DRAFT Technical Memorandum

Temperature Model Sensitivity Analyses Sets 1 & 2

SAN JOAQUIN RIVER RESTORATION PROGRAM

Preliminary Draft Subject to Revision
February 2008

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Tables and Figures

List of Abbreviations and Acronyms

CALFED	CALFED Bay-Delta Program
cfs	cubic feet per second
DMC	Delta-Mendota Canal
DWR	California Department of Water Resources
EC	electrical conductivity
HEC	Hydrologic Engineering Center
MP	mile post
PEIS/R	Program Environmental Impact Statement/Report
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
Settlement	Stipulation of Settlement
SJRRP	San Joaquin River Restoration Program
SJRRHRP	San Joaquin River Riparian Habit Restoration Program
SJR5Q	San Joaquin River HEC-5Q model
TM	Technical Memorandum
USACE	U.S. Army Corps of Engineers

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This Draft Technical Memorandum (TM) was prepared by the San Joaquin River Restoration Program (SJRRP) Team as a draft document in support of preparing a Program Environmental Impact Statement/Report (PEIS/R). The purpose for circulating this document at this time is to facilitate early coordination regarding initial concepts and approaches currently under consideration by the SJRRP Team with the Settling Parties, Third Parties, other stakeholders, and interested members of the public. Therefore, the content of this document may not necessarily be included in the PEIS/R.

This Draft TM does not present findings, decisions, or policy statements of any of the Implementing Agencies. Additionally, all information presented in this document is intended to be consistent with the Settlement. To the extent inconsistencies exist, the Settlement should be the controlling document and the information in this document will be revised prior to its inclusion in future documents. While the SJRRP Team is not requesting formal comments on this document, all comments received will be considered in refining the concepts and approaches described herein to the extent possible. Responses to comments will not be provided and this document will not be finalized; however, refinements will likely be reflected in subsequent SJRRP documents.

1.0 Introduction

In 1988, a coalition of environmental groups, led by the Natural Resources Defense Council (NRDC), filed a lawsuit challenging the renewal of long-term water service contracts between the United States and the Central Valley Project (CVP) Friant Division contractors. After more than 18 years of litigation of this lawsuit, known as *NRDC et al. v. Kirk Rodgers et al.*, a settlement (Settlement) was reached. On September 13, 2006, the Settling Parties, including NRDC, Friant Water Users Authority (FWUA), and the U.S. Departments of the Interior and Commerce, agreed on the terms and conditions of the Settlement, which was subsequently approved by the U.S. Eastern District Court of California on October 23, 2006.

The SJRRP will implement the San Joaquin River litigation Settlement. The "Implementing Agencies" responsible for managing the SJRRP are the U.S Department of the Interior, through the Bureau of Reclamation (Reclamation) and the Fish and Wildlife Service (USFWS); U.S Department of Commerce through the National Marine Fisheries Service (NMFS); and the State of California through the California Department of Water Resources (DWR), the California Department of Fish and Game (DFG), and the California Environmental Protection Agency (CalEPA). Consistent with the Memorandum of Understanding between the Settling Parties and the State, which was signed at the same time as the Settlement, the State, through DFG, DWR, the Resources Agency, and CalEPA, will play a major, collaborative role in planning, designing, funding, and implementing the actions called for in the Settlement.

The SJRRP is a comprehensive long-term effort to restore flows in the San Joaquin River from Friant Dam to the confluence of the Merced River, ensure irrigation supplies to Friant water users, and restore a self-sustaining fishery in the river.

The Settlement has two primary goals:

- **Restoration Goal –** To restore and maintain fish populations in "good condition" in the mainstem San Joaquin River below Friant Dam to the confluence of the Merced River, including naturally reproducing and self-sustaining populations of salmon and other fish.

- **Water Management Goal –** To reduce or avoid adverse water supply impacts on all of the Friant Division long-term contractors that may result from the Interim Flows and Restoration Flows provided for in the Settlement.

Reclamation and DWR have initiated environmental compliance documentation for the SJRRP. The Implementing Agencies have organized a Program Management Team (PMT) and several Technical Work Groups to develop a plan for implementing the Settlement through a joint National Environmental Policy Act (NEPA) and California Environmental Quality Act (CEQA) process, which includes preparation of a PEIS/R. Reclamation is the lead NEPA agency and DWR is the lead CEQA agency for the SJRRP.

1.1 Purpose of this Document

This TM presents the preliminary river temperature sensitivity analyses conducted to inform the early developmental phases of a fishery management strategy, as required for implementation of the Stipulation of Settlement (Settlement). River temperatures change with, and result from, ambient weather conditions, intended fishery management strategies, channel configurations under the Settlement, and water and temperature management at Friant Dam and upstream reservoirs. The complex interaction among these variables and actions requires an iterative approach to develop comprehensive fishery and water management options to implement the Settlement. With the first steps of this iteration in mind, the following sensitivity analyses have been constructed to highlight the effects of selected factors in a controlled analysis.

The San Joaquin River HEC-5Q (SJR5Q) model (Reclamation, 2007a) has been selected to perform these analyses. Additional temperature analyses are anticipated as the SJRRP team formulates a more comprehensive fishery and water management strategy. These additional analyses will be documented as needed separately.

The following sections provide the background of the SJR5Q, and the purpose and scope of the sensitivity analyses reported in this TM.

1.2 Background of the Temperature Modeling Tool

HEC-5Q, Simulation of Flood Control and Conservation Systems (including water quality analysis) is a generalized modeling tool developed by the Hydrologic Engineering Center (HEC) of the U.S. Army Corps of Engineers (USACE) to assess temperature in support of basin-scale planning and management decision-making (USACE, 1998).

HEC-5Q evaluates a river system's temperatures, as a result of coordinated reservoir releases throughout the system. The modeling tool simulates decision criteria for flood control, hydropower, instream flow (municipal, industrial, irrigation, water supply, and fish habitat) and water quality requirements. A comprehensive graphical user interface assists with the input of data and parameters, and the presentation of results.

In the late 1990s, under a collaborative effort proposed by the stakeholders, the Stanislaus Water Temperature Model was developed in HEC-5Q. This model included the New Melones Reservoir, Tulloch Reservoir, Goodwin Pool, and approximately 60 miles of the Stanislaus River from Goodwin Dam to the confluence with the San Joaquin River. Beginning in 2002, the CALFED Bay-Delta Program (CALFED) sponsored a project to extend the model to include the Tuolumne and Merced rivers below Lake Don Pedro and Lake McClure, respectively, and the San Joaquin River between Stevinson and Mossdale.

In 2005, the San Joaquin River Riparian Habitat Restoration Program (SJRRHRP) engaged in efforts to extend the development of water temperature models for Millerton Lake and the San Joaquin River. The SJRRHRP has been conducted since 1997 by the U.S. Department of the Interior, Bureau of Reclamation (Reclamation), under the authorization of the Central Valley Project Improvement Act to bring together diverse interest groups to promote the development of consensus-based riparian restoration, and to fund or support various restoration programs, activities, and efforts beneficial to restoration of the San Joaquin River.

SJR5Q was developed, for the SJRRHRP, to evaluate San Joaquin River temperatures. SJR5Q computes the vertical or longitudinal distribution of temperature in the reservoirs and longitudinal temperature distributions in stream reaches based on daily average flows, heat budgets, and daily hydrology and meteorology. The model runs calculations on a 6-hour interval. Observed historical 2000 through 2005 flow and temperature data were used for calibration purposes. Hydrodynamics related to the modeling environment, such as riparian shading, wind speed scaling, and substrate interaction, were set up in the model.

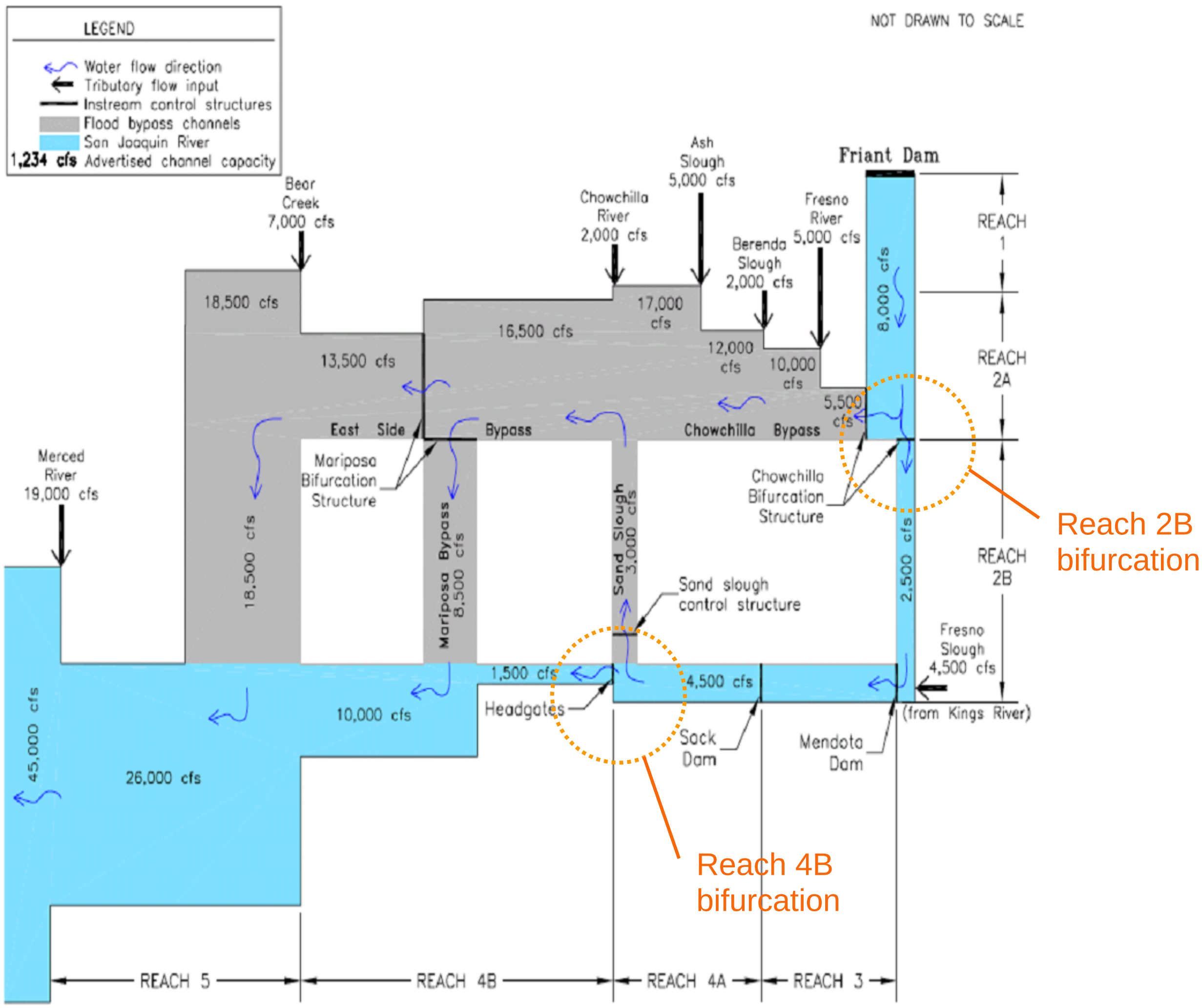
Details of this model are documented in the report San-Joaquin Basin Water Temperature Modeling and Analysis (Reclamation, 2007a). SJR5Q is used to evaluate temperature and conservative water quality constituents (e.g. electrical conductivity (EC)) in basin-scale planning such as the development of total maximum daily load regulations.

SJR5Q was selected to provide early information to the SJRRP Team in planning efforts, focusing on assistance to the Fishery Management Work Group. The sensitivity runs reported in this TM are part of those efforts.

1.3 Physical Scope for Modeling

SJR5Q can be expanded to include the entire San Joaquin River basin system (e.g., extending the mainstem San Joaquin River from Friant to the Old River and including tributaries, such as the Stanislaus, Tuolumne, and Merced rivers). However, the current configuration is limited to the mainstem channel between Friant Dam and the confluence of the Merced River (Reaches 1 through 5).

The modeling area for the San Joaquin River system and two major flow split locations are shown in Figure 1-1. Table 1-1 summarizes information on mile post (MP) locations and flood bypass reaches (i.e., flow splits) for both sets of sensitivity analysis. For reference, the physical elevations of the river outlets, canals, and minimum operating levels at Friant Dam are shown in Figure 1-2. Note that the current model does not include the Mendota Pool Bypass, which is called for in the Settlement.



Source of background schematic: San Joaquin River Restoration Study Background Report, Figure 2-44 (December, 2007).

Figure 1-1
Schematic for San Joaquin River Between Friant Dam and Merced River Confluence Under Existing Conditions

Table 1-1
Modeling Locations, Elements, and Mile Post Locations

Index	River	Reach	Name	Model Element*	Mile Post Location
1	San Joaquin River	1A	Friant Dam	1	264.3
2	San Joaquin River	1A	Ledger Island	13	258.7
3	San Joaquin River	1A	Highway 41	25	252.7
4	San Joaquin River	1A	Scout Island	36	247.1
5	San Joaquin River	1A/1B	Highway 99	47	241.5
6	San Joaquin River	1B	Highway 145	63	232.5
7	San Joaquin River	1B/2A	Gravelly Ford	75	225.7
8	San Joaquin River	2A/2B	Bifurcation Structure	95	214.3
9	San Joaquin River	2B	Mendota Pool Upstream	109	207.6
10	San Joaquin River	2B/3	Mendota Pool Outlet	112	202.3
11	San Joaquin River	3	Firebaugh	127	193.6
12	San Joaquin River	3/4A	Sack Dam	147	180.6
13	San Joaquin River	4A	Highway 152	159	172.3
14	San Joaquin River	4A/4B	Sand Slough	167	166.8
15	San Joaquin River	4B	Mariposa Bypass	193	146.0
16	San Joaquin River	4B	Bear Creek Confluence Upstream	276	134.0
17	San Joaquin River	5	Bear Creek Confluence Downstream	279	133.5
18	San Joaquin	5	Merced River Confluence Upstream	298	116.6
19	San Joaquin	5	Merced River Confluence Downstream	306	115.8
20	Chowchilla Bypass	CB	Avenue 7 Bridge	200	179.9
21	Chowchilla Bypass	CB	Fresno River	211	169.9
22	Chowchilla Bypass	CB	Ash Slough	218	164.4
23	Chowchilla Bypass	CB	East Side Bypass (upstream from confluence)	230	153.9
24	Eastside Bypass	EB1	East Side Bypass (upstream boundary)	233	153.1
25	Eastside Bypass	EB1	Chaimberlain Road	236	150.4
26	Eastside Bypass	EB1	Sandy Mush Road	240	146.8
27	Eastside Bypass	EB1/EB2	Mariposa Bypass	243	144.2
28	Eastside Bypass	EB2	Green House Road	246	141.8
29	Eastside Bypass	EB2	Bear Creek Confluence	250	138.3
30	Bear Creek	Bear	San Joaquin River Confluence	278	134.0

Note:
*Corresponds to column C in "Element-River Mile-Location" sheet.
Key: CB = Chowchilla Bypass EB = East Side Bypass

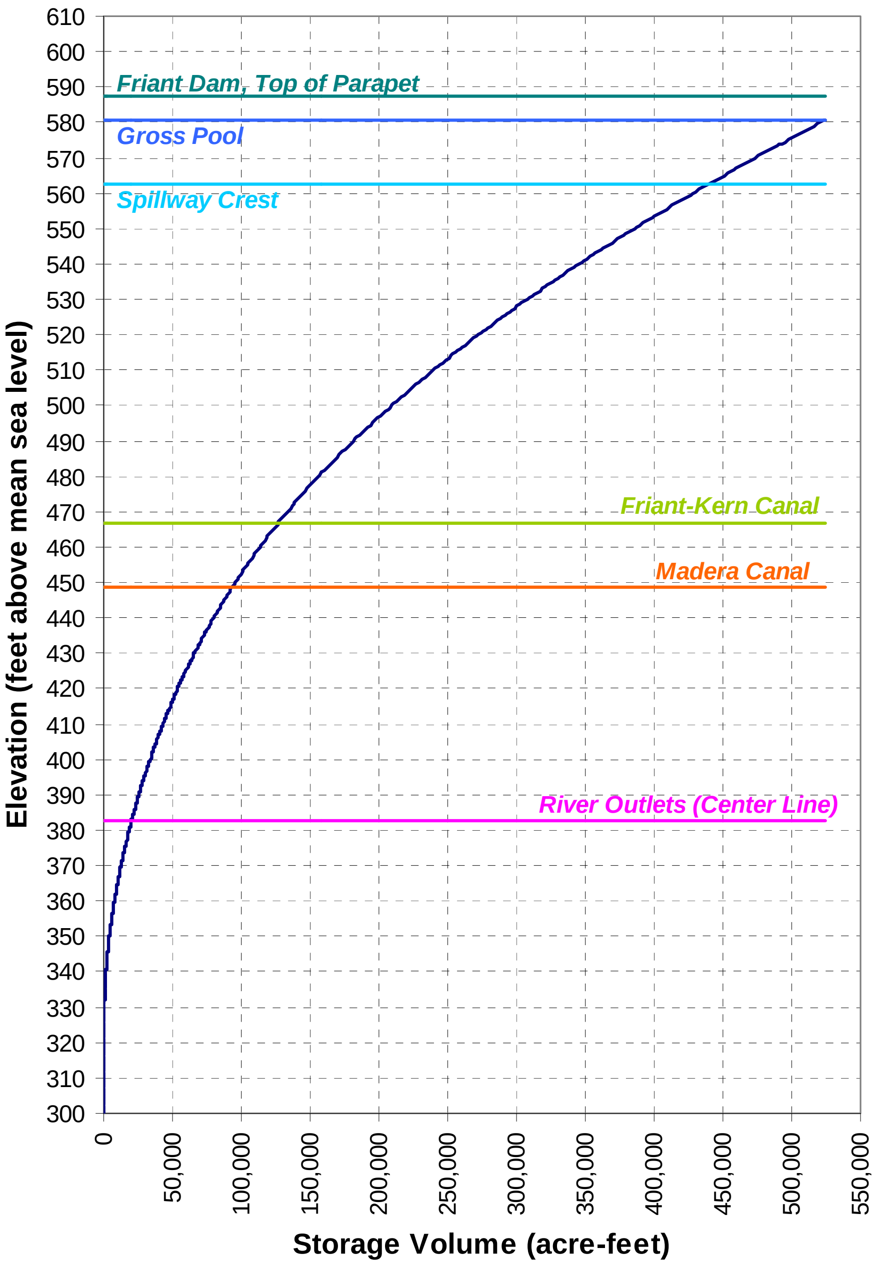


Figure 1-2
Storage-Elevation Relationship of Millerton Lake, and Elevations of Existing Outlets at Friant Dam

1.4 Sensitivity Sets 1 & 2

The following briefly summarizes the Sensitivity Analysis Sets 1 & 2 in terms of their purposes and operational scenarios for evaluation. The scope of these analyses is to provide additional information for ongoing development of SJRRP alternatives and management plans. These analyses are not intended to provide a detailed evaluation of Friant Dam operations and temperature management actions because many important features of channel modification and associated fishery and water management strategies are still under development.

Results of these two sets of sensitivity analyses are provided in Sections 2 and 3.

1.4.1 Sensitivity Analysis Set 1

Sensitivity Analysis Set 1 evaluates the effects of major flow splits in Reach 2B and Reach 4B on temperature, under existing operations. (Existing operations were based on the historical operation of Friant Dam, a set of assumed flow bifurcations for Reach 2B and Reach 4B, and the existing channel connectivity and configuration.)

At Reach 2B, it was assumed that flow above 4,500 cubic feet per second (cfs) would be diverted into the Chowchilla Bypass. There are no additional flow split scenarios at this location. For Reach 4B, three flow split scenarios were evaluated with assumed river capacity of 0, 475, and 4,500 cfs.

The effects of different meteorological conditions, hydrologic conditions and downstream inflows under existing operation are also discussed in the results. .

1.4.2 Sensitivity Analysis Set 2

Sensitivity Analysis Set 2 evaluates the extent to which Friant Dam releases control downstream river temperatures, independent of reservoir operations.

The operation of Friant Dam would affect the ability to provide temperature management in the San Joaquin River below the dam, and is related to other water management objectives such as providing water delivery to existing contractors via the Friant-Kern Canal and Madera Canal, which might have subsequent effects on managing the limited cold-water resources in Millerton Lake. Therefore, this analysis is only intended to evaluate the sensitivity of river temperatures to both release rates and temperatures at Friant Dam.

1.5 Future Studies

It is anticipated that additional sensitivity analyses could be performed during the alternatives formulation phase of SJRRP development. These sensitivity analyses would be developed as needed, and documented separately when completed. After program alternatives are formulated, sensitivity analyses would be concluded and alternatives evaluation would begin.

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2.0 Sensitivity Analysis Set 1

This section describes the modeling objectives, approach, assumptions, and results for the Sensitivity Analysis Set 1 under existing conditions with different flow splits.

2.1 Objectives

The objectives of the Set 1 analyses are as follows.

- To investigate the use of the Millerton Lake cold-water pool under existing operations (i.e., without Settlement conditions).
- To examine the impact of temperature differences from flow splits at the upstream end of Reach 2B and Reach 4B
- To examine the temperature effects of ambient conditions and downstream inflows.

As previously mentioned, these analyses are intended to inform the development of SJRRP alternatives and management plans. These analyses are not intended to evaluate Friant Dam operations or other temperature management plans or actions because many important features of the fishery and water management strategies are still under development.

2.2 Approach

Flow split scenarios are summarized as follows.

- **Flow split at the Chowchilla Bifurcation Structure –** Assume a flow capacity of 4,500 cfs in Reach 2B to the Mendota Pool; excess flow is diverted to Chowchilla Bypass. This assumption results in small bypass flows except during periods of elevated local inflows (storm events).
- **Flow split at Sack Dam –** Assume a flow capacity of 0, 475, and 4,500 cfs in Reach 4B below Sack Dam in three separate model simulations

Many of the modeling inputs and parameters were taken from previous studies and records for the past 20 years. DWR's timeseries of unimpaired runoff below Friant Dam was used as the inflow timeseries to Friant Dam. The operation of Friant Dam, under existing conditions, was approximated by the record of releases and diversions from 1980 through 2005. The estimated available amount of water from March through September is based on the California Department of Water Resources (DWR) April through July San Joaquin River runoff forecast. The development of other model parameters, such as evaporation losses, river demand, storage of the upper San Joaquin River system, and all water user deliveries[1], and concurrent meteorological and hydrologic conditions, is documented by Reclamation (2007).

Channel geometry developed during the previous effort was used without considering potential future channel modifications for increased flow capacity. Flows in excess of channel capacities pass through the model but with water in excess of the levee height. Reach 4B geometry reflects the channel as defined by the USACE Comprehensive Study data set. The channel roughness specified is typical of natural channels: the existing channel is considerably overgrown, thus, this assumption assumes some vegetation removal prior to initiation of flows.

2.3 Results

Detailed modeling results are provided in Appendix A of this TM. The following paragraphs highlight modeling results of Sensitivity Analysis Set 1 for existing operations. Three types of statistics are used in summarizing modeling results:

- Median of mean daily river temperature for representing general response from the river system
- Annual traces of mean daily river temperature for demonstrating variability within a year
- Exceedence probability of mean daily river temperature for variation across years

Figure 2-1 shows the annual traces of simulated mean daily release temperature at Friant Dam. The results are independent of the downstream flow split because no temperature management actions were simulated. Release temperatures in January through May are relatively consistent in all years. Greater variance is observed in late spring through fall, suggesting varying cold-water resources availability. High release temperatures in June and July occur during Friant Dam spill events. For an extreme wet year such as 1983, the release temperature is generally high throughout the year.

Figure 2-2 shows the 90-, 50-, and 10-percent exceedence probability values of simulated mean daily release temperature at Friant Dam. Note that some irregularities occur in the 90 percent statistics for spring months; these irregularities are the direct results of the high flow temperatures associated with spill events shown in Figure 2-1. The annual trace of simulated mean daily release temperature at Friant Dam is also shown for comparison purposes.

Figure 2-3 shows the annual traces of simulated mean daily flow temperature for the San Joaquin River at Gravelly Ford, which is about 38 miles downstream from Friant Dam. Compared with Figure 2-1, flow temperatures at Gravelly Ford are higher than release temperatures at Friant Dam, suggesting significant heating along the river. The greater variance in late spring related to spills is evident. However, higher flows preserve flow temperature better, resulting in lower flow temperatures at Gravelly Ford.

[1] Water deliveries include Class 1, Class 2 and 215 allocations.

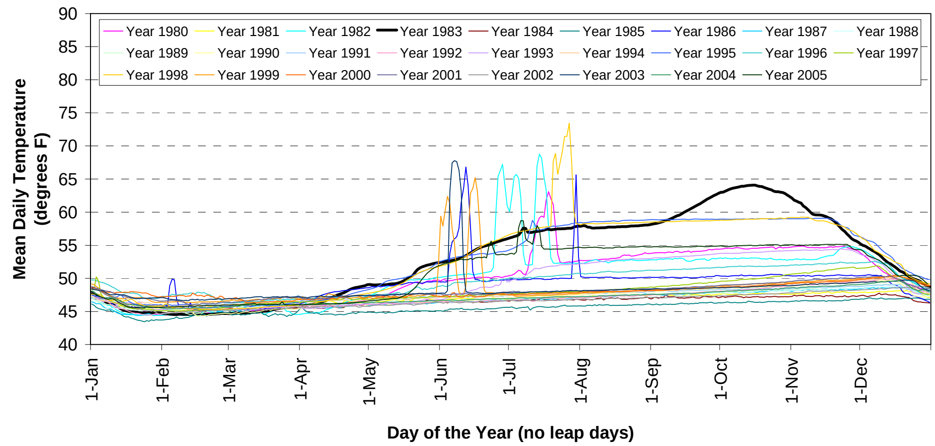

Figure 2-1
Annual Traces of Simulated Mean Daily Release Temperature at Friant Dam from 1980 Through 2005 Under Existing Operations

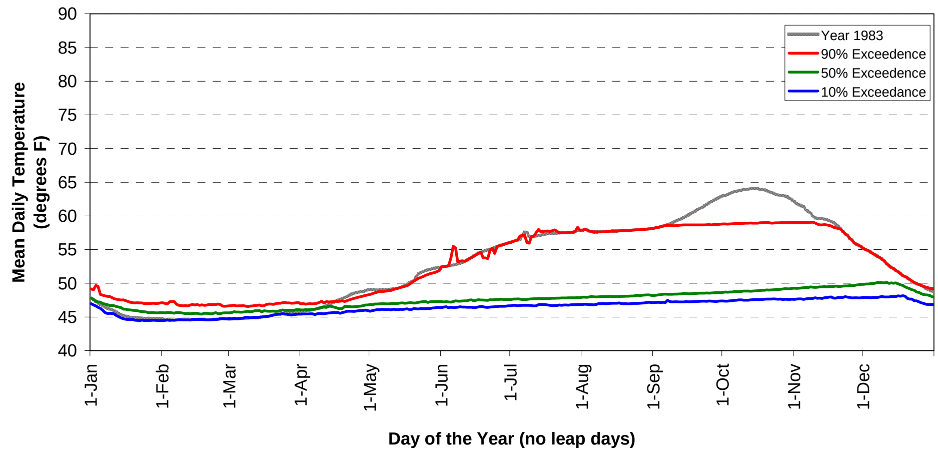

Figure 2-2
Selective Exceedence Probability Values of Simulated Mean Daily Release Temperature at Friant Dam from 1980 Through 2005 Under Existing Operations

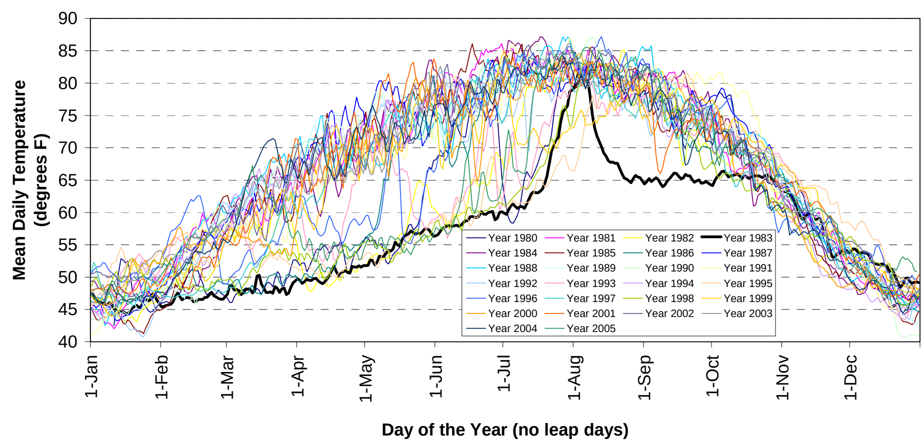

Figure 2-3
Annual Traces of Simulated Mean Daily Flow Temperature at Gravelly Ford from 1980 Through 2005 Under Existing Operations

Figure 2-4 shows the 90-, 50-, and 10-percent exceedence probability values of simulated mean daily flow temperature at Gravelly Ford. The near-parallel 90- and 50-percent exceedence probability values could result from the normal operation of Friant Dam in releasing only for riparian water rights above Gravelly Ford and, thus, the temperature of residual flows at Gravelly Ford is mostly dominated by ambient conditions.

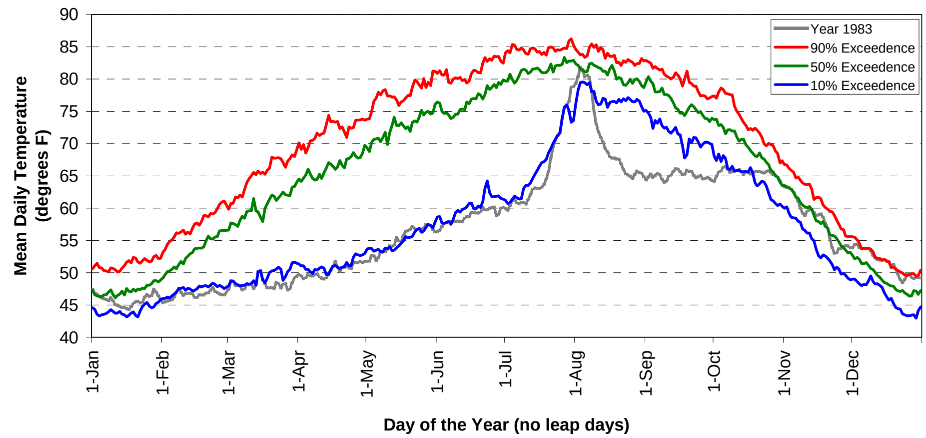

Figure 2-4
Selective Exceedence Probability Values of Simulated Mean Daily Flow Temperature at Gravelly Ford from 1980 Through 2005 Under Existing Operations

Figure 2-5 shows the 50 percent exceedence daily mean temperature profile (from Friant Dam to Mendota Pool) simulated under existing operations. The October results are used for illustrative purposes. The section of river is above Reach 4B and, thus, the results are identical in all flow-split scenarios. The simulated average heating rate between Friant Dam and Mendota Pool is about 1/3 degrees Fahrenheit per mile; however, note that these all-year, all-season statistics can only be used as a general depiction of river temperature conditions under existing operations. The heating rate gradually decreases downstream, suggesting conditions approaching equilibrium. The profile also suggests cooling effects of Delta-Mendota Canal (DMC) inflows at Mendota Pool.

Figure 2-6 shows the simulated mean daily flow temperature for all years. Results for 1983 are highlighted to show that although the flow temperature at Friant Dam is higher for this extreme wet year, the large quantity of flow helps preserve the temperature downstream.

Figure 2-7 shows 50 percent exceedence daily mean temperature profile (from Mendota Pool to the Merced River confluence) simulated under existing operations. Under existing operations, the different flow splits for Reach 4B do not have effects on the flow temperature profile below Sand Slough, suggesting dominant effects from ambient conditions.

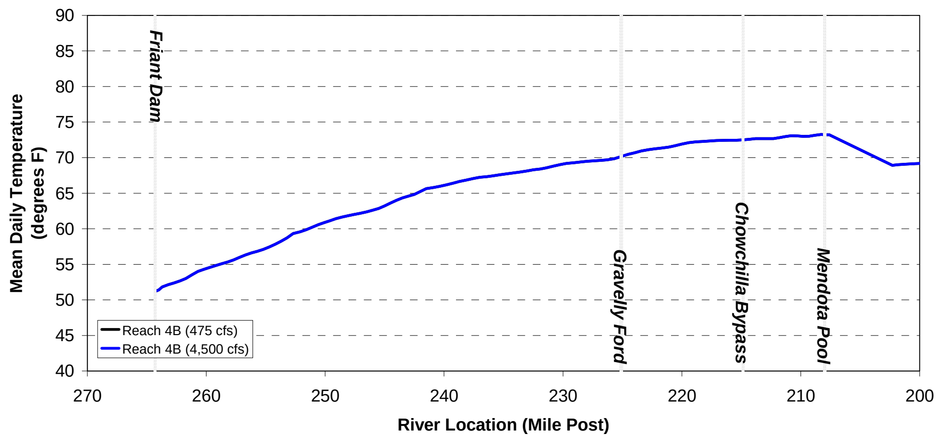

Figure 2-5
Fifty Percent Exceedence of Daily Mean Temperature Profiles for the San Joaquin River, Simulated Under Existing Operations (October, Friant Dam to Mentoda Pool)

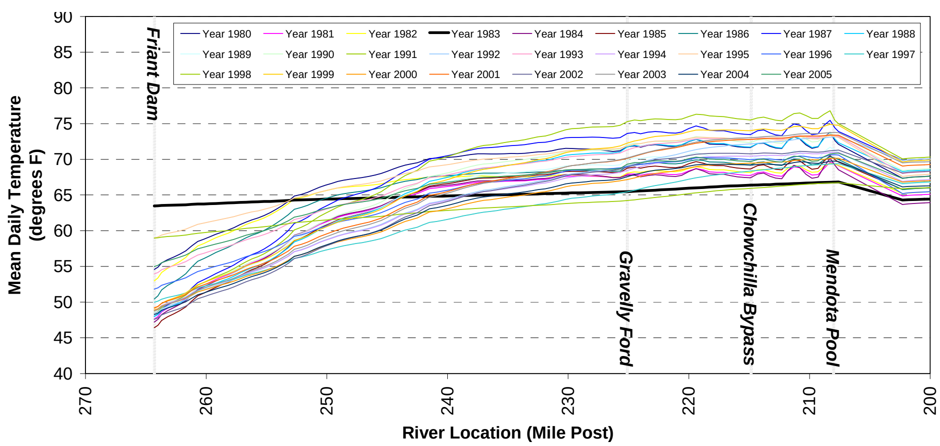

Figure 2-6
Daily Mean Temperature Profiles of the San Joaquin River Simulated Under Existing Operations (October)

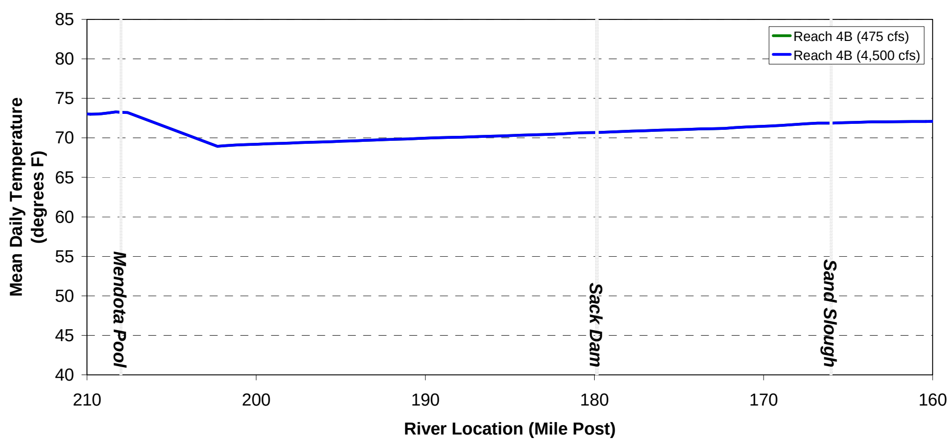

Figure 2-7
Fifty Percent Exceedence of Daily Mean Temperature Profiles for the San Joaquin River, Simulated Under Existing Operations (October, Mendota Pool to Sand Slough)

Figure 2-8 shows the 50 percent exceedence of simulated mean daily temperature for scenarios of different flow splits in Reach 4B. The nearly identical results shown in Figure 2-8 suggests that under existing operations, Reach 4B flow splits might have little effect on resulting river temperature, suggesting the river temperature may have reached equilibrium conditions. The results do not reflect conditions under the Settlement with channel modifications.

Figure 2-8
Fifty Percent Exceedence of Mean Daily Temperatures in Reach 4B Outflows Resulting from Different Reach 4B Flow Capacity Configurations, Simulated Under Existing Operations

Figure 2-9 shows that under existing operations, the temperature of the Merced River has cooling effects on the San Joaquin River flow.

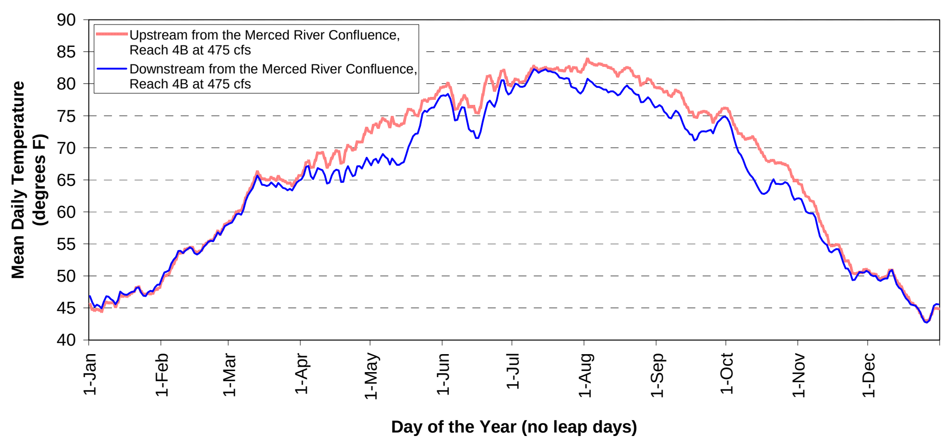

Figure 2-9
Fifty Percent Exceedence of Simulated Mean Daily Temperature Upstream and Downstream from Merced River Confluence in Reach 4B Flow Split Scenario of 475 cfs Under Existing Operations

3.0 Sensitivity Analysis Set 2

This section describes the modeling objectives, approach, assumptions, and results of Sensitivity Analysis Set 2 for examining the extent of temperature control with Friant Dam releases.

3.1 Objectives

Sensitivity Analysis Set 2 was designed very differently than Set 1. Set 1 analyses focus on the sensitivity of river temperatures to flow management decisions in Reaches 2A and 4B (i.e., flow split scenarios). These analyses were performed under a consistent reservoir operation, defined by existing Friant Dam operations. However, under the existing operation, the San Joaquin River is often dry below Gravelly Ford and the flow near Reach 4B area is largely from the DMC inflow to Mendota Pool. Therefore, Set 1 analyses are most helpful in examining river temperature profile along the river among different years under existing operations.

Set 2 was designed to provide more direct input to the development of strategies for fisheries management under the Settlement with the following specific objectives:

- Evaluate the extent to which temperatures are controlled by Friant Dam releases
- Examine the effects of Reach 4B flow splits on resulting temperatures
- Examine the effects of ambient (meteorological) conditions on temperatures

As previously mentioned, these analyses are intended to inform the development of SJRRP alternatives and management plans. These analyses are not intended to evaluate Friant Dam operations or other temperature management plans or actions because many important features of the fishery and water management strategies are still under development.

3.2 Approach

The release temperature at any time from a reservoir depends on how the reservoir was operated *a priori* because of accumulative changes in the cold-water pool. To examine the extent of flow temperature that could be affected by reservoir release of a given rate and temperature would require decoupling of cold-water pool operation. Therefore, the Set 2 analyses do not include operations of the Friant Dam component within SJR5Q.

For Set 2 analyses, under varying combinations of assumed release rate and temperature, the flow temperature in the San Joaquin River from Friant Dam to the Merced River confluence is simulated using 1980 through 2005 meteorological data, inflows, and temperatures developed by Reclamation (2007). Table 3-1 shows a tabulation of assumption matrix for release flow, release temperature, Reach 4B flow splits, and period of analysis for Set 2 analyses. The selected flow and temperature ranges are based on historical release temperatures and Restoration flow hydrographs. With combinations of various assumption categories, Set 2 analyses represent 17 model simulations to evaluate the effects of ambient conditions on flow temperature.

Table 3-1
Tabulation of Assumption Matrix for Set 2 Sensitivity Analyses

Period	Month	Release Temperature (ºF)*	Release Flow (cfs)**	Reach 4B Flow Split (cfs)
Spring	April-June	45, 50, 55	4,500, 2,000, 350	4,500, 475, 0
Fall	September-November	50, 55, 62	700, 350	4,500, 475, 0
Summer	July-August	50, 55, 60	350, 250	4,500, 475, 0

Notes:
* Based on the range of historical temperature
** Based on the range of restoration flow hydrographs
Key:
ºF = degrees Fahrenheit
cfs = cubic feet per second

Similar to Set 1 analyses, the channel geometry developed by Reclamation (2007) was used for Set 2 analyses. The Reach 4B geometry assumes a channel roughness typical of natural channels and therefore assumes some vegetation removal. The capacity of Reach 2B is assumed to be 4,500 cfs. This assumption results in small bypass flows except during periods of elevated local inflows (storm events). The Mendota Pool Bypass called for by the Settlement was not simulated.

The historical DMC inflow to Mendota Pool was used in Set 2 analyses without reduction in reaction to changes in inflow to Mendota Pool from the San Joaquin River. Therefore, the downstream flows could be overstated in some cases and understated in others. However, these conditions occur less than 5 percent of the time and, thus, would not affect the general results from this set of analyses.

3.3 Results

Detailed modeling results are provided in Appendix B of this TM. Modeling results of the Set 2 analyses are contained in Figure 3-1, which shows the scenario of modeling flow ranges of 350, 2,000, and 4,500 cfs and temperature ranges of 45, 50, and 55 °F for the month of May. Figure 3-1 illustrates the outcome from releasing temperatures of 55 °F at a flow rate of 4,500 and 350 cfs. The results demonstrate that with higher flow rates such as 4,500 cfs, the water temperature reaches 65 °F at Mendota (MP 210), and with the 350 cfs flow release, it reaches 65 °F around MP 247. Similar observations can be made in Figure 3-2 for August and Figure 3-3 for October.

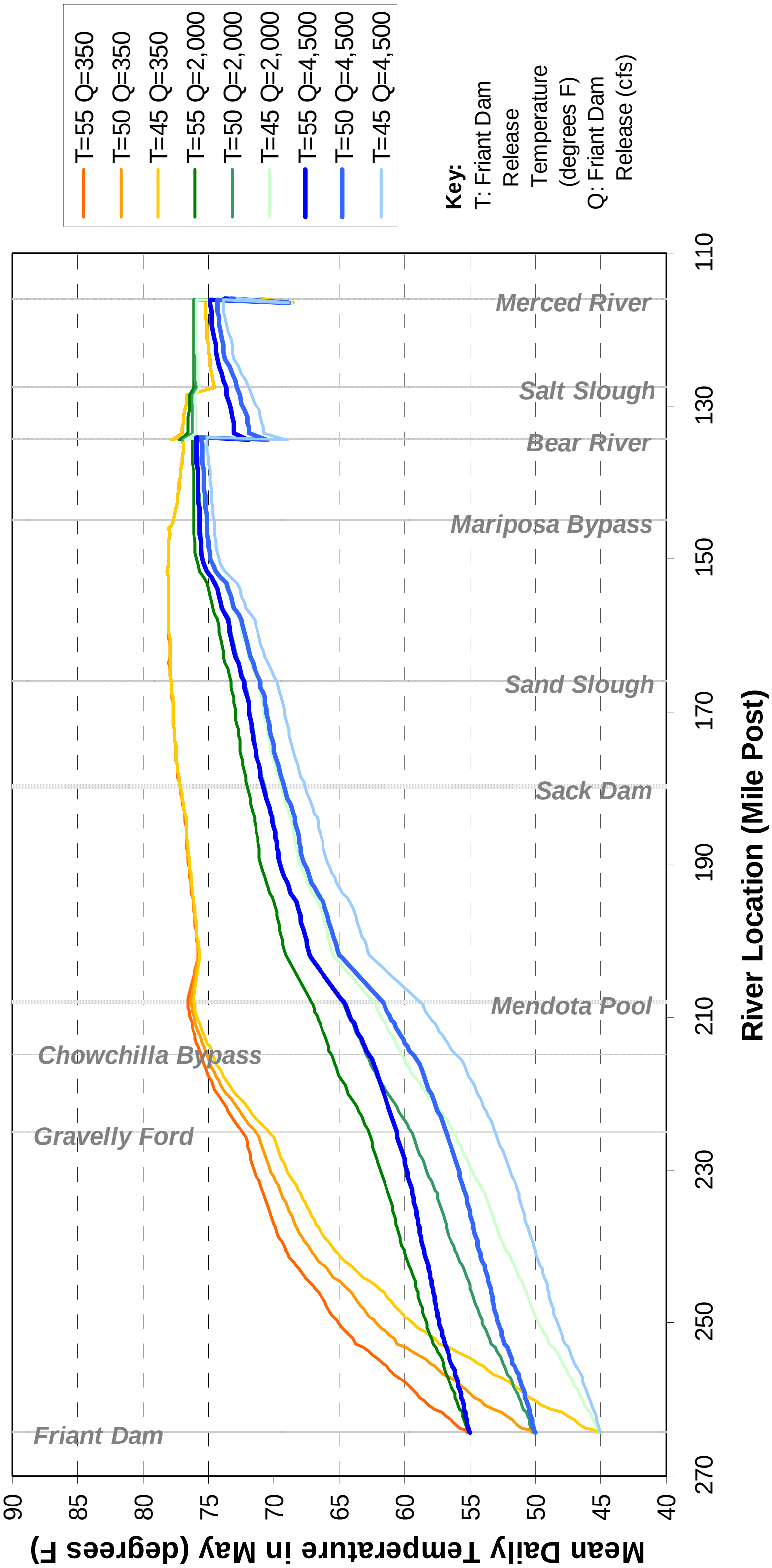

Figure 3-1
Median of Simulated Flow Temperature Profile for the San Joaquin River Between Friant Dam and Merced River Confluence (May)

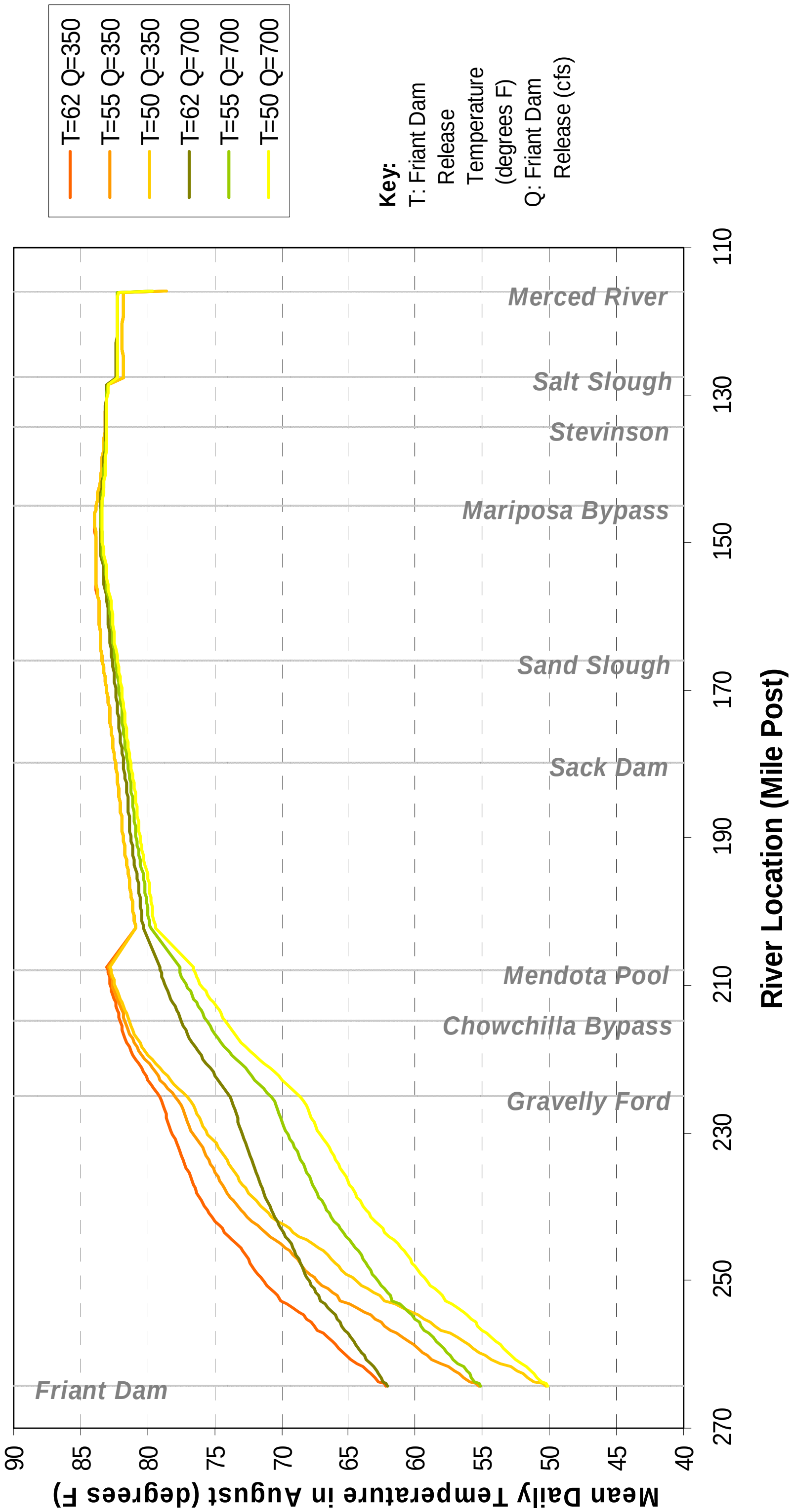

Figure 3-2
Median of Simulated Flow Temperature Profile for the San Joaquin River Between Friant Dam and Merced River Confluence (August)

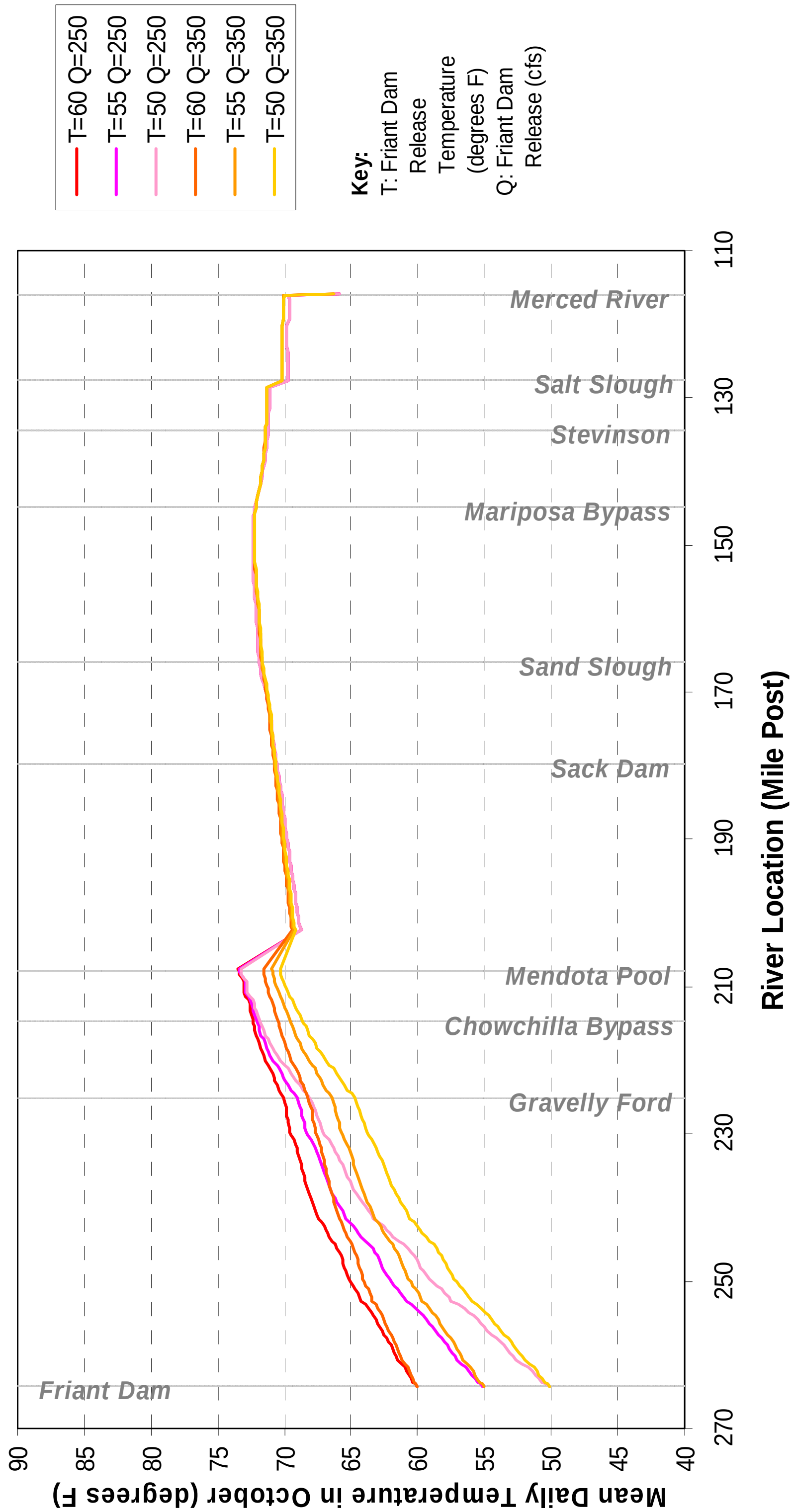

Figure 3-3
Median of Simulated Flow Temperature Profile for the San Joaquin River Between Friant Dam and Merced River Confluence (October)

By examining the model outputs for the Set 2 sensitivity analyses, the following conclusions were made:

- Ambient conditions exert significant effects on water temperature and, once the temperature reaches equilibrium conditions, there is not much impact from the flow.
- Higher flow rates sustain cooler temperatures in the river more successfully than colder releases from upstream reservoirs.
- DMC inflows to the Mendota Pool exert a cooling effect on the flow of the San Joaquin River (Mendota Pool Bypass was not simulated).
- The simulated flow temperature shows seasonal convergence at different locations along the river: spring (Stevinson), summer (Mendota Pool), and fall (varies between the Chowchilla Bifurcation Structure (Chowchilla Bypass) and Mendota Pool).

4.0 References

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