DRAFT Technical Memorandum

Temperature Model Sensitivity Analysis Set 3

SAN JOAQUIN RIVER RESTORATION PROGRAM

June 20, 2008

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List of Abbreviations and Acronyms

°F	degrees Fahrenheit
CalEPA	California Environmental Protection Agency
CALFED	CALFED Bay-Delta Program
CEQA	California Environmental Quality Act
cfs	cubic feet per second
CVP	Central Valley Project
DFG	California Department of Fish and Game
DWR	California Department of Water Resources
ft msl	feet above mean sea level
FWUA	Friant Water Users Authority
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NRDC	Natural Resources Defense Council
PEIS/R	Program Environmental Impact Statement/Report
PMT	Program Management Team
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
Settlement	Stipulation of Settlement
SJR5Q	San Joaquin River HEC-5Q Model
SJRRP	San Joaquin River Restoration Program
State	State of California
TAF	thousand acre-feet
TCD	temperature control device
TM	Technical Memorandum
USFWS	U.S. Fish and Wildlife Service

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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 before 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 greatest 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 stipulation of 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 San Joaquin River Restoration Program (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 U.S. Fish and Wildlife Service (USFWS); the U.S. Department of Commerce through the National Marine Fisheries Service (NMFS); and the State of California (State) 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 Programmatic Environmental Impact Statement/Report (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 Technical Memorandum (TM) is part of a series of preliminary river temperature sensitivity analyses conducted to inform the early developmental phases of a water management strategy. These three sets of sensitivity analyses aim to understand the model performance, ascertain the relationship of interactions between river temperature and ambient temperature, and examine existing and Settlement operations impacts on Millerton Reservoir and the San Joaquin River. These analyses were constructed to highlight the effects of selected factors.

Many important features of channel modification and associated fishery and water management strategies are still under development; therefore, these analyses are not intended to provide a detailed evaluation of reservoir operations and temperature management actions.

This TM documents and presents the results of the third sensitivity analysis performed in this series, Sensitivity Analysis Set 3.

2.0 Sensitivity Analysis Sets 1 and 2 Summary

Sensitivity Analysis Set 1 evaluated the effects of major flow splits in Reaches 2B and 4B on temperature under existing operations. Sensitivity Analysis Set 2 evaluated the extent to which Friant Dam releases control downstream river temperatures, independent of reservoir operations. The results of Sensitivity Analysis Sets 1 and 2 were described in a separate TM (Reclamation, 2008).

Major assumptions for the existing conditions simulation include the following:

- San Joaquin River HEC-5Q (SJR5Q) model (Reclamation, 2007) as the selected modeling tool.
- Analysis period of 1980 through 2003 with historical hydrology (inflow flows to Millerton Reservoir and the San Joaquin River, estimated depletions).
- Monthly canal diversion (Friant-Kern and Madera canals) and minimum reservoir releases based on preproject (existing conditions) model results, provided using daily average flows taken from the monthly Settlement spreadsheet model.
- Channel flow constraints by physical outlet limitations and minimum pool assumptions.
- All releases to the river made through the low-level outlet, except spillway flows when the river outlet capacity is exceeded.

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3.0 Sensitivity Analysis Set 3

This section describes the modeling objectives, approach, assumptions, and results for the Sensitivity Analysis Set 3 under settlement conditions.

3.1 Description

The existing conditions simulation used to perform the modeling in Sensitivity Analysis Sets 1 and 2 was also used as the starting point for this analysis. The Settlement specifies a set of required San Joaquin River flow hydrographs, commonly referred to as the Settlement hydrographs. These flows are significantly higher than existing releases from Millerton Reservoir to the San Joaquin River. Meeting these higher flows will impact Millerton storage operations, flow in the San Joaquin River downstream from the reservoir, and temperatures throughout the system.

Many important features of channel modification and associated fishery and water management strategies are still under development; therefore, these analyses are not intended to provide a detailed evaluation of reservoir operations and temperature management actions. This analysis is a preliminary look at potential impacts to the cold water pool in Millerton Reservoir, and temperature conditions in the San Joaquin River from Millerton to the Chowchilla Bypass under the Settlement hydrographs.

Two specific objectives of the Set 3 Analysis are as follows:

- Investigate potential impacts to Millerton Reservoir storage/elevation, San Joaquin River flows, and temperature impacts throughout the system.

- Investigate the potential for release and river temperature improvements in late summer by using a temperature control device (TCD).

3.2 Assumptions and Analysis

Potential impacts of implementing the Settlement releases were estimated by modifying the existing conditions simulation from Sensitivity Analysis Sets 1 and 2 to incorporate the Settlement hydrographs as minimum flows in the San Joaquin River. The SJR5Q model was then used to model the resulting Millerton Reservoir operations and water temperatures throughout the area of interest.

3.2.1 Reservoir and River Operation Impacts

This section describes the results of the water operations and temperature modeling.

Millerton Reservoir River Release

Figure 3-1 shows the release to the San Joaquin River from the existing conditions and Settlement simulations.

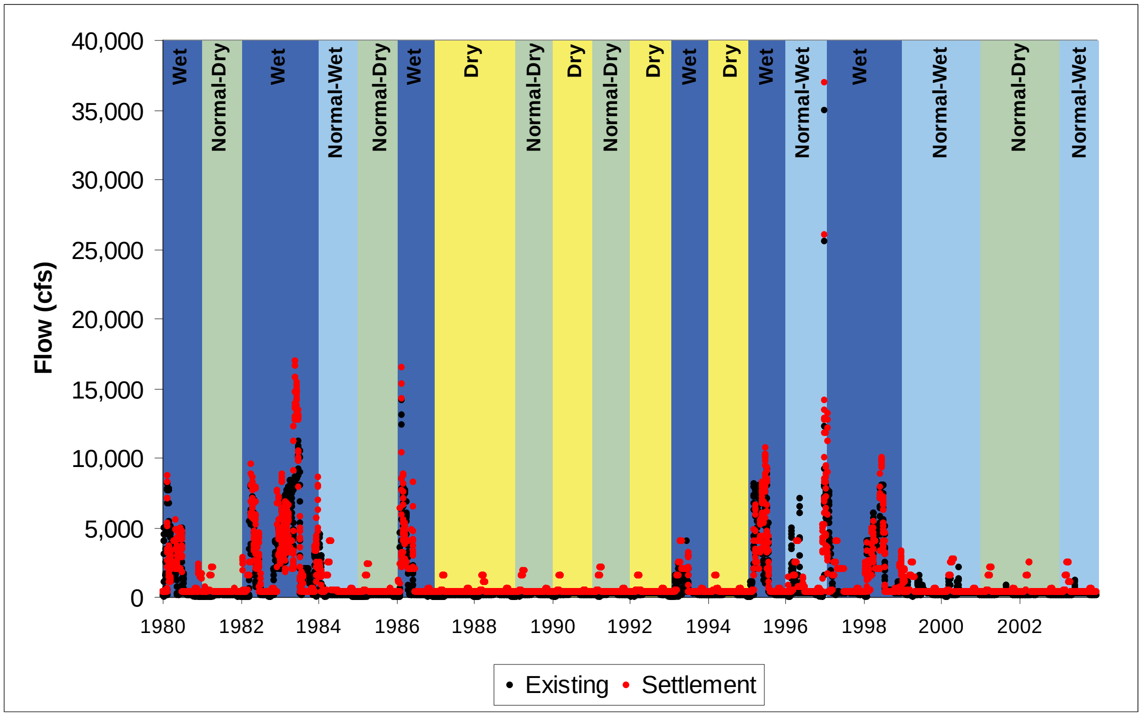

Figure 3-1.
Millerton Reservoir Release to the San Joaquin River Under Existing and Settlement Conditions

The Settlement hydrographs vary by restoration year-types defined in the Settlement. Note that in Figure 3-1 and subsequent figures colored bands represent the restoration year types. The restoration year type name is also placed on the figure near the top of the chart for ease of reference.

Millerton Reservoir typically releases just enough water to meet the minimum required flows and some downstream diversion requirements into the San Joaquin River except in flood conditions. The very large flows during flood operations mask the ability to see the change in the lower release levels in Figure 3-1. Figure 3-2 shows the release to the San Joaquin River with an upper limit of 5,000 cubic feet per second (cfs) on the plot.

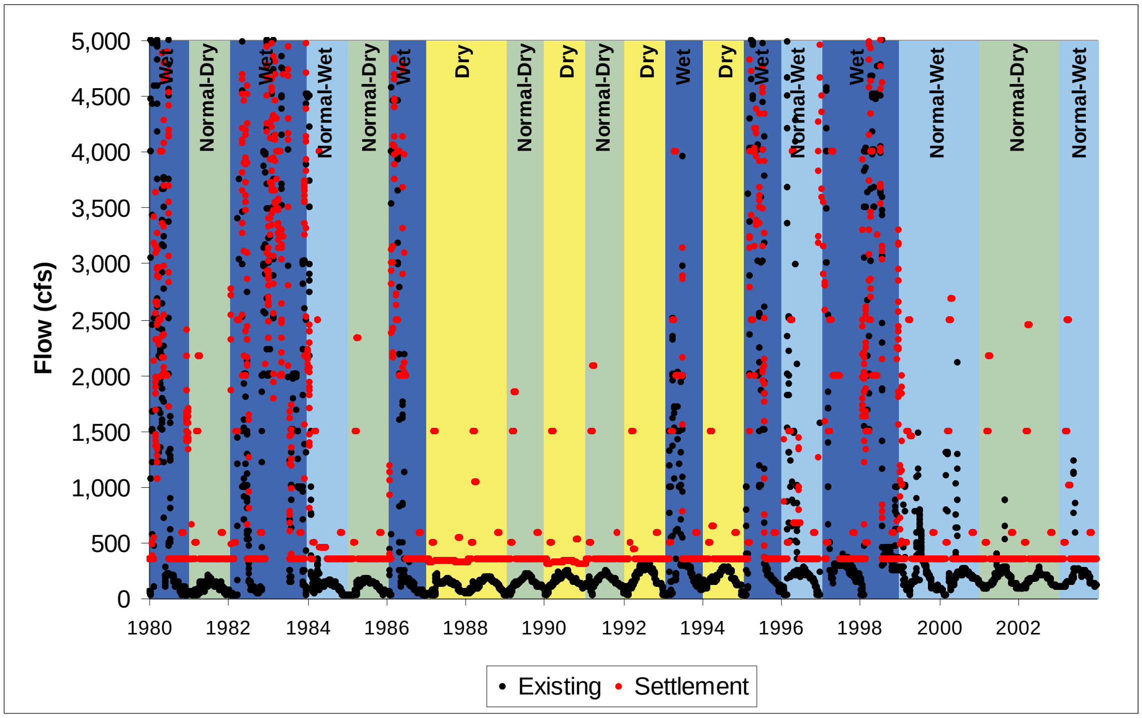

Figure 3-2.
Millerton Reservoir Release Under 5,000 cfs to the San Joaquin River Under Existing and Settlement Conditions

In the existing conditions operation, the release during the nonflood periods varies from near zero to about 350 cfs. With the Settlement hydrographs in place, the release during these same periods remains about 350 cfs.

Storage/Elevation

Figures 3-3 and 3-4 show the simulated Millerton Reservoir Storage in thousand acre-feet (TAF) and elevation in feet above mean sea level (ft msl) under existing and Settlement conditions, respectively.

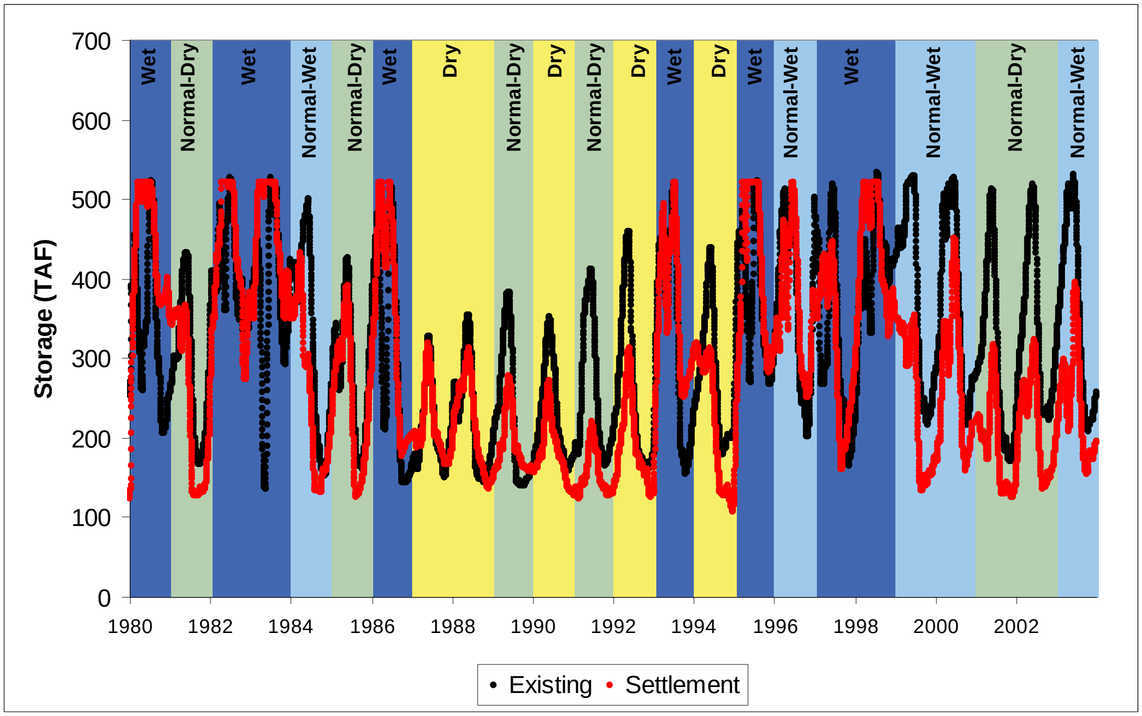

Figure 3-3.
Millerton Reservoir Storage Under Existing and Settlement Conditions

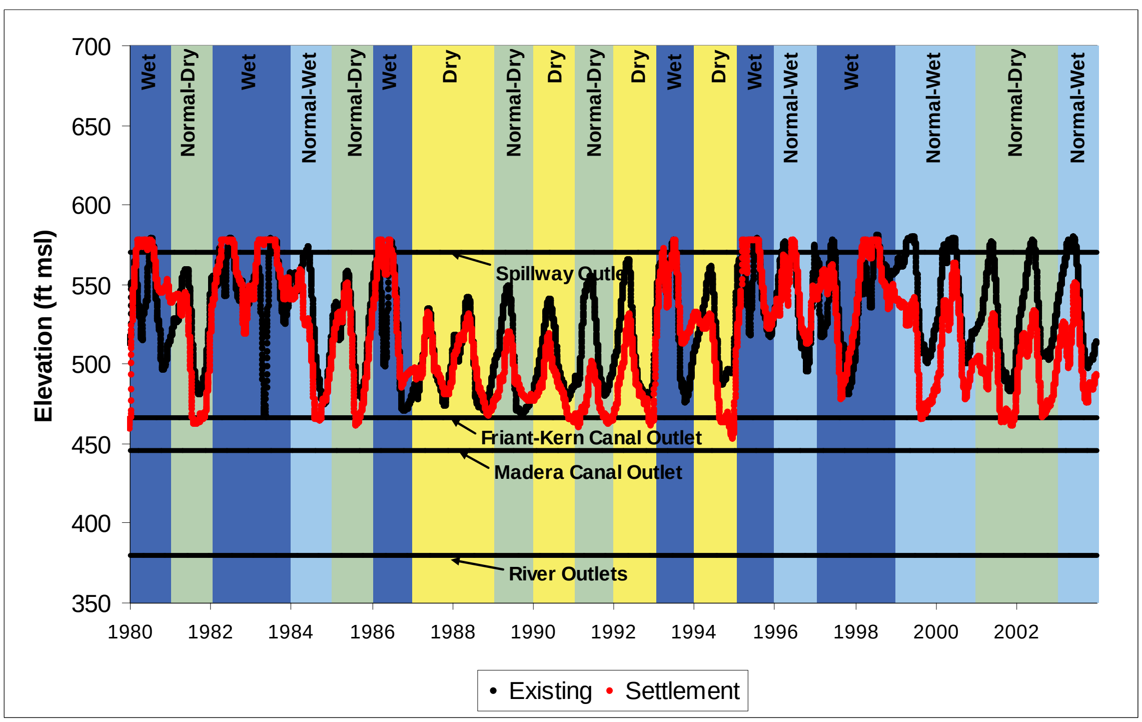

Figure 3-4.
Millerton Reservoir Elevation Under Existing and Settlement Conditions

An increased release to the San Joaquin River forces Millerton Reservoir to operate at a lower storage/elevation, especially in dry years. The minimum pool elevation target of about 460 ft msl was imposed in both simulations to allow use of the Friant-Kern Canal diversion. As can be seen in Figure 3-4, this target was not met in all years in the settlement simulation.

Canal (Friant-Kern and Madera) Delivery

Figure 3-5 shows the total simulated delivery from Millerton Reservoir to the Friant-Kern and Madera canals.

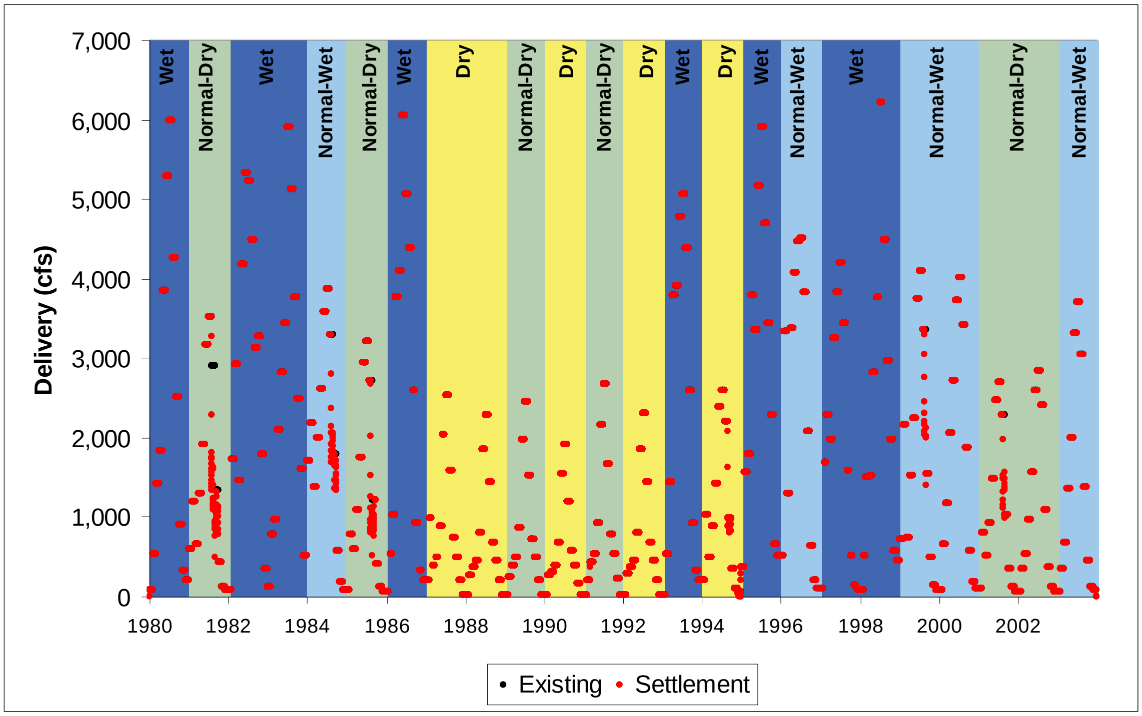

Figure 3-5.
Canal (Friant-Kern and Madera) Diversion from Millerton Reservoir Under Existing and Settlement Conditions

There are some very small differences in the years when storage was too low for the water to be physically diverted from the reservoir. These values do not appear to pose a significant risk of canal delivery shortage with the Settlement hydrographs.

Gravelly Ford Flow

Figures 3-6 and 3-7 show the simulated San Joaquin River flow at Gravelly Ford. The data are presented in two figures for the same scaling issues found when plotting the Millerton Reservoir release.

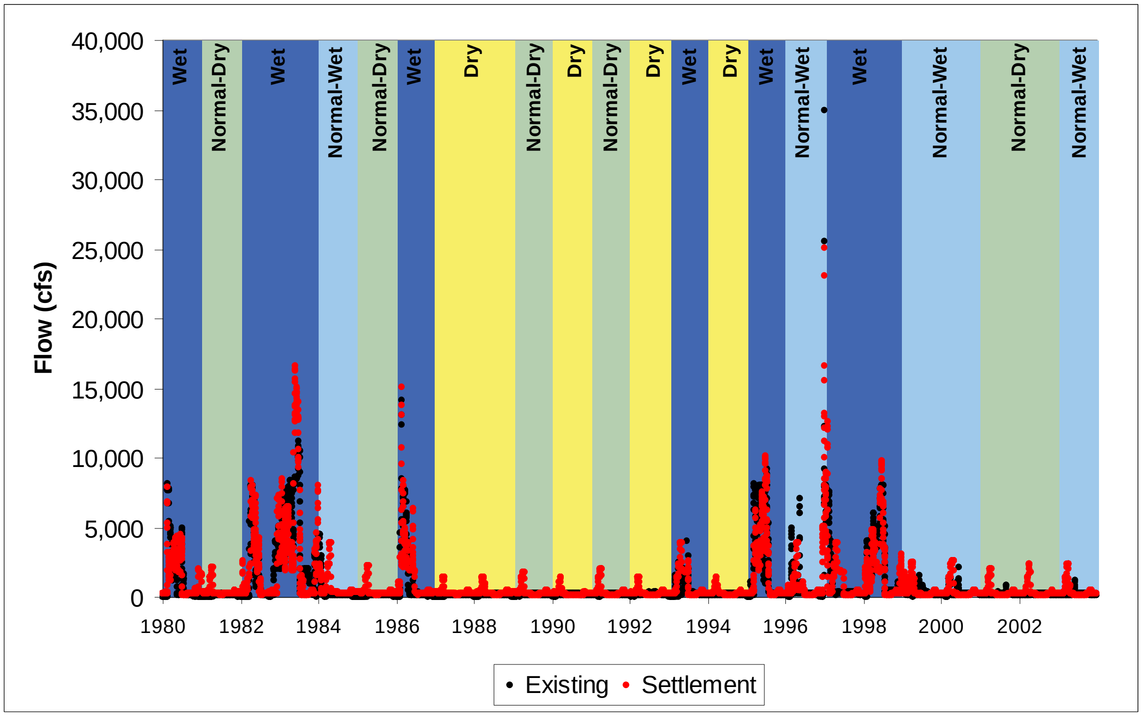

Figure 3-6.
San Joaquin River Flow at Gravelly Ford Under Existing and Settlement Conditions

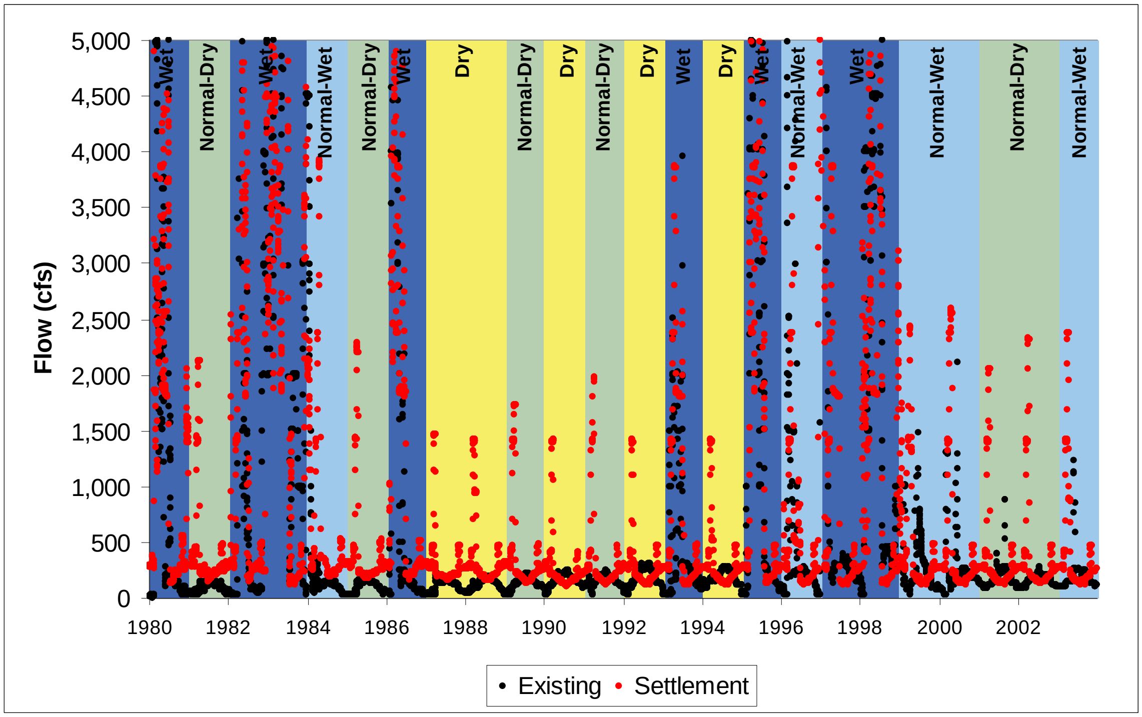

Figure 3-7.
San Joaquin River Flow Under 5,000 cfs at Gravelly Ford Under Existing and Settlement Conditions

The flow pattern at Gravelly Ford is similar to the Millerton Reservoir release pattern. The changes in the pattern are due to different accretion/depletion and flow attenuation in the San Joaquin River between the two locations due to the different flows in the river.

3.2.2 Temperature Impacts

This section discusses the temperatures from the simulations.

Millerton Reservoir Release Temperature

Figure 3-8 shows the Millerton Reservoir release temperature under existing and Settlement conditions.

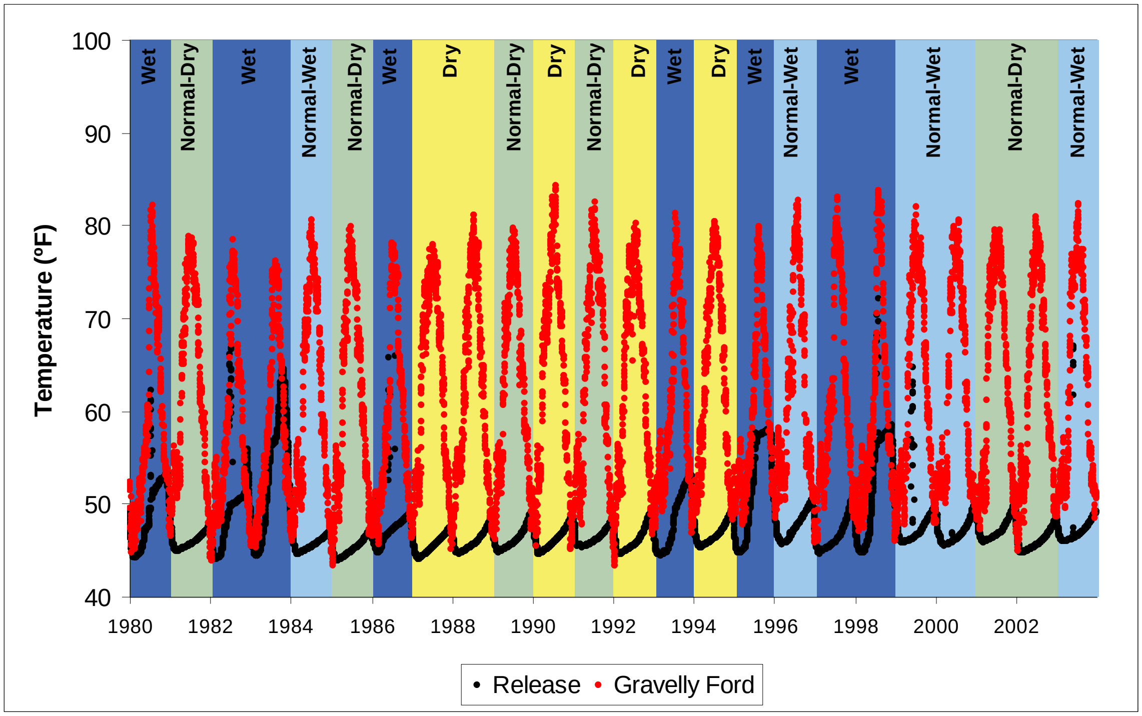

Figure 3-8.
Millerton Reservoir Release Temperature Under Existing and Settlement Conditions

In wetter years (e.g., 1993), the release temperature is lower under Settlement conditions. As noted in Sensitivity Analysis Sets 1 and 2, the release temperature tends to be higher during periods of flood releases because warmer water at the top of the reservoir is being released to the river via the spillway. Since the Settlement reservoir storages tend to be lower than existing conditions, flood spills may be reduced, resulting in lower release temperatures.

In dryer years (e. g., 1987 through 1993), release temperatures tend to be higher under Settlement conditions. During these periods, Millerton Reservoir storage tends to be lower under Settlement conditions. Since the river outlets are at the same physical elevation, this means the outlets are closer to the surface of the reservoir and release warmer water. Stated another way, the lower storage tends to "move" the outlet elevation up in the reservoir temperature profile to a higher temperature range.

The minimum release temperatures all remain in the 45 degrees Fahrenheit (ºF) range. This temperature is typical of the lowest temperature found in a lake or reservoir in California. These release temperatures tend to occur when storage is relatively high in the reservoir and the outlets are in the coldest portion of the temperature profile. Settlement conditions would not be expected to reduce these temperatures.

The descriptions above, referring to temperature impacts within Millerton Reservoir, are based on experience with the behavioral tendencies of reservoirs in California. Millerton's reservoir temperature will be more thoroughly studied and reported on during the SJRRP's alternative screening processes. For the purposes of this sensitivity analysis, it seems sufficient to note the general implications of lowering flood releases without providing a full diagnosis of reservoir temperature profiles.

Figure 3-9 shows the median and maximum Millerton Reservoir release temperatures for each day of the year.

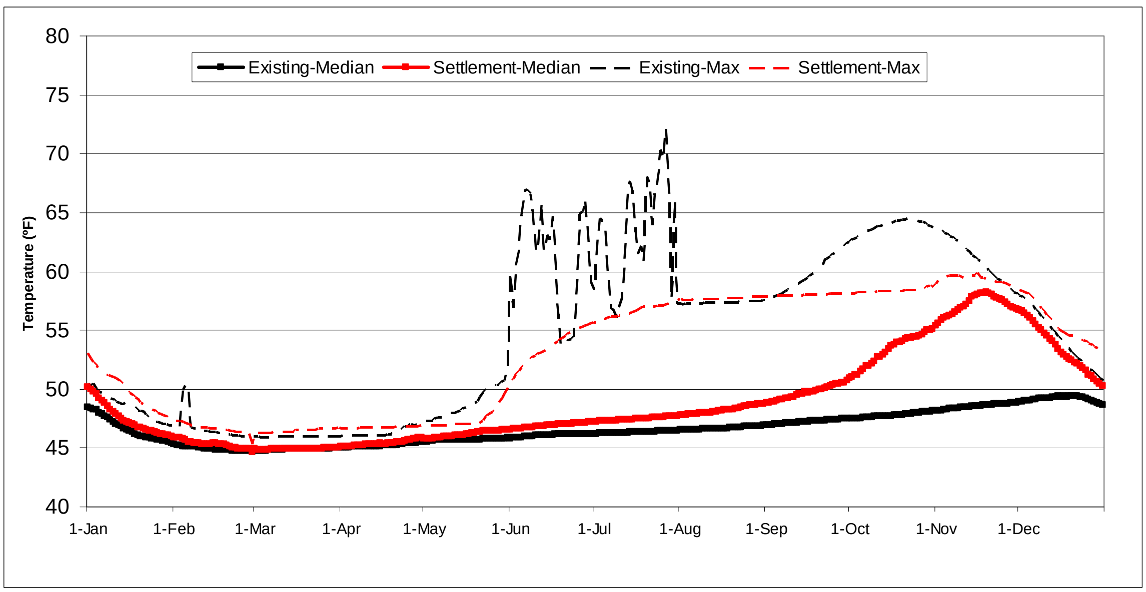

Figure 3-9.
Daily Median and Maximum Millerton Reservoir Release Temperature Under Existing and Settlement Conditions

From about January 1 to about May 30, the Settlement hydrographs appear to have little impact on the Millerton Reservoir release temperature (probably because the reservoir is well mixed during this time and is about the same temperature at all elevations, which is typical of California behavior). From June 1 to July 31, the median release temperature is only slightly affected; however, the maximum release temperature shows reductions of 10ºF to 15ºF. These impacts are due to the reduction in flood spills caused by the decrease in Millerton Reservoir storage, as discussed above.

From August 1 until December 31, the median release temperature shows an increase of about 2ºF at the start of the period up to nearly 10ºF by mid-November, then rapidly drops off until the existing and Settlement median are about the same. This rise is due to the reduction in Millerton Reservoir storage, as discussed above.

San Joaquin River Temperatures

Data for temperatures in the San Joaquin River under existing conditions were not available for use in this TM since under existing conditions there is zero flow at some points in the river. Figure 3-10 shows the temperature of the Millerton release and the temperatures of the San Joaquin River at Gravelly Ford under Settlement conditions.

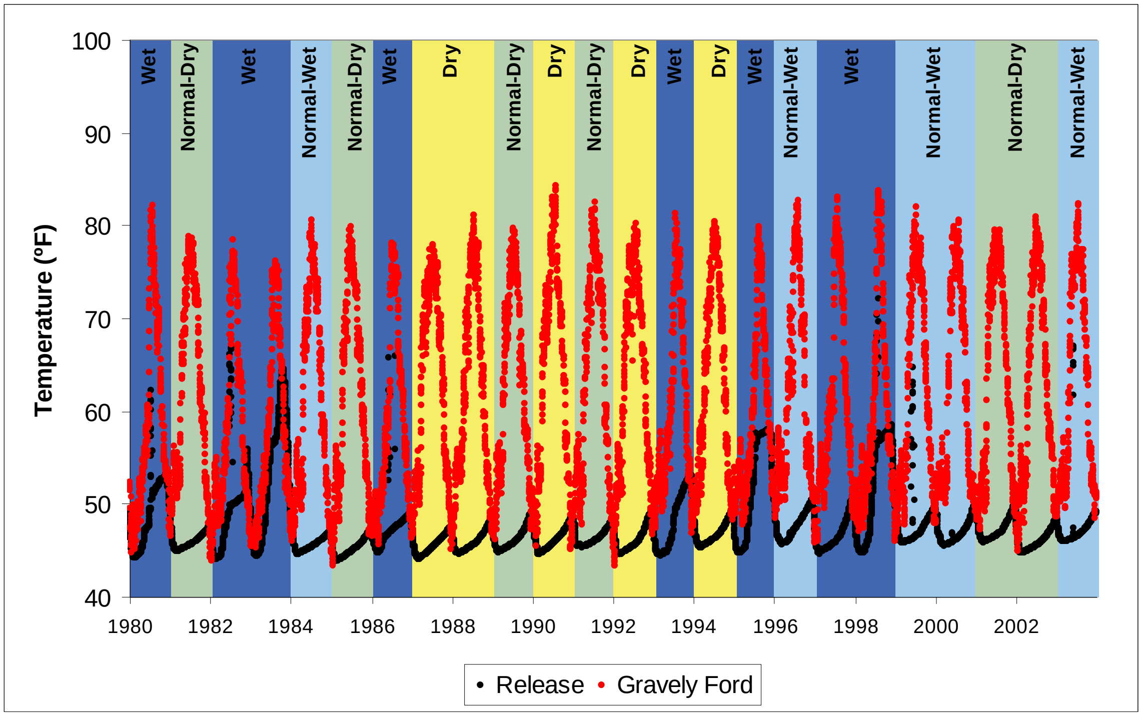

Figure 3-10.
Daily Mean Millerton Reservoir Release and Gravelly Ford Temperatures Under Settlement Conditions

The difference between the two curves is due to the heating in the San Joaquin River between the two points. Temperature Model Sensitivity Analysis Sets 1 and 2 contain additional analysis of the potential temperature gain in the San Joaquin River.

Temperature profiles were developed along the San Joaquin River between Millerton Reservoir and the Chowchilla Bypass bifurcation for different time intervals. Figures 3-11 and 3-12 show temperature profiles for the periods of January 1 through January 31 and July 1 through July 31, respectively.

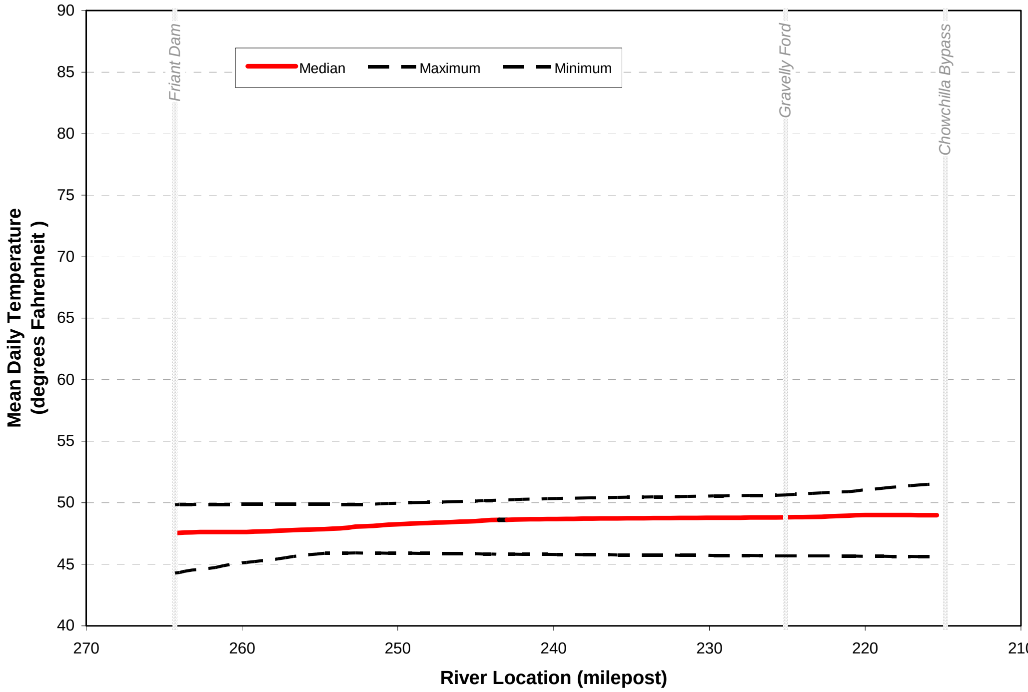

Figure 3-11.
Profile of Median, Minimum, and Maximum Daily Temperature Values for the Time Period of January 1 to January 31

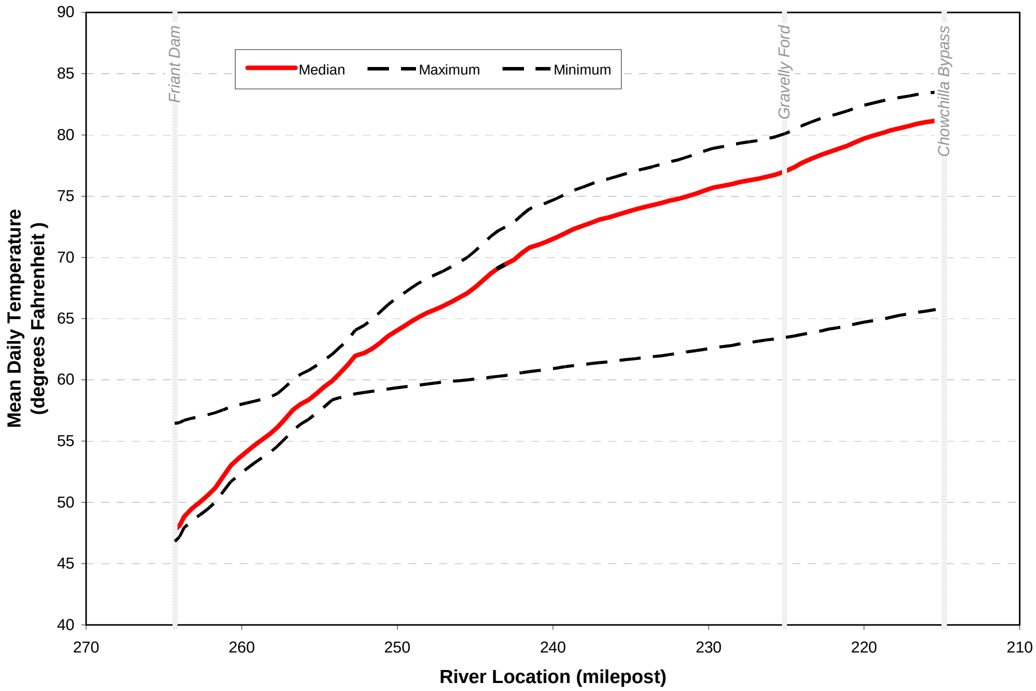

Figure 3-12.
Profile of Median, Minimum, and Maximum Daily Temperature Values for the Time Period of July 1 to July 31

These two periods show the difference in heating along the river during cooler and warmer portions of the year. A full set of temperature profiles covering periods representing the entire year is included in Appendix A.

3.3 Cold Water Pool Analysis Assumptions

The existing facilities and modeling do not include any type of TCD. A TCD allows control over the temperature of a release from a reservoir by allowing the release to be made from different elevations with different temperatures. This allows the operator to control the use of the cold water in the reservoir to manage temperature. The usual impacts from using a TCD are increased temperatures in the spring through summer period, when the TCD is releasing from the upper strata of the reservoir; conversely, release temperatures are lowered during the summer through fall period, when the TCD releases from lower strata and/or uses a larger cold water pool.

The SJRQ5 model used in this analysis does not include a TCD on the canal diversions or the river outlets. To evaluate potential temperature benefits of implementing a TCD, the minimum pool elevation was increased in Millerton Reservoir as a surrogate for a TCD. Downstream release volumes were maintained and diversions were reduced to maintain storage to meet the minimum pool requirement. The net impact of this operation is to maintain a larger cold water pool later in the summer, which is one of the goals of a TCD. The results were then analyzed to see if this increased cold water pool would have an impact on summer and fall temperatures in the San Joaquin River as an indication of the potential for a TCD to protect the cold water pool for use later in the year.

Millerton Reservoir is operated with a minimum pool elevation of 460 ft msl. For this analysis, two options, Option 1 – 500 ft msl and Option 2 – 520 ft msl, were simulated. Figure 3-13 shows the release temperatures from the simulations.

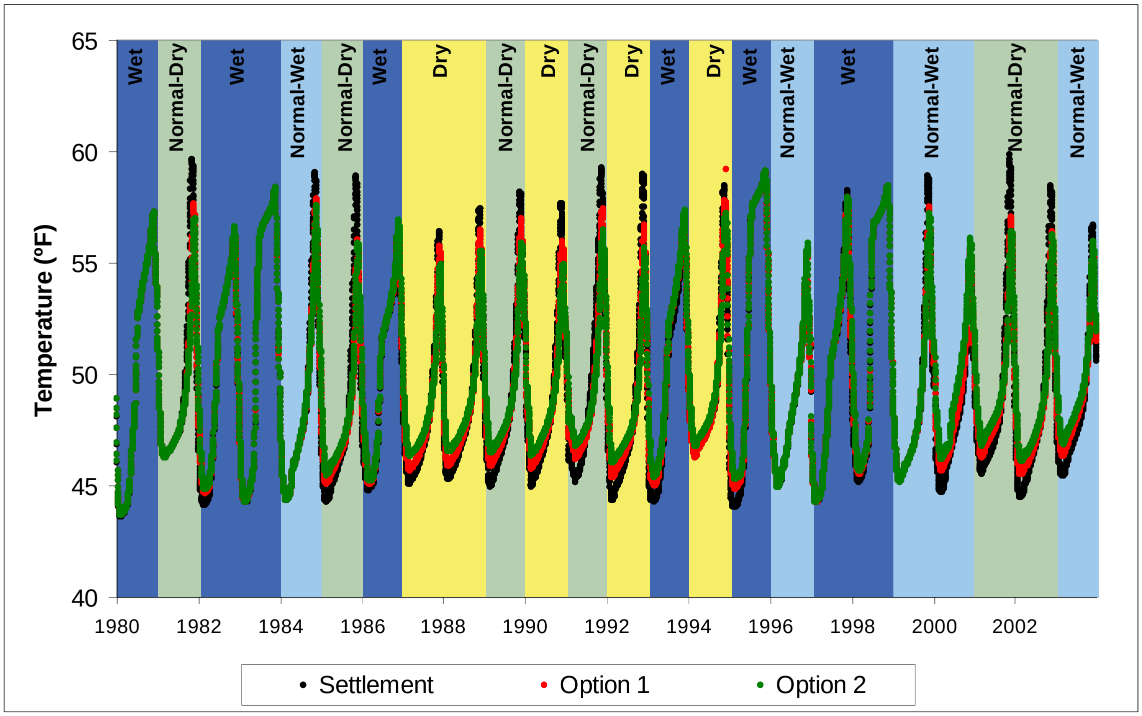

Figure 3-13.
Mean Daily Millerton Reservoir Release Temperature with Increased Cold Water Pool

The figure shows that late summer temperatures are reduced by the increase in the minimum pool elevation. Figure 3-14 shows the median mean daily value for each day of the year.

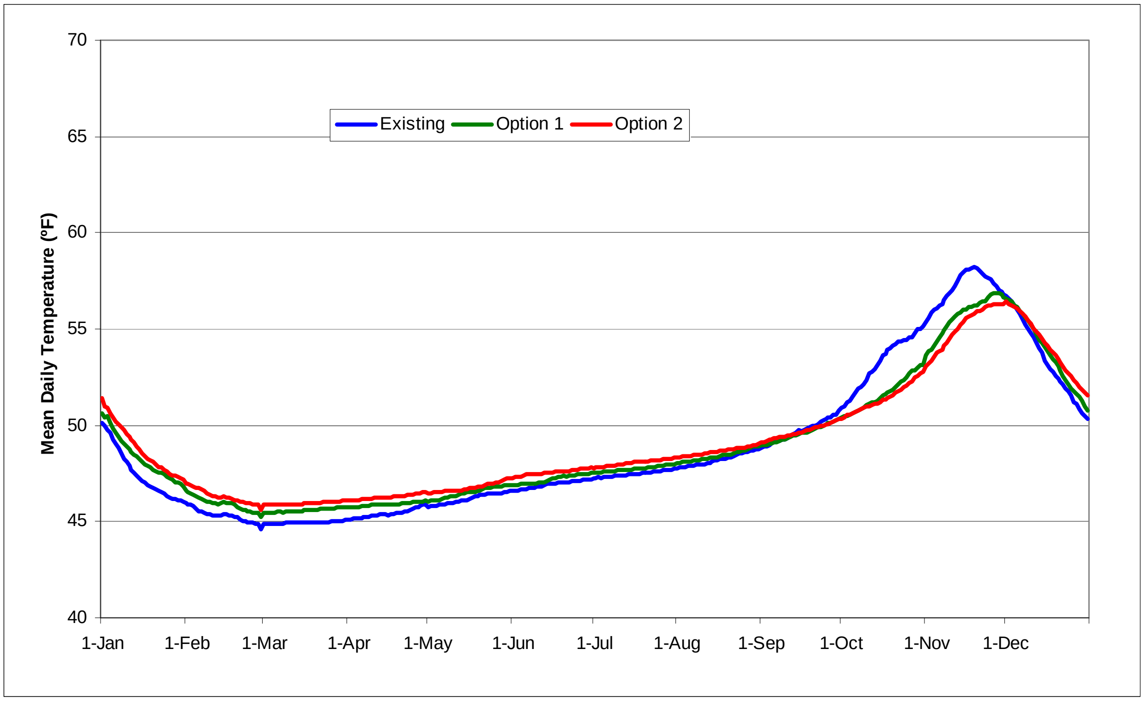

Figure 3-14.
Median Mean Daily Millerton Reservoir Release Temperature with Increased Cold Water Pool

The analysis shows apparent potential for a TCD to reduce the late summer Millerton Reservoir release temperature, and therefore the temperature in the San Joaquin River, through cold water pool management. The analysis is not intended to predict the magnitude of the reduction, only the potential for any reduction. A TCD may be more or less efficient at preserving the cold water pool than the increased minimum pool level used as a surrogate for the TCD in this analysis. The actual temperature reduction possible with a TCD will require further evaluation.

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4.0 References

Smith, Donald J. 2005. San Joaquin River HEC-5Q Temperature Modeling, Expert Report and Supplement. In support of legal case *Natural Resources Defense Council et al. (Plaintiffs) v. Kirk Rodgers as Regional Director of the United States Bureau of Reclamation et al.* (Defendants) and *Orange Cove Irrigation District et al. (Defendants-Intervenors)*; Case No. CIV-S-88-1658 (U.S. District Court for the Eastern District of California).

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