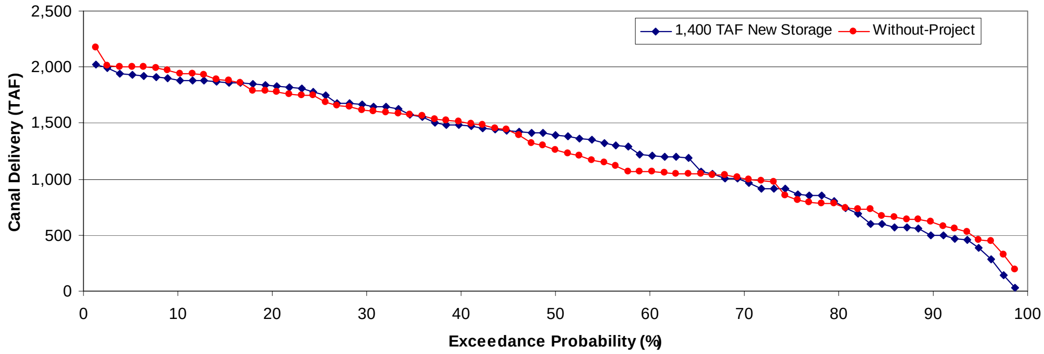

FIGURE 3-8.
TOTAL CANAL DELIVERY RESULTS FOR SCENARIO 3

Scenario 4

Consistent with Scenarios 1 through 3, average annual canal deliveries would be consistent with without-project conditions for Scenario 4. **Figure 3-9** shows the exceedence of total annual canal deliveries for Scenario 5 and without-project conditions. Supplemental releases during below-normal and dry years would result in decreased canal deliveries in these year types. This effect is offset by increases in deliveries during above-normal years.

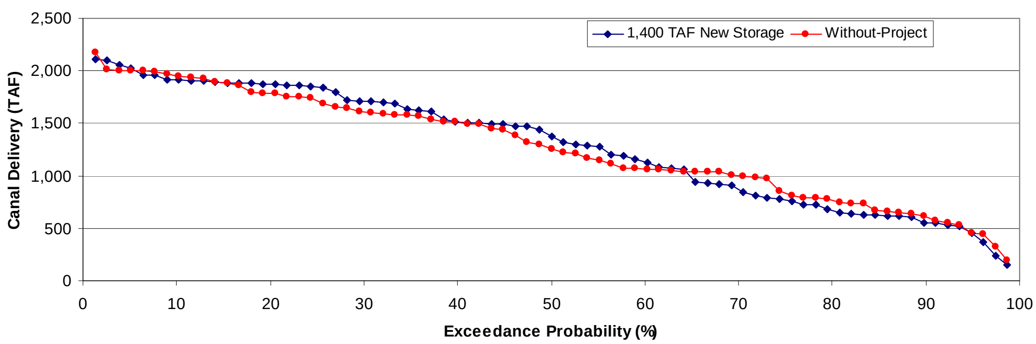

FIGURE 3-9.
TOTAL CANAL DELIVERY RESULTS FOR SCENARIO 4

Scenario 5

Figure 3-10 provides a chronological display of reservoir storage levels and changes in Friant releases to the San Joaquin River for the entire simulation period of 1922 through 1999 for Scenario 5 and without-project conditions. Each data point depicts the results for a month in the chronological sequence. Monthly storage levels demonstrate that developing new storage relative would allow more flow to be captured as compared to the without-project condition. Generally, increases in reservoir storage levels correspond to reductions in flood releases from Friant Dam to the San Joaquin River, depicted by a bar graph.

Figure 3-11 provides a complementary chronological plot of total Friant-Kern Canal and Madera Canal deliveries and the change in canal deliveries for Scenario 5 and the without-project conditions. The line chart represents monthly canal deliveries for the entire simulation period of 1922 through 1999, reflecting seasonal delivery patterns. The bar chart illustrates changes in monthly canal deliveries between the two studies. As evident, deliveries are often shifted in time from the flood season to the irrigation season because of the ability to better regulate high flows with new storage. This shift in timing generally reflects changes from Section 215 deliveries to Class 2 deliveries, as illustrated in **Figure 3-12**. The results shown in this figure illustrate the difference in frequency for each category of delivery for Scenario 5 and the without-project conditions. The following conclusions are made from this comparison:

- **Annual Class 1 Allocation -** Class 1 deliveries would increase in drier years due to the ability of new storage to carry over supplies from wetter years.
- **Annual Class 2 Allocation -** Class 2 allocations would increase with the addition of new storage. New storage allows high flows to be captured and delivered as Class 2 supply.
- **Annual Section 215 Allocation -** Section 215 allocations would decreases with the addition of new storage. Uncontrolled water delivered under the without-project conditions would be regulated in new storage and delivered as Class 2 supply.
- **Annual Total Canal Allocation**

  The addition of 1,400 TAF of new storage in Scenario 5 would increase annual average canal deliveries by 165 TAF over without-project conditions. Increased deliveries would generally occur during above and below normal years and in some dry years. Total deliveries would slightly decrease in the wettest years due to a decrease in uncontrolled delivery. Deliveries would increase very slightly in most critical and dry years.

Scenario 6

The variable carryover storage target incorporated in Scenario 6 was developed to illustrate how water supplies held in storage during wet years could result in increased deliveries during dry years. This approach would result in higher end-of-September reservoir storage levels for Scenario 6 than for Scenario 5, providing greater dry year reliability but lower long-term average annual and wet year deliveries.

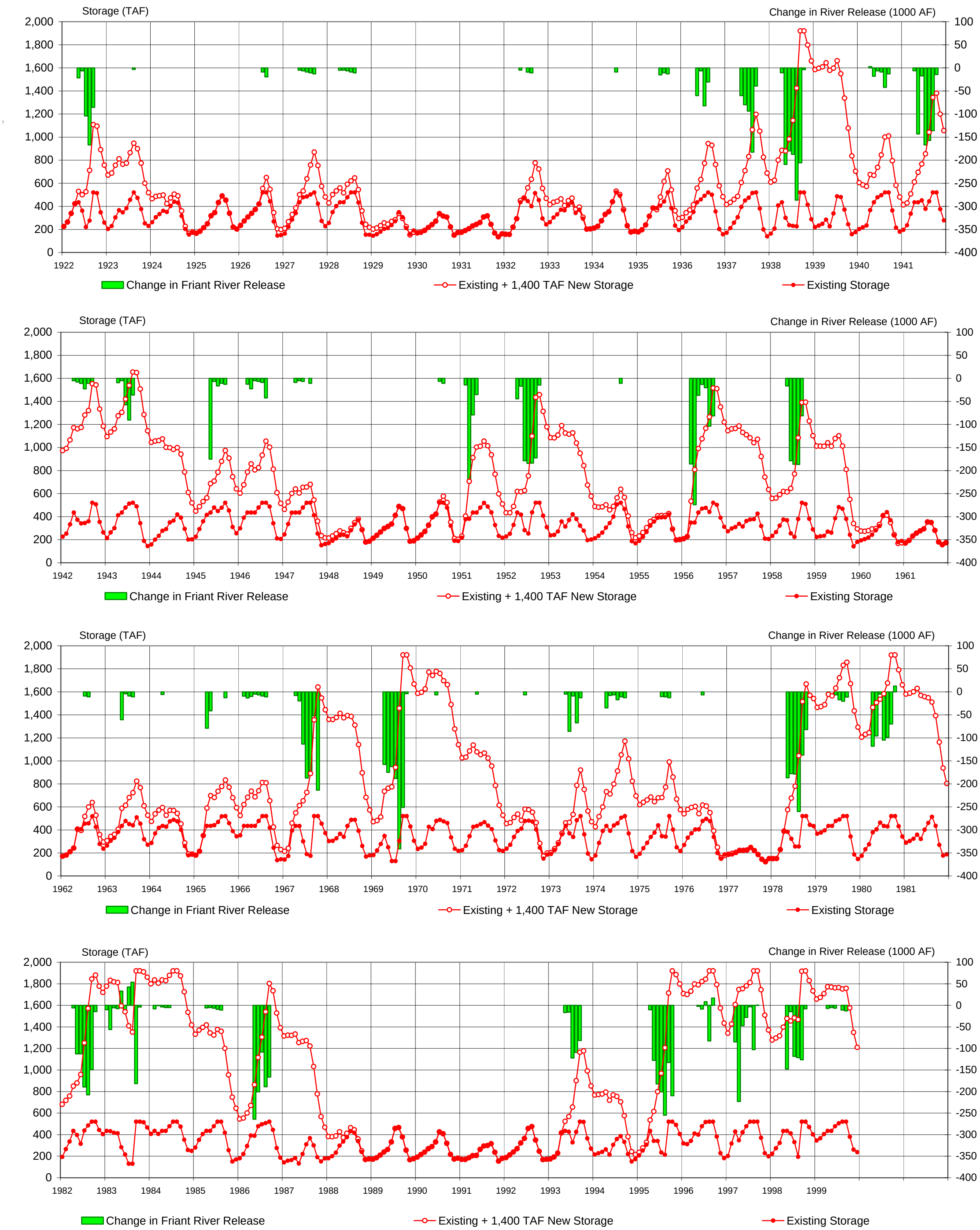

FIGURE 3-10.
FRIANT OPERATION RESULTS FOR SCENARIO 5

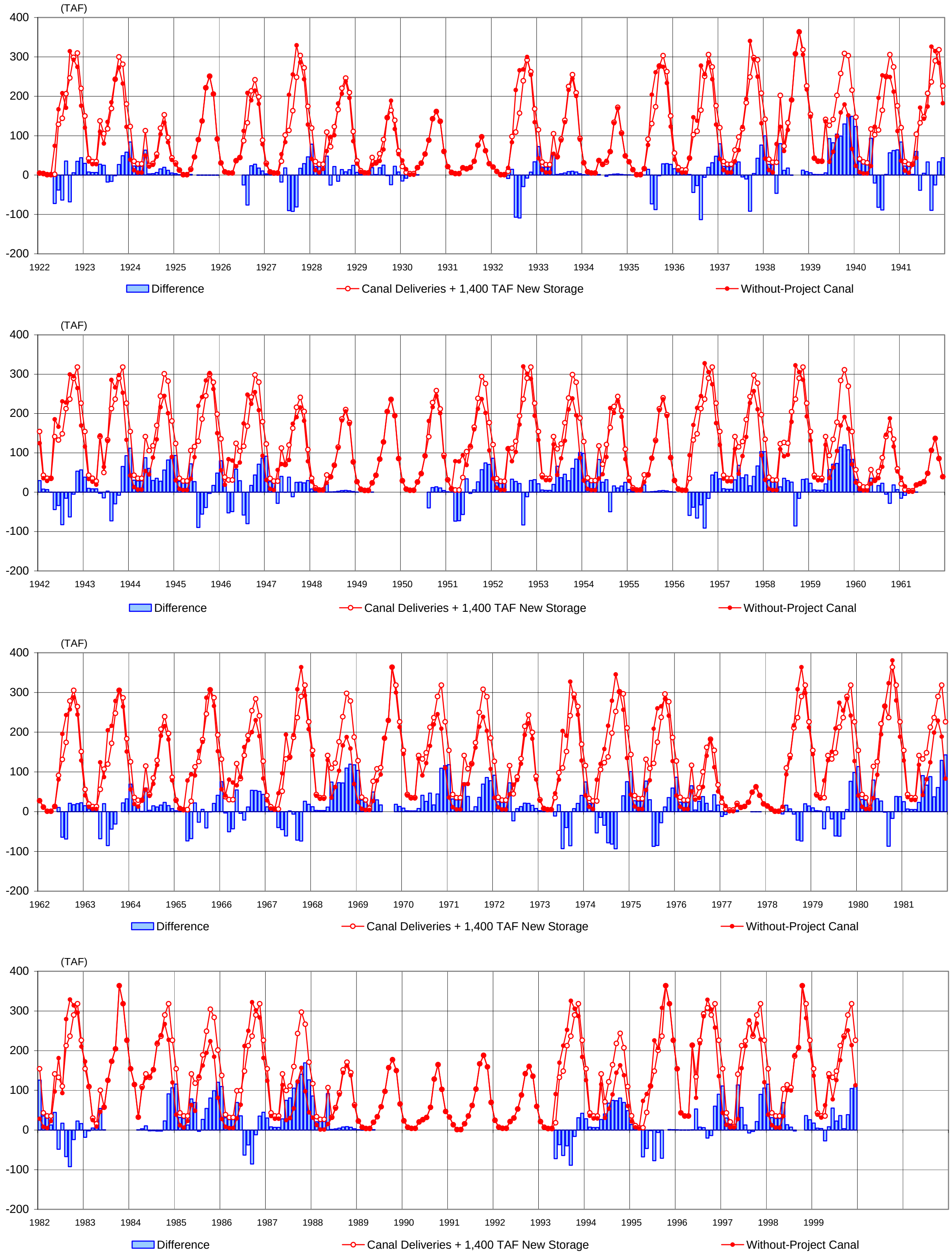

FIGURE 3-11.
TOTAL CANAL DELIVERIES FOR SCENARIO 5

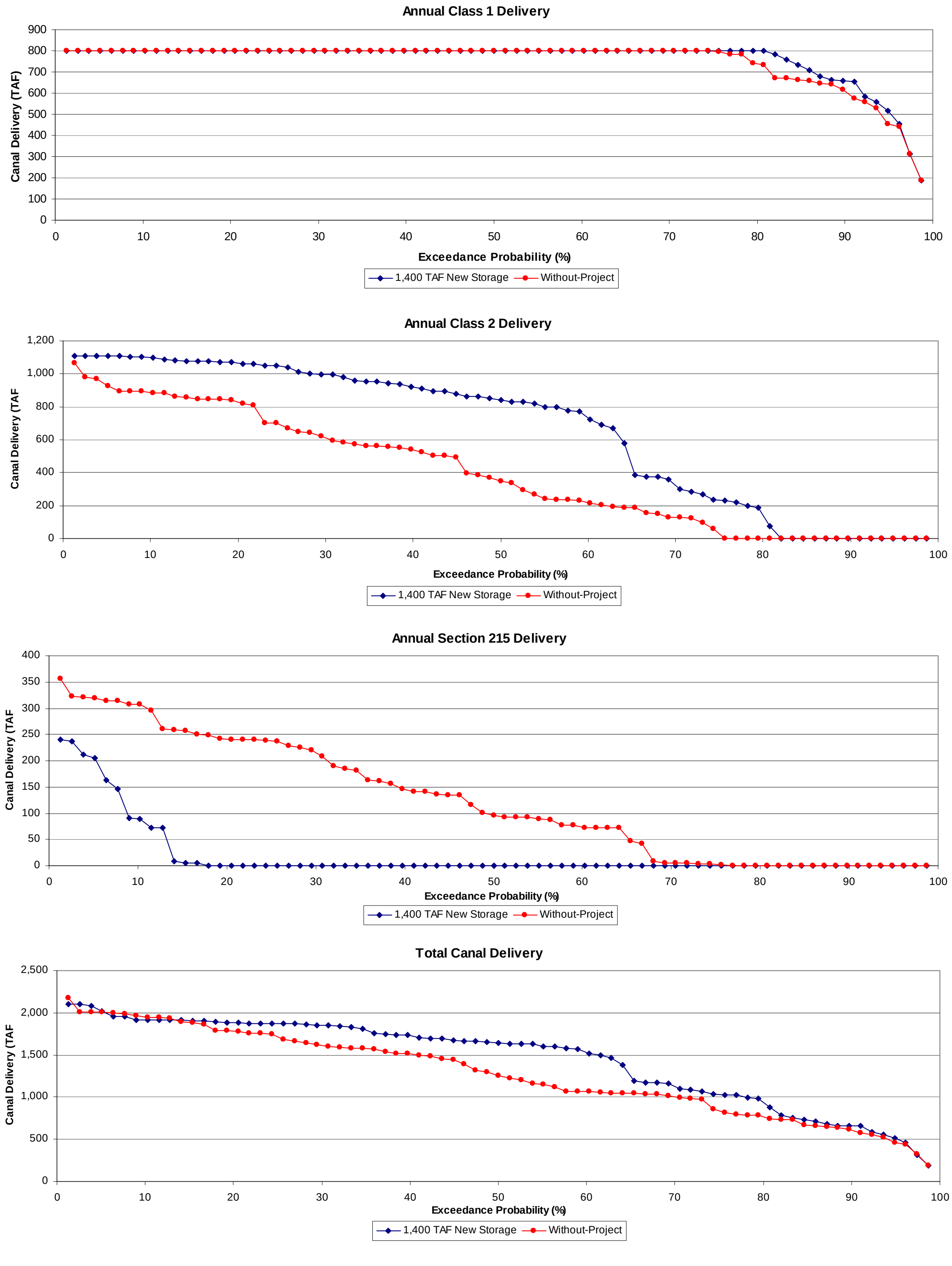

FIGURE 3-12.
FRIANT DIVISION DELIVERY RESULTS FOR SCENARIO 5

Operations Scenarios Effects on Friant Releases to the San Joaquin River

This section shows how an additional1,400 TAF of new storage could affect releases from Friant Dam to the San Joaquin River under the operations scenarios. Figures show simulated annual releases from Friant Dam to the San Joaquin River for existing requirements, flood spills, and increased releases to the San Joaquin River for the simulation period of 1922 through 1999. **Figure 3-13** shows annual without-project condition releases to the San Joaquin River.

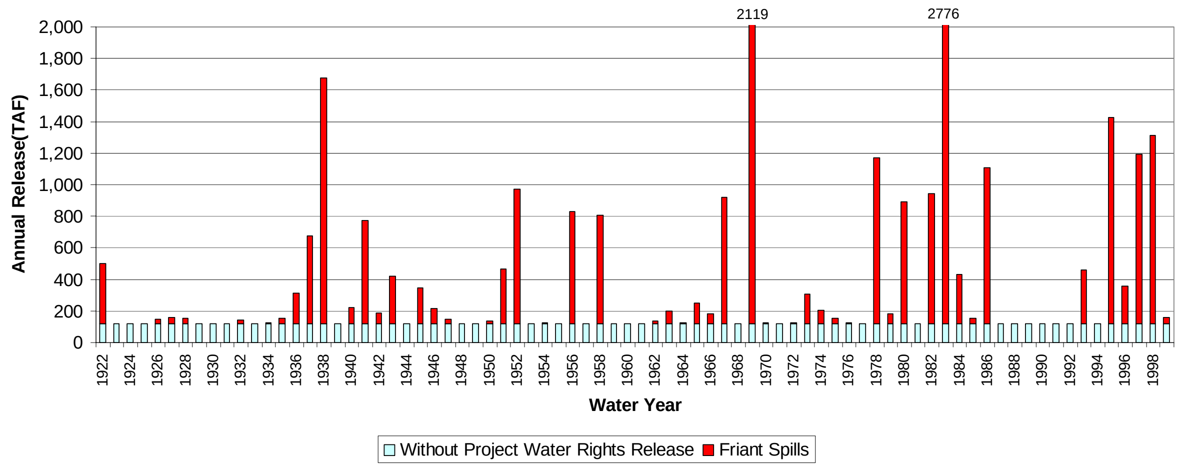

FIGURE 3-13.
ANNUAL FRIANT RIVER RELEASES FOR WITHOUT-PROJECT CONDITIONS

Scenarios 1 and 2

In Scenarios 1 and 2, the operational objective is to provide supplemental controlled releases to the San Joaquin River. Dedicated releases are based on water availability and are higher in wetter years and lower in drier years. As shown in **Figure 3-14**, compared to the without-project condition many flood control releases would be reduced or eliminated in Scenarios 1 and 2 and controlled annual river releases would increase.

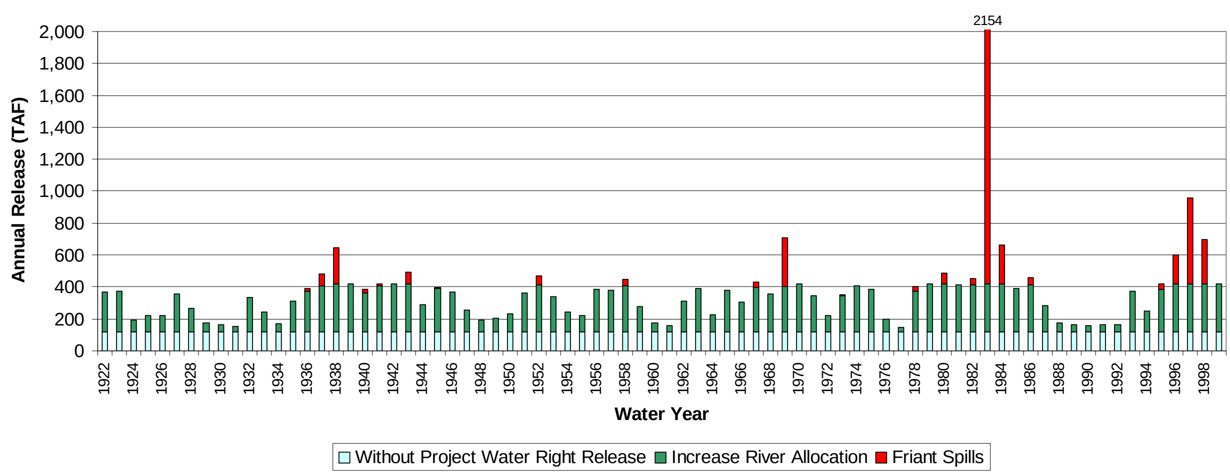

FIGURE 3-14.
ANNUAL FRIANT RIVER RELEASES FOR SCENARIOS 1 AND 2

Scenario 3

Scenario 3 would change the operational objective to provide sustained supplemental release of 175 TAF each year. This objective differs from the varying supplemental release for Scenarios 1 and 2, and is illustrated by the relatively constant annual release volume shown in **Figure 3-15**.

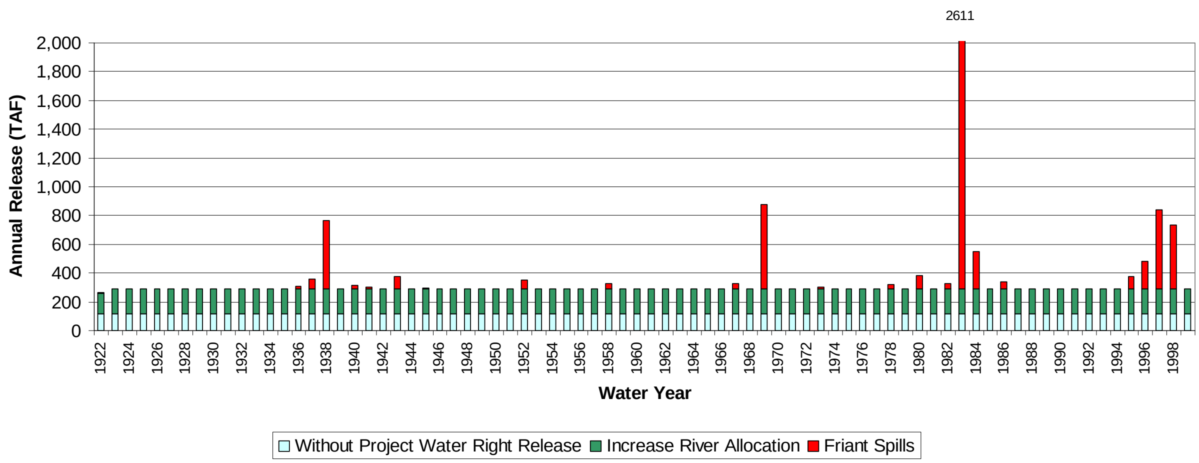

FIGURE 3-15.
ANNUAL FRIANT RIVER RELEASES FOR SCENARIO 3

Scenario 4

The operational objective of Scenario 4 is to improve San Joaquin River water quality through a change in the source water to diverters from Mendota Pool. Therefore, releases would be made in seasons and years when they would likely have the greatest influence on improving water quality. **Figure 3-16** illustrates Friant releases to the river for Scenario 4. Releases would be made in many below-normal years, while wet year dedicated releases are held to lower values. Due to the limited amount of water available, supplemental releases would be lower during drier years. The use of a carryover storage target in this scenario slightly improves this circumstance, however, the carryover rule was set low during dry years.

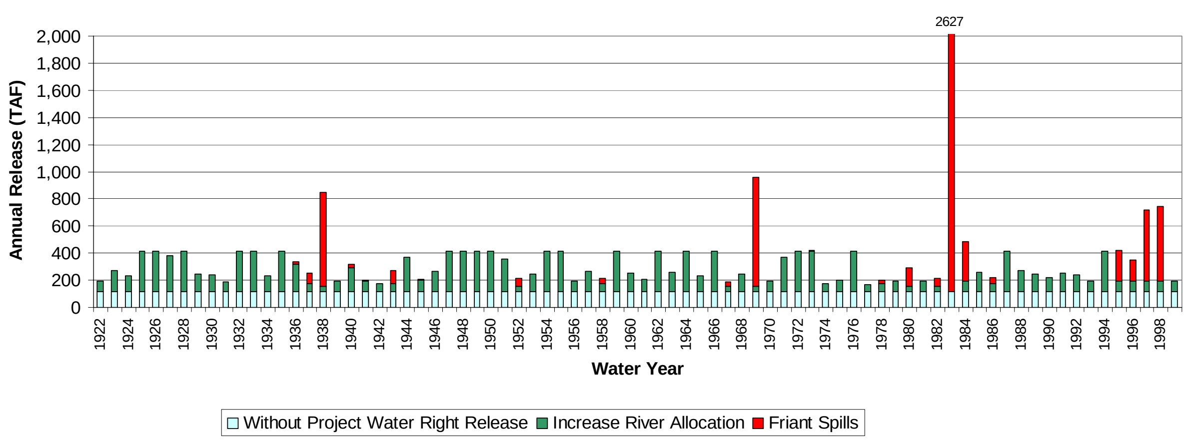

FIGURE 3-16.
ANNUAL FRIANT RIVER RELEASES FOR SCENARIO 4

Scenario 5

Figure 3-17 illustrates the effects from operating additional storage for increased canal deliveries on releases to the San Joaquin River. Existing flow requirements would be met, but flood control releases would reduce. Occasional flood control spills continue.

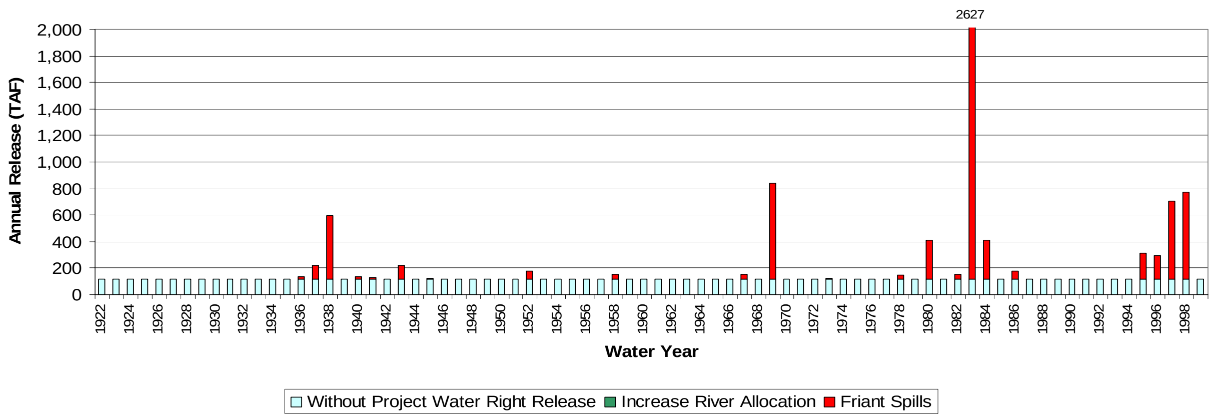

FIGURE 3-17.
ANNUAL FRIANT RIVER RELEASES AND SPILLS FOR SCENARIO 1

Mendota Pool Operations

This section illustrates how changes in San Joaquin River flows from Friant Dam could affect operations at Mendota Pool. Graphics include stacked bar charts of annual inflow to Mendota Pool from the DMC, Fresno Slough (James Bypass), and the San Joaquin River, with total annual diversions from Mendota Pool displayed as a solid line. As shown in **Figure 3-18**, total without-project inflow to Mendota Pool equals diversions in most years. In wetter years, water from the San Joaquin River or Fresno Slough that reach Mendota Pool are used to satisfy demands before DMC deliveries are required. The stacking of flood flows reflects operational priorities that direct San Joaquin River flows to the Chowchilla Bypass if James Bypass flows are available to Mendota Pool. In dry years, all demands are satisfied with DMC water supply.

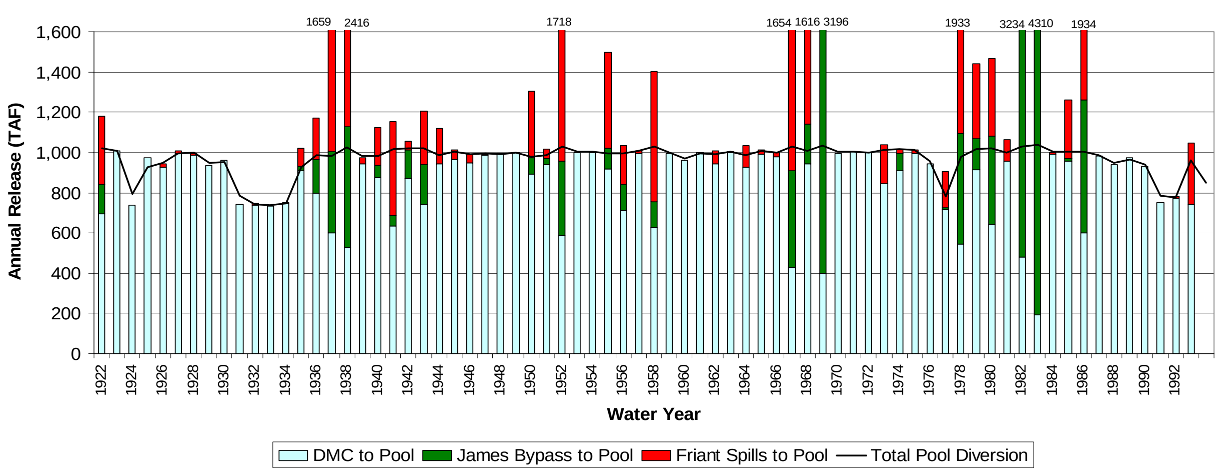

FIGURE 3-18.
MENDOTA POOL OPERATIONS FOR WITHOUT-PROJECT CONDITIONS

Scenario 1

As illustrated in **Figure 3-19**, Scenario 1 would increase the release of managed inflow to Mendota Pool by controlling the release of otherwise unused inflow to Mendota Pool (i.e. flood flows in the without-project condition). A significant portion of the supplemental release would occur when water would be diverted at Mendota Pool, which results in corresponding reductions in DMC deliveries to Mendota Pool.

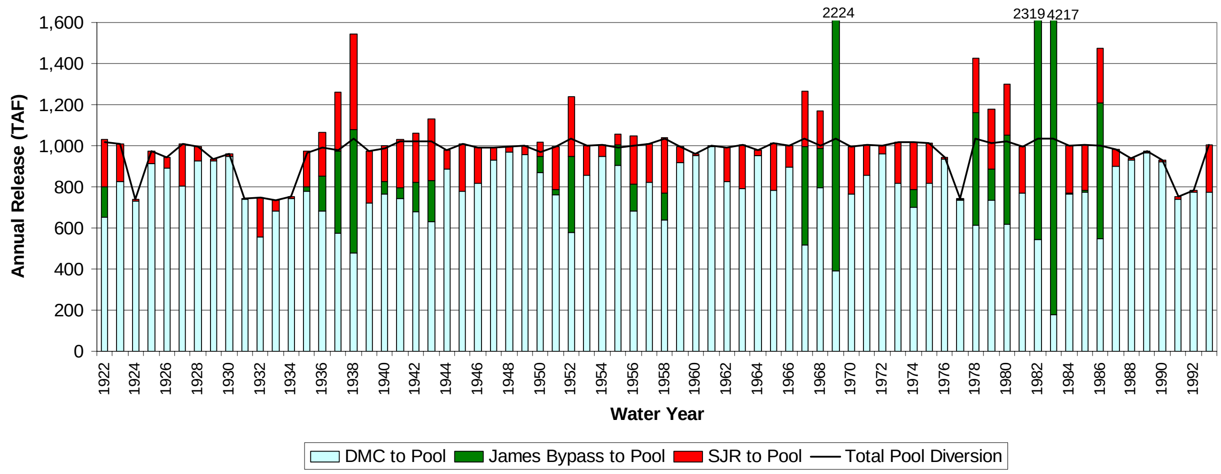

FIGURE 3-19.
MENDOTA POOL OPERATIONS FOR SCENARIO 1

Annual San Joaquin River flow upstream of the confluence of the Merced River and downstream from the Mendota Pool region is illustrated in **Figure 3-20** for Scenario 1 and other scenarios that include the diversion of San Joaquin River water at Mendota Pool. In comparison to without-project conditions, flows below Mendota Pool would reduce significantly.

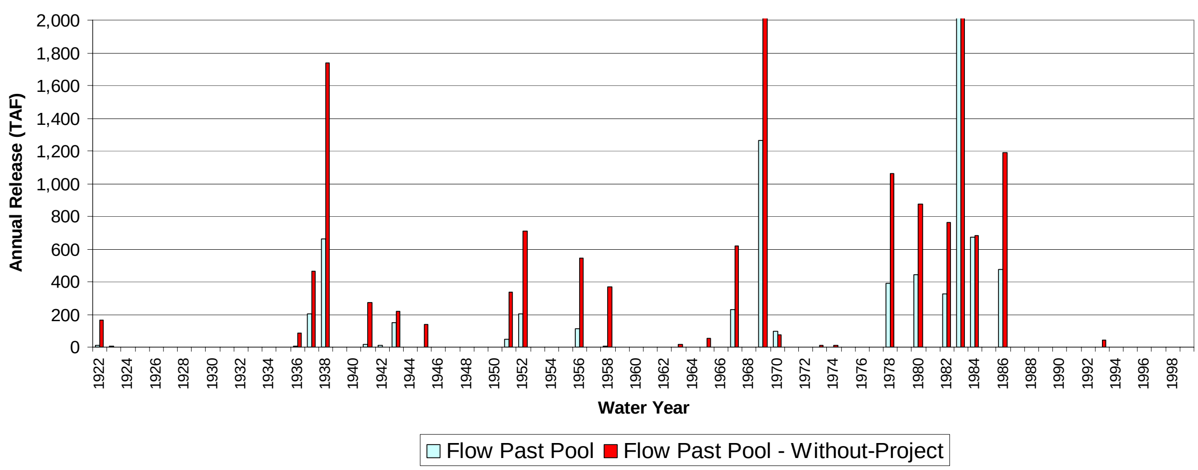

FIGURE 3-20.
ANNUAL SAN JOAQUIN RIVER FLOW DOWNSTREAM OF MENDOTA POOL FOR SCENARIOS WITH MENDOTA POOL DIVERSION

Scenario 2

Supplemental releases from Friant for this scenario are the same as provided in Scenario 1, but San Joaquin River flows would not be diverted at Mendota Pool. As seen in **Figure 3-21**, annual deliveries to Mendota Pool from the DMC would increase in Scenario 2 compared to the without-project condition. Although total supplemental releases to the river would increase in Scenario 2, the increased flows would not replace flood flows that would have been available for diversion at Mendota Pool in the without-project condition.

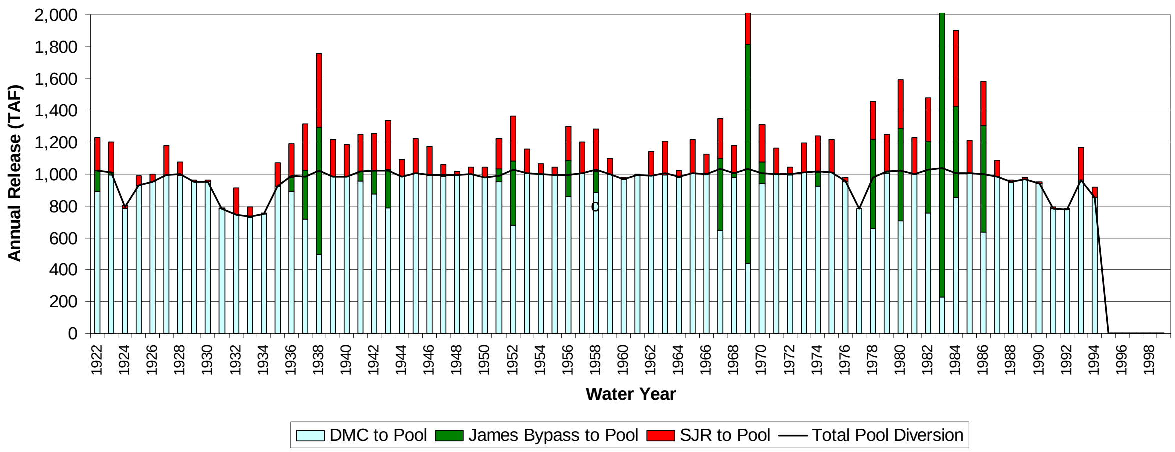

FIGURE 3-21.
MENDOTA POOL OPERATIONS FOR SCENARIO 2

Figure 3-22 compares annual San Joaquin River flow upstream from the confluence of the Merced River, and downstream from the Mendota Pool region, for Scenario 2 and the with without-project condition. In this scenario, San Joaquin River supplemental releases would not be diverted at Mendota Pool, and flows downstream of Mendota Pool would occur more frequently and larger without-project flood flows would be reduced.

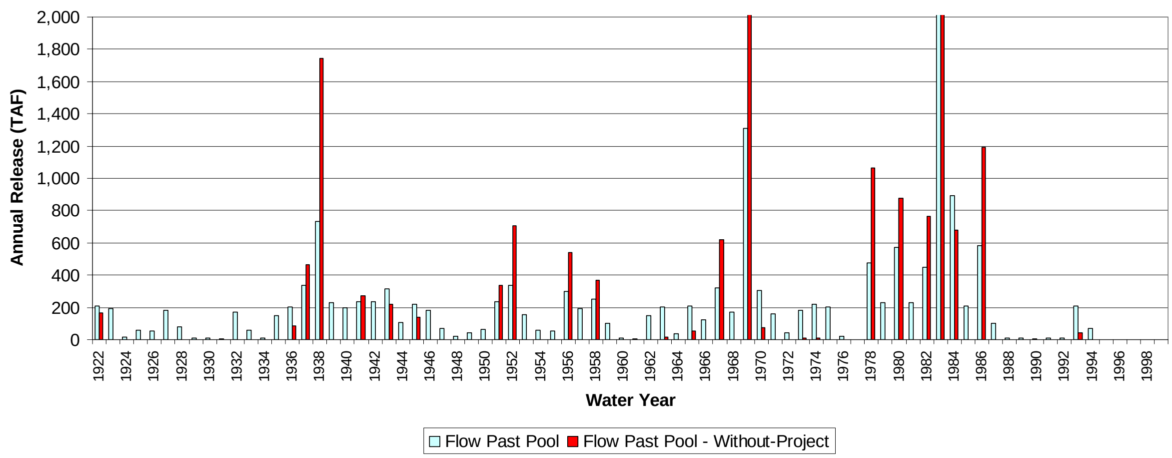

FIGURE 3-22.
ANNUAL SAN JOAQUIN RIVER FLOW UPSTREAM FROM MERCED RIVER FOR SCENARIOS WITHOUT MENDOTA POOL DIVERSION

Scenario 3

Scenario 3 would provides supplemental releases to the San Joaquin River every year and the diversion of those releases be used by the diverters at Mendota Pool. As illustrated in **Figure 3-23**, this scenario would result in a frequent use of supplemental releases for Mendota Pool deliveries and would reduce DMC supplies to Mendota Pool.

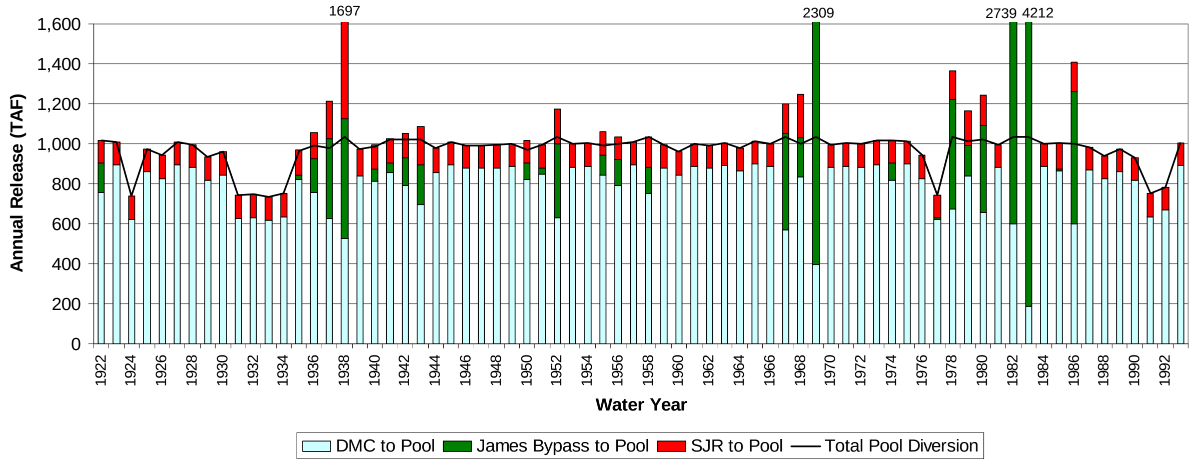

FIGURE 3-23.
MENDOTA POOL OPERATIONS FOR SCENARIO 3

Scenario 4

Supplemental Friant releases to the San Joaquin River in Scenario 4 focus on the irrigation season to reduce seepage losses and coincide with water diversions at Mendota Pool. As shown in **Figure 3-24**, the volume would vary by year, with greater volumes provided during below-normal to above-normal years.

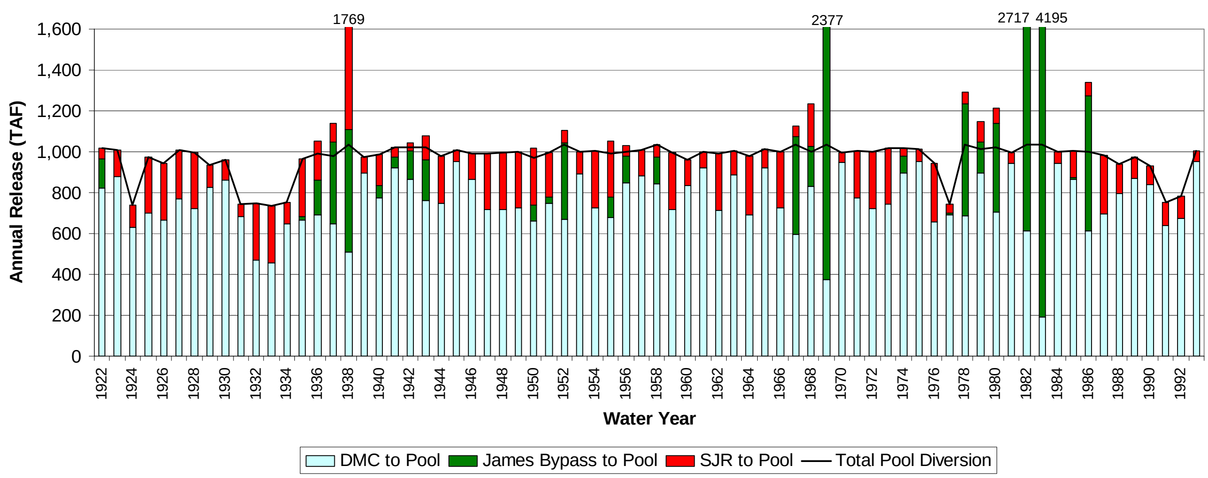

FIGURE 3-24.
MENDOTA POOL OPERATIONS FOR SCENARIO 4

Scenario 5

Scenario 5 focuses on increasing canal deliveries and would have a similar effect on Mendota Pool operations as Scenario 3. As shown in **Figure 3-25**, the frequency and magnitude of San Joaquin River flow to Mendota Pool would be reduced because of decreased flood releases. As compared to the without-project condition, deliveries from the DMC to Mendota Pool would increase slightly to meet demands.

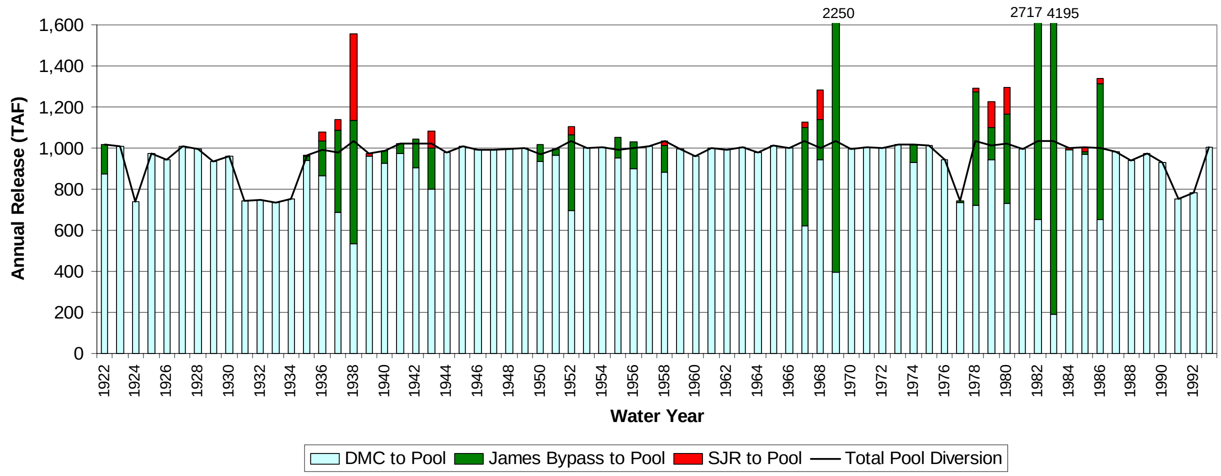

FIGURE 3-25.
MENDOTA POOL OPERATIONS FOR SCENARIO 1

POTENTIAL SYSTEM EFFECTS FROM CHANGES IN FRIANT OPERATIONS

The addition of new storage could result in significant changes in the operation of Millerton Lake and the Friant Division. As described in the previous section, releases to the San Joaquin River, water deliveries to the canals, and storage conditions are used as metrics to describe the effects of operating new storage. Changes to the operation of Friant Dam also could affect operations of other hydrologically connected (although intermittently in the without-project condition) water facilities in the study area. This section discusses several parameters that will be considered during development of hydrologic analysis or the PFR.

Friant Division Deliveries

New storage would provide operators of the Friant Division greater ability to regulate water supply, and thereby deliver water on patterns that may be more beneficial or economical. Regardless of how new water supply is allocated, the relative allocation of deliveries to Friant Division contract classes would change. In general, new storage would increase the flexibility to capture and regulate San Joaquin River flow resulting in a decreased occurrence of flood conditions and allocation of Section 215 water supply. Decreases in Section 215 supplies would correspond to an increase in Class 1 and Class 2 allocations for all operations scenarios considered. Shifts in allocations from Section 215 to Class 1 and Class 2 would likely affect the distribution of deliveries in the Friant service area. Deliveries to areas that do not have contracts for Class 1 or Class 2 water supply and can only use Section 215 supplies would reduce.

Currently, a significant portion of Friant Division contractors rely on conjunctive management and groundwater banking programs to store surplus Friant water for use during dry periods. This practice occurs within a single year or over several years. With a greater ability to regulate San Joaquin River flow, deliveries to the Friant Division could be made on patterns that more directly meet demands. This would affect groundwater use and groundwater conditions throughout the Friant service area. In particular, the frequency of short-term groundwater recharge and for subsequent withdrawal in a single year would likely reduce..

Storage Conditions

Water supplies held in storage would generally increase with the addition of new storage facilities, as shown in all scenarios evaluated. However, in many dry years storage could be similar to without-project conditions, depending on allocation and storage rules, and the management of storage conditions between existing and potential new reservoirs. For purposes of the IAIR, all new storage was simulated as an enlarged Millerton Lake. Balancing the interaction between Millerton Lake and potential new reservoir configurations will be developed for the PFR.

San Joaquin River Downstream of Friant Dam

Friant Dam flood releases would decrease with the addition of new storage, although the amount of the reduction would depend on operational objectives and size of new storage. Depending on how water supply developed from new storage is allocated, San Joaquin River flow could increase during some seasons that otherwise would have no or low flow. Methods to manage supplemental releases to the San Joaquin River, both seasonally and year-to-year, will be refined during the evaluation of restoration plans during the plan formulation stage.

San Joaquin River Flow Downstream of Mendota Pool

Depending on how water is allocated at Friant Dam, the addition of new storage could shift the volume and timing of San Joaquin River flow to Mendota Pool. If water supply developed from new storage is allocated to the San Joaquin River, flow could either be diverted at Mendota Pool or routed around the pool to provide flows to the downstream reach of the San Joaquin River. Alternative flow paths and their hydrologic characteristics were not considered in the IAIR, but will need to be defined in the evaluation of restoration plans during the plan formulation stage.

If supplemental flows are diverted at Mendota Pool, changes in DMC deliveries to Mendota Pool would result. Source water quality of Mendota Pool supply will change as a result of the supplemental flows. The effect of this change on water quality in downstream portions of the San Joaquin River will be estimated.

Groundwater Recharge from Gravelly Ford to Merced River

The evaluation of releasing new water supply to the San Joaquin River will require an evaluation of seepage from the river. Seepage would likely raise groundwater storage levels which could, in-turn, induce additional groundwater pumping. The amount of seepage will depend on the flow path of water (i.e. whether flows are conveyed directly to Mendota Pool and then diverted; conveyed to Mendota Pool and then bypassed; or routed around Mendota Pool).

San Joaquin River Flow Upstream from Merced River

Flow in the San Joaquin River upstream from the confluence of the Merced River would decrease during flood conditions as a result of developing additional storage. Flow also could increase seasonally in some circumstances,depending on how water is allocated at Friant Dam and used at Mendota Pool. In most circumstances, the flow and quality of San Joaquin River water downstream from the Merced River originating from the San Joaquin upstream of the confluence with the Merced River will differ from without-project conditions. Whether supplemental releases are routed around Mendota Pool or are used by Mendota Pool diverters, it is anticipated that the quality of the San Joaquin River would change, leading to additional potential changes in river operations within the basin.

San Joaquin River at Vernalis

Flow in the San Joaquin River will likely decrease during flood conditions. During other periods, the change in flow in the mainstem depends on the allocation of water from new storage and disposition of supplemental river releases. During the plan formulation stage, assumptions for evaluating potential San Joaquin River flow and quality effects will be developed. Currently, operation of mainstem San Joaquin River flow and quality is predicated on several multiparty agreements and regulatory requirements that do not anticipate releases from Friant Dam. The effects of Friant releases on the San Joaquin River Agreement (affecting other tributaries in the basin) and the New Melones Interim Plan of Operation will be addressed. Each of these institutional vehicles currently affects flow and quality conditions of the San Joaquin River upstream of Vernalis.

Water Quality

As discussed in a previous section, water quality in the San Joaquin River would change as a result of developing new storage, depending on the disposition of supplemental releases. Changes in water quality will occur over much of the San Joaquin River, from Gravelly Ford potentially to the Delta, and could also affect the CVP/SWP export system. The extent to which potential changes to water quality within the hydrologically connected system are analyzed and addressed will depend greatly on the breadth and detail of the hydrologic analysis below the Mendota Pool region.

Delta Conditions

The state of the Delta, being either in controlled (balanced) or excess conditions, could be changed by the operational effects of additional basin storage. It is expected that additional releases from Friant Dam evaluated in the six scenarios would affect Delta outflow during periods when the Delta is in balanced conditions. However, when flood flows are captured by new storage, it is possible that surplus Delta outflow could be reduced. Because a significant portion of flood releases from Friant Dam do not enter the Delta due to seepage and, in high flow periods, discharge to the floodplain resulting from levee breaks, the decrease in surplus may be less than spills captured by new storage. It is possible that changes in surplus San Joaquin River flow could move the position of X2, the salinity criteria of two parts per thousand that must be maintained in Suisun Bay, during the spring runoff period.

CVP and SWP Delta Exports

A change in Friant Dam releases has the potential to influence CVP and SWP export operations. As described above, decreases in Friant spills could affect the magnitude of Delta surplus, and therefore, water available for export. However, increases in Friant water supply allocation or San Joaquin River flow to Mendota Pool may offset this effect.

South-of-Delta Deliveries

The effects to SOD deliveries from changes in Friant operations are highly dependent on how developed water supply is allocated at Friant, and operational decisions at Mendota Pool. Deliveries could decrease due to reduction in Friant flood releases, but could also be increase depending on the allocation and disposition of supplement releases.

San Luis Reservoir Storage

The operation of San Luis Reservoir could be affected as CVP and SWP Delta exports react to changes in Delta conditions and demands at Mendota Pool.

Sacramento River Inflow to Delta

As described above, changing operations at Friant Dam has the potential to affect operations at Mendota Pool and in Delta exports and San Joaquin River inflow to the Delta. These changes have the potential, although low, to affect required Sacramento River releases into the Delta.

CHAPTER 4. ANALYTICAL TOOLS

The joint DWR/Reclamation CALSIM II (CALSIM) planning simulation model is the primary analytical tool that has been, and will be, used to evaluate water operations for the Investigation. The screening model developed for use in the IAIR analysis aided in establishing operational rules and mathematical algorithms, and performing preliminary simulations. Operations rules and mathematical algorithms developed using the screening model will be incorporated into CALSIM to perform more comprehensive analysis of storage alternatives during the plan formulation stage of the Investigation.

CALSIM

CALSIM simulates the State and Federal projects and many local projects on a monthly timestep from 1922 through 1994. CALSIM encompasses the operation of major Sacramento River basin reservoirs, including Trinity, Shasta, Oroville, and Folsom; operations of major San Joaquin Basin reservoirs, including New Melones, Don Pedro, Exchequer, and Millerton; and operations of numerous smaller reservoirs. Current flow and regulatory standards throughout the water system are included as constraints in the model, including Delta salinity standards.

CALSIM's representation of Millerton depicts current Friant Division water diversions and operations during a long-term simulation period. Canal diversions vary from year to year based on an annually varying water supply. The monthly distribution of an annual diversion is based on historical delivery practices of the water users. Minimum required releases below Friant Dam for riparian and contractual users are modeled as a constant annual requirement, consistent with recent records of operations. Flood control operations for Millerton and the lower San Joaquin River are based on rainflood space reservation requirements specified by the United States Army Corps of Engineers (Corps). Flood control operation during the snowmelt runoff period recognizes the competing objectives of water supply and flood control and attempts to maximize water supply carryover storage (into summer) while reducing the potential for downstream flooding.

IAIR SCREENING MODEL

The without-project Millerton operation was first developed in a spreadsheet for the Friant Water Users Authority (FWUA)/Natural Resources Defense Council (NRDC) settlement process, and then was incorporated into CALSIM using the same operational logic and mathematical algorithms as the spreadsheet simulation model. CALSIM and the spreadsheet model produce consistent representations of Millerton operations. The spreadsheet model of Millerton has been enhanced to serve as the screening model tool for the Investigation. Enhancements include rules for carrying over water from wetter years to drier years, incorporating rules to allocate water to the San Joaquin River based on water availability, and including Mendota Pool operations.

Although the spreadsheet simulation model has been enhanced, it still contains a simplified representation of the water system and new storage. Increases in Millerton storage are used as a surrogate for all new storage options being analyzed in the Investigation. The intent of the screening model is to explore various ways new water supply might be allocated, and to develop allocation strategies that can be incorporated into CALSIM. Once allocation strategies have been developed, CALSIM will be used to perform a more comprehensive analysis, including integrated operation of new facilities with existing facilities.

Description of Screening Model Parameters and Allocation Rules

The screening model includes input parameters to specify size of new storage, the ability to divert San Joaquin River flow at Mendota Pool, carryover storage targets based on available water supply, and allocations of releases to the San Joaquin River based on water supply. The screening model uses an enlarged Millerton Reservoir as a surrogate for all new storage facilities under investigation, allowing new storage to be fully integrated in the model by using existing water allocation, flood operations, and operations logic. Any size of new storage can be input to the screening model and be fully integrated in simulated Friant Division operations.

Mendota Pool operations are included in the screening model by using output from a CALSIM model simulation to specify without-project deliveries from Mendota Pool. DMC deliveries to Mendota Pool are calculated by the model based on available San Joaquin River flow. As Friant releases to the San Joaquin River and resulting flows to Mendota Pool change, DMC flow to Mendota Pool changes as needed to preserve without-project diversions. An input parameter specifies whether or not diversion of San Joaquin River water will occur at Mendota Pool.

A rule to specify a target end-of-September carryover storage based on available water supply has been incorporated into the screening model. The rule is used to specify higher carryover targets in years with greater available water supply, and lower targets in drier years with lower allocations. This rule allows new storage to be operated to provide water supply reliability in drier years.

A rule to allocate water to the San Joaquin River has been incorporated into the screening model based on water supply availability. This rule can be used to allocate water based on a range of operational objectives. The allocation can be structured to allocate more water to Friant releases as water supply increases, or it can be used to target reliability in Friant releases during drier years.

CHAPTER 5. NEXT STEPS

As the Investigation proceeds to the plan formulation stage, several modeling refinements will be performed to support formulation and evaluation of multiple-purpose alternatives. The following sections briefly describe the anticipated development of water operations models to support plan formulation technical evaluations.

PLANNED CALSIM MODEL REFINEMENTS

Several refinements will be made to the CALSIM model to incorporate the operation criteria developed and evaluated through use of the screening model. Additional planned refinements involve extending the hydrologic period and better defining the interactions of hydrology and water quality upstream from the Merced River. Further refinements to methodology and assumptions will likely be identified during the plan formulation stage when guidance and comments are received from cooperating agencies, stakeholders, and interested participants, and as the breadth of analysis is better defined.

Extend Hydrologic Period of Record

CALSIM currently simulates the 1922 through 1994 hydrologic period, which will be extended to include the period from 1995 through 2003. The 1995 through 1998 time frame is a wet period in the San Joaquin River watershed and 1999 through 2003 is a below-normal period in the watershed. The addition of these years in the analysis will provide greater insight on potential benefits and operations of new storage. It is anticipated that inclusion of these additional years in the hydrologic record will cause only a small change in the quantity of water available in the upper San Joaquin River watershed, and therefore, the estimated water yield of the storage measures would not change significantly.

Refine Estimation of Stream Gains and Losses

The current CALSIM model does not simulate flow in the San Joaquin River from Friant Dam to the confluence of the Merced River in a manner that could adequately support evaluations of restoration plans and changes in water quality. To support plan formulation, representation of this reach of the river will be disaggregated in CALSIM to better simulate existing operations and to support the development of water quality estimation analytical tools. A flow balance approach will be employed for each river reach to depict hydrology from Friant Dam to the confluence with the Merced River. As available, historical flow measurement locations will be used to guide development of river reaches. Each river reach will be depicted by a loss function using either historical flow data or commonly acceptable methods to estimate gains and seepage losses to address its distinctive hydrology. The following six reaches will be represented:

- Friant Dam to Gravelly Ford
- Gravelly Ford to Chowchilla Bypass
- Chowchilla Bypass to Mendota Pool
- Mendota Pool to Sack Dam
- Sack Dam to East Side Bypass
- East Side Bypass to Merced River

CALSIM also will be revised to improve the depiction of refuge delivery quantities, their operation, and their connectivity with the San Joaquin River. This will involve a refinement in mapping the route of refuge water from delivery point to return point.

WATER QUALITY TOOL DEVELOPMENT

Evaluations during plan formulation will focus on how storage can be operated to contribute to restoration and improve water quality in the San Joaquin River. Several water-quality-related analytical tools will be required to support these evaluations, as described in the following sections.

San Joaquin River Water Quality

As part of the hydrologic refinement process, several hydrologic components describing the flow network will be disaggregated for calculation of San Joaquin River water quality. Water quality attributes will be assigned to each hydrologic component and a linkage between source water and return flows will be established. This evaluation will entail close coordination with stakeholders and will rely on information from other studies, such as the Exchange Contractors' work in relating the quality of delivered water and resulting return flows. Information collected by Reclamation and others during a sustained flood release from Friant Dam during spring 2005 also will be used to the extent possible. A refinement of refuge water quality will be based on an "in-progress" model developed by Reclamation.

Reservoir and San Joaquin River Water Temperature

It is anticipated that some restoration plans will include requirements related to water temperature released from Friant Dam. Evaluating how storage can contribute to restoration will require developing and applying reservoir water temperature models for existing and potential expanded configurations of Millerton Lake, and for all other surface storage measures included in initial alternatives. The models would simulate changes in reservoir temperature in response to changes in inflow, storage, and ambient atmospheric conditions. Reservoir temperature models will calculate the temperature and volume of water in storage at various levels in each reservoir. The models may include attributes to support evaluation of selective withdrawal of water from specific reservoir depths.

Temperature evaluations also will be needed at key locations in the San Joaquin River. A river temperature model will be developed that can estimate changes in water temperature along the river in response to releases from Friant Dam, losses, gains from local streams, inflow from the DMC, agricultural return flows, and ambient atmospheric conditions. Both the reservoir and river temperature models will be developed in close coordination with agency stakeholders and will use information from other ongoing studies to the extent possible.

DEVELOPMENT OF MULTIPLE-PURPOSE SCENARIOS

Preliminary evaluations have demonstrated that water allocated to a specified project purpose also may contribute to other project purposes. As the investigation proceeds, scenarios will be developed to address multiple operational objectives rather than targeting single purposes.

Allocation and Storage Rules to Support Multiple Purposes

Development of multiple-purpose operational scenarios will require developing several key decision-making features in the CALSIM model. These scenarios will include a set of rules to guide allocation and reservoir storage levels based on a broad range of objectives that could include river restoration needs, reservoir water temperature, water delivery objectives, reservoir biological conditions, hydropower operations, flood management, and recreation. As discussed in this TA, a screening model was developed to help formulate preliminary allocation and storage rules during preparation of the IAIR. The screening model will continue to be used for this purpose as operational objectives for multiple purposes are developed. Information to guide reservoir operations in support of some of the possible operational objectives will be developed through the cooperating agency technical teams.

Project-Specific Operations

Integrated operation of proposed facilities with the existing system for various operational objectives will be evaluated. Proposed facilities will be integrated into the existing system in recognition of the unique characteristics associated with each facility. Integrated operations will evaluate strategies to balance storage levels among facilities in a manner that maximizes the ability to meet project objectives.

Potential Downstream Recapture of Released Water

It is possible that the new water supply that could be developed with additional storage would not be sufficient to support the flow objectives of all restoration plans. The Investigation also may consider opportunities to release some currently allocated water supplies that could be recaptured at downstream locations, thereby increasing flows for restoration and potentially improving water quality in the San Joaquin River. Recapture provides an opportunity to convey all or a portion of the water released for restoration or water quality purposes to Friant Division water users. The manner of recapture is defined by the rules for the operation and by the facilities that could enable downstream recapture of Friant Dam releases for offsetting diversions to the Friant-Kern Canal.

Two approaches have been identified to convey and use recaptured water. The first, direct return, involves water that would be immediately conveyed to lower Friant-Kern Canal water users to offset diversion requirements at Friant Dam in the month of recapture. The second, stored return, involves regulation of recaptured water with San Luis Reservoir storage. The application of these recapture approaches could increase the quantity of sustainable releases from Friant Dam without the reallocation of existing water supplies. Downstream recapture will not be included in initial alternatives, but may be added to address specific restoration flow and water delivery objectives.

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CHAPTER 6. LIST OF PREPARERS

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