PROJECT OPERATIONS
WATER BALANCE MODEL
AMENDED STUDY REPORT
DON PEDRO PROJECT
FERC NO. 2299



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MID Modesto Irrigation District

Prepared for:
Turlock Irrigation District – Turlock, California
Modesto Irrigation District – Modesto, California

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September 2017

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Project Operations/Water Balance Model
Study Report and Model User's Guide

In support of the Project relicensing, the Districts have developed a Project operations computer model (Operations Model) to simulate current Don Pedro Project operations and alternative scenarios for future operations of the Project. The Operations Model is available to relicensing participants for their use in evaluating existing conditions and potential future Project operations.

There have been three model releases:

- Version 1.0 – Test Case was used for training relicensing participants on the model (October 2012)
- Version 2.0 – Base Case added the base case operations (May 2013)
- Version 3.0 – Base Case Model updated with hydrology through WY2012 (December 2013)
- Version 3.1 - Additional refinements and modifications to the Model (September 2017)

The development of the Operations Model has been informed by consultation with relicensing participants, and information shared through a series of consultation workshops is provided in Attachment A of the Draft License Application. This Final Study Report is a compilation of all model documentation developed through December 2013, as summarized below.

Project Operations/Water Balance Model Study Report and documentation (filed with the Initial Study Report January 2013 unless otherwise noted):

- Operations Model Study Report
- Attachment A: Tuolumne River Daily Operations Model
    - Appendix A - Examination of a Gauge Proration Method for Tuolumne River Unimpaired Hydrology Development
    - Appendix B - Lower Tuolumne River Accretion (La Grange to Modesto) Estimated daily flows (1970-2010)[1]
    - Appendix C - Field Accretion Measurement Information (updated April 25, 2013)[2]
- Attachment B: Model Description and User's Guide
    - Addendum 1 – Presented in two documents, an update to the User's Guide to describe refinements and modifications for Version 2.0 of the model and a Base Case Description (May 2013)
    - Addendum 2 – Describes updates to the model and the inclusion of an additional three water years of hydrology data (through WY2012) (December 2013)
- Attachment C: Model Validation Report
- Attachment D: Model Description and User's Guide, Addendum 3, Tuolumne River Daily Operations Model Version 3.1

[1] This appendix describes assumptions used for accretion in the Operations Model.

[2] Final accretion flow measurements for June 2012, October 2012, and February 2013. Filed with FERC on April 25, 2013 and previously filed on March 19, 2013 with Don Pedro Relicensing W&AR-02 Consultation Workshop No. 2 Final Meeting Notes.

Project Operations/Water Balance Model
Amended Study Report

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List of Acronyms

ac ....acres

ACEC ....Area of Critical Environmental Concern

AF ....acre-feet

ACOE.........................U.S. Army Corps of Engineers

ADA ....Americans with Disabilities Act

ALJ.............................Administrative Law Judge

APE ....Area of Potential Effect

ARMR........................Archaeological Resource Management Report

BA ....Biological Assessment

BDCP ....Bay-Delta Conservation Plan

BLM ...........................U.S. Department of the Interior, Bureau of Land Management

BLM-S ....Bureau of Land Management – Sensitive Species

BMI ....Benthic macroinvertebrates

BMP ....Best Management Practices

BO ....Biological Opinion

CalEPPC ....California Exotic Pest Plant Council

CalSPA.......................California Sports Fisherman Association

CAS ....California Academy of Sciences

CCC............................Criterion Continuous Concentrations

CCIC ....Central California Information Center

CCSF..........................City and County of San Francisco

CCVHJV ....California Central Valley Habitat Joint Venture

CD ....Compact Disc

CDBW........................California Department of Boating and Waterways

CDEC ....California Data Exchange Center

CDFA ....California Department of Food and Agriculture

CDFG ....California Department of Fish and Game (as of January 2013, Department of Fish and Wildlife)

CDMG........................California Division of Mines and Geology

CDOF ....California Department of Finance

CDPH ....California Department of Public Health

CDPR ....California Department of Parks and Recreation
CDSOD ....California Division of Safety of Dams
CDWR........................California Department of Water Resources
CE ....California Endangered Species
CEII...........................Critical Energy Infrastructure Information
CEQA.........................California Environmental Quality Act
CESA ....California Endangered Species Act
CFR ....Code of Federal Regulations
cfs..............................cubic feet per second
CGS ....California Geological Survey
CMAP ....California Monitoring and Assessment Program
CMC...........................Criterion Maximum Concentrations
CNDDB......................California Natural Diversity Database
CNPS..........................California Native Plant Society
CORP ....California Outdoor Recreation Plan
CPUE ....Catch Per Unit Effort
CRAM........................California Rapid Assessment Method
CRLF..........................California Red-Legged Frog
CRRF ....California Rivers Restoration Fund
CSAS..........................Central Sierra Audubon Society
CSBP..........................California Stream Bioassessment Procedure
CT ....California Threatened Species
CTR............................California Toxics Rule
CTS ....California Tiger Salamander
CVRWQCB ....Central Valley Regional Water Quality Control Board
CWA ....Clean Water Act
CWHR........................California Wildlife Habitat Relationship
Districts ....Turlock Irrigation District and Modesto Irrigation District
DLA ....Draft License Application
DPRA.........................Don Pedro Recreation Agency
DPS ....Distinct Population Segment
EA ....Environmental Assessment
EC ....Electrical Conductivity

EFH............................Essential Fish Habitat
EIR.............................Environmental Impact Report
EIS..............................Environmental Impact Statement
EPA............................U.S. Environmental Protection Agency
ESA............................Federal Endangered Species Act
ESRCD.......................East Stanislaus Resource Conservation District
ESU............................Evolutionary Significant Unit
EWUA........................Effective Weighted Useable Area
FERC..........................Federal Energy Regulatory Commission
FFS.............................Foothills Fault System
FL...............................Fork length
FMU...........................Fire Management Unit
FOT............................Friends of the Tuolumne
FPC ....Federal Power Commission
ft/mi............................feet per mile
FWCA........................Fish and Wildlife Coordination Act
FYLF..........................Foothill Yellow-Legged Frog
g.................................grams
GIS ....Geographic Information System
GLO ....General Land Office
GPS ....Global Positioning System
HCP............................Habitat Conservation Plan
HHWP........................Hetch Hetchy Water and Power
HORB ....Head of Old River Barrier
HPMP.........................Historic Properties Management Plan
ILP.............................Integrated Licensing Process
ISR ....Initial Study Report
ITA.............................Indian Trust Assets
kV..............................kilovolt
m ....meters
M&I...........................Municipal and Industrial
MCL...........................Maximum Contaminant Level
mg/kg ....milligrams/kilogram

mg/L..........................milligrams per liter

mgd ....million gallons per day

mi ....miles

mi^2 ....square miles

MID...........................Modesto Irrigation District

MOU ....Memorandum of Understanding

MSCS.........................Multi-Species Conservation Strategy

msl.............................mean sea level

MVA ....Megavolt Ampere

MW ....megawatt

MWh ....megawatt hour

mya............................million years ago

NAE ....National Academy of Engineering

NAHC ....Native American Heritage Commission

NAS...........................National Academy of Sciences

NAVD 88..................North American Vertical Datum of 1988

NAWQA ....National Water Quality Assessment

NCCP ....Natural Community Conservation Plan

NEPA ....National Environmental Policy Act

ng/g ....nanograms per gram

NGOs ....Non-Governmental Organizations

NHI ....Natural Heritage Institute

NHPA.........................National Historic Preservation Act

NISC ....National Invasive Species Council

NMFS.........................National Marine Fisheries Service

NOAA ....National Oceanic and Atmospheric Administration

NOI ....Notice of Intent

NPS ...........................U.S. Department of the Interior, National Park Service

NRCS ....National Resource Conservation Service

NRHP ....National Register of Historic Places

NRI............................Nationwide Rivers Inventory

NTU ....Nephelometric Turbidity Unit

NWI............................National Wetland Inventory

NWIS ....National Water Information System
NWR ....National Wildlife Refuge
NGVD 29 ....National Geodetic Vertical Datum of 1929
O&M ....operation and maintenance
OEHHA......................Office of Environmental Health Hazard Assessment
ORV ....Outstanding Remarkable Value
PAD............................Pre-Application Document
PDO............................Pacific Decadal Oscillation
PEIR...........................Program Environmental Impact Report
PGA............................Peak Ground Acceleration
PHG............................Public Health Goal
PM&E ....Protection, Mitigation and Enhancement
PMF............................Probable Maximum Flood
POAOR ....Public Opinions and Attitudes in Outdoor Recreation
ppb.............................parts per billion
ppm ....parts per million
PSP ....Proposed Study Plan
QA ....Quality Assurance
QC ....Quality Control
RA ....Recreation Area
RBP ....Rapid Bioassessment Protocol
Reclamation ...............U.S. Department of the Interior, Bureau of Reclamation
RM ....River Mile
RMP ....Resource Management Plan
RP..............................Relicensing Participant
RSP ....Revised Study Plan
RST ....Rotary Screw Trap
RWF ....Resource-Specific Work Groups
RWG ....Resource Work Group
RWQCB.....................Regional Water Quality Control Board
SC..............................State candidate for listing under CESA
SCD...........................State candidate for delisting under CESA
SCE ....State candidate for listing as endangered under CESA

SCT ....State candidate for listing as threatened under CESA
SD1 ....Scoping Document 1
SD2 ....Scoping Document 2
SE...............................State Endangered Species under the CESA
SFP.............................State Fully Protected Species under CESA
SFPUC ....San Francisco Public Utilities Commission
SHPO ....State Historic Preservation Office
SJRA ....San Joaquin River Agreement
SJRGA ....San Joaquin River Group Authority
SJTA ....San Joaquin River Tributaries Authority
SPD ....Study Plan Determination
SRA............................State Recreation Area
SRMA ....Special Recreation Management Area or Sierra Resource Management Area (as per use)
SRMP.........................Sierra Resource Management Plan
SRP ....Special Run Pools
SSC ....State species of special concern
ST...............................California Threatened Species under the CESA
STORET ....Storage and Retrieval
SWAMP.....................Surface Water Ambient Monitoring Program
SWE ....Snow-Water Equivalent
SWRCB......................State Water Resources Control Board
TAC............................Technical Advisory Committee
TAF ....thousand acre-feet
TCP ....Traditional Cultural Properties
TDS ....Total Dissolved Solids
TID.............................Turlock Irrigation District
TMDL ....Total Maximum Daily Load
TOC............................Total Organic Carbon
TRT ....Tuolumne River Trust
TRTAC ....Tuolumne River Technical Advisory Committee
UC ....University of California
USDA.........................U.S. Department of Agriculture

USDOC .... U.S. Department of Commerce
USDOI .... U.S. Department of the Interior
USFS .... U.S. Department of Agriculture, Forest Service
USFWS .... U.S. Department of the Interior, Fish and Wildlife Service
USGS .... U.S. Department of the Interior, Geological Survey
USR .... Updated Study Report
UTM .... Universal Transverse Mercator
VAMP .... Vernalis Adaptive Management Plan
VELB .... Valley Elderberry Longhorn Beetle
VRM .... Visual Resource Management
WPT .... Western Pond Turtle
WSA .... Wilderness Study Area
WSIP .... Water System Improvement Program
WWTP .... Wastewater Treatment Plant
WY .... water year
μS/cm .... microSeimens per centimeter

1.0 INTRODUCTION

1.1 General Description of the Don Pedro Project

Turlock Irrigation District (TID) and Modesto Irrigation District (MID) (collectively, the Districts) are the co-licensees of the 168-megawatt (MW) Don Pedro Project (Project) located on the Tuolumne River in western Tuolumne County in the Central Valley region of California. The Don Pedro Dam is located at river mile (RM) 54.8 and the Don Pedro Reservoir formed by the dam extends 24-miles upstream at the normal maximum water surface elevation of 830 ft above mean sea level (msl; NGVD 29). At elevation 830 ft, the reservoir stores over 2,000,000 acre-feet (AF) of water and has a surface area slightly less than 13,000 acres (ac). The watershed above Don Pedro Dam is approximately 1,533 square miles (mi^2).

Both TID and MID are local public agencies authorized under the laws of the State of California to provide water supply for irrigation and municipal and industrial (M&I) uses and to provide retail electric service. The Project serves many purposes including providing water storage for the beneficial use of irrigation of over 200,000 ac of prime Central Valley farmland and for the use of M&I customers in the City of Modesto (population 210,000). Consistent with the requirements of the Raker Act passed by Congress in 1913 and agreements between the Districts and City and County of San Francisco (CCSF), the Project reservoir also includes a “water bank” of up to 570,000 AF of storage. CCSF may use the water bank to more efficiently manage the water supply from its Hetch Hetchy water system while meeting the senior water rights of the Districts. CCSF’s “water bank” within Don Pedro Reservoir provides significant benefits for its 2.6 million customers in the San Francisco Bay Area.

The Project also provides storage for flood management purposes in the Tuolumne and San Joaquin rivers in coordination with the U.S. Army Corps of Engineers (ACOE). Other important uses supported by the Project are recreation, protection of the anadromous fisheries in the lower Tuolumne River, and hydropower generation.

The Project Boundary extends from approximately one mile downstream of the dam to approximately RM 79 upstream of the dam. Upstream of the dam, the Project Boundary runs generally along the 855 ft contour interval which corresponds to the top of the Don Pedro Dam. The Project Boundary encompasses approximately 18,370 ac with 78 percent of the lands owned jointly by the Districts and the remaining 22 percent (approximately 4,000 ac) is owned by the United States and managed as a part of the U.S. Bureau of Land Management (BLM) Sierra Resource Management Area.

The primary Project facilities include the 580-foot-high Don Pedro Dam and Reservoir completed in 1971; a four-unit powerhouse situated at the base of the dam; related facilities including the Project spillway, outlet works, and switchyard; four dikes (Gasburg Creek Dike and Dikes A, B, and C); and three developed recreational facilities (Fleming Meadows, Blue Oaks, and Moccasin Point Recreation Areas). The location of the Project and its primary facilities is shown in Figure 1.1-1.

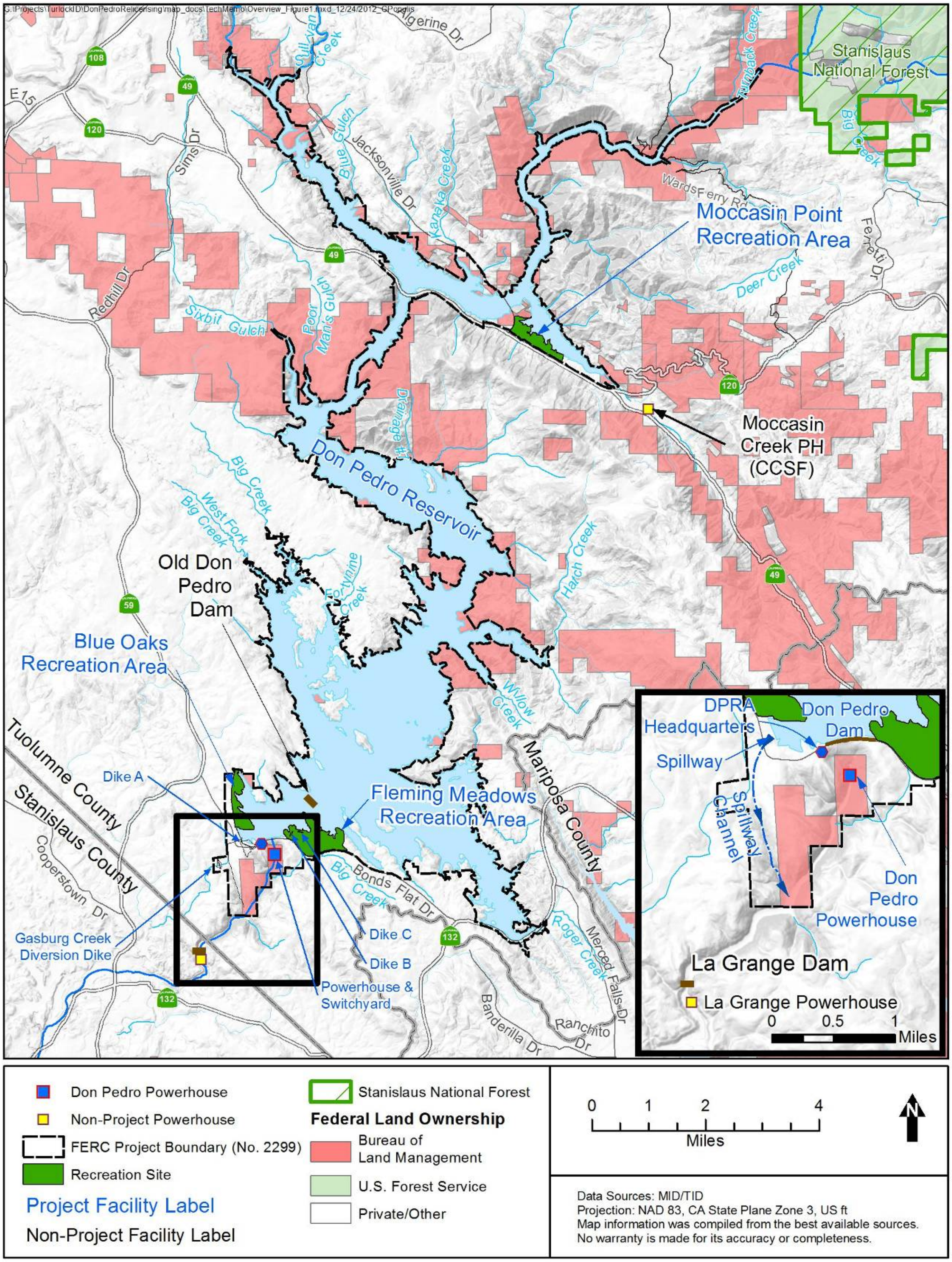

Figure 1.1-1. Don Pedro Project location.

1.2 Relicensing Process

The current FERC license for the Project expires on April 30, 2016, and the Districts will apply for a new license no later than April 30, 2014. The Districts began the relicensing process by filing a Notice of Intent and Pre-Application Document (PAD) with FERC on February 10, 2011, following the regulations governing the Integrated Licensing Process (ILP). The Districts' PAD included descriptions of the Project facilities, operations, license requirements, and Project lands as well as a summary of the extensive existing information available on Project area resources. The PAD also included ten draft study plans describing a subset of the Districts' proposed relicensing studies. The Districts then convened a series of Resource Work Group meetings, engaging agencies and other relicensing participants in a collaborative study plan development process culminating in the Districts' Proposed Study Plan (PSP) and Revised Study Plan (RSP) filings to FERC on July 25, 2011 and November 22, 2011, respectively.

On December 22, 2011, FERC issued its Study Plan Determination (SPD) for the Project, approving, or approving with modifications, 34 studies proposed in the RSP that addressed Cultural and Historical Resources, Recreational Resources, Terrestrial Resources, and Water and Aquatic Resources. In addition, as required by the SPD, the Districts filed three new study plans (W&AR-18, W&AR-19, and W&AR-20) on February 28, 2012 and one modified study plan (W&AR-12) on April 6, 2012. Prior to filing these plans with FERC, the Districts consulted with relicensing participants on drafts of the plans. FERC approved or approved with modifications these four studies on July 25, 2012.

Following the SPD, a total of seven studies (and associated study elements) that were either not adopted in the SPD, or were adopted with modifications, formed the basis of Study Dispute proceedings. In accordance with the ILP, FERC convened a Dispute Resolution Panel on April 17, 2012 and the Panel issued its findings on May 4, 2012. On May 24, 2012, the Director of FERC issued his Formal Study Dispute Determination, with additional clarifications related to the Formal Study Dispute Determination issued on August 17, 2012.

This study report describes the objectives, methods, and results of the Project Operations/Water Balance Model Study (W&AR-02) as implemented by the Districts in accordance with FERC's SPD and subsequent study modifications and clarifications. Documents relating to the Project relicensing are publicly available on the Districts' relicensing website at www.donpedro-relicensing.com.

1.3 Study Plan

FERC approved the Districts' Operations Model Study Plan in the December 22, 2011 Study Plan Determination. FERC modified the study plan by directing the Districts to include in the Workshops proposed by the Districts a discussion of relicensing participant (RP) preferences for graphical and statistical output to include in the model as appropriate any licenses or agreements that are not part of the FERC license, and to extend the model to the San Joaquin River confluence after the conduct of the accretion/depletion measurements in the lower Tuolumne River.

The model was developed in accordance with the approved study plan. There were no variances from the FERC Study Plan Determination dated December 22, 2011. However, the study plan was modified by FERC in the Director's Formal Study Dispute Determination issued on May 24, 2012. In this May 24 Determination, and subsequent clarification dated August 17, 2012, FERC directed the Districts to use the Consultation Workshop process to define (1) the statistical output required by NMFS in its previous study request NMFS-4, Element 1 and (2) the appropriate number of and locations for accretion flow measurements in the lower Tuolumne River. Subsequently, the Districts on June 6, 2012, forwarded to RPs for review and comment a plan to collect accretion flow measurements at various points along the lower Tuolumne River. No comments were received. The Districts conducted these field measurements on June 25 and 26, and provided the results to the RPs on July 26 in advance of Consultation Workshop No. 2 held on September 21. The Districts' reviewed with RPs an approach for conducting two additional accretion measurements, and consulted with RPs regarding additional measurement locations. The Consultation Workshop on September 21 also was used to discuss the details of all the flow data available to the Districts and the statistical analyses to be conducted in accordance with the Director's May 24 Determination. Draft meeting notes were prepared and submitted to RPs on October 22. The SWRCB provided comments on November 27. No other comments have been received. Two model training sessions were held with RPs, one on October 23, 2012 and the second on December 7, 2012.

On May 18, 2017, the Districts hosted a Modeling Tools Update Meeting with RPs. At the meeting, the Districts described several modifications that had been made to the Project Operations/Water Balance Model in order to correct minor errors in the model. These modifications, which are described in Attachment D, did not result in any changes to this study report.

2.0 STUDY GOALS AND OBJECTIVES

The study goal is to develop a Project operations computer model (Operations Model) to simulate current Don Pedro Project operations and alternative scenarios for future operations of the Project. The Operations Model is intended to be available to RPs for their use in evaluating existing conditions and potential future Project operations.

Study objectives include developing a model that simulates current Project operations for a period of analysis that covers a range of historical hydrologic conditions. The Operations Model is able to simulate basic decisions made during Project operations for flood control management, water supply, river releases, reservoir levels, and hydropower generation. Objectives for the Operations Model also include:

- adequate reproduction of observed reservoir levels, reservoir releases, and hydropower generation, within acceptable calibration standards over a range of hydrologic conditions,
- providing output to inform other studies, analyses, and models,
- evaluating alternative scenarios of future Project operations to estimate effects on reservoir levels, reservoir releases and hydropower generation, and
- providing the model for use by RPs.

3.0 STUDY AREA

Consistent with the FERC-approved study plan and in consultations with RPs, the Tuolumne River Operations Model extends from the CCSF's Hetch Hetchy system in the upper Tuolumne basin to the Districts' Don Pedro Reservoir, then to the Tuolumne River's confluence with the San Joaquin River. Hydrologic records of Tuolumne River flows at La Grange have been recorded by the Districts and CCSF dating back to the early 1900s in order to implement and monitor the provisions of the 4^{th} Agreement between the Districts and CCSF regarding the allocation of flows of the Tuolumne River. The Districts are in the process of extending the Operations Model to the confluence of the San Joaquin River by a combination of analysis of intervening flows between Don Pedro Dam and the mouth of the river using USGS and CDEC gage records and through actual field measurements of accretion flows in the lower Tuolumne River.

4.0 METHODOLOGY

4.1 Summary of Model Development Process

Model development was completed using an Excel platform in accordance with the approved study plan. A "test case" model and complete Model Description and User's Guide was provided to RPs prior to an October 23 Workshop. The Operations Model simulates both the Districts' system and the CCSF Hetch Hetchy system, also as described in the approved study plan. The model development process included four Consultation Workshops with RPs as follows:

- Consultation Workshop No. 1 was held on April 9, 2012, focusing on the development of the hydrology for the model;
- Consultation Workshop No. 2 was held on September 21, focusing on discussing accretion flows in the lower Tuolumne River to support location of nodes, the results of the first set of actual field accretion flow measurements, and additional hydrologic analyses requested by RPs;
- Consultation Workshop No. 3 was held on October 23 and focused on discussing the Operations Model's architecture and computational methods, and review of the Model User's Guide; and
- Consultation Workshop No. 4 was held on December 7 and consisted of discussing the Model Validation segment of the overall model development. This workshop included a second hands-on training session on model use with RPs.

The first model training session for RPs interested in using the model was held on October 23 and a second session was held on December 7, in conjunction with workshops.

The Districts have also provided additional materials and analyses relevant to the development of the Tuolumne River Operations Model as described below:

- On November 6, 2012, the Districts provided to RPs for review and comment a report entitled *Lower Tuolumne River Accretion Flows (La Grange to Modesto) -- Estimated Daily Flows (1970-2010) for the Operations Model.* This report described the Districts' estimate of daily intervening flows occurring on the lower Tuolumne River from WY 1971 to WY 2010. These flows were proposed to be included in the Operations Model to extend the model to the San Joaquin River.
- On December 27, 2012, the Districts responded to a letter dated September 10, 2012 from CDFG to SWRCB regarding the Districts development of the unimpaired hydrology for the Operations Model. In their response to the CDFG letter, the Districts included the results of a study conducted to evaluate the gage proration method for the development of the unimpaired hydrology as suggested by CDFG's September 10 letter. The study showed that the Districts mass balance approach and the CDFG's gage proration approach compared well where there were adequate gage records for the evaluation, but that the gage proration approach lacked a sufficient period of record for operations modeling purposes.

4.2 Field Accretion Measurements

The Districts conducted these field measurements on June 25 and 26, and provided the results to the RPs on July 26. An additional accretion flow measurement was conducted on October 3-4, 2012, and results of both field events are included in Attachment A of this ISR. Two sets of accretion flow measurements have been undertaken to date and a third is planned for late January/early February when weather conditions are favorable to permit the measurement of accretion flows occurring from primarily groundwater sources. The January/February accretion measurements will be targeted to occur following a one-two week period with little or no precipitation.

5.0 RESULTS

The Tuolumne River Operations Model development is proceeding on schedule. Four Workshops and two model training sessions have been conducted. Relicensing participants have been actively engaged and provided highly valued comments and feedback. The "base case" model is on schedule to be provided to RPs for review and comment in March 2013. The attached detailed reports document and describe the model development process to date. An electronic version of the model developed for the training session has been provided to interested RPs, and is available upon request from the Districts.

6.0 STUDY FINDINGS

The Operations Model has been vetted within RP workshops and is currently available for use. In accordance with the approved study plan, the "base case" representing Don Pedro and Hetch Hetchy "no action" alternative operations will be developed and provided to RPs for review and comment in March 2013. At that point the model will be ready for evaluation of future operating scenarios. The Districts are considering further refinements to model validation dealing with hydropower generation. These are scheduled for completion by January 31, 2013. These refinements will not alter model operations because both Hetch Hetchy and Don Pedro operate under a "water first" guide, meaning water releases are made for water supply purposes with hydropower generation being an ancillary use.

This report primarily consists of the four fundamental building blocks of model development:

- Hydrology
- Model Description
- User's Guide
- Validation Report

The first item, concerning Tuolumne River hydrology, is provided as Attachment A entitled Model Hydrology Report. The second two items have been combined into a single report entitled Model Description and User's Guide, provided as Attachment B, and the Validation Report is provided as Attachment C. Some of these materials have previously been provided as drafts to RPs during the Consultation Workshops.

7.0 STUDY VARIANCES AND MODIFICATIONS

There have been no study variances in the development of the Operations Model. The Districts have discussed accretion field work and preliminary findings through the Workshop process and have undertaken two sets of accretion flow field measurements to date. A third is scheduled for late January/early February 2013, streamflow conditions permitting.

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ATTACHMENT A

TUOLUMNE RIVER DAILY OPERATIONS MODEL

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1.0 INTRODUCTION

The Turlock Irrigation District (TID) and Modesto Irrigation District (MID) (collectively, the Districts) have developed a computerized Project Operations Model (Model) to assist in evaluating the relicensing of the Don Pedro Project (Project) (FERC Project 2299). On November 22, 2011, in accordance with the Integrated Licensing Process schedule for the relicensing of the Don Pedro Project, the Districts filed their Revised Study Plan containing 35 proposed studies with the Federal Energy Regulatory Commission (FERC) and relicensing participants. On December 22, 2011, FERC issued its Study Plan Determination approving, with modifications, the proposed studies, including Study Plan W&AR-2: Project Operations /Water Balance Model Study Plan. Consistent with the FERC-approved study plan, the objective of the Model is to provide a tool to compare current and potential future operations of the Project. Due to the fact that the geographic scope of the Model extends from the City and County of San Francisco's (CCSF) Hetch Hetchy system in the upper part of the watershed to the confluence of the Tuolumne and San Joaquin rivers, the Model is now entitled the Tuolumne River Daily Operations Model (Model).

In accordance with the study plan, the Districts have prepared a Model Development Report filed with FERC in January 2013 (W&AR-02 Study Plan, page 7). This Model Hydrology Report is an attachment to the Model Development Report and provides information concerning the development of the hydrology for the Model. Section 2.0 describes the development of the unimpaired flow of the Tuolumne River Basin, subcomponents of unimpaired flow and other components of flow needed by the Model. Section 3.0 describes the analysis used to estimate accretion flow in the Tuolumne River below La Grange Dam and the Modesto Gage in the Tuolumne River, and the estimated flow of Dry Creek.

2.0 TUOLUMNE RIVER UNIMPAIRED AND COMPUTED FLOW

Included in the Model are numerous user-controlled parameters that allow the simulation of alternative Project operations, such as the prescription of lower Tuolumne River minimum flow requirements. The Model performs a simulation of Project operations for a sequential period of years that covers a range of historical hydrologic conditions. The period of hydrologic record selected for the Model is Water Year[1] 1971 through Water Year 2009, which includes extreme years of hydrology (1977 dry and 1983 wet) and multi-year periods of challenging water supply conditions such as 1976-1977, 1987-1992, and 2001-2004.

Underlying Project operations and water supply in the Tuolumne River Basin is the unimpaired flow of the river and its tributaries. "Unimpaired flow" is surface water that is available for management and use. The California Department of Water Resources (DWR) provides a definition of unimpaired flow as "… runoff that would have occurred had water flow remained unaltered in rivers and streams instead of stored in reservoirs, imported, exported, or diverted. The data is a measure of the total water supply available for all uses after removing the impacts of most upstream alterations as they occurred over the years." By computing the unimpaired flow one acquires the record of flow at a location, had no physical (e.g., dams and diversions) facilities been developed upstream of the location. At times, this record is fundamental to modeling the operations of a project as it provides a record of inflow to a facility. At other times, this record is needed to identify the total available water supply of the stream for purposes of division or allocation, which would not be known by simple measurement of the stream at a location that is below controlling facilities.

The unimpaired flow of the Tuolumne River has been computed for various locations within the basin for decades. From a water project development perspective, this information was important during project planning in understanding water availability within the basin. Today, it plays directly into Project and basin operations as a key factor in establishing annual water deliveries and the provision of flows to the lower Tuolumne River. The Districts and CCSF have used unimpaired flow computations to comply with Raker Act and Fourth Agreement provisions, and for the operational and planning needs of their respective projects. Further, unimpaired flow data, along with other data is provided by the Districts to the DWR for incorporation into Statewide water management efforts.

The Model requires several records of unimpaired flow. Three primary records are: 1) unimpaired flow (inflow) at Hetch Hetchy Reservoir, 2) unimpaired flow (inflow) at Lake Lloyd Reservoir and Eleanor Reservoirs, and 3) unimpaired flow at La Grange. Unimpaired flows at each of these locations must be calculated from flows measured from other locations. The Model utilizes a unique fourth component of unimpaired flow which depicts the runoff entering Don Pedro Reservoir that is not affected by upstream CCSF facilities. This runoff concerns runoff from tributaries and streams such as the South and North Forks of the Tuolumne River.

An unimpaired record of flow at a location requires an identification of the flow occurring at that location and the alterations of flow occurring upstream of that point. If no man-made alterations

[1] In California the Water Year is defined as the period of time between and inclusive of October 1 of a year and September 30 of the following year. Water Year 1971 begins October 1, 1970 and ends September 30, 1971.

are occurring upstream of a point of interest the measured flow at that location can be considered the unimpaired flow at the location. When storage reservoirs and diversions occur upstream of the point of interest the effect on the flow due to these alterations of a freely flowing stream must be taken into consideration. The general form of equation to compute unimpaired flow follows:

$$\text{Inflow}_t\,(\text{unimpaired}) = \text{Outflow}_t\,(\text{measured}) + \text{Storage}_t - \text{Storage}_{t-1} + \text{Reservoir Evaporation}_t + \text{Diversions}$$

Where, inflow is the unimpaired flow computed at a specific location for a specified time period (the Model utilizes a daily time step). Outflow is the measured flow at the location, which has been altered by upstream activity. The change in storage recognizes the amount of stream flow that has been reduced from or added to the measured flow due to upstream reservoir operation. The reservoir evaporation term recognizes that the measured flow would also be affected by a loss of flow equal to the amount of evaporation caused by the surface area of upstream reservoirs. The diversion term recognizes flow being removed (and not returned) from the stream upstream of the point of interest.

As indicated above three primary records are developed: unimpaired flow (inflow) at Hetch Hetchy Reservoir, unimpaired flow (inflow) at Lake Lloyd Reservoir and Eleanor Reservoirs, and unimpaired flow at La Grange. Unimpaired flows at each of these locations must be calculated from flows measured from other locations. Figure 2.1-1 illustrates hydrologic measurement and computation points within the Tuolumne River basin and other flow parameters of interest.

The following Section 2.1 provides a narrative description of the computation of unimpaired flow for several components of flow needed by the Operations Model. Accompanying this appendix is a workbook entitled “Don Pedro unimpaired and other flow data Version 2.xlsx” (Hydrology Workbook) with the data used to compute these components.[2] Also described are other components of flow computed from this information that was used for Model result comparison and validation purposes. Following the columnar description is a description and documentation of an adjustment of the historical unregulated component of inflow to Don Pedro Reservoir that is used in Project modeling (Section 2.2) and a discussion (Section 2.3) of other hydrologic information pertaining to the modeling. Also presented (Section 2.4) is an analysis that compares the results of the unimpaired flow computation method used by the Districts (mass balance approach) to an alternative method of flow computation that uses a watershed comparison approach.

2.1 Worksheet Columnar Description

Each section and column of the Hydrology Workbook is described below.

[2] An earlier version of the Hydrology Workbook was presented to RPs during the W&AR-2 Workshop No. 1 held on April 9, 2012. The workbook contained hydrologic records for the Period WY1971 through WY2010. Due to the needs of Don Pedro Reservoir and Tuolumne River temperature modeling validation and calibration processes preliminary hydrologic data and computations have been extended in the workbook through December 18, 2012.

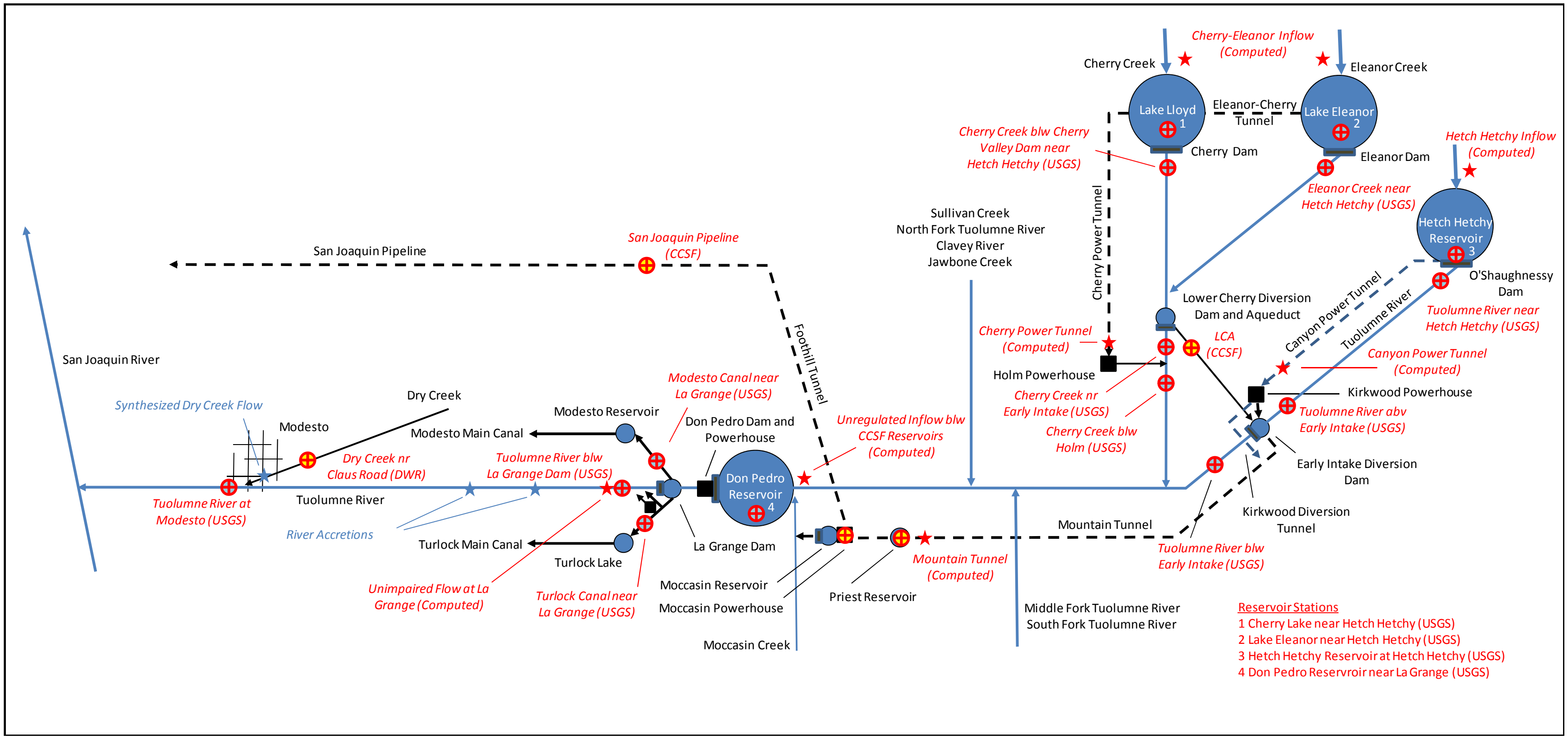


Figure 2.1-1. Tuolumne River Basin hydrologic measurement and computation points.

<u>Date Indices</u> Columns A, B and C
The numeric and alphanumeric values identifying the date of applicable record. These values are also used for data assemblage purposes. All records reported by date represent either end-of-day status (e.g., storage ending at midnight, in acre-feet (ac-ft)) or average daily flow (e.g., average flow occurring throughout the day, in cubic feet per second (cfs)).

<u>Reservoir Storage</u> Columns D, G, J, and M
Reservoir storage reported by USGS:

- 11275500 Hetch Hetchy Reservoir at Hetch Hetchy, CA, Column D
- 11277200 Cherry Lake near Hetch Hetchy, CA, Column G
- 11277500 Lake Eleanor near Hetch Hetchy, CA, Column J
- 11287500 Don Pedro Reservoir near La Grange, CA, Column M

The record is reported in units of ac-ft.

<u>Change in Storage</u> Columns E, H, K, and N
The algebraic difference of the previous day storage record and the current day storage record. The value provides the storage change from the previous day, and is converted from ac-ft to cfs by multiplying by a conversion constant of 0.504167.

- Hetch Hetchy Reservoir, Column E
- Lake Lloyd Reservoir, Column H
- Lake Eleanor, Column K
- Don Pedro Reservoir, Column N

The record is reported in units of cfs.

<u>Reservoir Evaporation</u> Columns F, I, L, and O
Daily evaporation in a reservoir, estimated by determining the surface area of a reservoir from reservoir storage applied to area rating tables and multiplying the surface area by the evaporation factor (tables) for the month involved.

- Hetch Hetchy Reservoir, Column F
- Lake Lloyd Reservoir, Column I
- Lake Eleanor, Column L
- Don Pedro Reservoir, Column O

For CCSF reservoirs an estimate of monthly net depth of evaporation is applied. These factors were developed from the mean of monthly observed depths of evaporation and precipitation readings taken at Lake Eleanor from 1909 to 1933. These factors are shown in the Table 2.1-1 below.

The same daily reservoir evaporation value for each of its reservoirs is used for the applicable month based on the ending storage of the previous month. The factor shown in the table is multiplied by the area, with the result being in units of cfs.

Table 2.1-1. CCSF Reservoir Daily Evaporation Factors.

Month	Daily Factor	Month	Daily Factor
January	-0.00325269	July	0.00975807
February	-0.00360119	August	0.00975807
March	0.00000000	September	0.00672222
April	0.00000000	October	0.00325269
May	0.00325269	November	0.00000000
June	0.00672222	December	0.00000000

For Don Pedro Reservoir, monthly evaporation factors were also derived from monthly averages from historical experience. These factors, converted to apply as a daily factor multiplied by the surface area of Don Pedro Reservoir are shown in the Table 2.1-2 below.

Table 2.1-2. Don Pedro Reservoir Daily Evaporation Factors.

Month	Daily Factor	Month	Daily Factor
January	-0.00088458	July	0.01397570
February	-0.00025777	August	0.01410893
March	0.00113491	September	0.01072018
April	0.00308124	October	0.00639480
May	0.00796822	November	0.00178105
June	0.01094715	December	-0.00013449

Don Pedro Reservoir evaporation is computed for every day, and results are in units of cfs.

The storage to surface area rating tables used for the estimated evaporation loss calculation are included in the Hydrology Workbook within the worksheet labeled “Reservoir”.

<u>Measured Flow</u> Columns P, Q, R, S, T, U, V, W, X, Y, Z, AA, AB, AC, and AD
Several measured flow components are needed to compute unimpaired flow at the three primary locations. To compute unimpaired flow at La Grange, the following measured flow records are needed:

- CCSF[3] San Joaquin Pipelines (SJPL), Column Z
- 11289000 Modesto Canal near La Grange, CA, Column AA
- 11289500 Turlock Canal near La Grange, CA, Column AB
- 11289650 Tuolumne River below La Grange Dam, near La Grange, CA, Column AC

3 CCSF gage locations are shown Figure 2.1-1.

The diversion to the SJPL, measured in million gallons per day (mgd) at the Oakdale Meters, is multiplied by a conversion constant of 1.547229 and reported by CCSF in units of cfs. The other three records are reported by USGS, also in units of cfs.

The other records of measured flow pertain to the computation of unimpaired flow at Hetch Hetchy Reservoir and Lake Lloyd Reservoir and Eleanor Lake. With little or no impairment upstream of these reservoirs, the computation of unimpaired inflow at these locations also represents the inflow to these reservoirs. The records provided are:

- 11276500 Tuolumne River near Hetch Hetchy, CA, Column P
- 11276600 Tuolumne River above Early Intake, near Mather, CA, Column Q
- 11276900 Tuolumne River below Early Intake, near Mather, CA, Column R
- 11278000 Eleanor Creek near Hetch Hetchy, CA, Column S
- 11277300 Cherry Creek below Cherry Valley Dam, near Hetch Hetchy, CA, Column T
- 11278300 Cherry Creek near Early Intake, CA, Column U
- 11278400 Cherry Creek below Dion R. Holm Powerplant, near Mather, CA, Column V
- CCSF Lower Cherry Aqueduct, Column W
- CCSF Mountain Tunnel, Column X
- CCSF Holm Powerhouse, Column Y

The use of these records within computation procedures is described in the next section. Column AD "Total Release Don Pedro Dam" is for informational purposes and is the summation of Columns AA, AB and AC, in cfs.

<u>Computed Unimpaired Flow</u> Columns AE, AF, AG, and AH
As described earlier, unimpaired flow is computed by removing the effects that upstream storage and diversions have upon the flow in the stream. In a developed basin such as the Tuolumne River the procedures involve the recognition of the physical impairments that happen along the course of the stream.

There is no gage to measure inflow to Hetch Hetchy Reservoir. Hence, the computation of unimpaired flow into Hetch Hetchy Reservoir (Column AE), which is accepted as the inflow to Hetch Hetchy Reservoir, is calculated for a time period, *t*, using recorded historical storage, outflow and reservoir evaporation data using the following equation. The equation is of a form that recognizes all flow entering and exiting a reservoir must balance.

$$\text{Inflow}_t = \text{Ouflow}_t + \text{Storage}_t - \text{Storage}_{t-1} + \text{Reservoir Evaporation}_t$$

The storage and reservoir evaporation components of the equation have already been defined or computed for Hetch Hetchy Reservoir by Column D (Hetch Hetchy Reservoir storage) computed as a change in storage expressed as average daily flow (Column E), and Column F (reservoir evaporation) expressed as average daily flow. Outflow from Hetch Hetchy Reservoir is the summation of water released to the stream below O'Shaunessy Dam and to Canyon Power Tunnel.

Releases from Hetch Hetchy Reservoir to the stream below O'Shaunessy Dam are measured at the USGS gaging station below the dam (USGS gage 11276500; Column P). Releases to Canyon Power Tunnel are computed by accounting for the flow through Mountain Tunnel (Column X) and the flow that is released back to the Tuolumne River from Kirkwood Powerhouse. The release back to the Tuolumne River from Kirkwood Powerhouse is estimated by measuring the flow in the Tuolumne River upstream of the release (USGS gage 11276600; Column Q) and downstream of the release (USGS gage; 11276900; Column R), and adjusting the difference in flow by amount of flow that occurs to the reach from the Lower Cherry Aqueduct (Column W).

By substituting the recorded values into the equation, the following computation results. Results are shown in Column AE.

Unimpaired Flow (inflow) at Hetch Hetchy Reservoir

Inflow $_t$ = Column P $_t$ (flow below dam) + Column X $_t$ (Mountain Tunnel) - Column Q $_t$ (above Early Intake) + Column R $_t$ (below Early Intake) - Column W $_t$ (Lower Cherry Aqueduct) + Column E $_t$ (change in storage) + Column F $_t$ (reservoir evaporation)

For the computation of unimpaired flow of Cherry Creek and Eleanor Creek into Lake Lloyd Reservoir and Lake Eleanor (combined) (Column AF) the same basic reservoir equation is used. The change in storage and reservoir evaporation components of the equation have already been computed for Lake Lloyd Reservoir and Lake Eleanor by Column H and Column K (Lake Lloyd Reservoir storage change and Lake Eleanor storage change) computed as a change in storage expressed as average daily flow, and Column I and Column L (reservoir evaporation, respectively for Lake Lloyd Reservoir and Lake Eleanor) expressed as average daily flow. Outflow from Lake Lloyd Reservoir and Lake Eleanor is the summation of water released to the streams below Cherry Valley Dam and Eleanor Dam, and to Cherry Power Tunnel.

Releases from Cherry Valley Dam and Eleanor Dam to the streams are measured at USGS gaging stations below the dams (USGS gage 11277300, Column T, and USGS gage 11278000, Column S). Flow diverted to Cherry Power Tunnel from Lake Lloyd Reservoir and released back to Cherry Creek is estimated by measuring the flow in Cherry Creek above Holm Powerhouse (USGS gage 11278300, Column U) and below Holm Powerhouse (USGS gage 11278400, Column V), and computing the difference between measurements.

By substituting the recorded values into the equation, the following computation results. Results are shown in Column AF.

Unimpaired Flow (inflow) at Lake Lloyd Reservoir and Lake Eleanor (combined)

Inflow $_t$ = Column T $_t$ (flow below Cherry Valley Dam) + Column S $_t$ (flow below Eleanor Dam) + Column V $_t$ (flow below Holm Powerhouse) - Column U $_t$ (flow above Holm Powerhouse) + Column H $_t$ (change in Lake Lloyd Reservoir storage) +

Column K $_t$ (change in Lake Eleanor storage) + Column I $_t$ (Lake Lloyd Reservoir evaporation) + Column L $_t$ (Lake Eleanor evaporation)

For the computation of unimpaired flow at La Grange, the basic inflow equation again applies, only in this instance the combined effects of both CCSF and District diversions and storage (above La Grange) are incorporated. For this computation the storage effects of Don Pedro Reservoir, Hetch Hetchy Reservoir, Lake Lloyd Reservoir and Lake Eleanor affect flow in the Tuolumne River. Regarding diversions from the river above La Grange that affect the computation, CCSF's SJPL diversion and the Districts' two canal diversions at La Grange Dam are incorporated. The other diversions described previously for CCSF operations remain within the basin and are assumed to be diverted and returned to the river instantaneously. The regulated release to the Tuolumne River below La Grange Dam is treated as an outflow in the equation.

By substituting the recorded values into the equation below the following computation results. Results are shown in Column AG.

Unimpaired Flow at La Grange

Unimpaired Flow $_t$ = Column AC $_t$ (flow at La Grange) + Column Z $_t$ (CCSF SJPL) + Column AA $_t$ (MID Canal) + Column AB $_t$ (TID Canal) + Column N $_t$ (change in Don Pedro Reservoir storage) + Column E $_t$ (change in Hetch Hetchy Reservoir storage) + Column H $_t$ (change in Lake Lloyd Reservoir storage) + Column K $_t$ (change in Lake Eleanor storage) + Column O $_t$ (Don Pedro Reservoir evaporation) + Column F $_t$ (Hetch Hetchy Reservoir evaporation) + Column I $_t$ (Lake Lloyd Reservoir evaporation) + Column L $_t$ (Lake Eleanor evaporation)

The Model incorporates two components of inflow to Don Pedro Reservoir, a component of regulated inflow through CCSF facilities and a component of inflow (considered unimpaired) not affected by CCSF facilities. This second component of inflow was described previously and concerns runoff from tributaries and streams such as the South and North Forks of the Tuolumne River. A computation of this component of flow is provided in Column AH and is the algebraic difference between the total unimpaired flow computed at La Grange (Column AG) and the two components of unimpaired flow (inflow) to Hetch Hetchy Reservoir (Column AE, calculated above) and Lake Lloyd Reservoir and Lake Eleanor (Column AF, calculated above).

Also computed from the information used to develop the unimpaired flow records is the computed historical record of total inflow to Don Pedro Reservoir. Although unnecessary for scenario modeling since inflow to Don Pedro Reservoir will be the result of modeling assumptions, the computed historical record of inflow serves as a benchmark for Model validation. Computed inflow to Don Pedro Reservoir is derived from the basic mass balance equation:

$$\text{Inflow}_t = \text{Ouflow}_t + \text{Storage}_t - \text{Storage}_{t-1} + \text{Reservoir Evaporation}_t$$

Where, outflow is the total release from Don Pedro Reservoir which is the combined measured flow at La Grange (Column AC) plus diversions to Modesto Canal (Column AA) plus diversions to Turlock Canal (Column AB). The result of the computation is provided in Column AU noted as "Inflow to Don Pedro".

For reservoir temperature modeling calibration and validation purposes, both the regulated and unregulated components of computed historical inflow to Don Pedro Reservoir were needed. The unregulated inflow and total inflow to Don Pedro Reservoir have been described above. The computed historical regulated component of inflow to Don Pedro Reservoir is the difference between the total inflow and unregulated inflow, and is reported in Column AV.

2.2 Adjustment of Historical Inflow to Don Pedro Reservoir

Although not directly used by the Model, unimpaired flow at La Grange is needed to develop a unique component of unimpaired flow which depicts the runoff entering Don Pedro Reservoir that is not affected by upstream CCSF facilities. This runoff concerns runoff from tributaries and streams such as the South and North Forks of the Tuolumne River. This component of runoff is referred to as unregulated inflow to Don Pedro Reservoir. It is computed as the difference between the unimpaired flow at La Grange and the unimpaired flows entering Hetch Hetchy Reservoir, Lake Lloyd and Lake Eleanor.

Due to computational procedures, gage accuracy, and reporting errors there can be on occasion a reporting of a "negative" flow associated with one or more of the just described unimpaired flow components. These computed negative flows are typically the result of applying a computational mass balancing of several flows and changes in storage components, which may result in an occasional computed negative value for flow. These occurrences are considered anomalies in the day to day record, which tend to occur during low flow periods when a small misinterpretation of reservoir stage can overwhelm the determination of a small flow value. These anomalies in daily values will normally self-correct over several days of record. Within the modeling of CCSF facilities, the unimpaired flow data that will be used consists solely of the inflows to Hetch Hetchy Reservoir and Lake Lloyd and Lake Eleanor. This daily record, potentially inclusive of intermittent negative daily flows, will be absorbed by reservoir operations (storage in Hetch Hetchy Reservoir up to 360,000 acre-feet and storage in Lake Lloyd and Lake Eleanor up to 295,000 acre-feet). Within the model, an anomaly in inflows such as a negative flow one day and a compensating overestimation of inflow the next will be correctly accounted for, but the precise day-to-day fluctuation will be "lost" within the operation of the reservoir and not cause a decisional effect to simulated operations.

The release from CCSF facilities, components from Hetch Hetchy Reservoir and components from Lake Lloyd and Lake Eleanor, is added to the unregulated inflow to Don Pedro Reservoir which becomes the total inflow to Don Pedro Reservoir. Due to the same data challenges as described above for the computation of inflow to CCSF reservoirs and the unimpaired flow at La Grange, there are occurrences of "negative flows" within the record of the mathematically derived unregulated inflow to Don Pedro Reservoir. From a perspective of modeling the operations of Don Pedro Reservoir, the intermittent occurrence of negative flows for the unregulated component of total Don Pedro Reservoir inflow is also not problematic. In many instances the computed negative unregulated flows will be overwhelmed by the positive regulated flow being released from CCSF facilities. However, even if there remained a net negative inflow Don Pedro Reservoir storage would absorb negative inflows as an adjustment to reservoir storage and not affect operation decisions which rely on greater-than-daily hydrology.

That all said, a need to refine (adjust) the negative flow values for unregulated inflow to Don Pedro Reservoir occurs due to modeling needs of the Don Pedro Reservoir temperature model. Inflow is modeled as two distinct components as described above, with separate temperature characteristics associated with each component. With this approach, negative inflow values associated with a component of inflow is not acceptable for reservoir temperature modeling. Therefore, the daily unregulated inflow component must be adjusted through data smoothing techniques to remove the occurrence of negative values.

The following provides documentation of the procedures and results of performing adjustments to hydrology used for modeling purposes.

Procedures for Adjusting Historical Unregulated Inflow to Don Pedro Reservoir

This component of hydrology is derived as the mathematical difference between the computed unimpaired flow at La Grange and the computed unimpaired flow entering Hetch Hetchy Reservoir, Lake Lloyd and Lake Eleanor (CCSF facilities). This component of flow is a fact of the computed historical record and is unaffected by CCSF facility operation. The daily-varying values will be consistent among all scenario studies and calibration-validation studies. The procedures employed to remedy negative values were guided by the following steps:

For each month in a year:

- Isolated negative values were replaced by a 3-day (or other short duration) average when possible, preserving the volume of the three days (or other duration). This form of adjustment was typically applied during non-summer or fall months. These instances appeared to occur from isolated day-to-day anomalies in the data. The shortness of the averaging period preserved adjacent period flow fluctuations including storm events.
- During chronic extended periods of anomalies (typically summer and fall months), a month was split into 1/3 periods and averaged during each period, preserving the period's volume. Within a month the values were sometimes averaged over longer or shorter periods to preserve the hydrology of apparent storms. Monthly volumes were preserved when possible.
- Values within a month were sometimes averaged over longer periods to eliminate sub-month period negative averages.
- When a month average was less than zero, the entire period was set as 1 cfs. This form of adjustment does not maintain the annual volume of runoff but was relatively small when compared to the annual volume. Some sub-month period 1 cfs adjustments were made.

Procedures for Adjusting Historical Regulated Inflow to Don Pedro Reservoir

This component of historical hydrology is not germane to scenario modeling. Within scenario modeling the regulated inflow to Don Pedro Reservoir will be determined by Model logic and assumptions, and may be unique to each study. However, for Don Pedro Reservoir temperature model calibration-validation and analysis, the historical computed record of the regulated inflow component of Don Pedro Reservoir must also be absent of negative values. The regulated inflow component is the mathematical difference between the computed inflow to Don Pedro Reservoir and the computed unregulated component of inflow. Due to the far fewer number of instances of occurrence and the limited use of this data set for temperature model calibration-validation and analysis a more simple approach of adjustment was employed. All negative values were replaced with a positive 1 cfs value.

Results

The computation and results of adjustments to the computed unregulated and regulated components of historical Don Pedro Reservoir inflow are shown in the Hydrology Workbook in Column AP through Column AY. A summary of annual computed historical hydrology and the adjustments is shown in Table 2.2-1 below. Reported "adjustments" represent the difference in volume of water associated with replacing a computed negative flow value with a 1 cfs flow assumption. This circumstance only occurs when the computed average flow in a month was less than zero.

Table 2.2-1. Summary of adjustments to computed historical inflow (annual).

	Before Adjustment			After Adjustment					
CY	Don Pedro Inflow AF	Regulated Inflow AF	Unregulated Inflow AF	Regulated Inflow AF	Regulated Adjustment AF	Unregulated Inflow AF	Unregulated Adjustment AF	Total Adjustment AF	Percent Adjustment %
1971	1,452,671	950,336	502,335	950,336	0	502,335	0	0	0.0
1972	994,994	628,774	366,220	628,774	0	366,220	0	0	0.0
1973	1,792,297	939,056	853,240	939,056	0	853,240	0	0	0.0
1974	1,846,644	1,163,328	683,316	1,163,328	0	683,316	0	0	0.0
1975	1,854,713	1,065,222	789,491	1,065,222	0	789,491	0	0	0.0
1976	440,985	303,132	137,852	303,132	0	145,444	7,592	7,592	1.7
1977	172,395	87,011	85,384	87,358	348	92,329	6,945	7,292	4.2
1978	2,574,771	1,497,986	1,076,785	1,497,986	0	1,076,785	0	0	0.0
1979	1,764,273	1,030,030	734,243	1,030,030	0	734,243	0	0	0.0
1980	2,712,898	1,582,413	1,130,485	1,582,413	0	1,130,485	0	0	0.0
1981	1,081,994	631,448	450,546	631,448	0	450,546	0	0	0.0
1982	3,712,941	1,946,427	1,766,513	1,946,427	0	1,766,513	0	0	0.0
1983	4,609,612	2,450,196	2,159,416	2,450,196	0	2,159,416	0	0	0.0
1984	1,918,102	1,322,120	595,983	1,322,120	0	595,983	0	0	0.0
1985	1,013,642	645,960	367,682	645,960	0	367,682	0	0	0.0
1986	2,582,309	1,536,733	1,045,576	1,536,733	0	1,045,576	0	0	0.0
1987	354,807	189,168	165,639	190,182	1,014	167,231	1,591	2,605	0.7
1988	722,606	507,453	215,153	507,453	0	215,153	0	0	0.0
1989	957,854	670,506	287,349	670,506	0	296,119	8,770	8,770	0.9
1990	725,340	550,191	175,149	550,191	0	184,956	9,807	9,807	1.4
1991	811,674	475,624	336,051	475,776	152	336,051	0	152	0.0
1992	720,161	462,794	257,368	462,794	0	257,368	0	0	0.0
1993	1,961,791	1,030,845	930,946	1,030,986	141	930,946	0	141	0.0
1994	856,778	604,162	252,616	608,056	3,894	258,434	5,818	9,712	1.1
1995	3,449,475	1,920,640	1,528,835	1,920,640	0	1,531,139	2,304	2,304	0.1
1996	2,601,289	1,541,146	1,060,143	1,541,146	0	1,060,143	0	0	0.0
1997	2,553,789	1,575,350	978,439	1,575,512	163	978,439	0	163	0.0
1998	3,002,931	1,547,432	1,455,500	1,547,855	423	1,455,500	0	423	0.0
1999	1,851,119	1,094,397	756,722	1,094,508	111	756,722	0	111	0.0
2000	1,861,233	1,082,329	778,904	1,083,865	1,536	778,904	0	1,536	0.1
2001	833,845	470,290	363,555	470,464	175	363,555	0	175	0.0
2002	1,137,527	760,735	376,792	760,735	0	384,724	7,932	7,932	0.7
2003	1,302,788	929,971	372,817	929,971	0	374,967	2,149	2,149	0.2
2004	1,098,453	790,920	307,532	790,936	16	307,532	0	16	0.0
2005	2,793,607	1,659,349	1,134,258	1,659,349	0	1,134,258	0	0	0.0
2006	2,897,316	1,737,130	1,160,186	1,737,130	0	1,160,186	0	0	0.0
2007	720,006	542,423	177,582	542,628	205	179,629	2,047	2,251	0.3
2008	810,433	509,554	300,879	509,554	0	300,879	0	0	0.0
2009	1,403,951	965,427	438,523	965,427	0	438,523	0	0	0.0

The following graphs illustrate the daily computed historical hydrology for total inflow to Don Pedro Reservoir and its regulated and unregulated inflow components, and the computed unimpaired runoff at La Grange for each year of the 1971 through 2009 modeling period. The data labeled "Adj Unregulated Inflow to Don Pedro" is the adjusted unregulated inflow to Don Pedro Reservoir and is shown as the solid red line. It lays over the original unregulated value which is shown as the solid royal blue line. During a significant amount of time there is no adjustment.

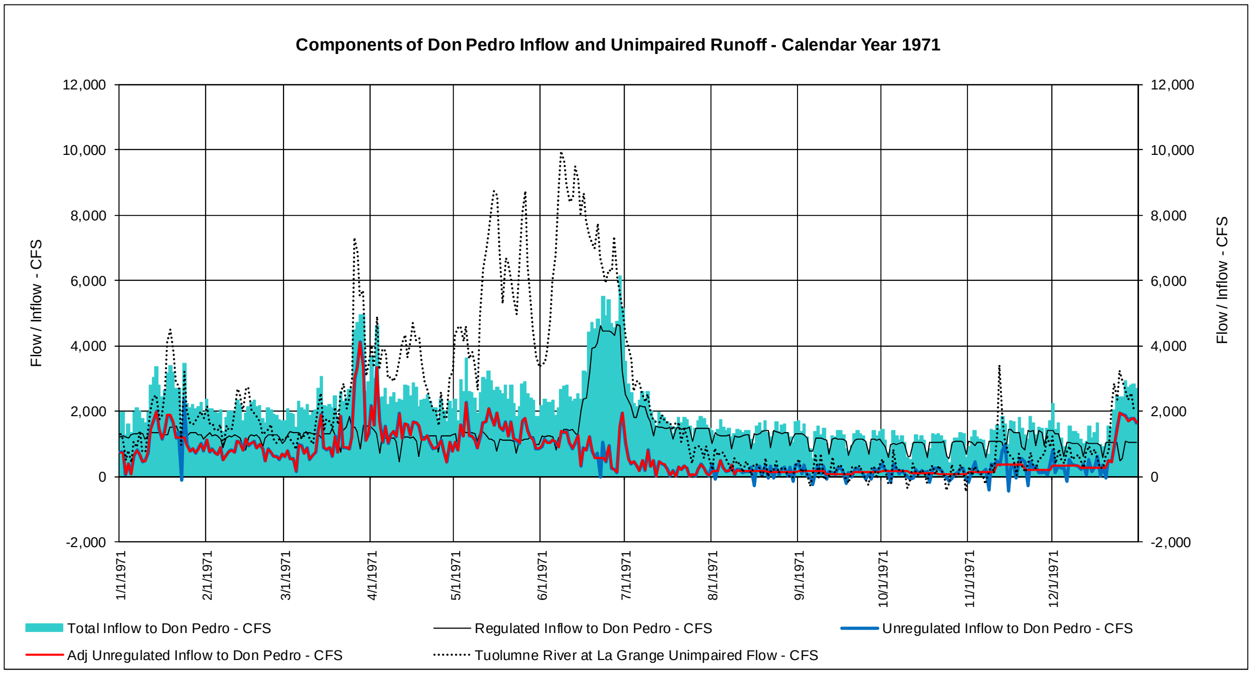


Figure 2.2-1. Calendar Year 1971.

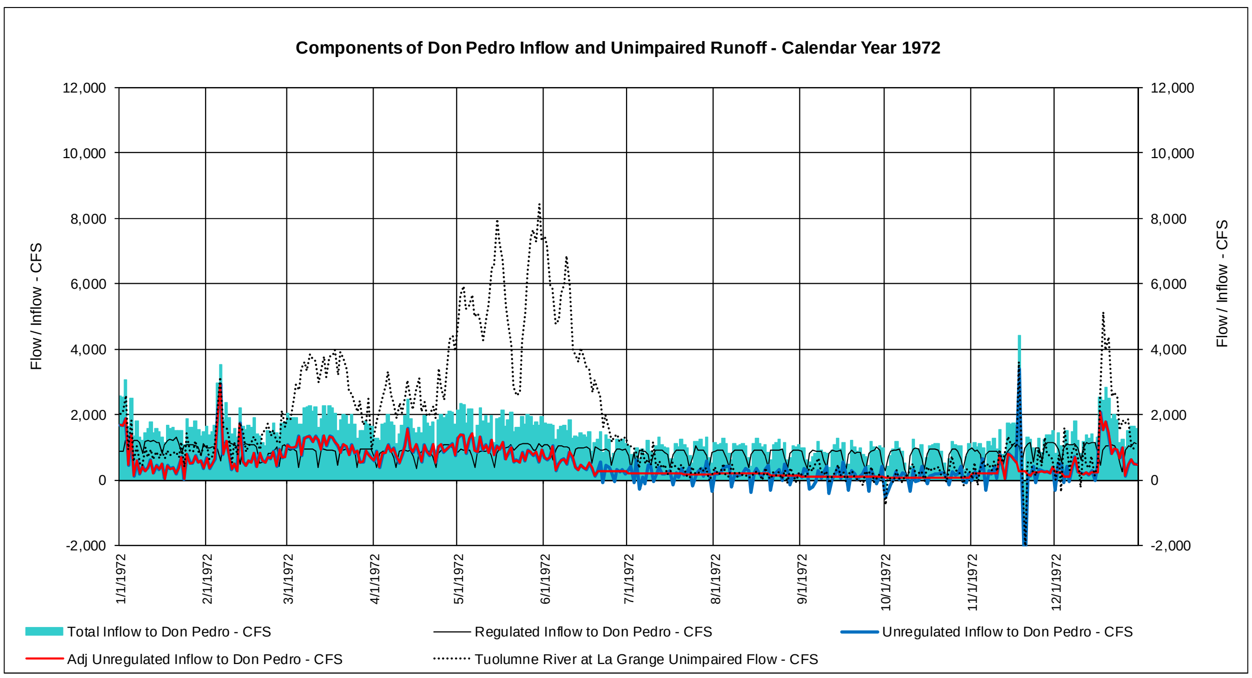


Figure 2.2-2. Calendar Year 1972.

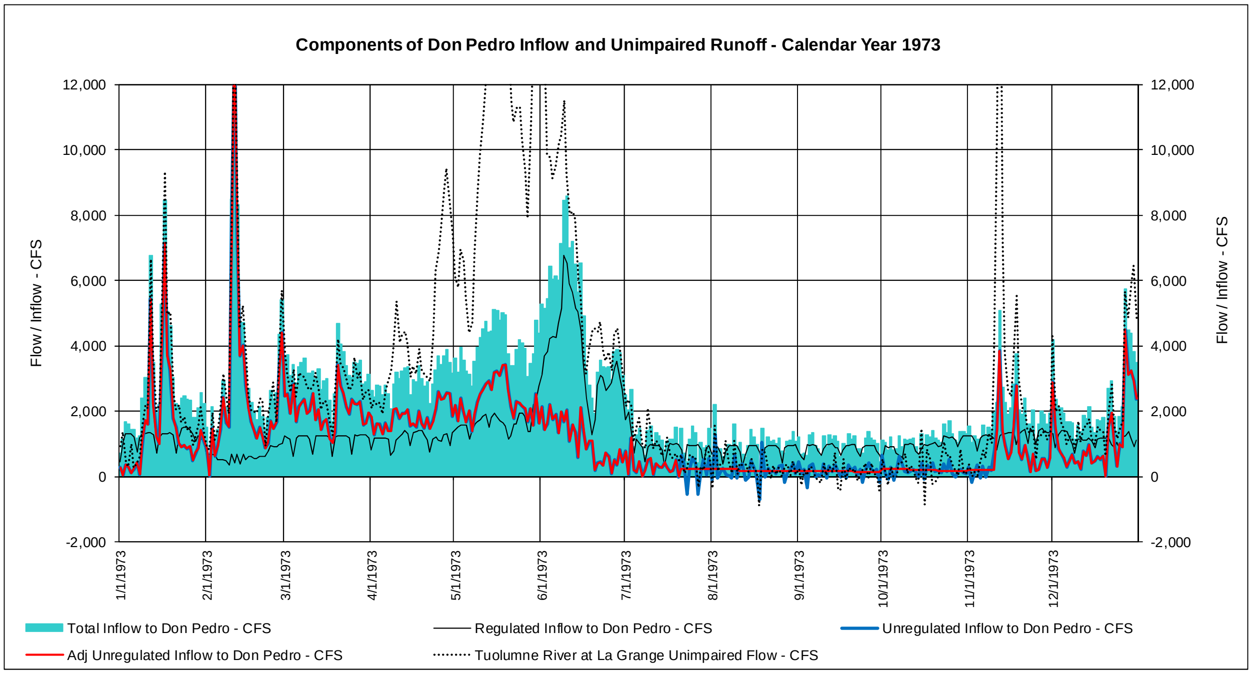


Figure 2.2-3. Calendar Year 1973.

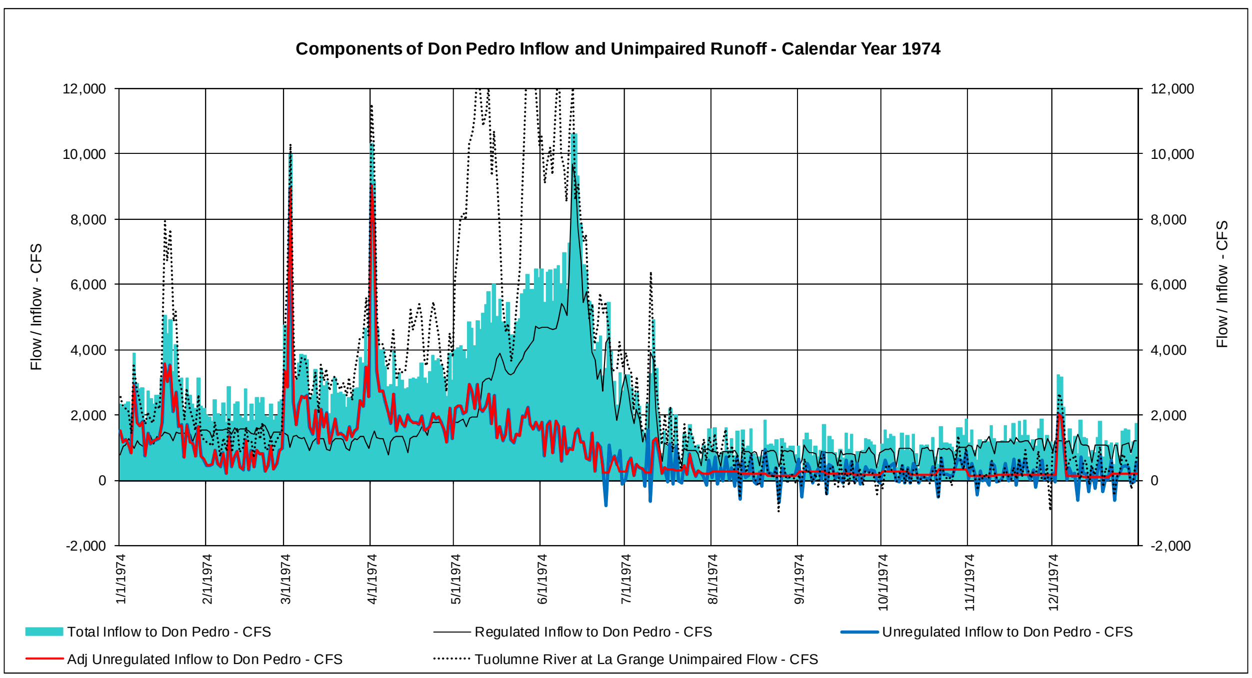


Figure 2.2-4. Calendar Year 1974.

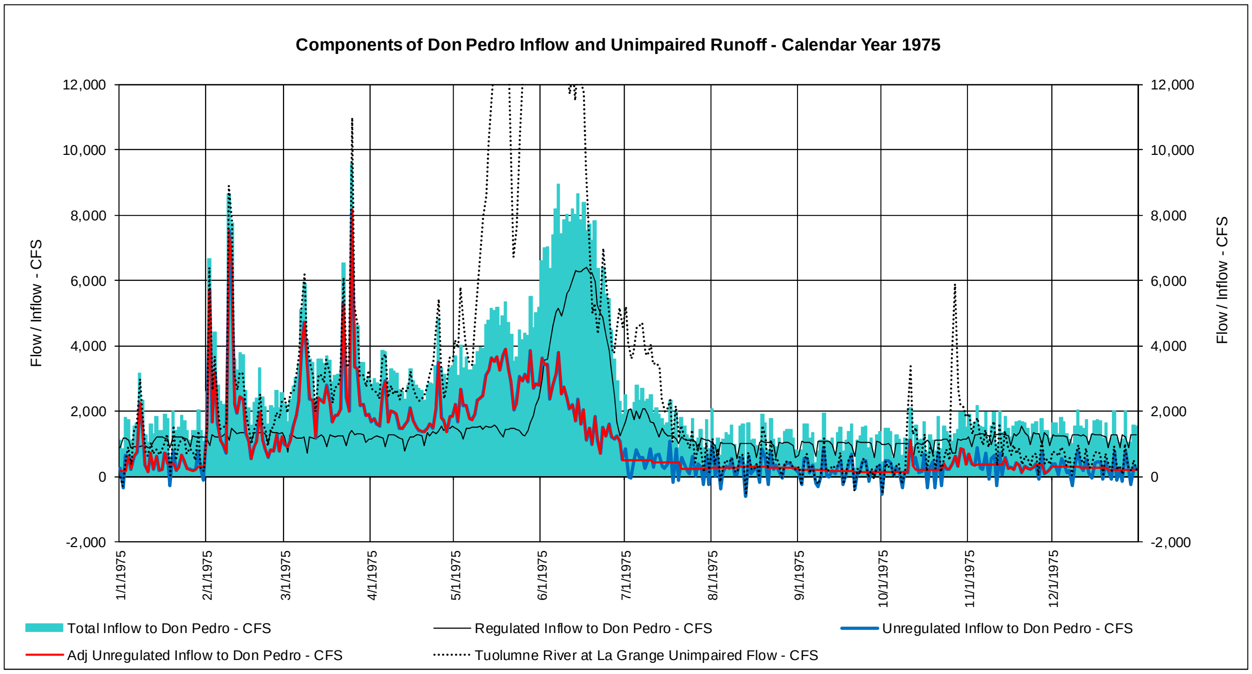


Figure 2.2-5. Calendar Year 1975

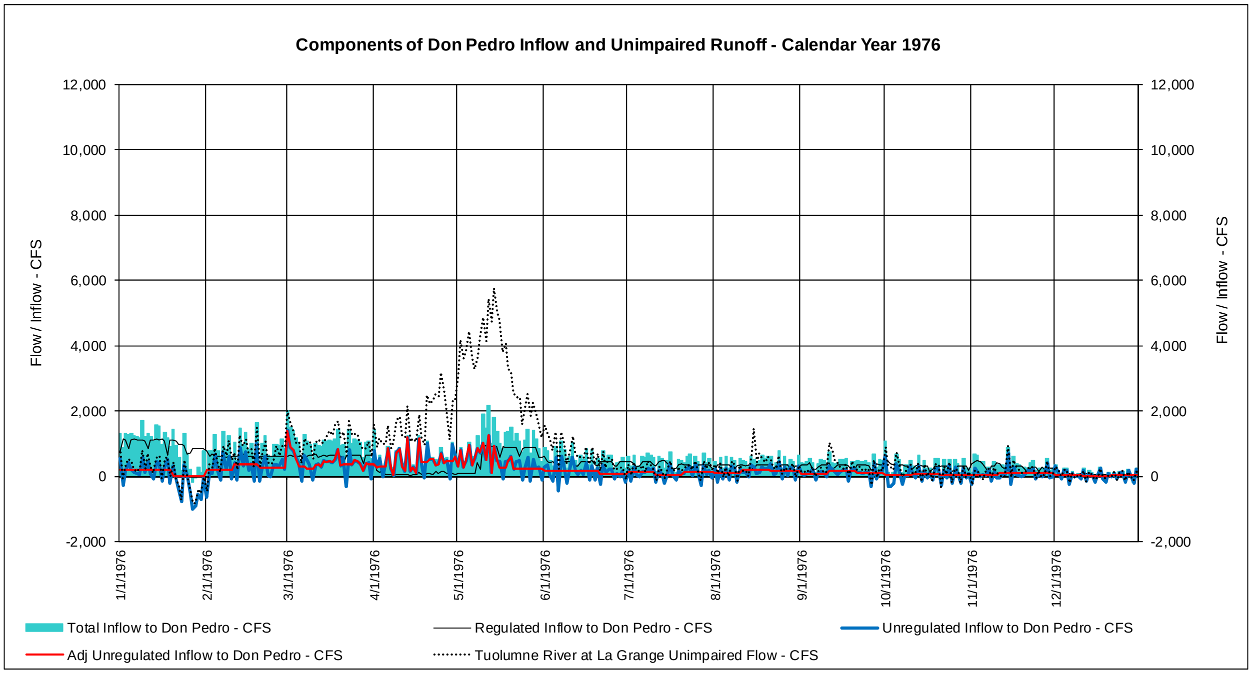
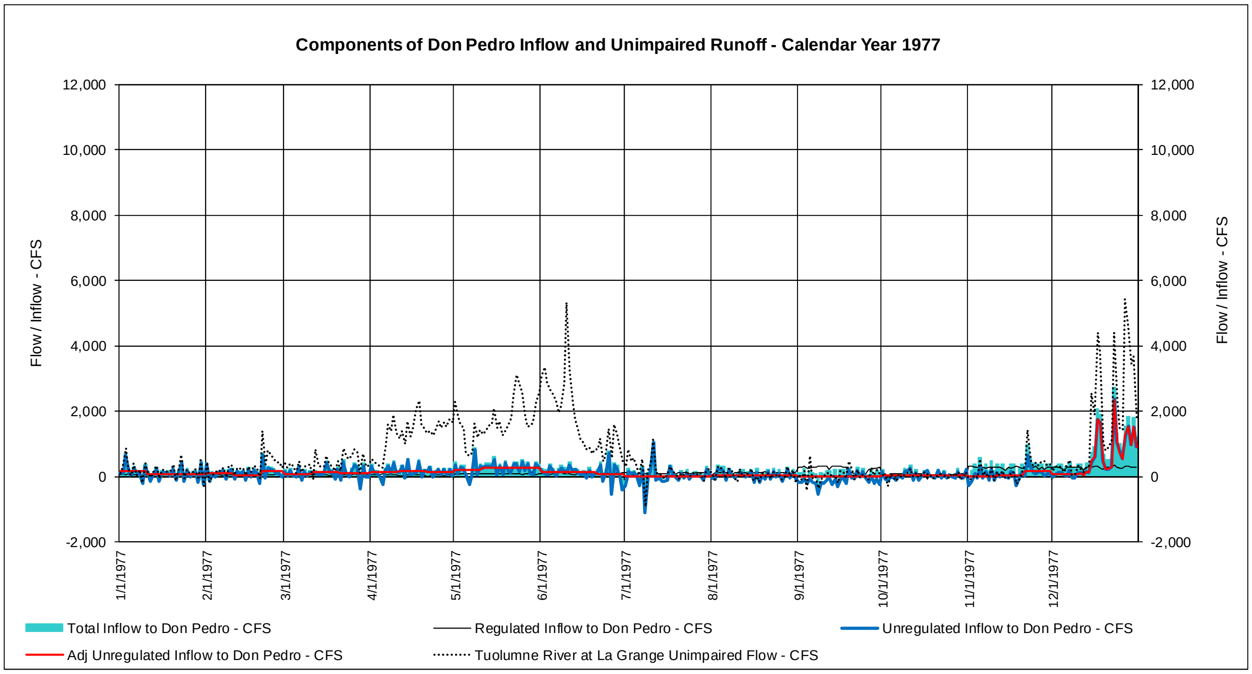


Figure 2.2-6. Calendar Year 1976.



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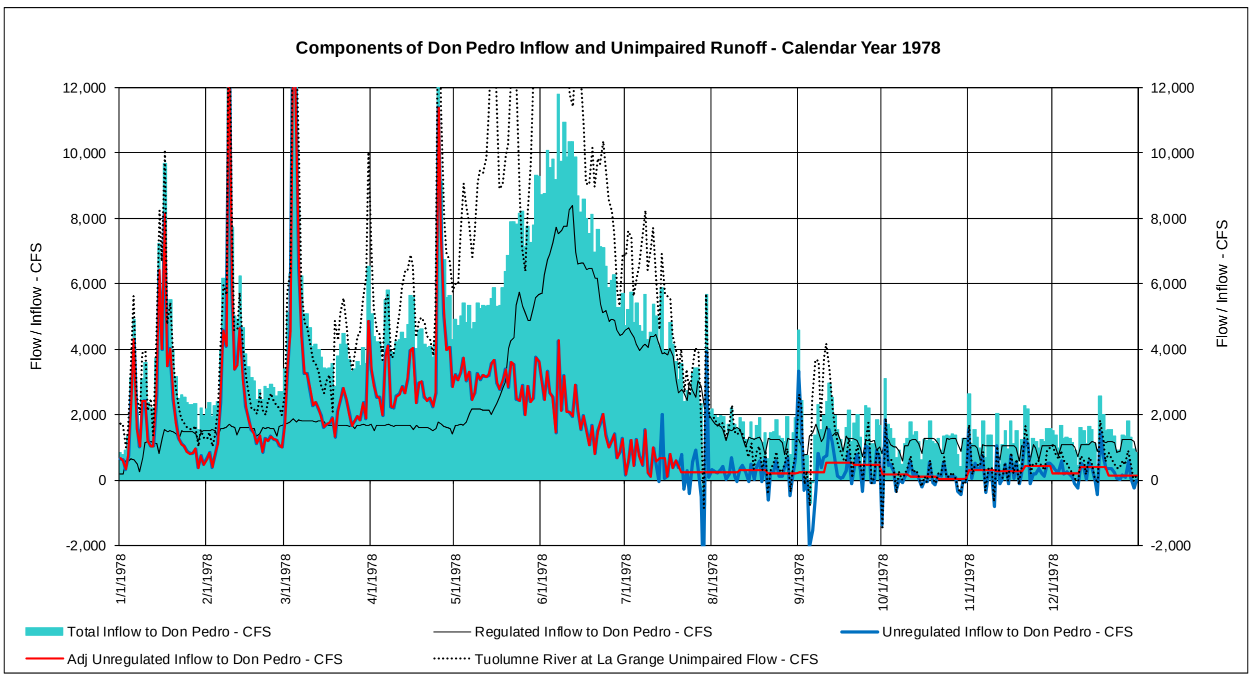

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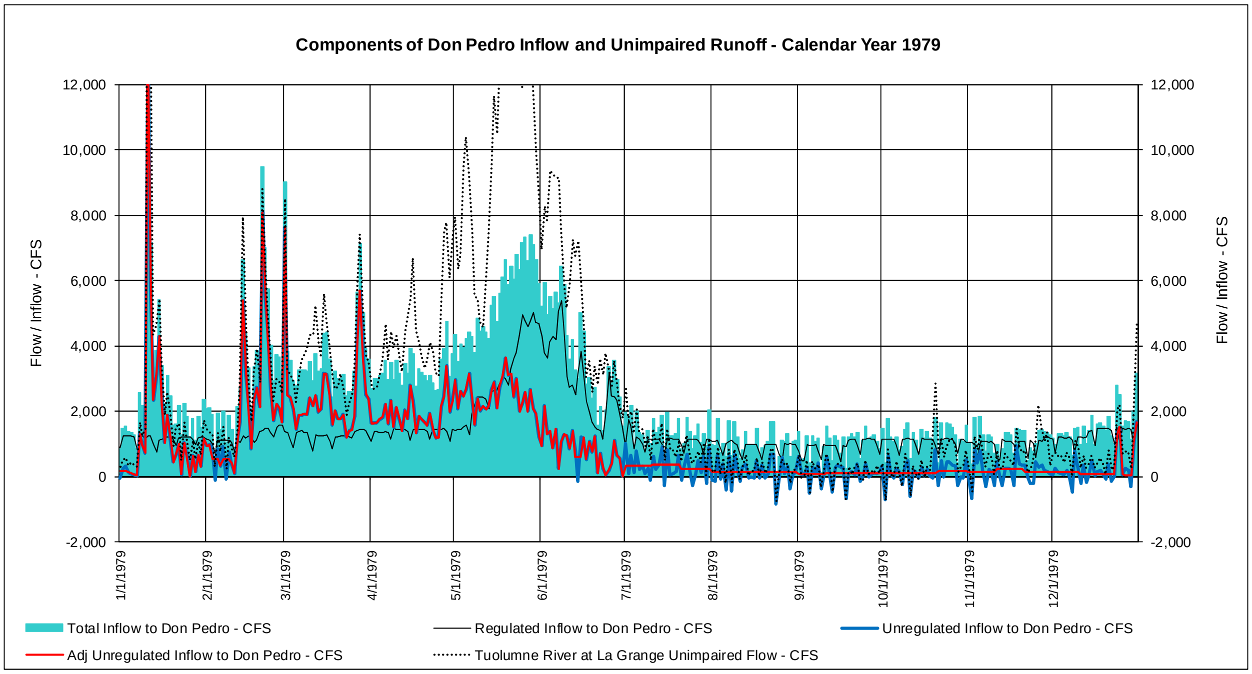

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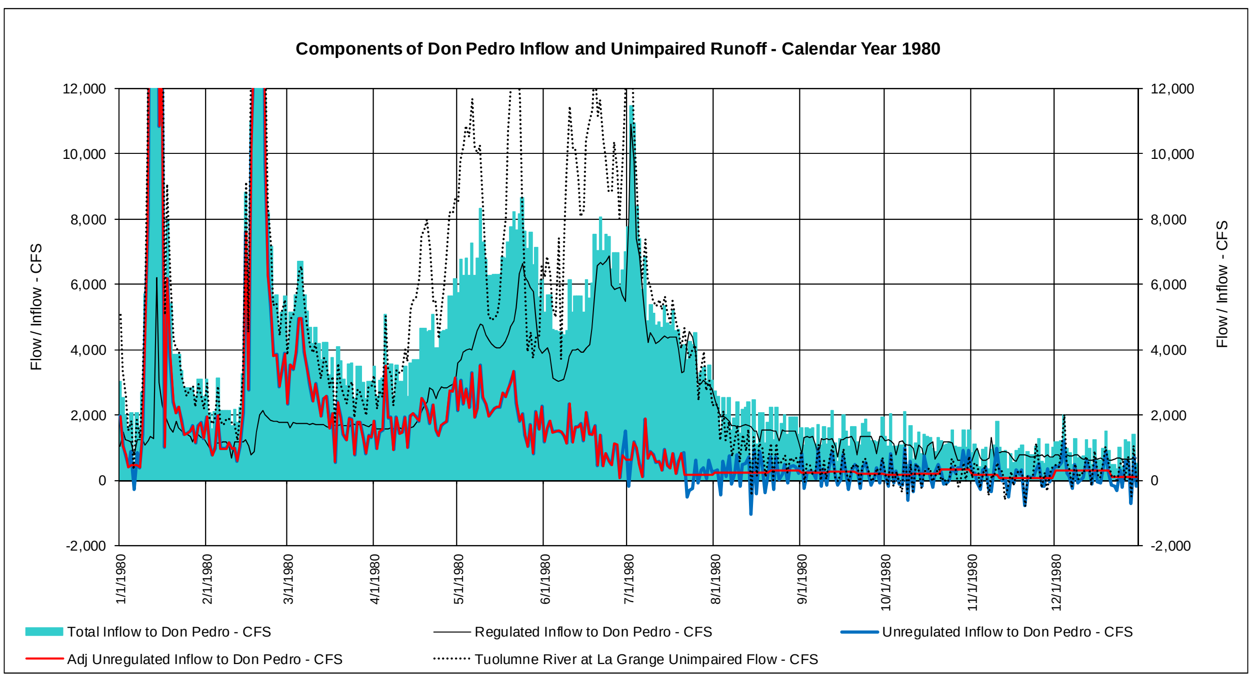

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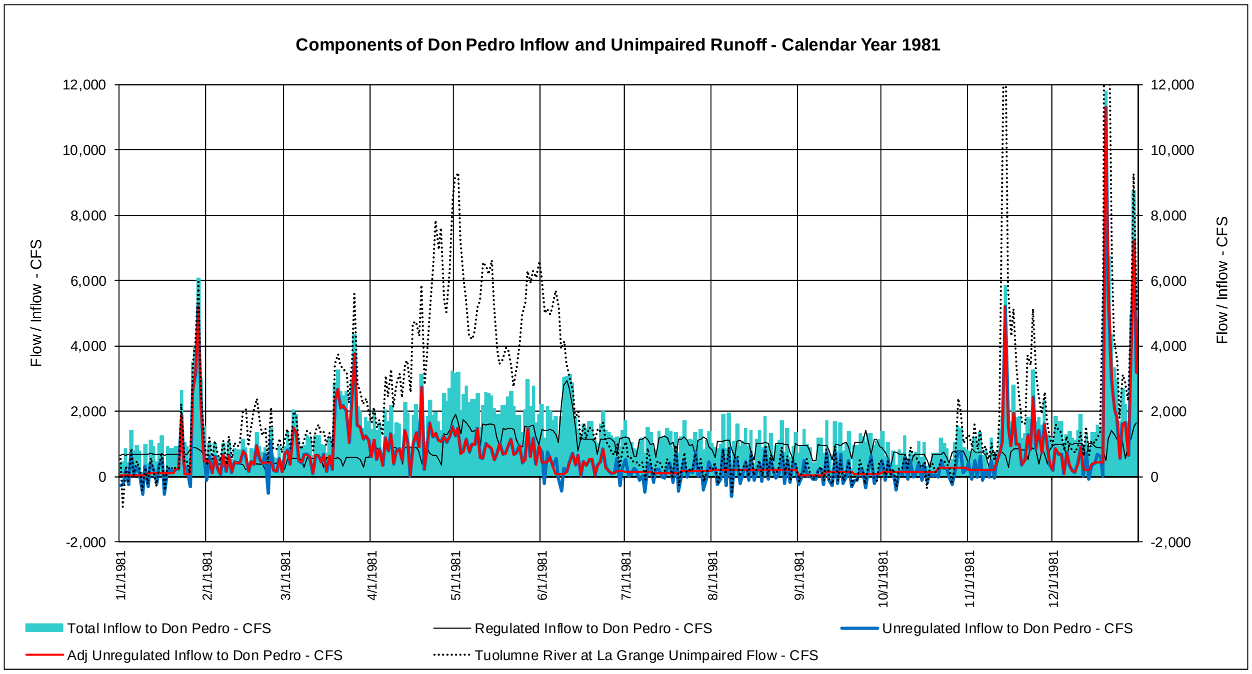

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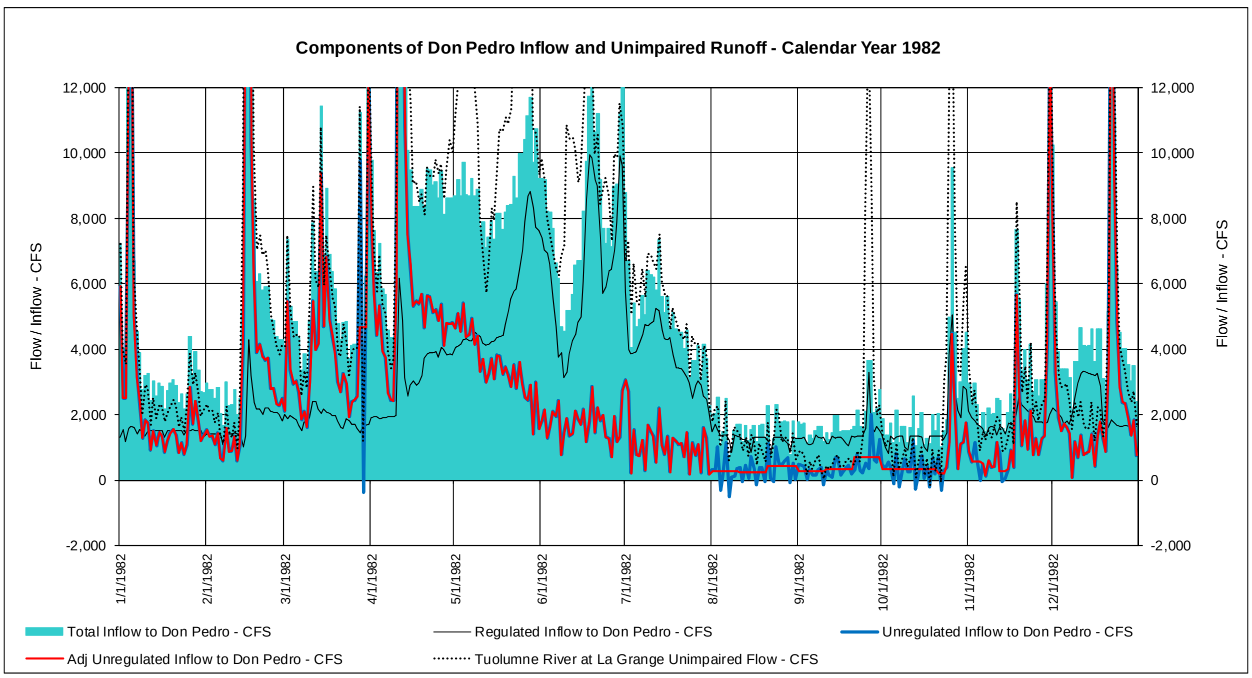

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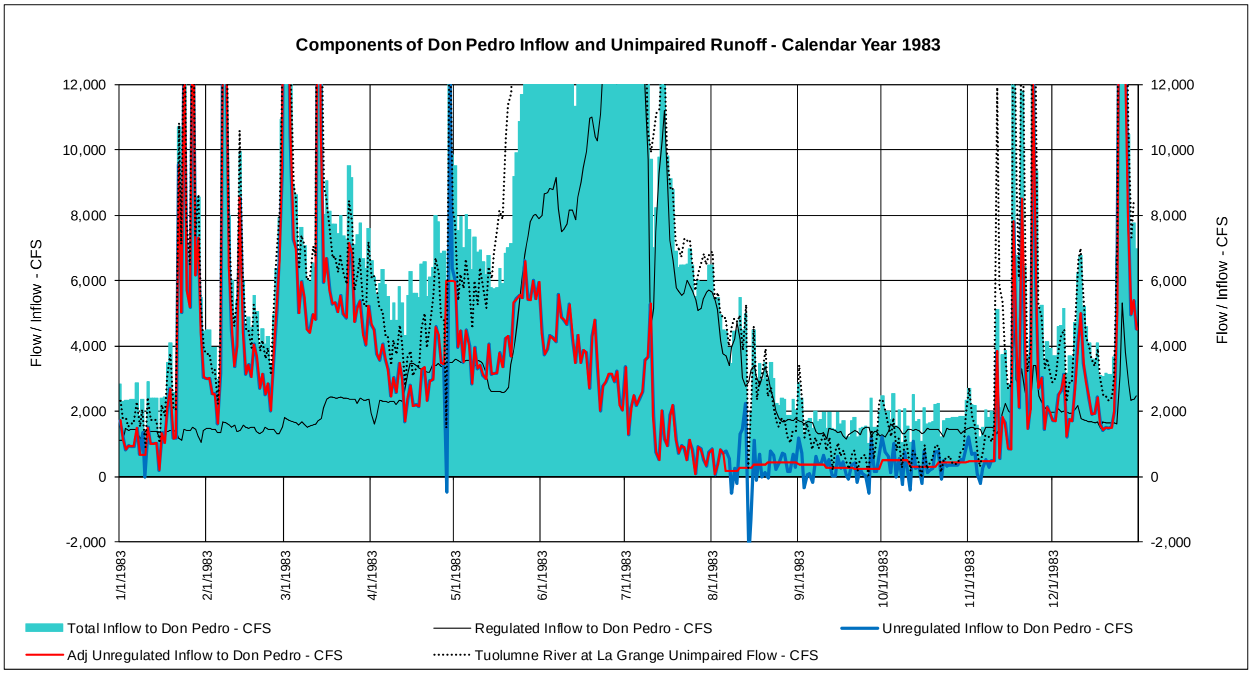

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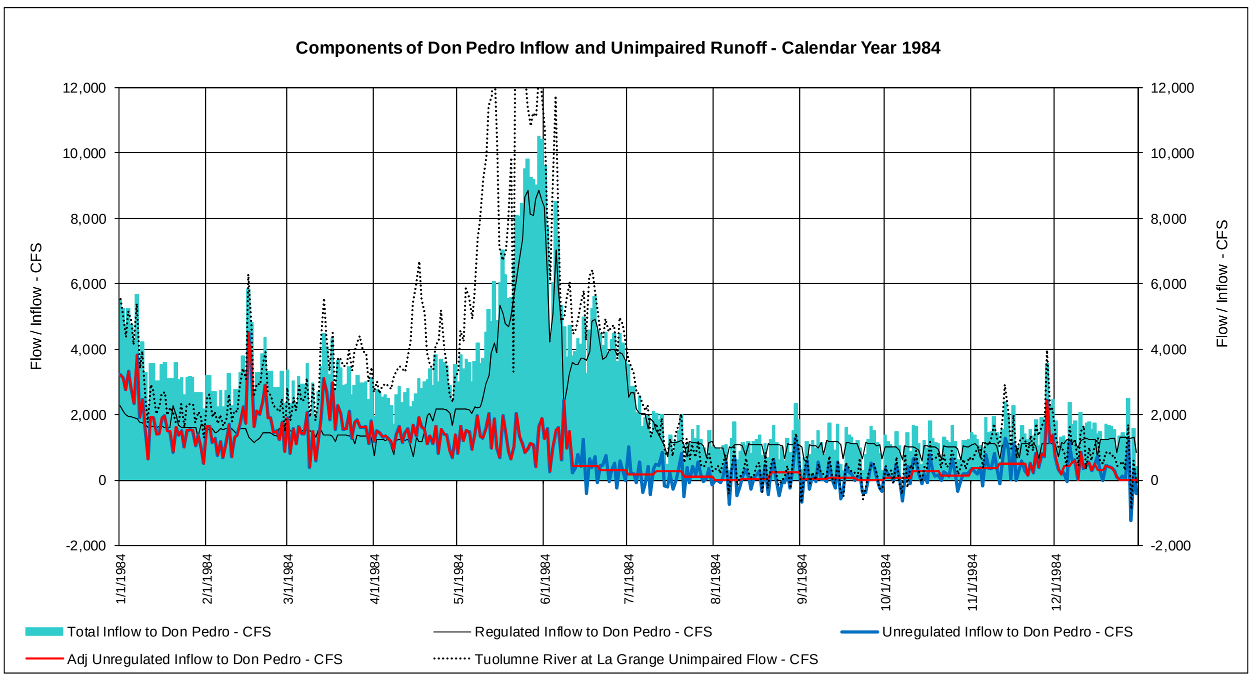

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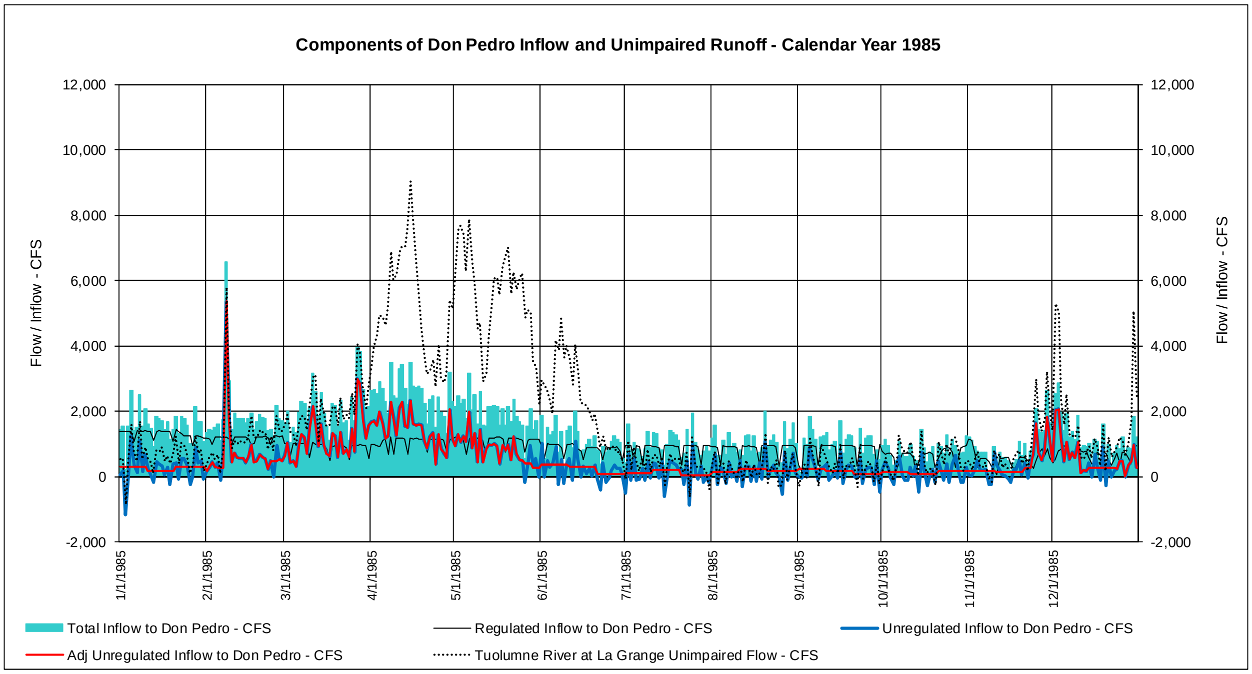

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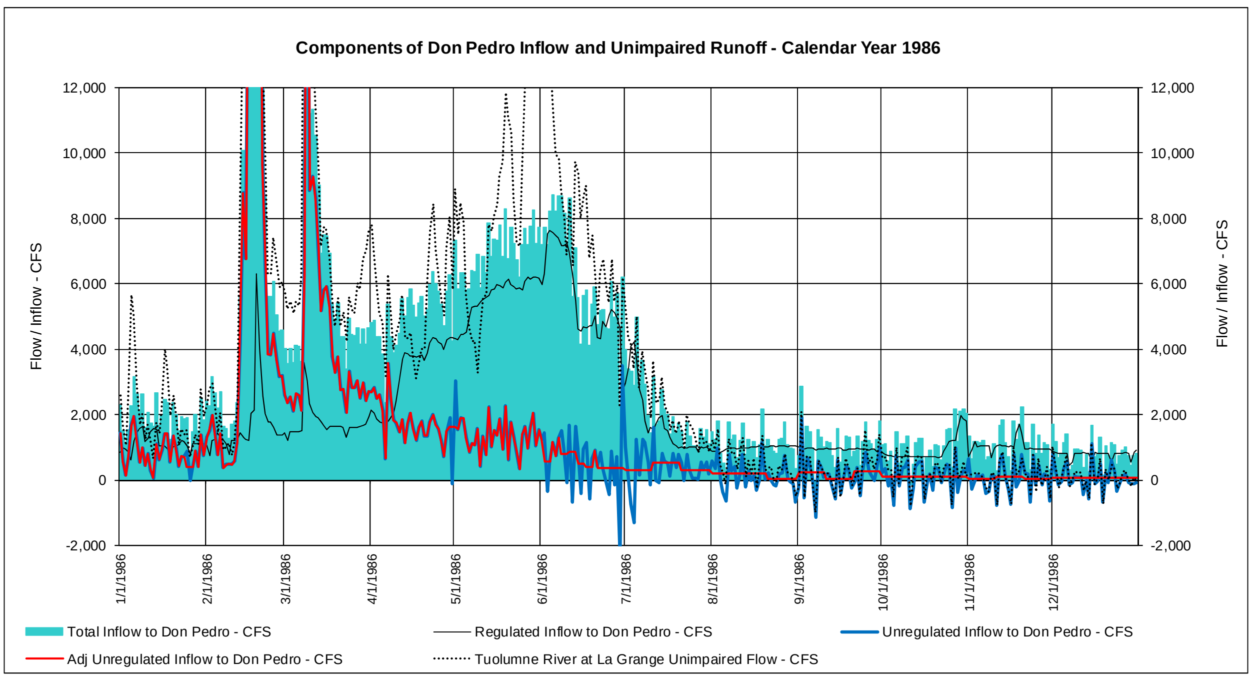

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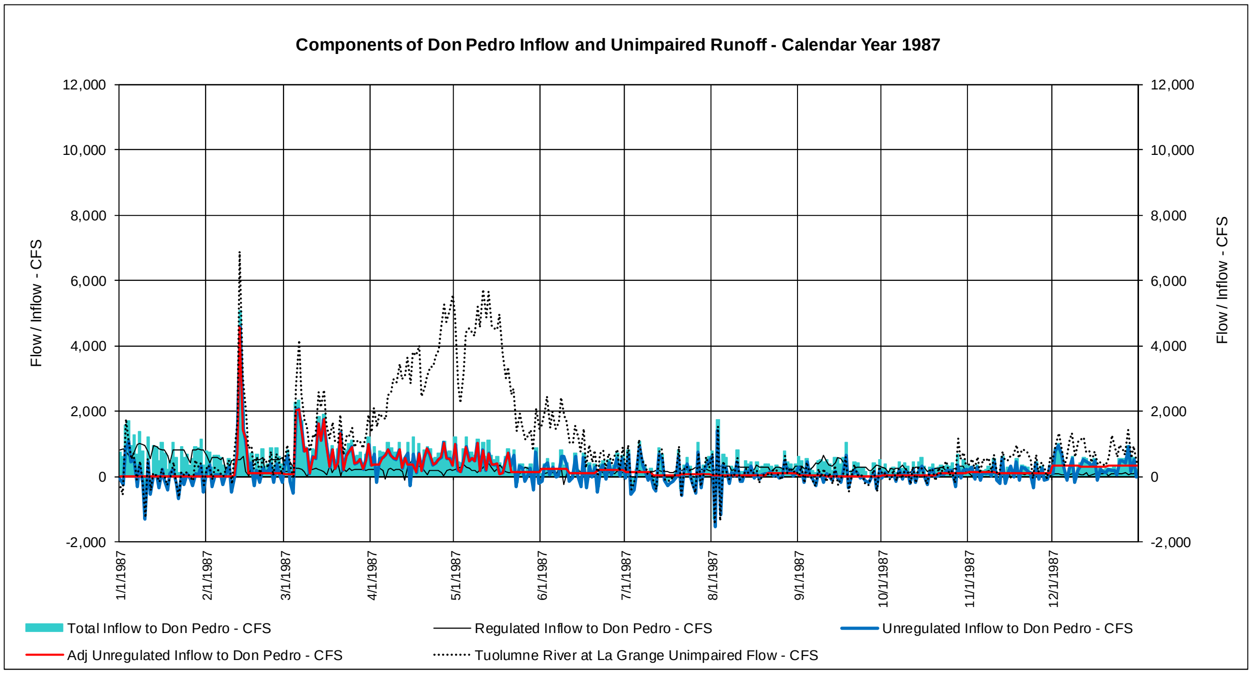

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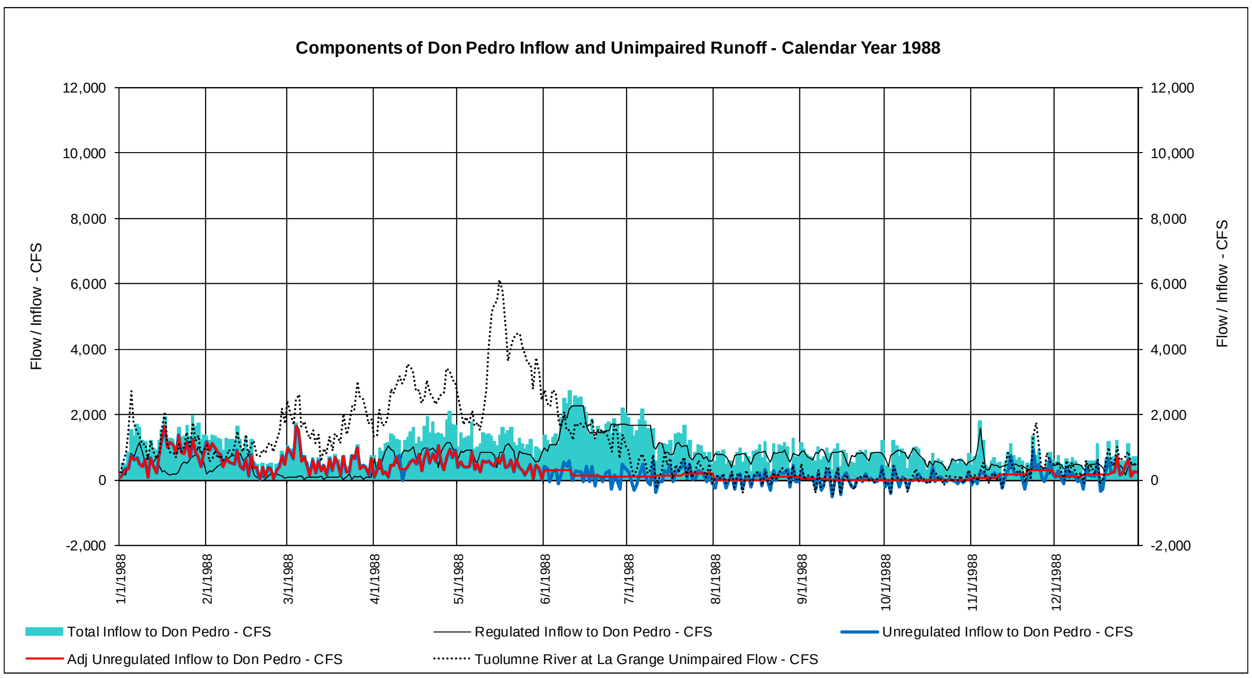

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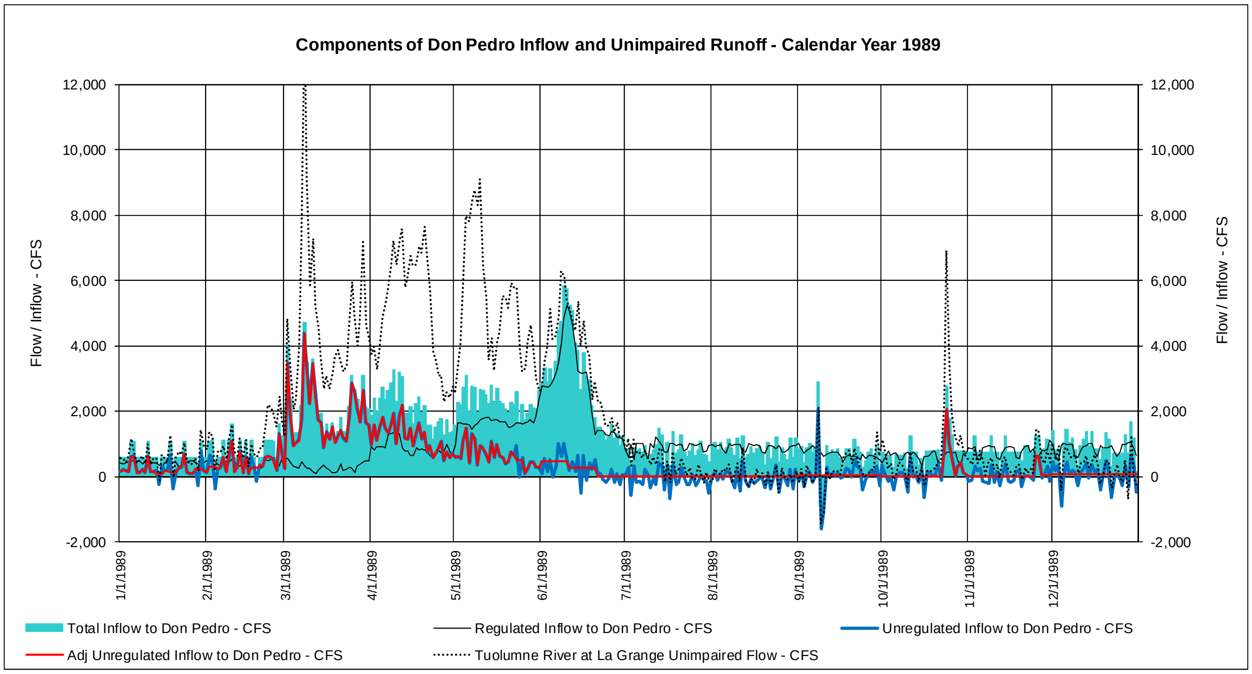

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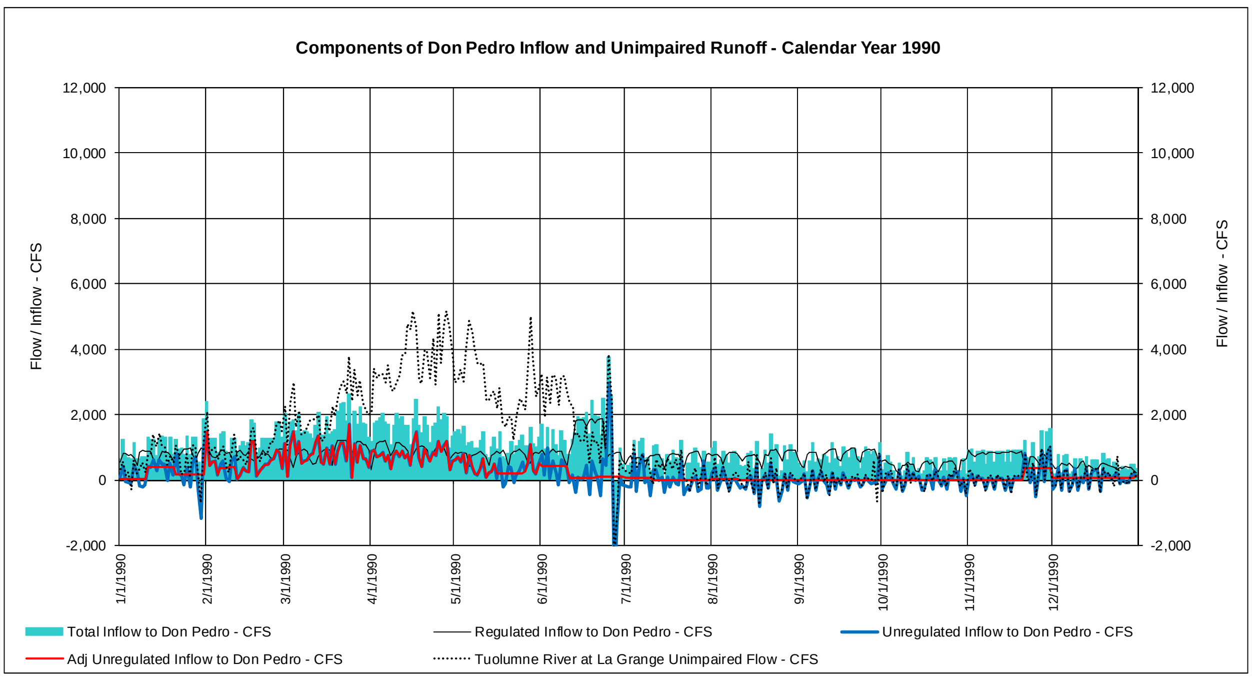

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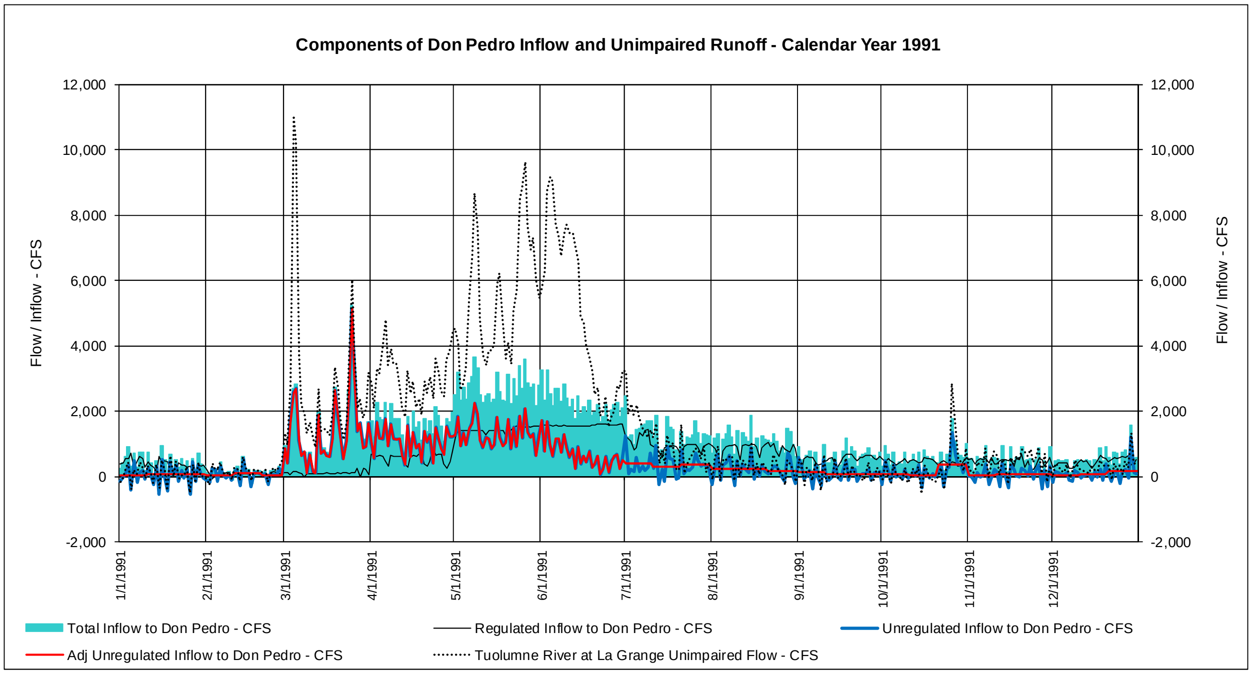

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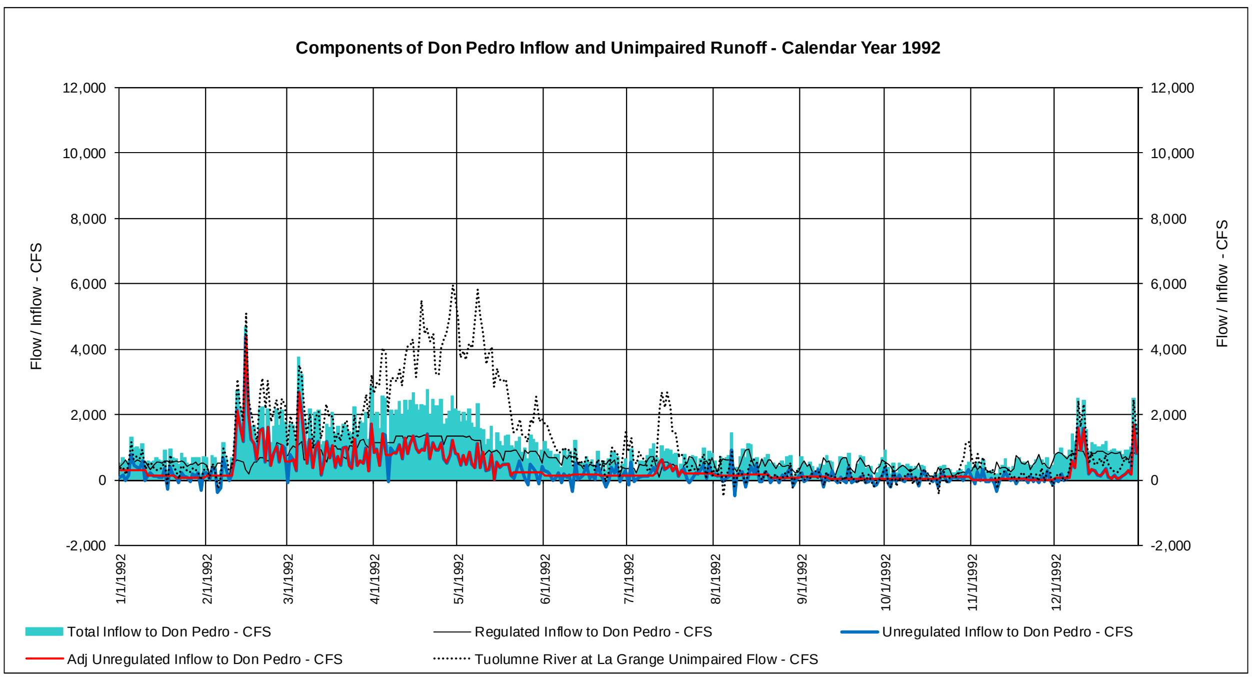

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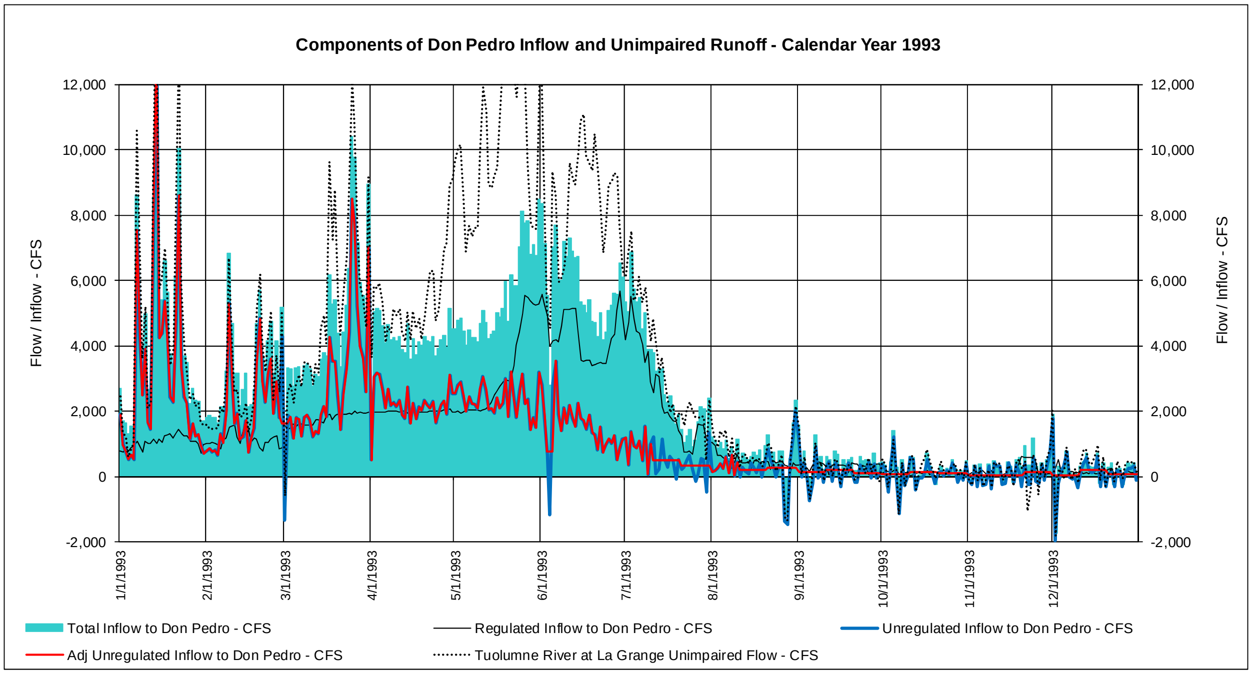

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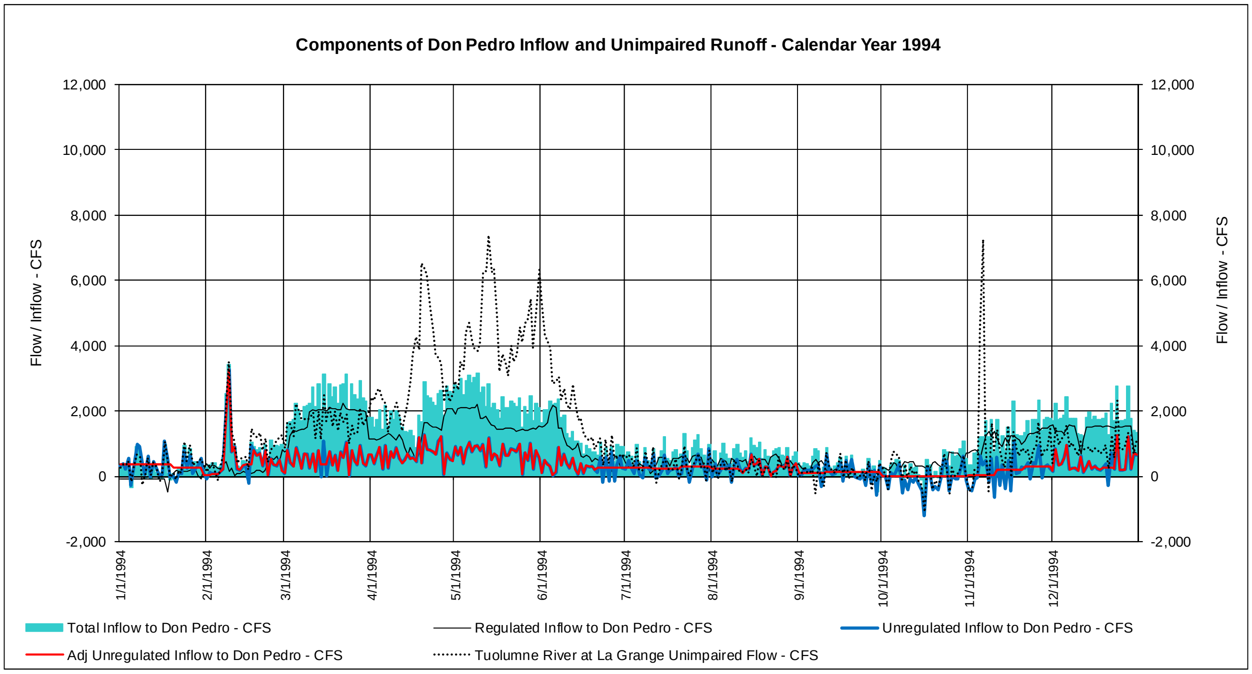

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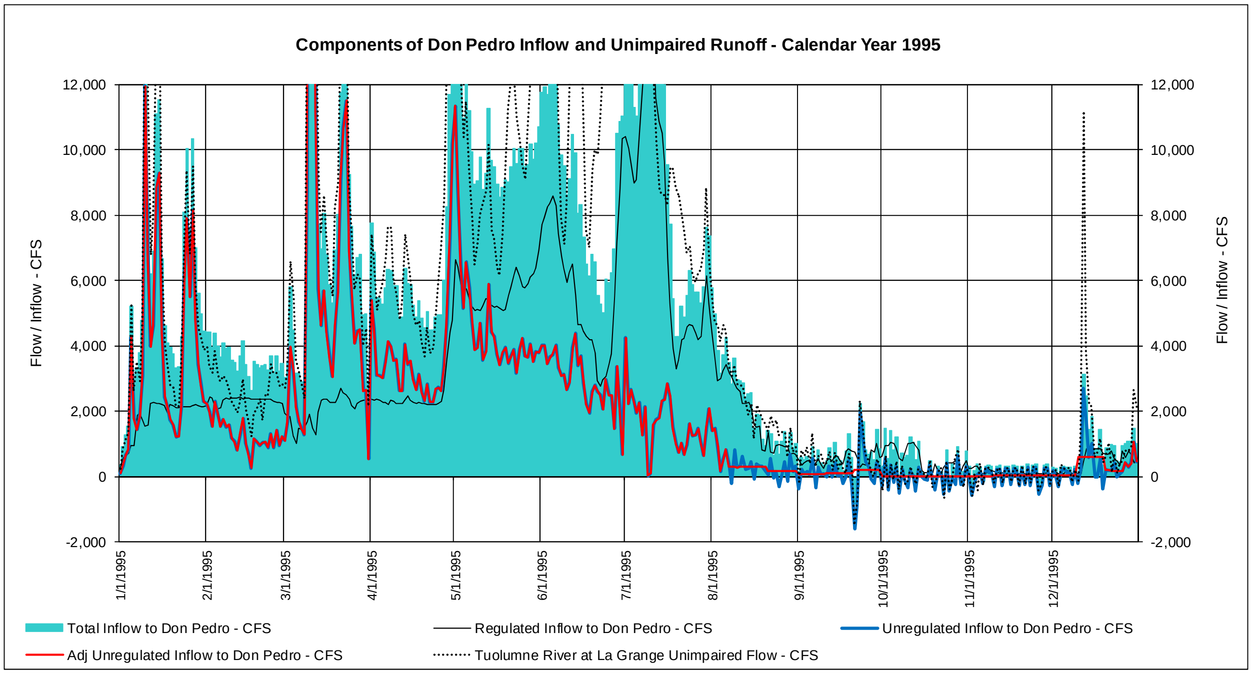

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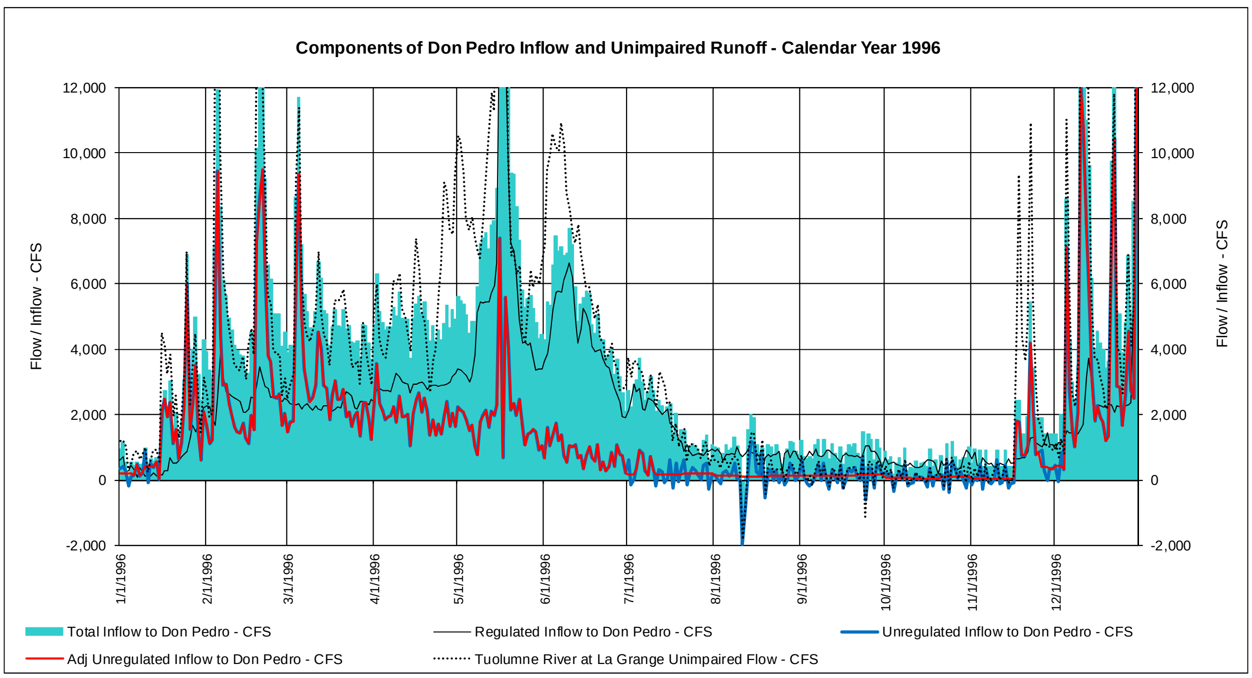

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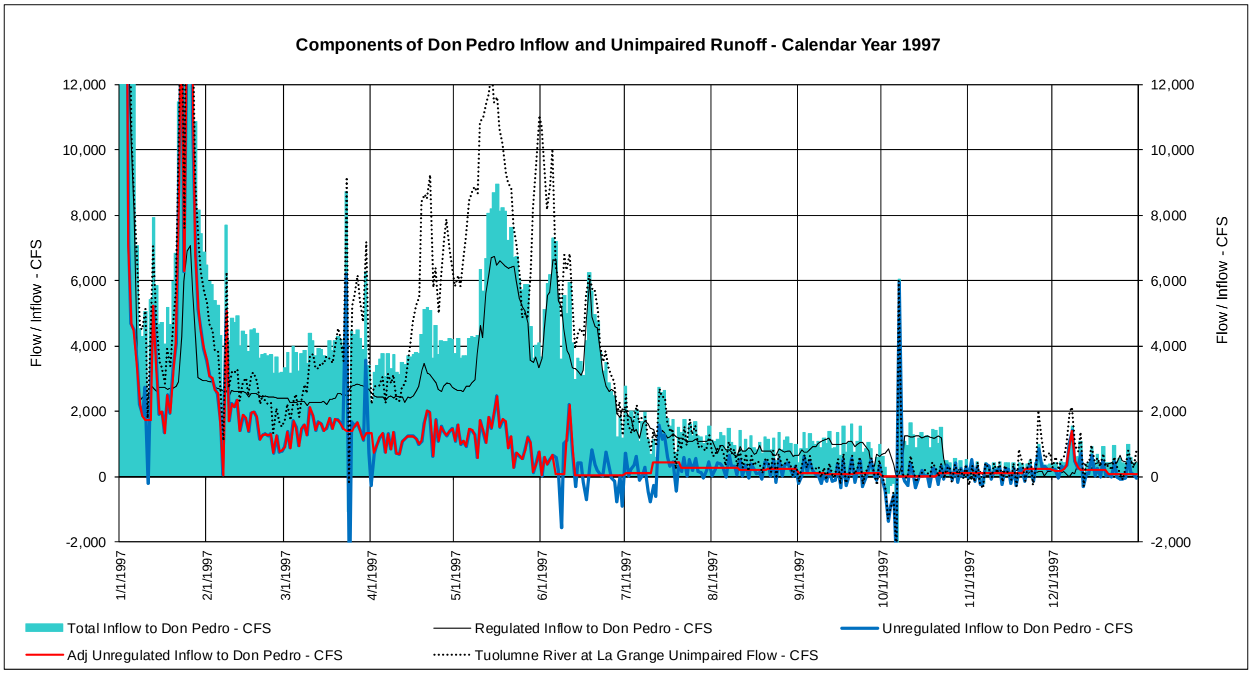

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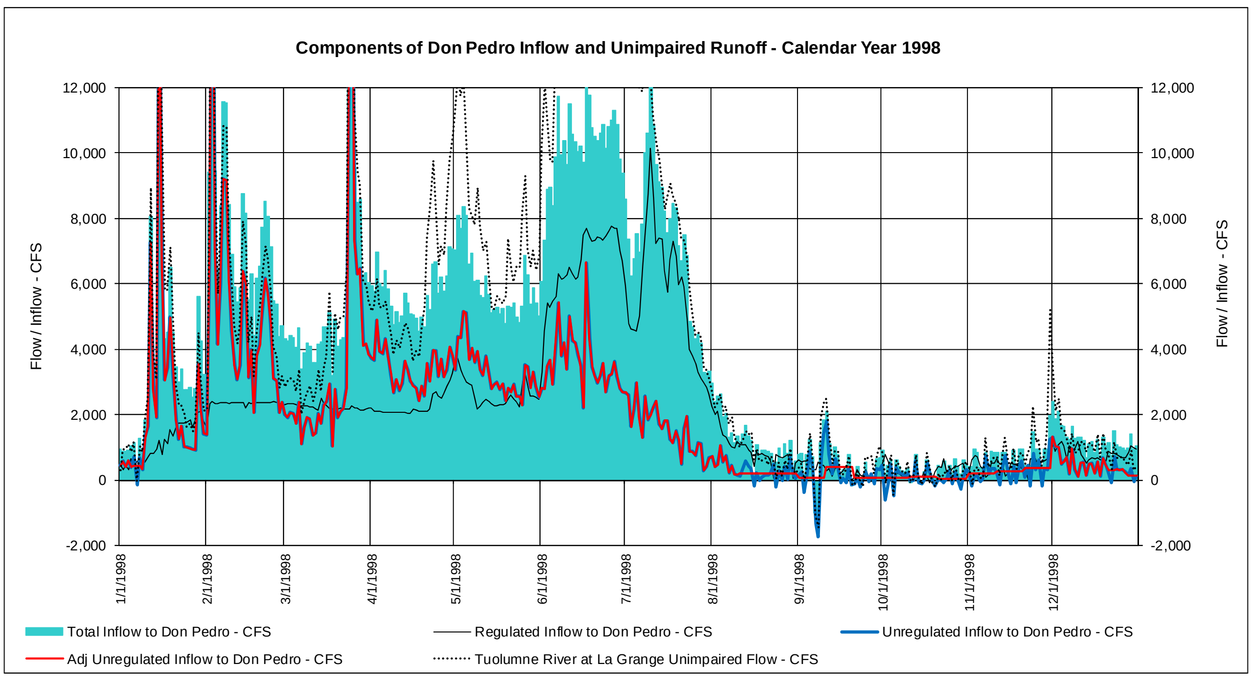

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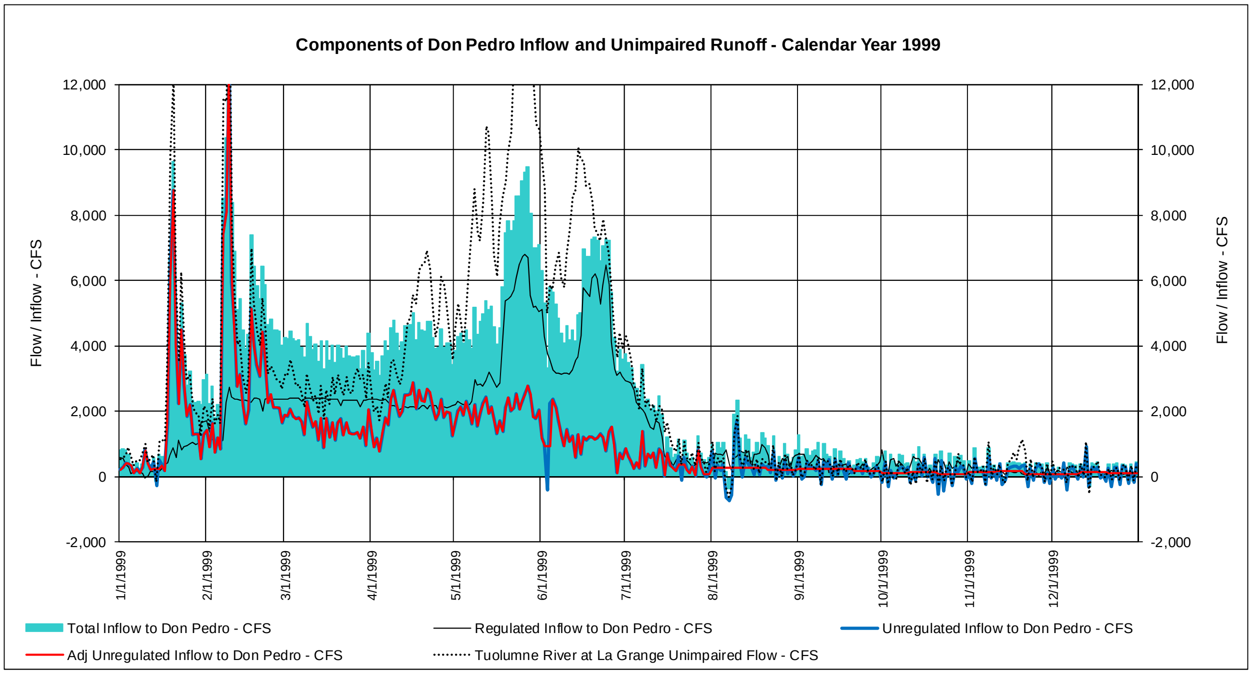

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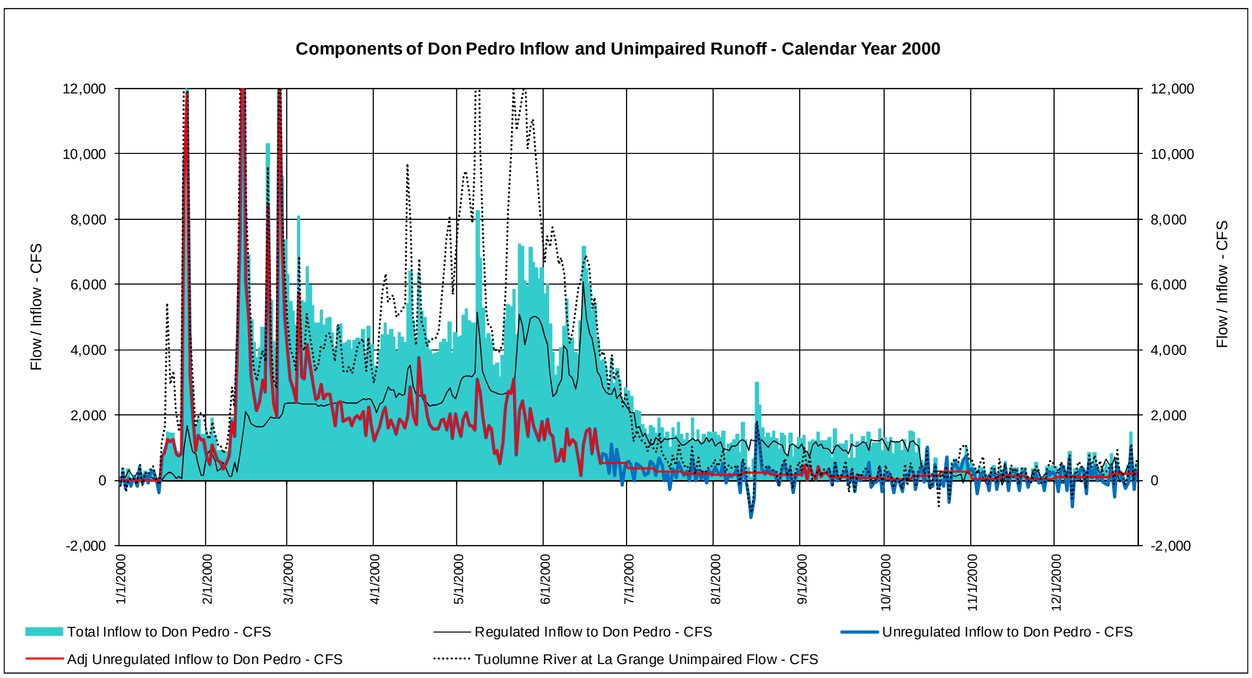

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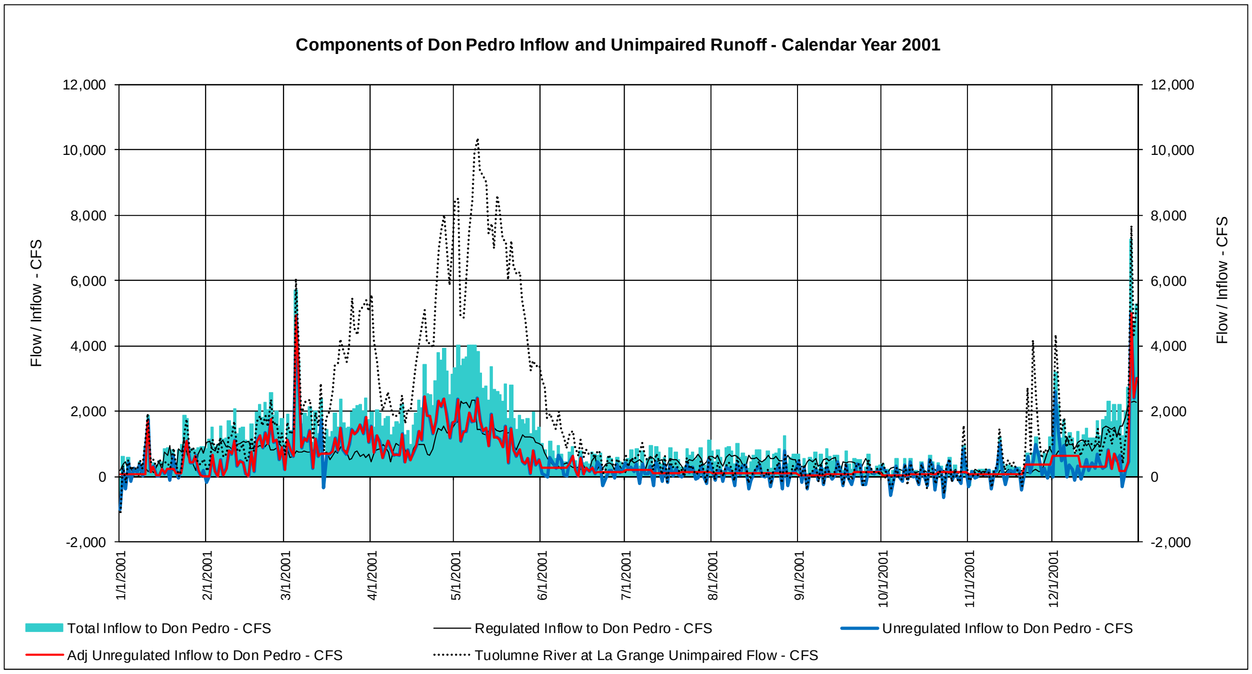

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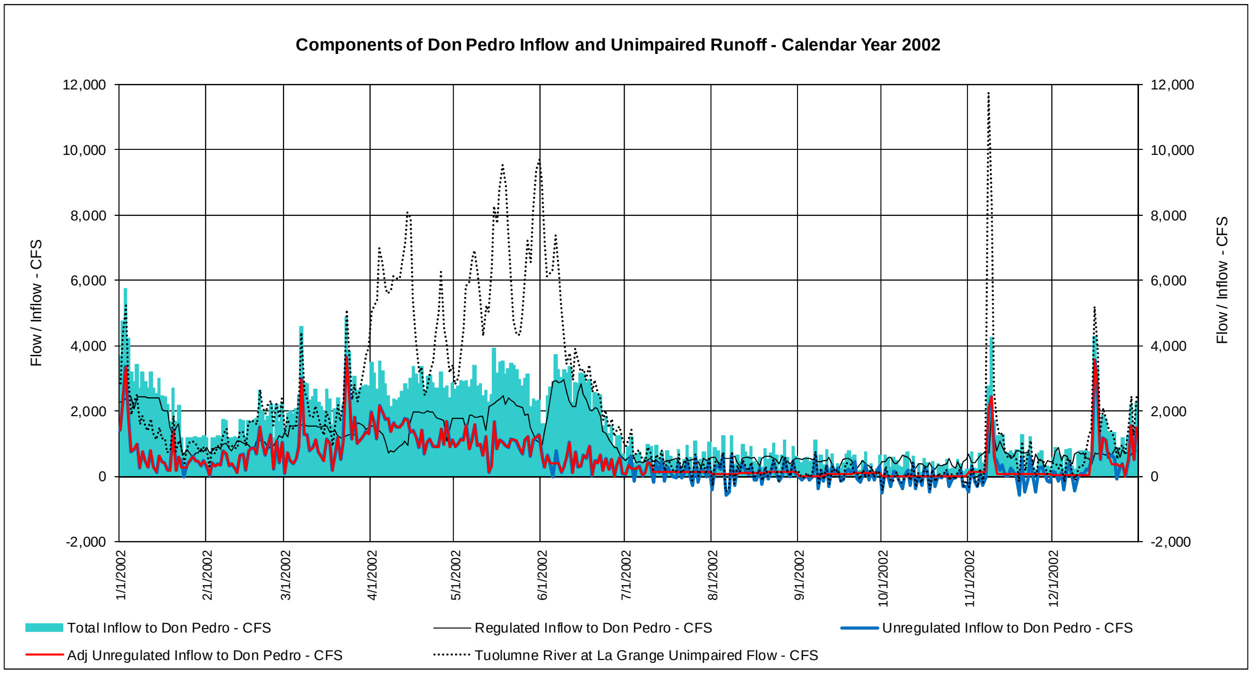

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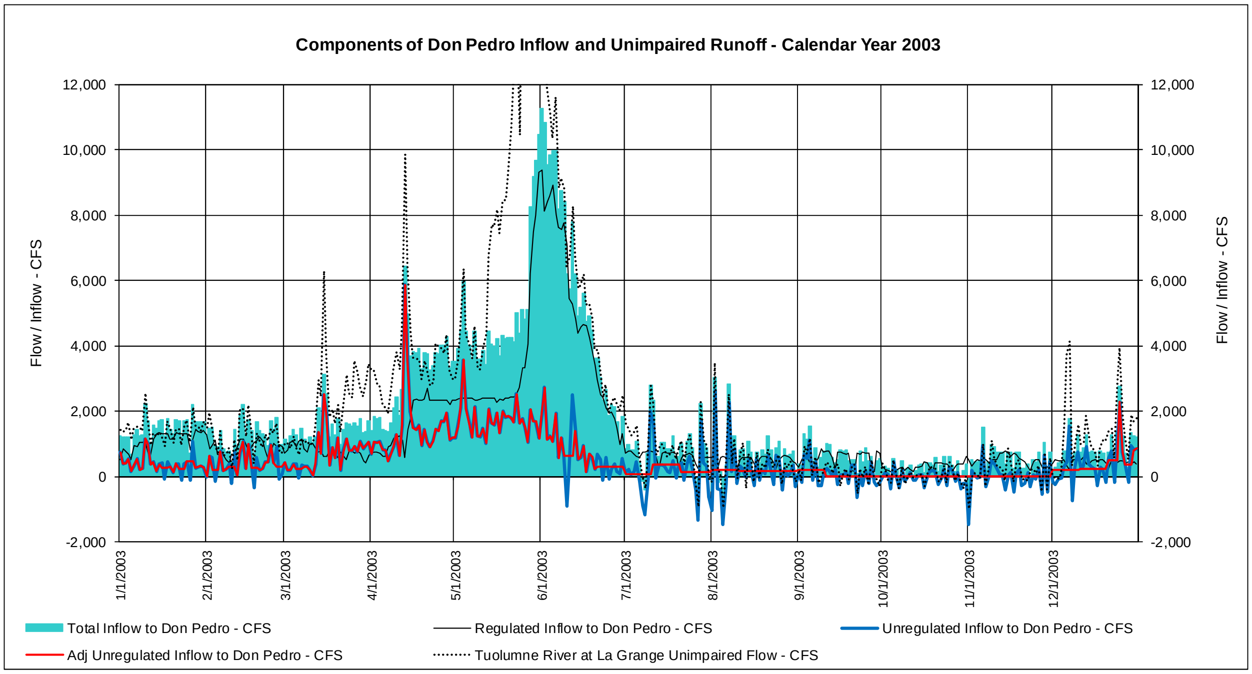

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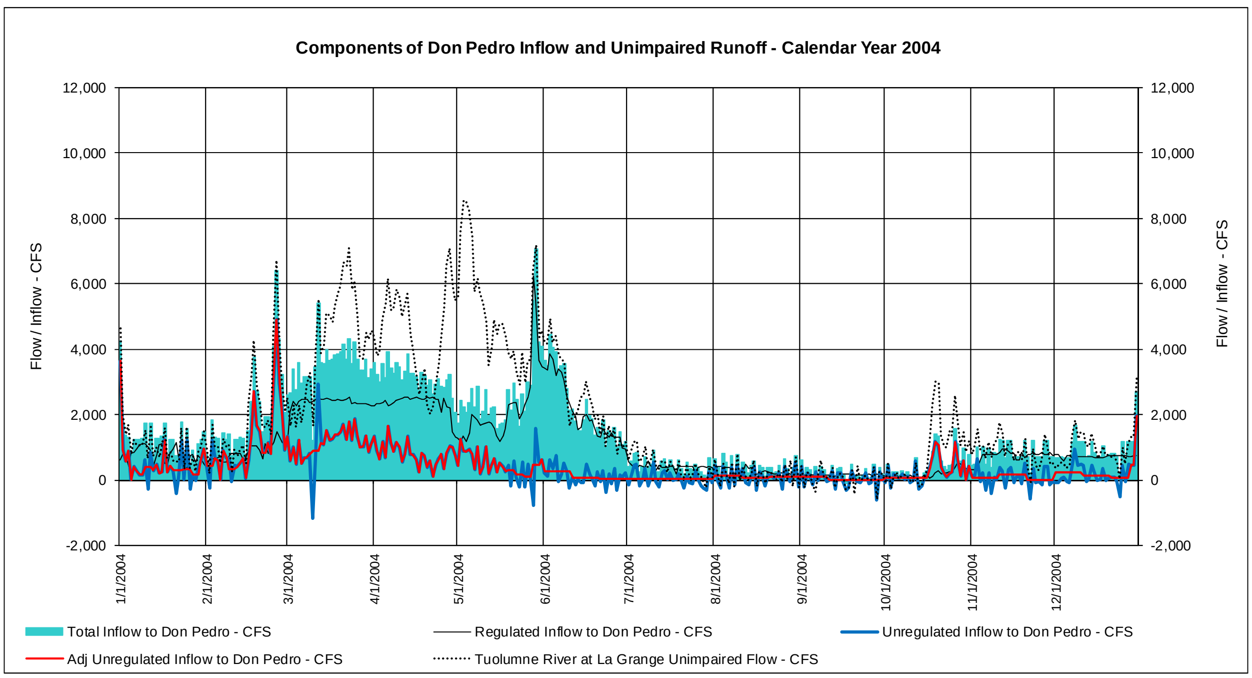

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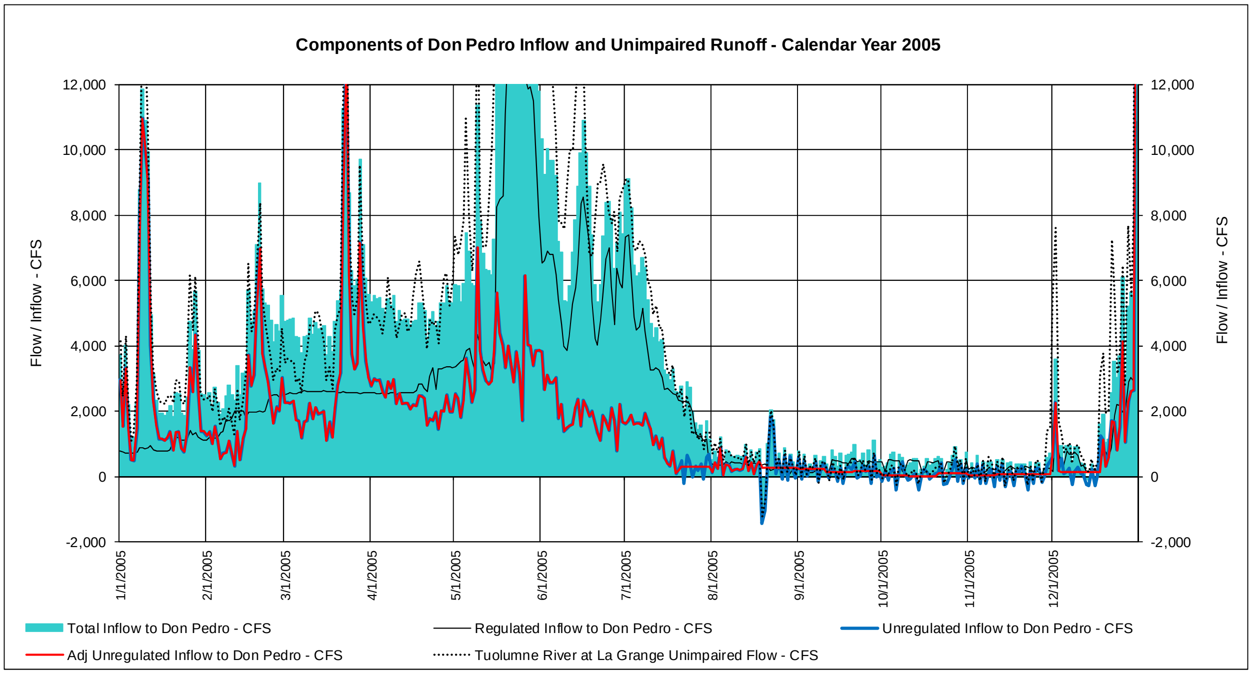

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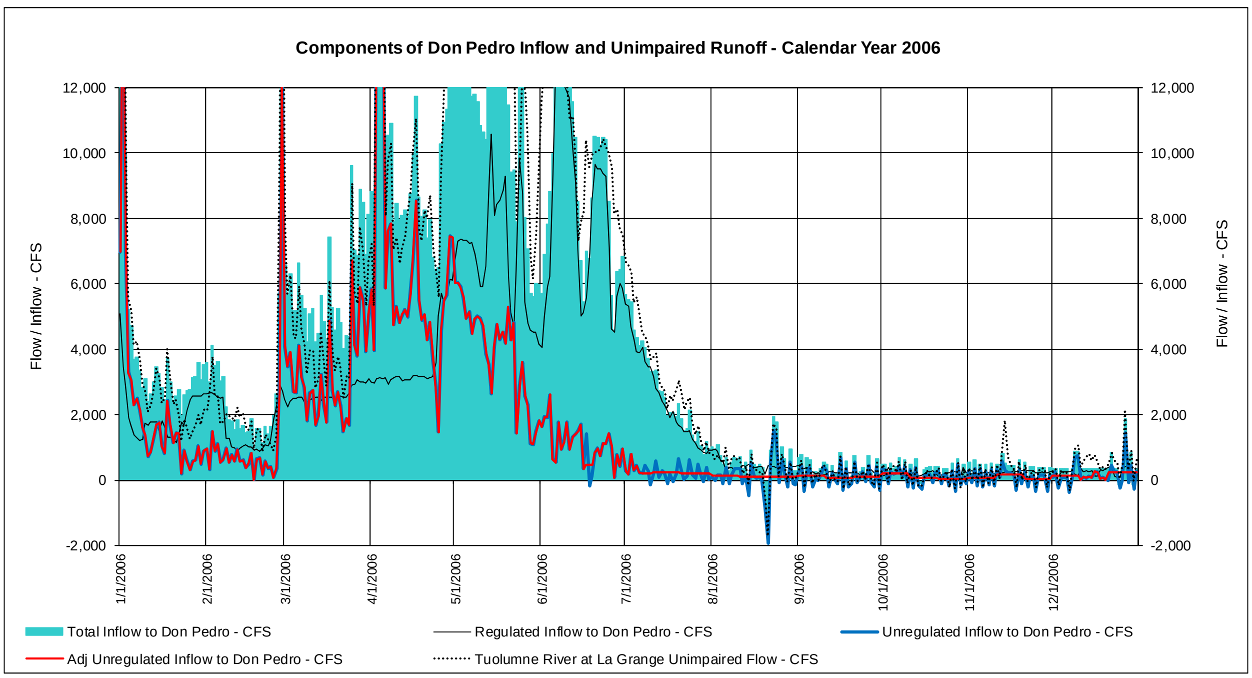

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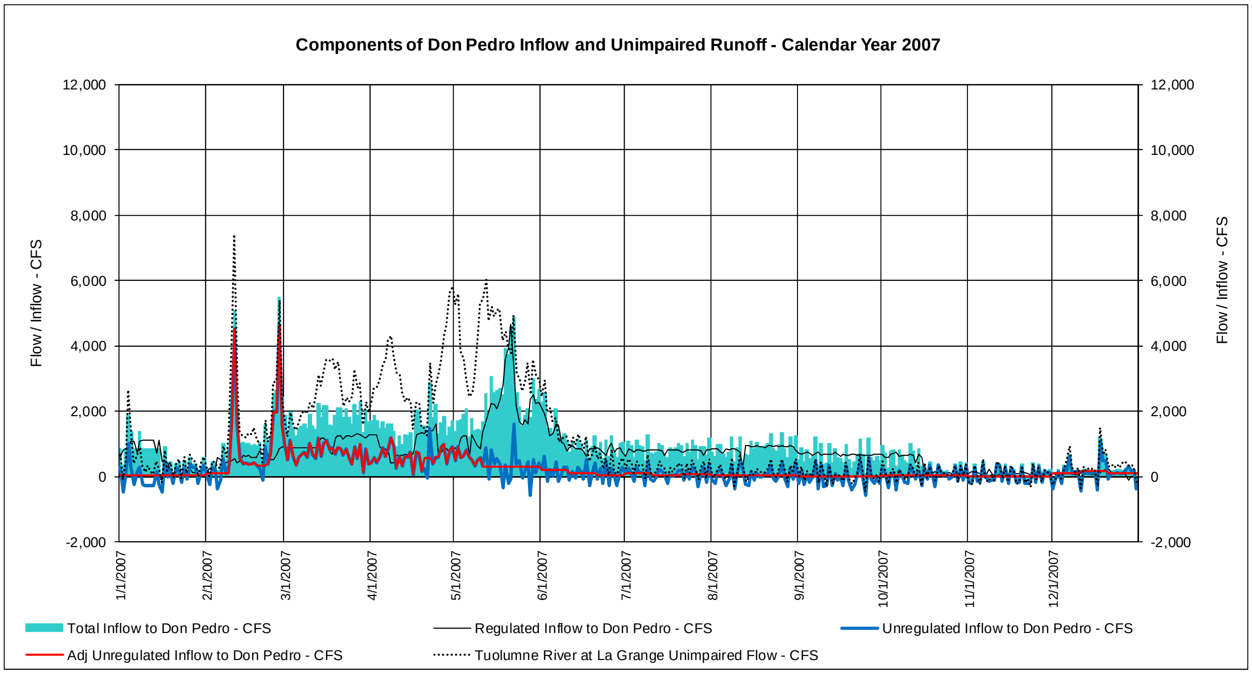

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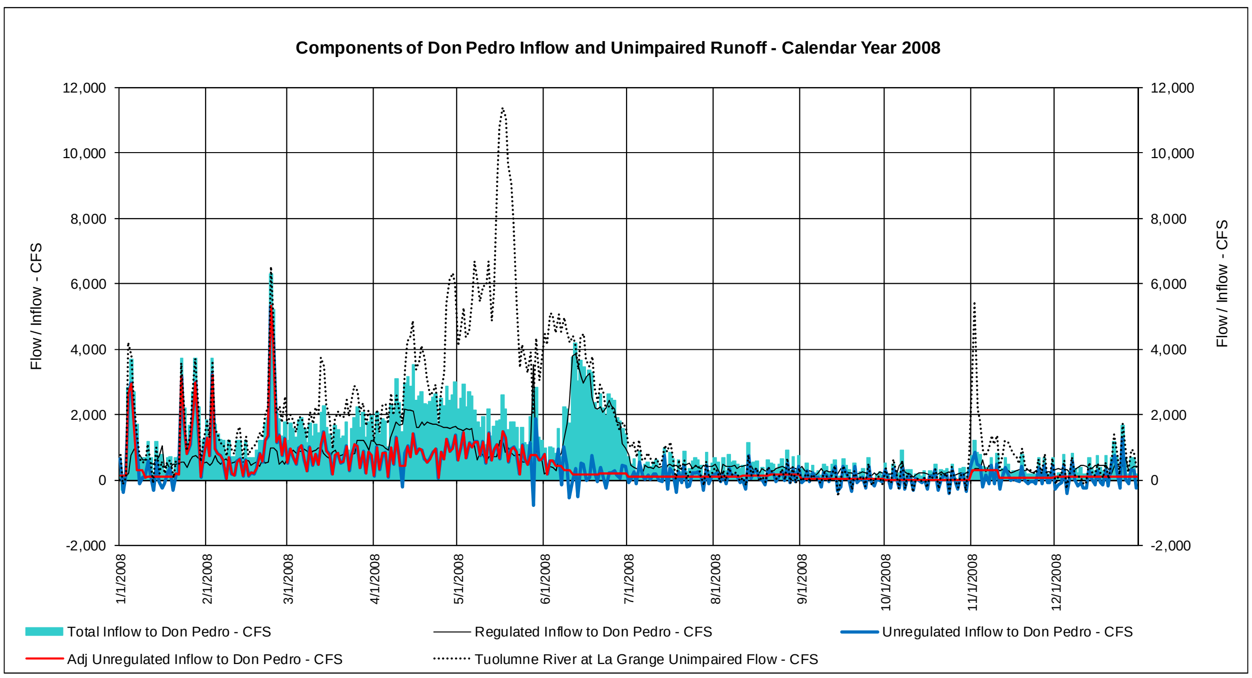

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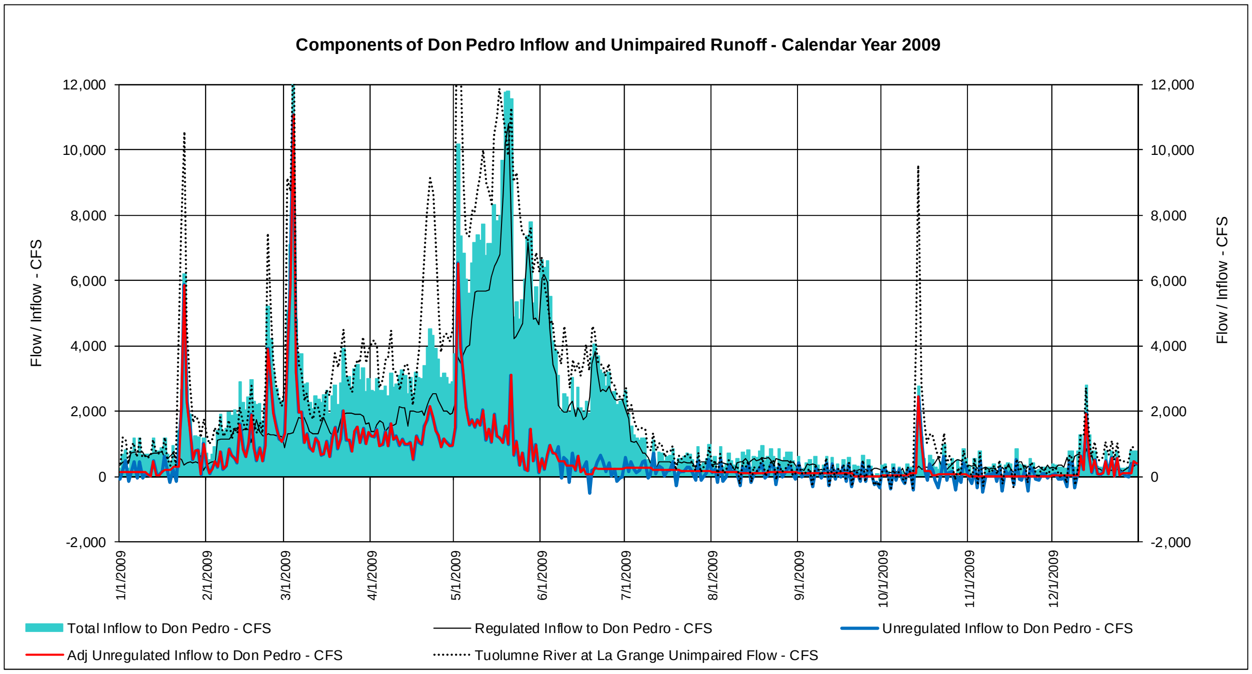

Figure 2.2-39. Calendar Year 2009.

2.3 Additional Flow Information

The Hydrology Workbook also lists a long-term record of computed unimpaired flow of the Tuolumne River at La Grange as reported by the DWR. The record is a mixture of values (1921 through 2003) published by DWR as planning estimates, and more recent records acquired through the DWR CDEC data system which are considered preliminary. The overlapping record of DWR's data and the detailed daily data provided by the Districts in the worksheet at times illustrate differences. To the best of the Districts' knowledge, current DWR procedures accept the Districts' computation of unimpaired flow as being the record. Differences that exist might be explained as a change in DWR protocols for the record or the absence on the part of DWR of incorporating revised records. Nonetheless, the differences are small and the Districts will use its computation of unimpaired flow for the FERC analysis. The extended DWR record is provided to provide context of the 1971-2009 period of record used for the Model within the perspective of the longer hydrologic record.

2.4 Alternative Method of Estimating Tuolumne River Unimpaired Flow

The California Department of Fish and Game suggested that the Districts consider using a "gage proration methodology" to estimate unimpaired flows, using several reference gages of the watershed or other watersheds for use in a "prorated gauge synthesis". Using historical gage data, the Districts developed an estimate of unimpaired hydrology for the Tuolumne River below La Grange Dam (La Grange), and compared the resulting dataset to the mass balance approach previously described. The complete analysis performed by the Districts is included as Appendix A to this Attachment. The following is a discussion of results and conclusions.

Due to a lack of available gage records for employment in the prorated gage synthesis, the comparison was limited to the WY 1971 to 1983 period. The magnitude and shape of the hydrographs for the examined period compared quite well between the two approaches. The cumulative volume for the full thirteen-year analysis is 9.5% less using the gage proration approach when compared to the mass balance approach. The type of deviation between the two approaches suggests a relatively consistent difference in volumes that occurs each year, rather than a difference caused by a small number of discrete flow events.

While individual storm and runoff events appear to have consistently good agreement between the two approaches, there are periods of significant discrepancy, likely resulting from poor basin representation by the reference gages. There appears to be a chronic underestimation of the late season snowmelt by the gauge proration approach. This can be explained by the lack of reference gage representation within the higher elevation portions of the basin, where much of the remaining snowmelt runoff is likely occurring during the early summer.

The mass balance approach provides a consistent, defensible, long-term approach to the development of the unimpaired hydrology at La Grange, in particular the estimation of seasonal and annual volumes of watershed runoff. The main drawback to the approach is the uncertainty (including negative values) that occurs during the low flow portion of the year (i.e., late summer and fall months). As described previously, these below zero values are primarily due to inaccuracies in the stage readings of the reservoirs used; any remaining uncertainty may be an artifact of indirect evaporation estimates from Don Pedro Reservoir and upstream impoundments. The anomalies (negative flows) in the daily dataset have been addressed through the adjustment procedures described in Section 2.2 above.

3.0 LOWER TUOLUMNE RIVER ACCRETION FLOW AND DRY CREEK FLOW

Additional flow data is needed for construction of the Model. These data include flows that are not technically “unimpaired” but are representative of flows that affect the depiction of flow within the lower Tuolumne River, and may contribute to conditions that affect Project operations. Such a flow component is the flow from Dry Creek which enters the Tuolumne River near Modesto. The flow from Dry Creek at times can influence flood control operations at Don Pedro Reservoir. The flow can also influence the temperature of flow in the Tuolumne River at and below the Dry Creek confluence. This flow information is included in the Hydrology Workbook.

Column AK lists a synthesized estimate of the flow that enters the Tuolumne River from Dry Creek for the modeling period. The synthesized record is representative of current circumstances that affect flow. Surface runoff was estimated for Dry Creek manually using base flow separation techniques. The entire period of record of the gage was examined graphically to determine if the flows recorded were likely to be surface runoff, base flow, or return flow from irrigation canals. The synthetic base flow values were then used to fill in all hydrograph values judged to be base flow, or return flow. Also included in the Hydrology Workbook (Column AJ) is the record of flow as measured by the DWR station Dry Creek near Modesto (Station BO4016), located upstream of the City of Modesto near Claus Road.

Column AL presents an estimate of lower Tuolumne River accretions to be used in modeling. These accretions represent the net flow change between the La Grange gage and the Modesto gage, and will be added to the regulated releases of the Project to the lower Tuolumne River. The sum of the regulated Project release plus the accretion flow plus the flow from Dry Creek will represent the modeled flow occurring at the Modesto gage location.

The analysis supporting the Dry Creek and lower Tuolumne River accretion estimates is included at Appendix B of this Attachment.

The Districts collected accretion measurements at the locations, and using the methods proposed by the Districts on June 6, 2012 (memorandum included in Appendix C of this Attachment). The measurements were conducted on June 25, 2012 and the results are presented in Appendix C. A second set of measurements were acquired during October 2012. These data are also presented in Appendix C.

TUOLUMNE RIVER DAILY OPERATIONS MODEL

APPENDIX A

EXAMINATION OF A GAUGE PRORATION METHOD FOR TUOLUMNE RIVER UNIMPAIRED HYDROLOGY DEVELOPMENT

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Examination of a Gauge Proration Method for Tuolumne River Unimpaired Hydrology Development

November 12, 2012 – prepared by Rob Sherrick and Rick Jones, HDR

Objective

Using historical gauge data, develop an estimate of unimpaired hydrology for the Tuolumne River below La Grange Dam (La Grange), and compare the resulting dataset to a mass balance approach previously developed by Modesto Irrigation District and Turlock Irrigation District (Districts). Assess the option of using a guage proration methodology.

Background

By letter dated September 10, 2012, Mr. Jeffrey R. Single, Regional Manager for the California Department of Fish & Game (CDFG), provided comments to the State Water Resources Control Board (SWRCB) related to the unimpaired hydrology for the operations/water balance model being developed for the Don Pedro Project relicensing. In summary, CDFG states that it is concerned "that the Districts' proposed method of estimating unimpaired hydrology is not appropriate for the purpose of the state of California's environmental review process required for a new license."

In its letter, the CDFG suggests that the Districts consider using a "gauge proration methodology" to estimate unimpaired flows. The CDFG recommends the evaluation of several reference gauges for use in a "prorated gauge synthesis". The specific gauges that were referenced for consideration are shown in Table 1.

Table 1. List of potential reference gauges identified by CDFG in September 10, 2012 letter to SWRCB.

Gauge and Description	Drainage Area / Elevation	Period of Record	USGS Remarks
USGS 11281000 SF Tuolumne R near Oakland Recreation Camp	87.0 sq. mi. El. 2,800 ft.	4/1/1923 to 9/30/2002 1/26/2009 to present (excluding WY 1997)	Records good. No storage or diversion above station.
USGS 11282000 M Tuolumne R at Oakland Recreation Camp	73.5 sq. mi. El. 2,800 ft.	10/1/1916 to 9/30/2002 1/26/2009 to present (excluding WY 1997)	Records good. No regulation; small diversion above station for irrigation.
USGS 11283500 Clavey R near Buck Meadows	144 sq. mi. El. 2,374 ft.	10/1/1959 to 6/13/1995 12/7/2009 to present (excluding WY 1984-1986)	Records excellent. No storage or diversion above station.
USGS 11284700 NF Tuolumne R near Long Barn	23.1 sq. mi. El. 4,650 ft.	9/1/1962 to 9/30/1986	Records good. No storage or diversion above station.

In addition to these gauges, HDR has identified five additional locations that are potentially useful for the development of unimpaired hydrology at La Grange. It should be noted that, even with the additionally identified gauges, the period of record with adequate data coverage only spans the period of Water Year 1971-1983. While this duration is insufficient for the development of a long-term unimpaired estimate at La Grange or an inflow dataset for use in the water balance/operations model, it is adequate for the purposes of comparison with the aforementioned mass balance approach. At least eight out of nine of the identified gauges have continuous data for the thirteen-year period. Table 2 presents the complete list of gauges and date range used in this analysis. Figure 1 presents a map of the Tuolumne River watershed with the location of each of the gauged basins specified.

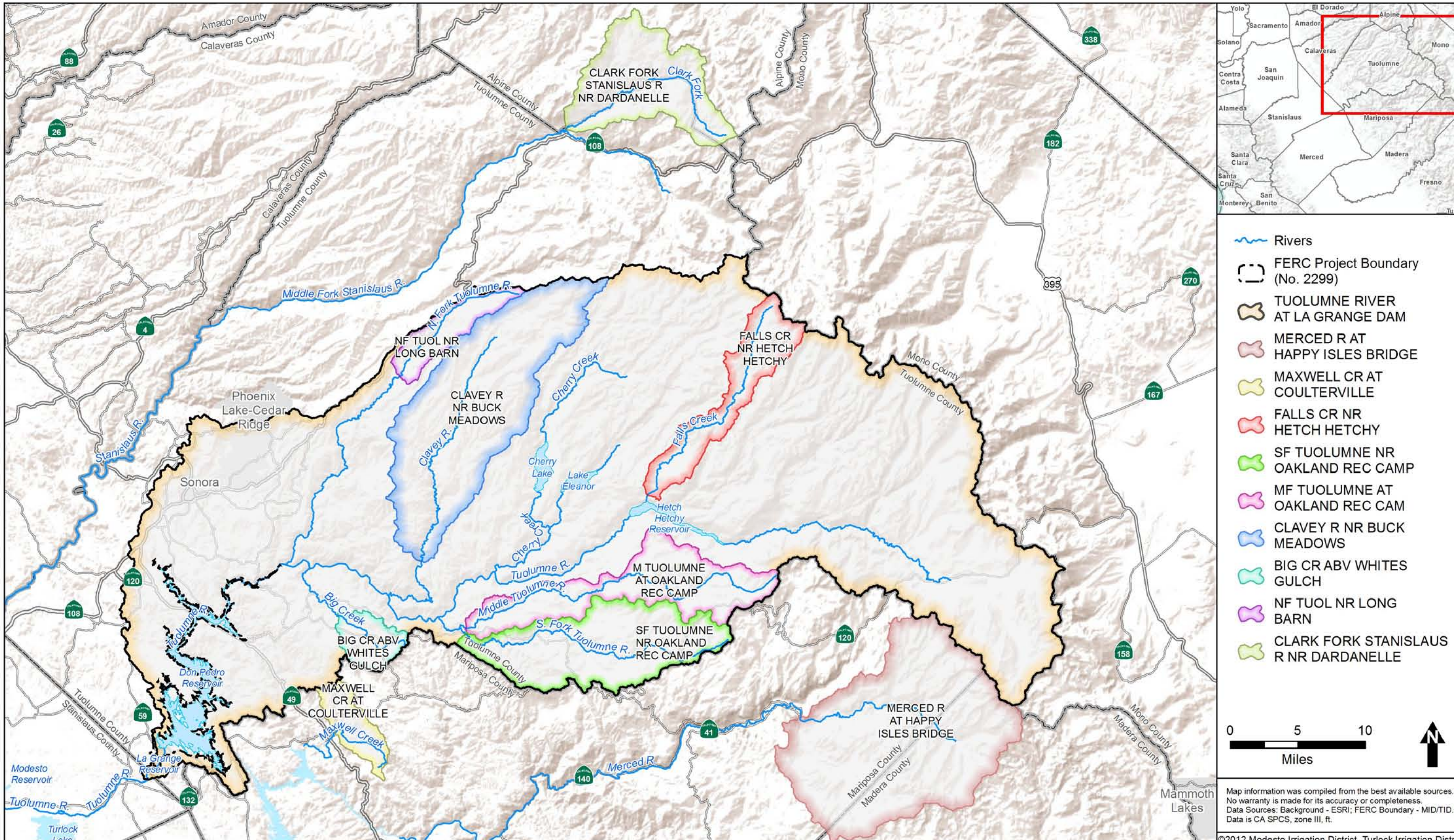

Figure 1. Map of gauges used in proration method for unimpaired hydrology

Table 2. List of gauges used for development of prorated unimpaired hydrology at La Grange

USGS No.	Gage Name	Drainage Area (mi²)	Date Range Used
11281000	SF TUOLUMNE NR OAKLAND REC CAMP	87	WY 1971 - 1983
11282000	MF TUOLUMNE AT OAKLAND REC CAMP	73.5	WY 1971 - 1983
11283500	CLAVEY R NR BUCK MEADOWS	144	WY 1971 - 1983
11284700	NF TUOL NR LONG BARN	23.1	WY 1971 - 1983
11284400	BIG CR ABV WHITES GULCH	16.4	WY 1971 - 1983
11275000	FALLS CR NR HETCH HETCHY	46	WY 1971 - 1983
11292500	CLARK FORK STANISLAUS R NR DARDANELLE	67.5	WY 1971 - 1983
11264500	MERCED R AT HAPPY ISLES BRIDGE	181	WY 1971 - 1983
11269300	MAXWELL CR AT COULTERVILLE	17	WY '71-'74, '76-'80

The last three gauges in Table 2 are not within the Tuolumne River basin, but were added to provide representation for elevation ranges that were not well represented by gauged data within the Tuolumne River basin.

Methods

In order to prorate the gauged data to a larger ungauged area, three physical variables were considered – elevation, drainage area, and average annual precipitation (precipitation). Each gauged basin, along with the full basin (La Grange), was divided into 100-foot "elevation bands" for its entire drainage area. This was done using USGS National Elevation Dataset, 1/3 arc-second (USGS, 2009), which equates to about a 30 foot pixel size. Each elevation band for each gauge had attributes added for the drainage area within this band (e.g., the number of square miles of the Tuolumne River drainage that exists between elevation 500 and 600 feet) and precipitation (e.g. the average annual precipitation for the drainage area between elevation 500 and 600 feet).

The Oregon Climate Service's PRISM model results were used to estimate average annual precipitation from 1971 – 2000 (PRISM, 2006) for each of the elevation bands represented by the basins being evaluated (elevation beginning 100 to 13,000 feet). PRISM uses the observed precipitation gauge and radar data network, in conjunction with an orographic precipitation and atmospheric model, to develop an estimate of average annual precipitation for the contiguous United States at a pixel size resolution of 2,500 feet. Bi-linear interpolation was used to resample the PRISM values to the same pixel size as the elevation model.

Figure 2 is a suite of "elevation histograms" that shows the amount of area covered by the gauged basins cumulatively (shaded region), as compared to the full area of La Grange to which the gauged data will apply (region with no shading, along with the shaded region). Areas at low elevations and high elevations in the La Grange basin that are poorly represented or not represented at all by the reference gauges were "artificially added" into the elevation distributions of the most representative gauges in order to provide some amount of coverage for those elevation ranges. When artificial areas were added to the gauges, the amount of area added for each gauge was nominally established as one percent of the total La Grange area for that elevation bin. This can be seen graphically in Figure 2 for elevations below 1,800 feet, where the three lowest elevation gauges were artificially augmented to cover three percent of the La Grange area. For precipitation in artificially augmented elevation bands, a multiplier was applied to the La Grange precipitation values equal to the multiplier for the nearest observed elevation band for that gauge. Due to a lack of reference data, the regions where artificial gauge representation were necessary are expected to have the poorest correlation to the La Grange basin overall.

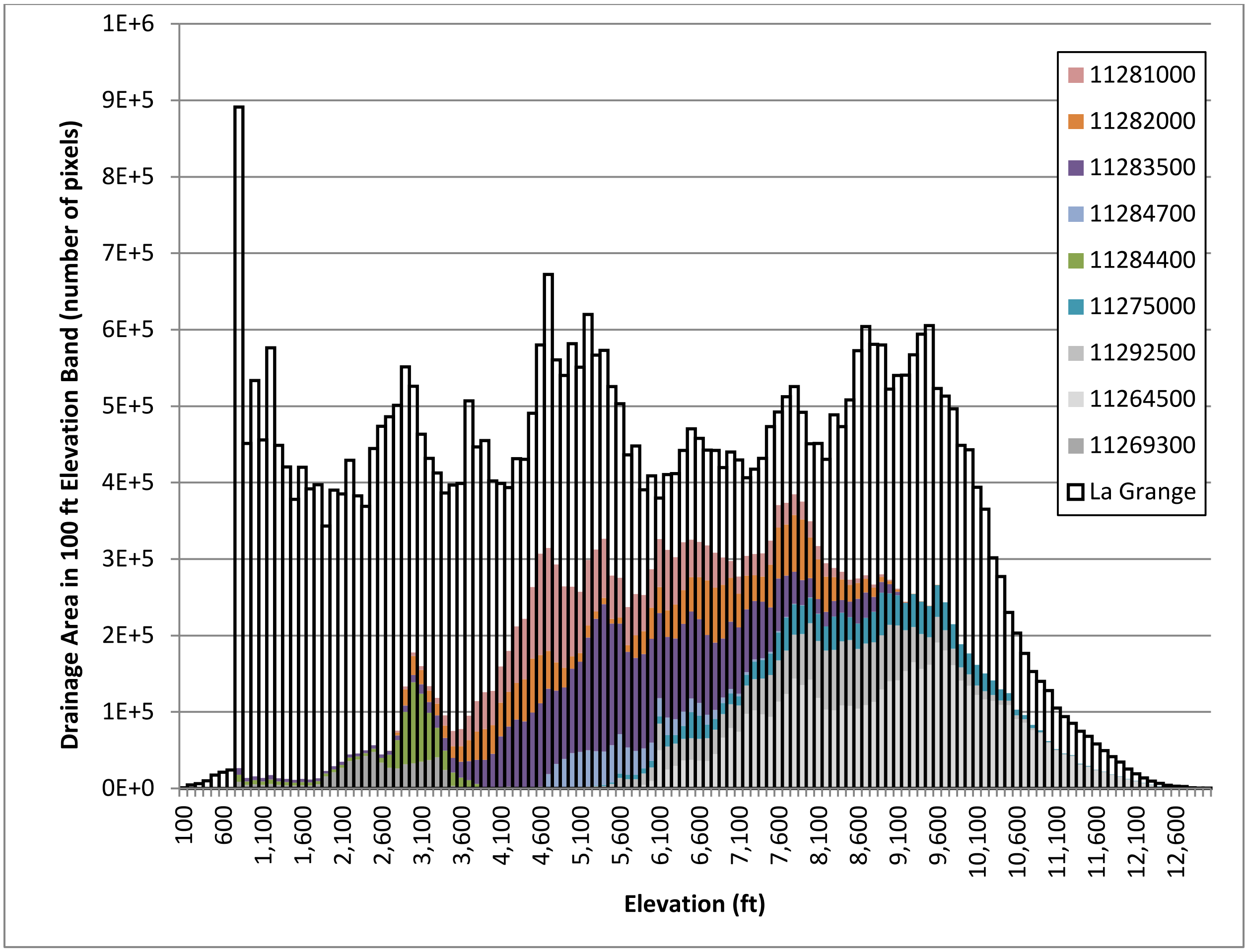

Figure 2. Relative drainage area analysis using elevation histograms for reference gauges used, compared to the watershed above La Grange

The proration calculation includes two main steps. First, the daily flow for a given gauge is divided across the elevation range that the gauge represents, in equal proportion to the drainage area represented within each 100-foot elevation band. Second, the sum of each of the individual "elevation band flows" for each gauge is scaled up to the unimpaired elevation band. Each of these steps includes a scaling factor for both area and precipitation. Equation 1 shows the calculation for prorated flow on a single day, with the first step in the left set of parenthesis, and the second step in the right set of parenthesis (mathematical summation form).

$$q_u = \sum_{e=1}^{130} \sum_{g=1}^{9} q_g \left(\frac{a_{ge} p_{ge}}{\sum_e a_{ge} p_{ge}} \right) \left(\frac{a_{ue} p_{ue}}{\sum_g a_{ge} p_{ge}} \right)$$

Equation 1. Daily unimpaired flow where q is daily average flow, a is area, and p is average annual precipitation. Where $_g$ is each gauged basin, $_u$ is the unimpaired basin, and $_e$ is the lower limit of the 100-foot elevation band divided by 100.

It is worth noting here that a few of the reference gauge basins had facilities that resulted in measurable amounts of stream regulation and/or diversion during the period of data use; no effort was made to modify the observed data to account for these hydrologic effects. However, it is not expected that these water regulation facilities would have a meaningful impact on the results of this analysis.

Results

The methods described above were employed to create an estimate of unimpaired daily flows at La Grange over the WY 1971 to 1983 period. This dataset was then compared to the mass balance methodology developed previously by the Districts, and presented in a prior Hydrology Workshops. The magnitude and shape of the hydrographs for the examined period compare quite well between the two approaches, as seen in Figure 3. The cumulative volume for the full thirteen-year analysis is 9.5% less using the gauge proration approach when compared to the mass balance approach, as seen in Figure 4. The type of deviation between the two approaches (also shown in Figure 4) suggests a relatively consistent difference in volumes that occurs each year, rather than a difference caused by a small number of discrete flow events.

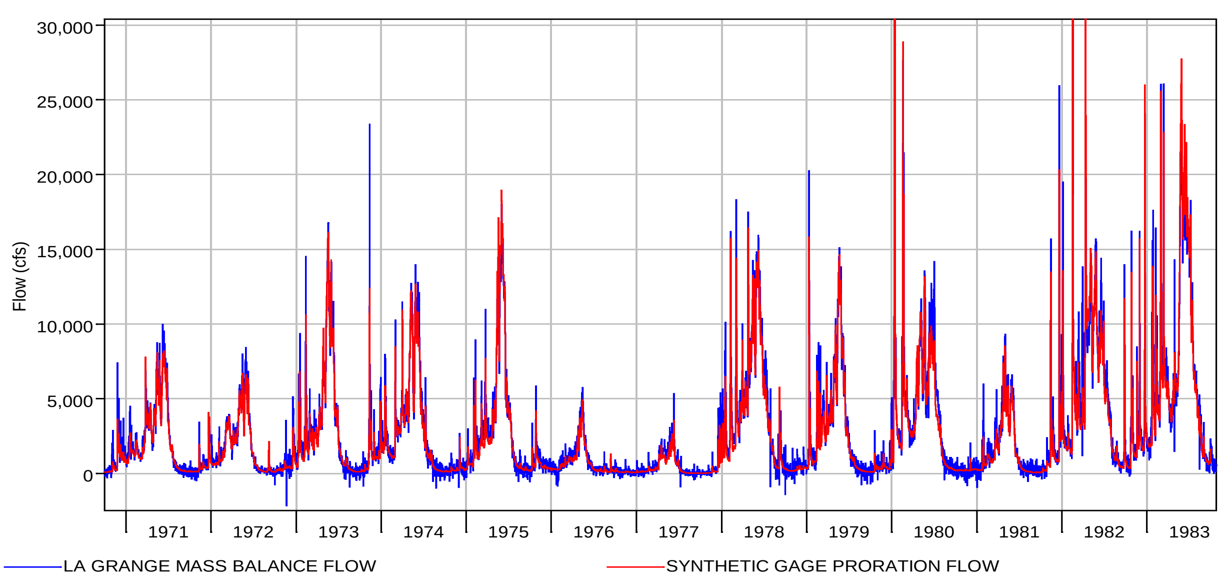

Figure 3. Comparison between mass balance and gauge proration approach, Water Years 1971-1983.

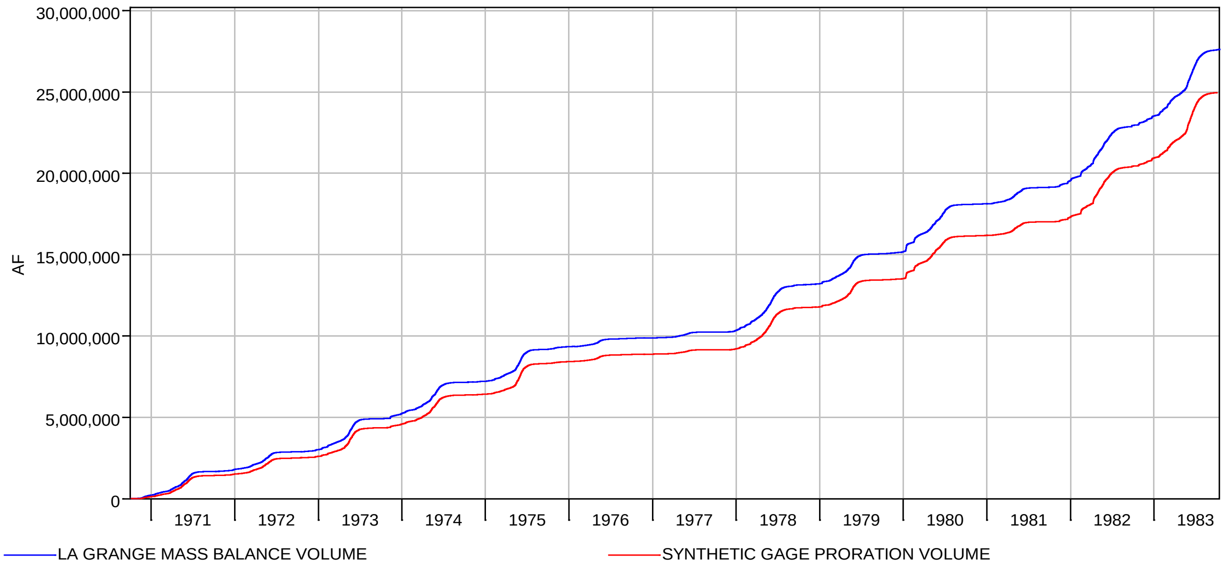

Figure 4. Comparison between mass balance and gauge proration approach, accumulated volume (values in acre-feet).

While individual storm and runoff events appear to have consistently good agreement between the two approaches, closer examination reveals periods of significant discrepancy, likely resulting from poor La Grange basin representation by the reference gauges. Figure 5 shows a chronic underestimation of the late season snowmelt in 1980 by the gauge proration approach. This can be explained by the lack of reference gauge representation within the higher portions of the La Grange basin, where much of the remaining snowmelt runoff is likely occurring during the early summer. Without the inclusion of the Merced River at Happy Isles gauge, the underestimation of the proration approach is even worse due to a complete lack of high elevation gauge coverage in the Tuolumne River.

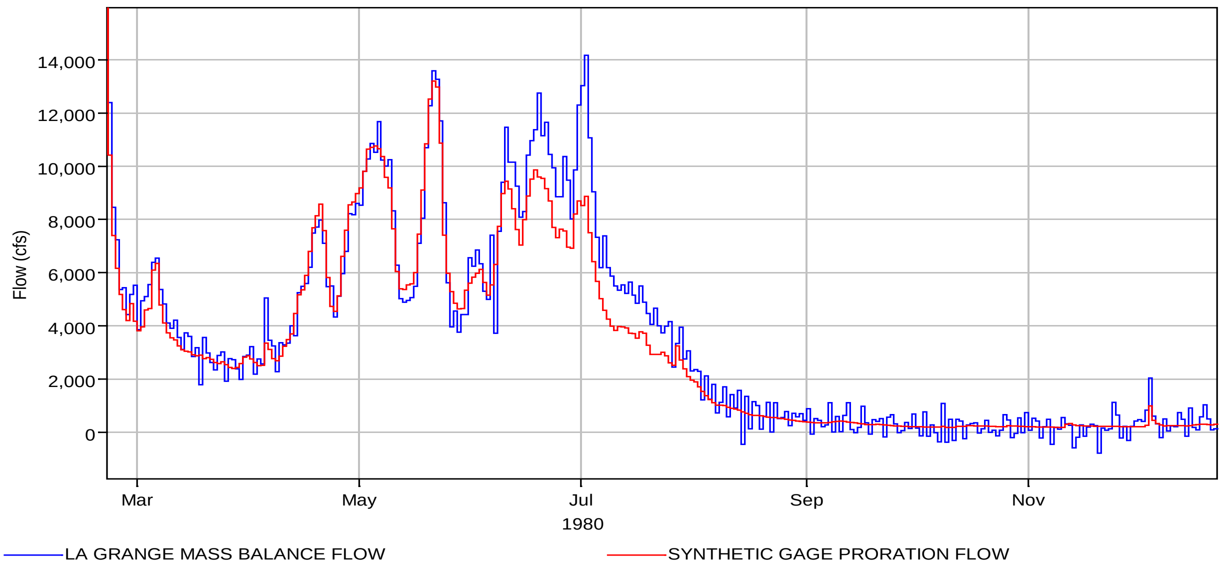

Figure 5. Underestimated late season snowmelt 1980 using gauge proration approach

Figure 6 shows an underestimated rainfall in January of 1972, likely due to a lack of low-elevation reference gauge coverage. Also seen in Figure 6 is another period of underestimated snowmelt in June. A small September storm that occurred only in the Yosemite area (Merced R at Happy Isles),was factored into the gauge proration calculation for the Tuolumne River as an inherent artifact of the approach.

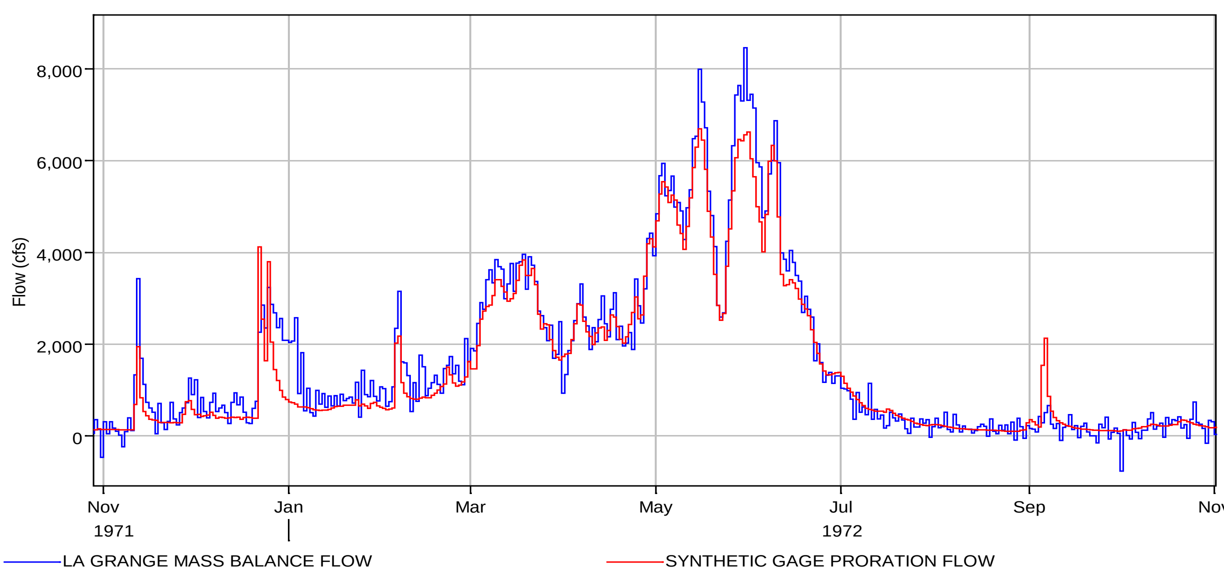

Figure 6. Localized rainfall discrepancies between gauge proration and mass balance approaches

Summer and fall baseflow comparisons are fair between the two approaches, although the mass balance method contains a substantial number of negative flows on a daily basis during low flow periods. It is expected that, with adequate temporal smoothing, the negative values would be adjusted while still retaining the mass balance approach.

Discussion and Conclusion

The period assessed for gauge proration in this report (Water Year 1971 to 1983) has the most complete data coverage of any period covered by the operations model's period of record (Water Year 1971 to 2009). This can therefore be considered a reasonable sample for a comparison of the mass balance and proration methodologies. For the remainder of the period of record, there are intermittent data for at most five of the nine gages. Only two of the nine have continuous records for the whole period of record – Big Creek above White's Gulch and Merced River at Happy Isles Bridge. These two gauges alone are not sufficient for implementation of a gauge proration method for development of a unimpaired flow record at La Grange. If the gauge proration method were to be used when less gauge data are available, the discrepancies and uncertainties will be considerably larger and more frequent.

In terms of the noted discrepancies between the two approaches, the gauge proration method could be more fully "calibrated" to the mass balance approach through the scaling of the prorated data with monthly observed mass balance volumes. This would improve the data comparison where the runoff patterns match well, but it would also potentially amplify errors during discrete events with poor correlation (see Figure 6) and in years where the gauge record is less complete than the period examined in this report.

The mass balance approach provides a consistent, defensible, long-term approach to the development of the unimpaired hydrology at La Grange. The main drawback to the approach is the uncertainty (including negative values) that occurs during the low flow portion of the year (i.e., late summer and fall months). These below zero values are primarily due to inaccuracies in the stage readings of the reservoirs used; any remaining uncertainty may be an artifact of indirect evaporation estimates from Don Pedro Reservoir and upstream impoundments. If a temporal smoothing function was applied to the entire dataset, it would mostly likely degrade the shape of the larger hydrographs, which have been validated by the results of this gauge proration methodology. At higher flows the inflow volumes overwhelm the inaccuracies in the stage readings and evaporation estimates. A selective smoothing function could be used only during the lower flow periods to avoid this side effect. Such a function could be tested against the gauge proration method to ensure it did not degrade the hydrograph correlations across the seasons.

References

PRISM Climate Group, 2006, *United States Average Monthly or Annual Precipitation 1971 – 2000*, <http://prism.oregonstate.edu>, Oregon State University, Created 12 Jun 2006.

United States Geologic Survey (USGS), 2009, *1/3 Arc Second National Elevation Dataset*, <http://seamless.usgs.gov>, USGS Earth Resources Observation & Science (EROS) Center, Sioux Falls, SD, Created 23 March 2009.

TUOLUMNE RIVER DAILY OPERATIONS MODEL

APPENDIX B

LOWER TUOLUMNE RIVER ACCRETION
(LA GRANGE TO MODESTO)

ESTIMATED DAILY FLOWS (1970-2010)
FOR THE OPERATIONS MODEL

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Lower Tuolumne River Accretion (La Grange to Modesto)
Estimated daily flows (1970-2010) for the Operations Model
Don Pedro Project Relicensing

1.0 Objective

Using available data, develop a daily time series representing the total accretion and/or depletion flows between La Grange Dam and the Modesto gage on the Tuolumne River. These data will serve as input into the relicensing operations model. Accretion or depletion in this context is defined as the full inflow or outflow, respectively, contributed by or to the local drainage basin, incorporating both groundwater/baseflow and surface runoff considerations.

2.0 Existing Information

As shown in Table 1, there are three permanent flow gages currently installed in the lower Tuolumne River: (1) the Modesto gage, operated by the USGS (USGS 11290000); (2) the gage below La Grange Dam, operated by Turlock Irrigation District and calibrated to USGS standards (USGS 11289650); and (3) the Dry Creek at the Tuolumne River gage, operated by the California Department of Water Resources (DWR; Gage Code DCM on the California Data Exchange Center) on Dry Creek.

Table 1. Historical flow data for the lower Tuolumne River.

River Mile	Location	Gage Identifier	Period of Analysis	Data Quality	Notes
TUOLUMNE RIVER					
51.5	Tuolumne River at La Grange	USGS: 11289650	October 1 1970 – September 30 2010	Records are "good" with expected accuracy to about 5%.[2]	La Grange gage is located 0.5 miles downstream of La Grange Dam.
16.2	Tuolumne River at Modesto	USGS: 11290000	October 1 1970 – September 30 2010	Records are "fair", except for estimated daily discharges which are "poor". About 3% of the daily values since 1970 are estimated.[2]	The flood control flow objective for the lower Tuolumne River is 9,000 cubic feet per second (cfs) at the Modesto Gage (RM 16.2). As Dry Creek confluences with the lower Tuolumne River just upstream of the Modesto gage, inflows from Dry Creek are accounted for the this management objective.
DRY CREEK					
--	Dry Creek at Tuolumne River Confluence	DWR: B04130/CDEC: DCM	October 1 1970 – September 30 2010	Qualifiers are provided: Good data, Estimated Data or Missing Data. About 1.2% of the daily values are estimated or missing.	Dry Creek is a tributary to the Tuolumne River at RM 16.2. Dry Creek operations changed substantially in 1987. Prior to 1987, substantially greater flows were diverted at LaGrange into the Modesto Canal in fall (October-December) months, with a portion being returned back to the Tuolumne River through Dry Creek.

USGS = US Geological Survey
DWR = Department of Water Resources
[2] USGS defines fair as having accuracy to approximately 8%, and poor as greater than 8% (Turnipseed, 2010). Typically natural bottomed streamflow measurements are considered "good" if accurate to about 5% (Turnipseed, 2010).

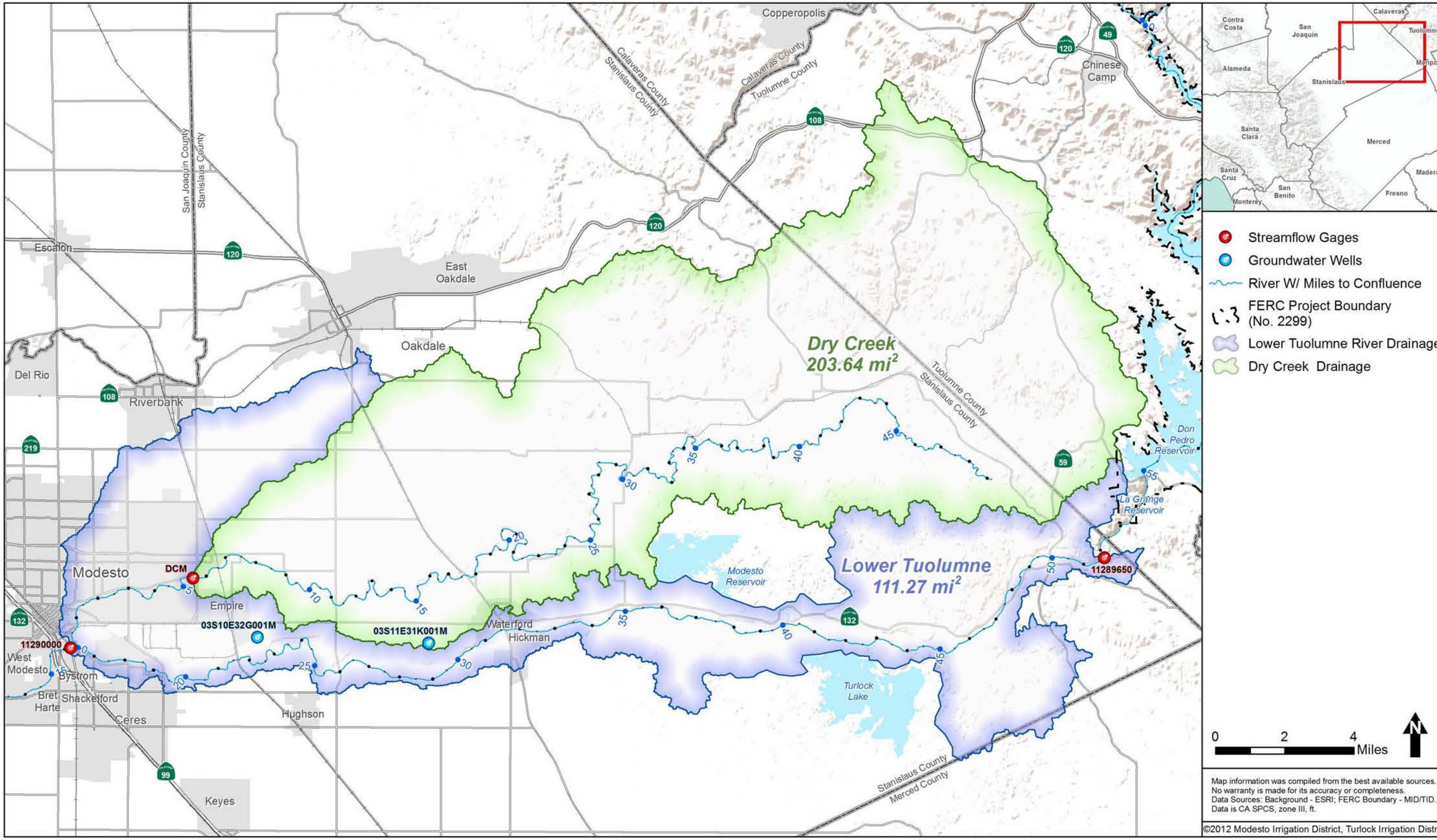

Figure 1. Map of lower Tuolumne drainage, Dry Creek drainage, and gages.

Using data collected at the three gages, accretion was calculated for the lower Tuolumne through the following equation:

Accretion flow (cfs)	=	Flow at the Modesto gage (cfs)	−	Flow at La Grange gage (cfs)	−	Flow at Dry Creek gage (cfs)

Average daily accretions in the Lower Tuolumne range from 40 cfs to 200 cfs, with an annual average accretion of 218 cfs from water year 1970-1987 and 103 cfs from water year 1988-2010, resulting in a water year 1970-2010 average of 152 cfs (calculated daily accretion data are provided in Attachment B). Deviations from the average are highest in the winter months; as the flows increase, so does the uncertainty in the gage rating. The largest difference in flow observed was during the January 1997 storm; it has been determined that the computations are not reliable during large storm events due to the cumulative gage rating uncertainty associated with the calculation.

A review of the historical gage data from these three locations indicates a higher degree of variability of accretions than would be expected to naturally occur. For example, as shown in Figure 2, when calculated accretions[1] are graphed without any data smoothing or other adjustment, values are erratic and frequent negative flows are observed.

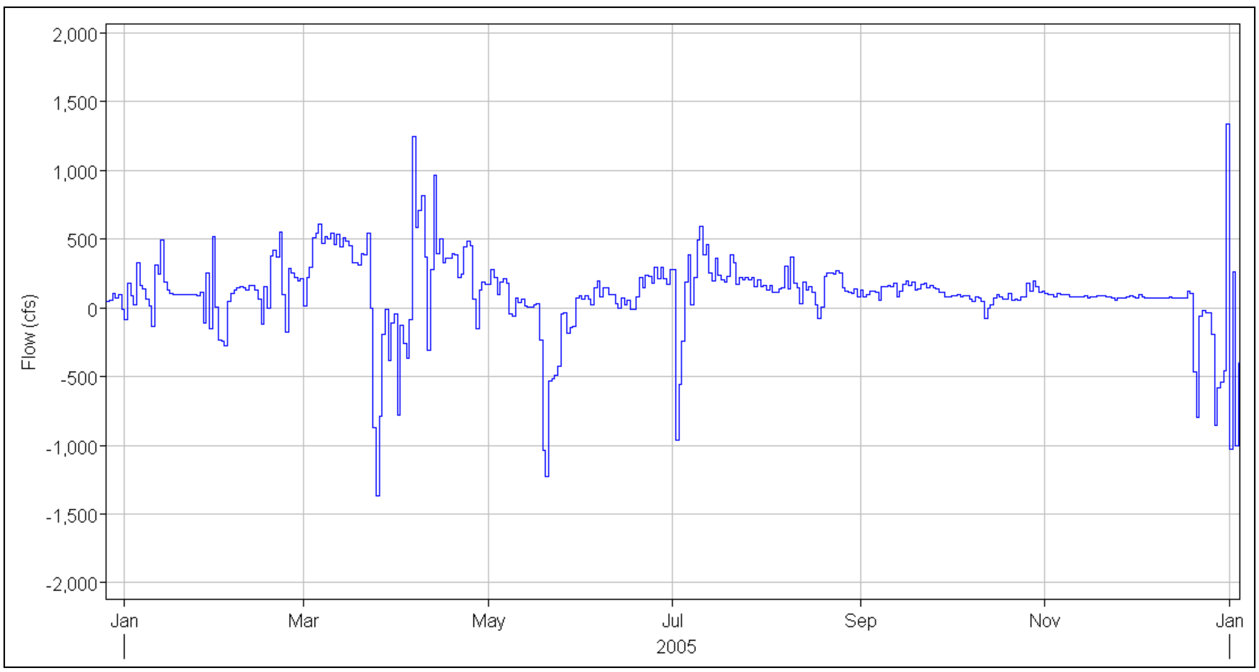

Figure 2. Sample computation of daily Lower Tuolumne accretion (flows at Modesto gage less La Grange gage and Dry Creek gage).

This variability is likely due to the relatively small magnitude of accretions compared to the actual gaged flow; relatively small errors and hydrograph timing differences and would explain much of the variability in accretions determined through a strict mathematical interpretation of

[1] It should be noted that this calculation does not allow for any travel time between locations; at the typical flow rates in the lower Tuolumne River, travel time would be expected to be on the order of hours rather than days.

USGS and DWR gage data. Additionally there may be agricultural withdrawals and return flows that are not being accounted for, as well as some interaction with the groundwater.

Inclusion of these data "as is" into the operations model will introduce variability that is distracting to the planning process, and at times invalid. A synthetic daily time series that represents the total accretion flow between La Grange Dam and the Modesto gage (including the contributions of Dry Creek) is therefore necessary to provide a reasonable estimate for modeling and planning purposes.

3.0 Methods

Due to the nature and quality of data, slightly different approaches were followed for synthesizing Dry Creek accretion and the lower Tuolumne accretion data sets. In addition, the total accretion calculations were split into two separate approaches for estimation of groundwater baseflow and surface runoff contributions. The two approaches are then aggregated to provide an estimate of total accretion.

3.1 Dry Creek

There are several locations within Dry Creek where accretion and depletion may occur. The gage on Dry Creek located about 5.6 miles upstream of the confluence with the Tuolumne River, is the best available approximation of the total flow at the mouth of Dry Creek.

Monthly synthetic baseflow values were then estimated using the average monthly flow rate in months that had less than ¾ inches of rain, representing periods with minimal expected surface runoff.

Surface runoff was estimated for Dry Creek manually using baseflow separation techniques. The entire period of record of the gage was examined graphically to determine if the flows recorded were likely to be surface runoff, baseflow, or return flow from irrigation canals. The synthetic baseflow values were then used to fill in all hydrograph values judged to be baseflow, or return flow.

Attachment A contains the synthetic flow record for Dry Creek for the period of 1970-2010, using the methods described above. Attachment B provides all the data files used to derive the synthetic flow record.

3.2 Lower Tuolumne

An estimate of total accretion for the 35.3 mile reach between the La Grange and Modesto gages was developed from the available gage data. Methods were separated into independent baseflow and surface runoff estimates, similar to the approach used to estimate Dry Creek accretion.

For the lower Tuolumne, the long-term daily median demonstrates the annual trend more clearly than the daily calculation using observed data, due to erratic swings in the daily calculation between large values and negative values. Long-term daily median in this case is the 50% exceedance of each individual date across all years in the record (e.g. the 50% exceedance of all October 1st daily values from 1988 to 2010 is used to represent a single October 1st estimate). During periods of agricultural return flows, rainfall, or high flow, the values can be especially erratic, so the yearly median was examined for comparison to the yearly average.

The long-term daily median datasets were restricted to synthesized values from water year 1988-2010 because the pre-1987 Dry Creek flows from irrigation sources significantly impacted the gage calculation. A piece-wise linear synthetic time series was developed using visual inflection points from the yearly median, while honoring the annual volume estimate derived from the long-term daily median. This piece-wise linear estimation of the median annual accretion curve was then applied to the whole period (1970 to 2010). Figure 3 shows the annual median and resulting synthetic accretion. Attachment B contains the results of this computation.

The gage calculation was too erratic to be useful for surface runoff estimation. Therefore, a simple drainage area proration was applied to estimate surface runoff for the lower Tuolumne natural runoff accretion. This was done using the Dry Creek gage hydrographs, separated from baseflows as described in Section 3.1 above.

4.0 Results

4.1 Baseflow Calculations

Calculated daily time step accretions are provided in the accompanying Attachment B, along with supporting measured gage data.

Synthetic baseflow values[2] for Dry Creek are developed in Attachment B and summarized, by month, in Table 2. These values were inserted into the daily accretion series, provided in Attachment B.

Table 2. Synthetic baseflow rates for Dry Creek by month in cubic feet per second (cfs).

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
10	30	30	40	45	50	55	70	65	30	3	1

Synthetic baseflow accretion values for the lower Tuolumne reach between La Grange and Modesto gages are developed in Attachment B and summarized by month in Figure 3.

[2] The observed base flow in Dry Creek likely includes agricultural return flows during the typical growing season of April through October. Flows typically recede sharply in November, suggesting the elimination of seasonal return flows.

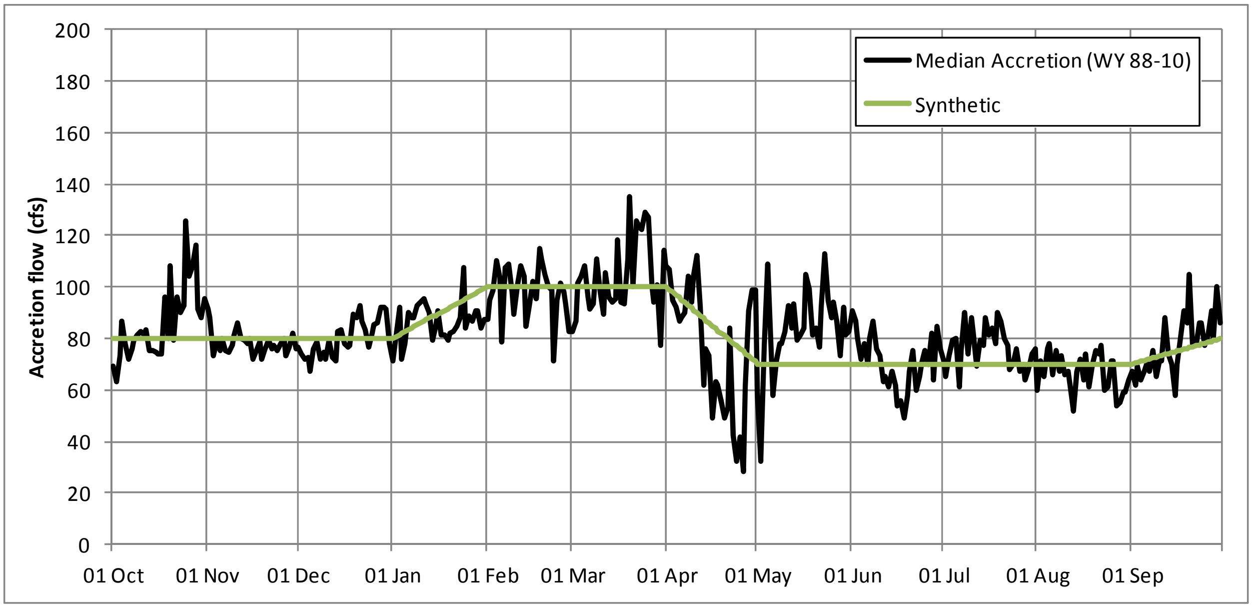

Figure 3. Synthetic accretion flow rates for lower Tuolumne in cubic feet per second (cfs).

4.2 Surface Runoff Calculations

The drainage area to the Dry Creek gage was measured to be 203.6 mi², and the accretion drainage area of the lower Tuolumne was measured to be 111.3 mi². This yields a proration factor of 0.5464, therefore all of the hydrographs separated for use in the Dry Creek synthetic time series were multiplied by 0.5464. A visual examination of the gage computation and synthetic time series for the lower Tuolumne demonstrated that erratic swings in the gage computation are coincident with runoff events in Dry Creek. An example of this phenomenon is shown in Figure 4.

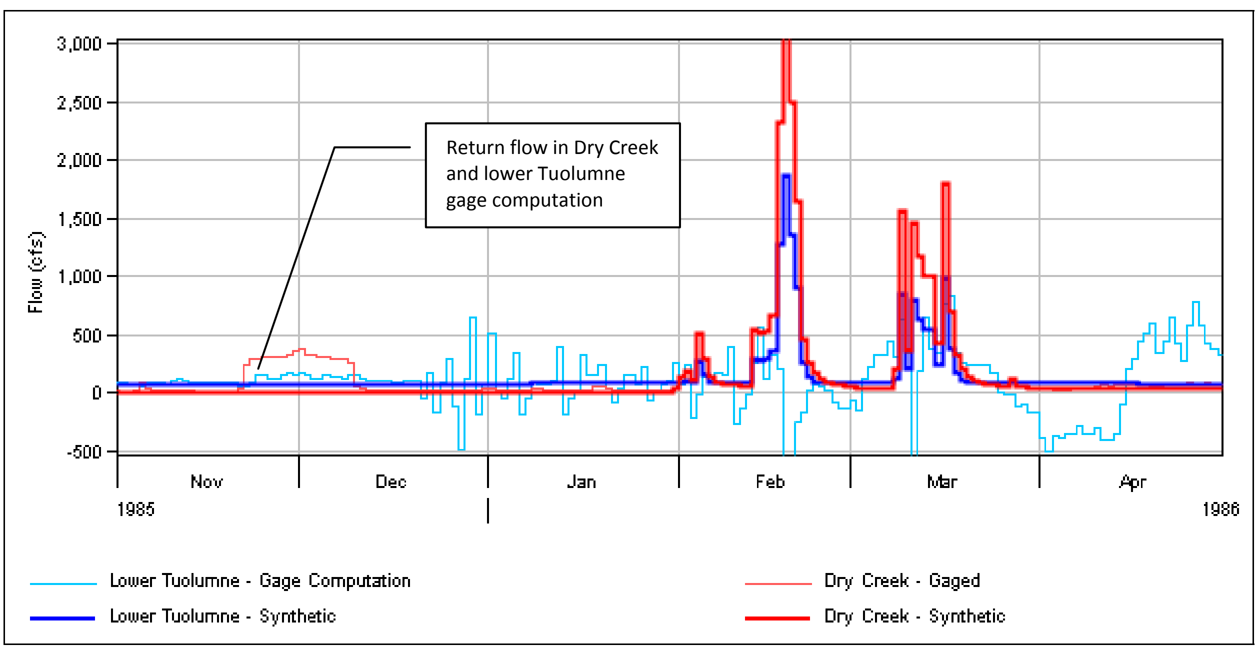

Figure 4. Sample synthetic and gaged data for lower Tuolumne accretion and Dry Creek.

5.0 Discussion

5.1 Dry Creek Accretion

From 1987 to 2011, the period for which Dry Creek operations have been relatively consistent, the volume of synthetic baseflow with observed surface runoff hydrographs is compared to the volume of the unaltered gage data in Figure 5, which indicates the synthetic baseflow values are an appropriate substitute for the gaged data.

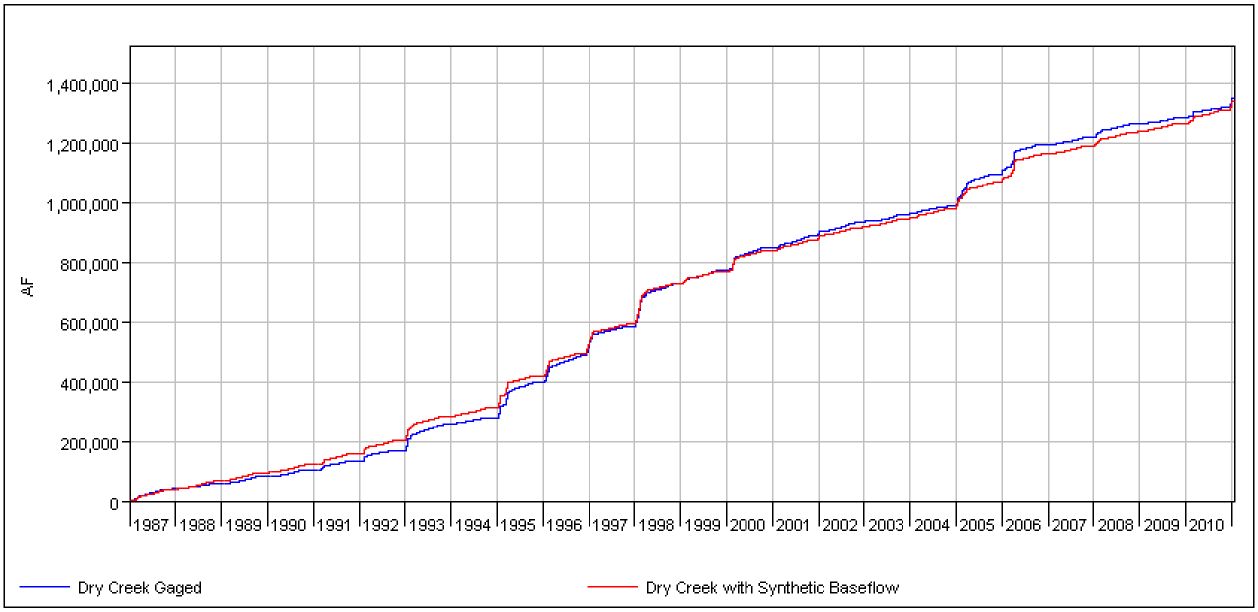

Figure 5. Dry Creek synthetic baseflow and gaged flow, cumulative volumes 1987-2010.

This comparison provides excellent validation in both the annual and long-term volumetric approach to accretion estimates in Dry Creek.

5.2 Lower Tuolumne Accretion

Below, the influence of groundwater synthetic baseflow volume is examined, followed by a comparison of the synthetic accretion dataset to the unaltered gage computation.

5.2.1 Groundwater Influence

The influence of groundwater interactions with the river on computed lower Tuolumne accretions (Modesto flows, less La Grange and Dry Creek) is further examined in Figure 6. The purpose of this examination is to explore the extreme variability in the accretion computation – whether it's due to gage errors, gage re-rating (Modesto gage has been at four different locations during this time[3]), or interactions with the groundwater. The location of two representative groundwater wells relative to the basin can be seen in Figure 1.

[3] United States Geologic Survey (USGS), 2010. *Water-Data Report 2010. 11290000 Tuolumne River at Modesto, CA.* <http://wdr.water.usgs.gov/wy2010/pdfs/11290000.2010.pdf>

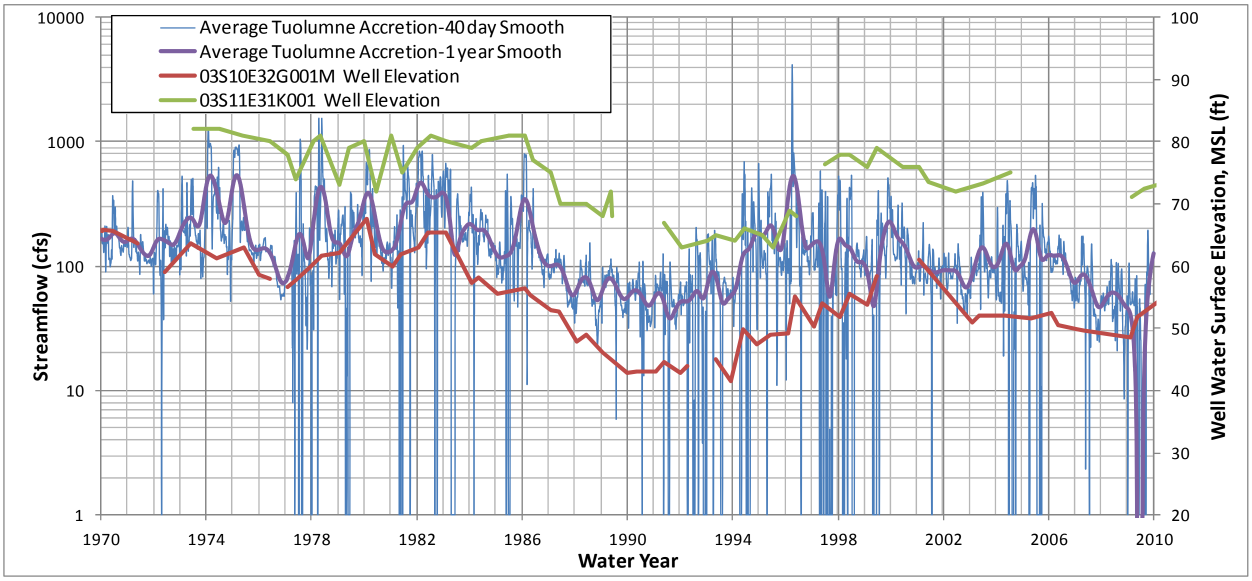

Figure 6. Relationship between lower Tuolumne accretion and groundwater wells 1970-2010.

It can be seen that baseflow and groundwater level roughly correspond to one another. Even though 1977 is the driest year in this period of record, it is a relatively short drought period, and groundwater levels do not have a chance to respond, but in the six-year drought period of 1987-1992, groundwater levels drop dramatically, and accretions respond accordingly.

Given that there is a demonstrated relationship between groundwater level and accretion, this leaves several factors that can cause the extreme variation in the daily time series.

- Gage lag-time and inaccuracy
- Local rainfall runoff
- Agricultural return flows and withdrawals
- Agricultural irrigation and M&I withdrawals from groundwater

Quantifying these factors would require many assumptions, as available information is highly uncertain and/or unavailable. It is possible that the periods of depletion in the time series are actually during groundwater pumping or they could be due to something else. Accounting for all of these factors in development of the synthetic accretion values would require many additional assumptions. Given the accuracy and precision of the input data, it could not be reported with any additional confidence.

5.2.2 Comparison to synthetic accretion

The synthetic accretion data set for the lower Tuolumne (Section 4.0) is checked against period of consistent hydrology (1987-2008) in Figure 7. In other words, Figure 7 shows the computed accretion volumes for the reach between the La Grange and Modesto gages compared to synthetic values.

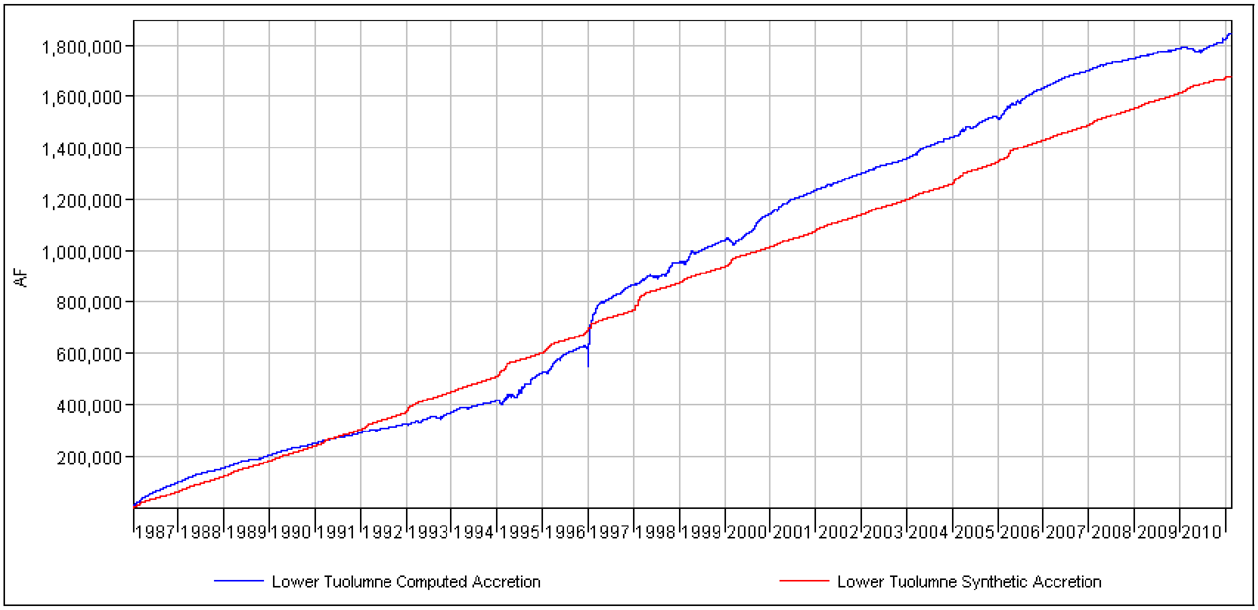

Figure 7. Lower Tuolumne River accretion, synthetic and computed, cumulative volumes (1987-2010).

A significant discontinuity can be seen following the New Years Day 1997 storm. Upon closer examination, it was found that following the 1997 flood, the gage at La Grange had to be re-rated, making its measurements during the storm unreliable. Further, the average accretion between Jan 2nd to Jan 10th 1997 from the gage calculation is about 4,000 cfs, which is just 7% of the peak flow observed at Modesto of 55,800 cfs, well within the margin or error for a three-gage calculation at high flow. If the discontinuity following the New Years Day storm is ignored, the cumulative volume of the synthetic accretion appears to match the cumulative volume of the computed accretion.

5.2.3 Comparison to Accretion Flows Measured in June 2012

On June 25, 2012, Modesto Irrigation District and Turlock Irrigation District collected flow information for the lower Tuolumne River between the La Grange Gage and the San Joaquin River confluence, as well as within Dry Creek. Table 3 presents the results of the measurement.

Table 3. Measured and gaged discharge on the Tuolumne River and Dry Creek.

Location	Measured Discharge (cfs)	Gaged Discharge (cfs)	Percent Difference (%)
Tuolumne at La Grange	114.9	130	12
Tuolumne at Modesto	208.2	219	5
Dry Creek [a]	55.5	38 [b]	46
Lower Tuolumne Accretion	55.3 [c]	-	-

[a] Measured at confluence with Tuolumne River, 5.3 miles downstream of the gage.
[b] Value from CDEC (DCM), not yet available on Water Data Library (B04130).
[c] Using Dry Creek gaged discharge, rather than measured.

It is important to note that the Dry Creek measurement was not taken at the gage. The lower Tuolumne accretion calculation discussed herein uses values from the gage on Dry Creek, and does not attempt to subtract any accretions below the Dry Creek gage. The accretions in Dry Creek, below the gage, are therefore included in the lower Tuolumne accretion numbers. Another distinction to make is that the Dry Creek gage values are published twice, first in real time on CDEC (DCM), and later on the Water Data Library (B04130) after some quality control procedures by the California Department of Water Resources. The computations in this report used the Water Data Library values when available, and CDEC values only to fill in gaps in the record, and the values are often considerably different.

The synthetic baseflow value for Dry Creek in June is 50 cfs, which is in the range of values estimated by the measurement. The synthetic accretion for the lower Tuolumne in June (including accretion below the Dry Creek gage) is 70 cfs. In this case the synthetic accretion is more than the measured accretion (55 cfs), which could be due to lower groundwater levels in 2012. The lower amount could also be due to efforts to minimize all operational spills into the Tuolumne River during the measurement. Using the gaged measurements alone, the accretion would be estimated to be 51 cfs.

The Dry Creek gage has been deemed to provide the most reliable data for estimation for surface runoff-based accretion in the entire lower Tuolumne River drainage. Other elements of accretion estimation, such as groundwater contributions, have been estimated by honoring as much of the source data as possible in the lower Tuolumne. The resulting synthetic, aggregate hydrograph provides a reasonable estimate for both long-term and rainfall event-driven contributions to the lower Tuolumne River from the La Grange gage to the Modesto gage.

6.0 Attachments

The following attachments to this memo are available on http://www.donpedro-relicensing.com.

- AttachmentA.pdf
- AttachmentB.dss

Attachment A contains the final time series data for Dry Creek, lower Tuolumne (excluding Dry Creek), and total accretion from La Grange to Modesto gage.

A brief description of each of the DSS tables that comprise Attachment B is provided as Table 3.

Table 3. Attachment B Contents, final datasets indicated with bold font.

Name - /LOWER TUOLUMNE/B/C//E/F/	Contents
//DRY CREEK/FLOW//1MON/BASEFLOW/	A time series containing averaged monthly baseflow values in months with less than 0.75" of precipitation (cfs)
//DRY CREEK/FLOW//1DAY/DCM_ADJUSTED/	Gaged flow at Dry Creek DWR record B04130 , combined with CDEC DCM, for missing days (cfs)
//DRY CREEK/FLOW//1DAY/HYD_ONLY/	Dry creek gaged flow, with baseflow deleted (cfs)
//DRY CREEK/FLOW//1DAY/SYNTHETIC/	**Synthetic time series using BASEFLOW_EST in all places that HYD_ONLY is missing data (cfs)**
//DRY CREEK 87/ACCUM//1DAY/DCM_ADJUSTED/	1987-2010 cumulative volume for gaged dry creek flow (acre-ft)
//DRY CREEK 87/ACCUM//1DAY/SYNTHETIC/	1987-2010 cumulative volume for SYNTHETIC dry creek

Name - /LOWER TUOLUMNE/B/C//E/F/	Contents
	dataset (acre-ft)
//TUOLUMNE ACCRETION/FLOW//1DAY/COMPUTED/	Time series of computation: Modesto [11290000] minus La Grange [11289650] and Dry Creek [DCM_ADJUSTED] (cfs)
//TUOLUMNE ACCRETION/FLOW//1DAY/BASEFLOW/	Generalized median of COMPUTED values from 1988 to 2010 (cfs)
//TUOLUMNE ACCRETION/FLOW//1DAY/HYD_ONLY/	//DRY CREEK///HYD_ONLY/ times the drainage area proration of 0.5464 (cfs)
//TUOLUMNE ACCRETION/FLOW//1DAY/SYNTHETIC/	**Synthetic time series using greater of HYD_ONLY and BASEFLOW (cfs)**
//TUOLUMNE ACCRETION 87/ACCUM//1DAY/COMPUTED/	1987-2010 cumulative volume of COMPUTED daily accretion (acre-ft)
//TUOLUMNE ACCRETION 87/ACCUM//1DAY/SYNTHETIC/	1987-2010 cumulative volume of SYNTHETIC daily accretion (acre-ft)

7.0 References

Durbin, T.J., 2003, *Turlock Groundwater Basin Water Budget 1952-2002.* Turlock Groundwater Basin Association. ftp://ftp.water.ca.gov/uwmp/completed-plans/Ceres/2.pdf

TID/MID 2012. Study W&AR 2 Operations Model Action Item from April 9, 2012, Hydrology Workshop Proposed Lower Tuolumne Flow Accretion and Depletion Measurement Locations. Memo to Relicensing Participants. June 6.

Turnipseed, D.P., and Sauer, V.B., 2010, *Discharge measurements at gaging stations:* U.S. Geological Survey Techniques and Methods book 3, chap. A8, 87 p. <http://pubs.usgs.gov/tm/tm3-a8/>

TUOLUMNE RIVER DAILY OPERATIONS MODEL

APPENDIX C

FIELD ACCRETION MEASUREMENT INFORMATION
UPDATED APRIL 25, 2013

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REVIEW

ONE COMPANY
Many Solutions[SM]

Memo

To:	Don Pedro Relicensing Participants		
From:	Turlock Irrigation District / Modesto Irrigation District	Project:	Don Pedro Hydroelectric Project
Date:	June 6, 2012		

RE: Study W&AR 2 Operations Model
Action Item from April 9, 2012, Hydrology Workshop
Proposed Lower Tuolumne Flow Accretion and Depletion Measurement Locations

In accordance with our Study Plan W&AR-2 (November 22, 2011), the FERC Study Plan Determination (December 22, 2011), and the most recent FERC Study Dispute Determination (May 24, 2012), we are planning to undertake between June 25 and 29, 2012, flow measurements along the lower Tuolumne River between La Grange Gage and the San Joaquin River confluence, as well as within Dry Creek, to develop estimates of flow accretions and/or depletions (Table 1 and Figure 1). Using accepted flow measurement methodologies, flows will be measured at permanent gage locations, established Instream Flow Incremental Methodology (IFIM) transect locations, and other sites where flow changes may be discernible. Fieldwork will consist of direct measurement of in-channel discharge at ten locations when flows of 100 cubic feet per second are scheduled, as well as opportunistic flow data acquisition at six additional irrigation canal outflow locations, if outflows are occurring. Discharge at each site will be measured using standard methods for collecting data in wadeable streams (Rantz 1982). Depths and mean column water velocities will be measured across each transect using the same methods as used in the co-occurring IFIM stream habitat assessment (Stillwater Sciences 2009). Where transects have a series of water depths greater than approximately 3.5 feet, depth and velocity may be measured using Acoustic Doppler Current Profiler methods (e.g., Simpson 2002). ***Please provide suggestions or comments on this plan to John Devine (john.devine@hdrinc.com) by Wednesday, June 20th.*** This data is targeted to be compiled, checked, and then shared with Relicensing Participants by the first week in August.

Table 1. Flow measurement and data acquisition June 2012.

River Mile	Location
51.5	Near La Grange Gage
49.1	Basso Pool
43.4	Bobcat Flat
39.5	Roberts Ferry Bridge
37.1	Santa Fe Aggregates
33	Waterford Main (MID)[1]
33	Hickman Spill (TID)[2]
31.5	Waterford
20	Faith Home Spill (TID)[2]
18	Lateral No. 1 (MID)[1]
17.2	Legion Park
16.4	Dry Creek Gage
16.2	Modesto Gage
11	Lateral 1 (TID)[2]
3.4	Shiloh Road
2	Lateral No. 5 (MID)[1]

[1]Opportunistic site. Flow data provided by MID if outflow is occurring during study period
[2]Opportunistic site. Flow data provided by TID if outflow is occurring during study period

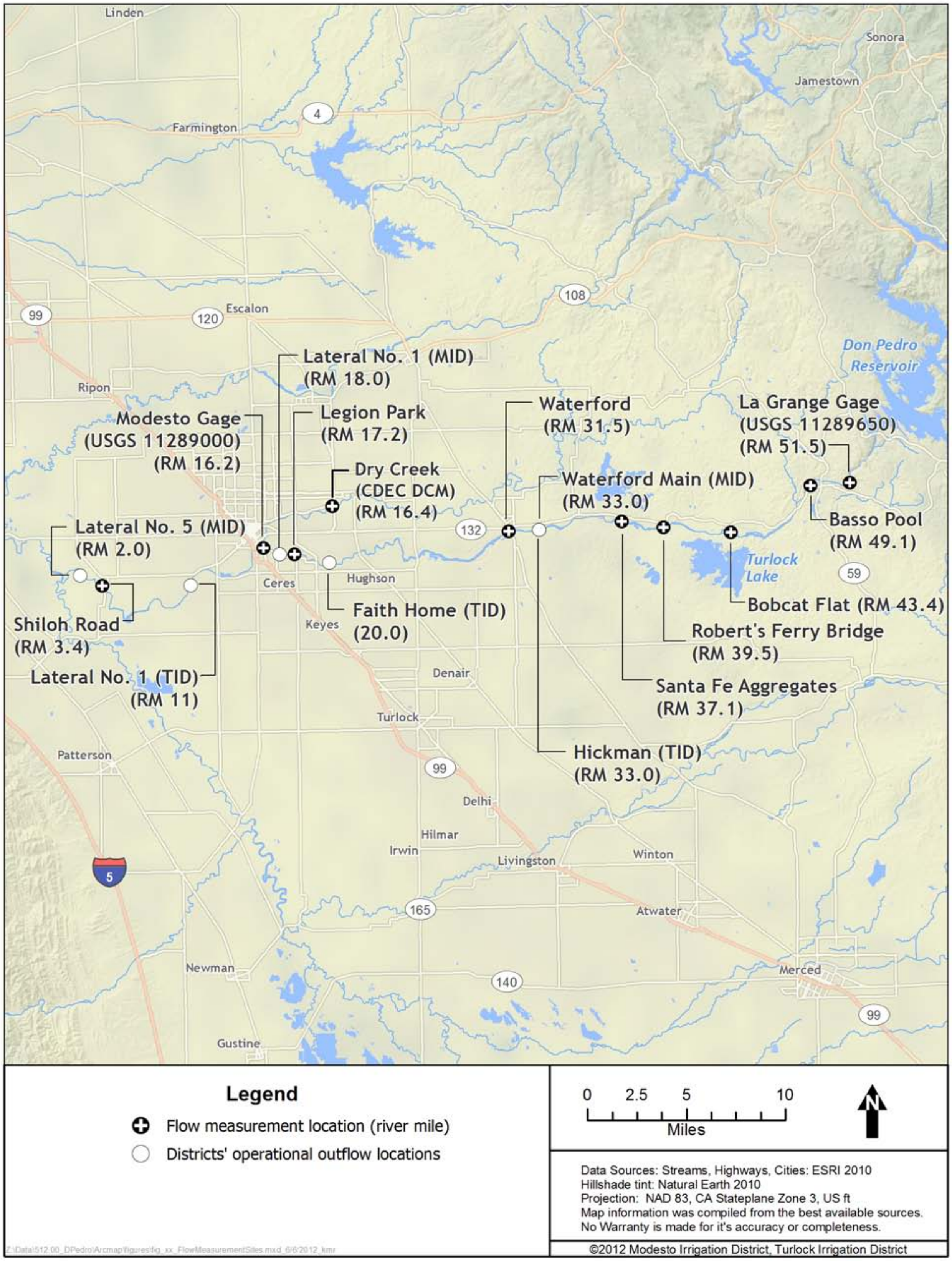

Figure 1. Flow measurement site locations along the lower Tuolumne River, June 2012.

References

Rantz, S.E. 1982. Measurement and computation of streamflow: volume 1. Measurements of stage and discharge. USGS Water Supply Paper 2175. U.S. Geological Survey.

Stillwater Sciences. 2009. Tuolumne River Instream Flow Studies. Final Study Plan. Prepared by Stillwater Sciences, Davis, California for Turlock Irrigation District and Modesto Irrigation Districts, California.

Simpson, M.R., 2002, Discharge measurements using a Broad-Band Acoustic Doppler Current Profiler: U.S. Geological Survey Open-File Report 01-01, 123 p.

Accretion Study Overview

Site	Dry Creek River Mile	Tuolumne River Mile	Irrigation Season[a]	Irrigation Season--Low Flow[a]	Non-Irrigation Season[b]	Reason behind location selection	Reach[c]	Notes
Tuolumne River at La Grange gage house	--	51.5	6/25/12	10/3/12	2/11/13	For comparing measured values to gaged values	Dominant Salmon Spawning Reach	--
Tuolumne River at La Grange (USGS 11289650)	--	51.5	6/25/12	10/3/12	2/11/13	Gage	Dominant Salmon Spawning Reach	--
Tuolumne River at La Grange (CDEC LGN)	--	51.5	6/25/12	10/3/12	2/11/13	Gage	Dominant Salmon Spawning Reach	--
Tuolumne River at Basso Pool	--	49.1	6/25/12	10/3/12	2/11/13	From Instream Flow Study	Dominant Salmon Spawning Reach	--
Tuolumne River at Zanker property	--	45.5	--	10/4/12	2/12/13	Targets potential depletion/ recharge area	Dredger Tailings Reach	--
Tuolumne River at Bobcat Flat	--	43.4	6/25/12	10/4/12	2/12/13	From Instream Flow Study	Dredger Tailings Reach	--
Tuolumne River at Roberts Ferry Bridge	--	39.5	6/25/12	10/4/12	2/11/13	Downstream of Turlock Lake but above Modesto Reservoir	Gravel Mining Reach	--
Tuolumne River at Santa Fe Aggregates	--	37.1	6/25/12	10/4/12	2/12/13	From Instream Flow Study	Gravel Mining Reach	--
Waterford Main (MID)	--	33.0	6/25/12	10/3/12	2/12/13	Operational outflow	--	--
Hickman Spill (TID)	--	33.0	6/25/12	10/3/12	2/12/13	Operational outflow	--	--
Tuolumne River at Waterford	--	31.5	6/25/12	10/3/12	2/11/13	From Instream Flow Study	In-channel Gravel Mining Reach	--
Tuolumne River at Delaware Road	--	30.5	6/29/12	10/3/12	2/11/13	From Instream Flow Study	In-channel Gravel Mining Reach	--
Tuolumne River at Fox Grove Park	--	26.0	--	10/4/12	2/12/13	Information between RM 30.5 and RM 17.2	In-channel Gravel Mining Reach	--
Faith Home Spill (TID)	--	20.0	6/25/12	10/3/12	2/12/13	Operational outflow	--	--
Lateral No. 1 (MID)	--	18.0	6/25/12	10/3/12	2/12/13	Operational outflow	--	--
Tuolumne River at Legion Park	--	17.2	6/25/12	10/3/12	2/11/13	Added at 9/21/12 Workshop	Urban Sand-Bedded Reach	--
Dry Creek (CDEC DCM)	5.3	16.4	6/25/12	10/4/12	2/12/13	Gage	--	MID's Lateral 2 outlet is the only true operational outlet with consistent flow into Dry Creek at latitude/longitude 37.652142; -120.930206 (Loschke, pers. comm. 2013). [d,e,f]
Dry Creek at gage	5.3	16.4	--	10/4/12	2/12/13	For comparing measured values to gaged values	--	
Dry Creek 2.0	2.0	16.4	--	10/4/12	2/12/13	Information between RM 5.3 and RM 0.0	--	
Mouth of Dry Creek	0.0	16.4	6/25/12	10/3/12	2/12/13	Inflow to Tuolumne River	--	
Tuolumne River at Modesto 9th St. Bridge	--	16.2	6/25/12	10/3/12	2/11/13	For comparing measured values to gaged values	Urban Sand-Bedded Reach	--
Tuolumne River at Modesto (USGS 11290000)	--	16.2	6/25/12	10/3/12	2/11/13	Gage	Urban Sand-Bedded Reach	--
Tuolumne River at Modesto (CDEC MOD)	--	16.2	6/25/12	10/3/12	2/11/13	Gage	Urban Sand-Bedded Reach	--
Lateral 1 (TID)	--	11.0	6/25/12	10/3/212	2/11/13	Operational outflow	--	--
Tuolumne River near Riverdale Park	--	10.0	--	10/3/12	2/12/13	Information between RM 16 and RM 3.7	Lower Sand-Bedded Reach	
Tuolumne River at Shiloh Bridge	--	3.7	6/25/12	10/3/12	2/11/13	Added at 9/21/12 Workshop	Lower Sand-Bedded Reach	
Lateral No. 5 (MID)	--	2.0	6/25/12	10/3/12	2/11/13	Operational outflow	--	--

-- not measured or not applicable

Grey is used to highlight inflow locations and flows.

Notes:

[a] Irrigation deliveries for 2012 started mid-March and ended October 10.

[b] Irrigation deliveries for 2013 started March 5

[c] See W&AR-04 Spawning Gravel (TID/MID 2013).

[d] Lateral 2 has 15 minute flow records back to 2007 and chart recorders and staff gage records back to 1972 (Loschke, pers. comm. 2013).

[e] As of 10/30/2012, the small amount of flow in MID's WTFD L-3 is captured by a private land owner (Loschke, pers. comm. 2013).

[f] All spills from the Waterford system into dry creek are inconsistent and minimal (Loschke, pers. comm. 2013).

Tuolumne River and Dry Creek Flow Measurements
June 25, 2012 (Revision 1 - 3/10/13)

Site	Date	Dry Creek River Mile	Tuolumne River Mile	Time (military)		Field Measurements[a] Measured Discharge (ft^3/sec)				Discharge (ft^3/sec)	Accretion per mile (ft^3/sec)	Difference between Gage & Measured[b] (%)
				Start	End	Q1[c]	Q2	Q3	AVG			
Tuolumne River at La Grange gage house	6/25/12	--	51.5	0950	1120	119.2	110.6	--	114.9	114.9		--
Tuolumne River at La Grange (USGS 11289650)[d]	6/25/12	--	51.5	0945	1130	--	--	--	--	130		12
Tuolumne River at La Grange (CDEC LGN)[e]	6/25/12	--	51.5	0000	2345	--	--	--	--	94		22
Tuolumne River at Basso Pool	6/25/12	--	49.1	1325	1440	101.3	103.7	--	102.5	102.5	-5.2	--
Tuolumne River at Bobcat Flat	6/25/12	--	43.4	1300	1625	93.3	105.5	99.0	99.2	99.2	-0.6	--
Tuolumne River at Roberts Ferry Bridge	6/25/12	--	39.5	1535	1635	128.6	122.4	--	125.5	125.5	6.7	--
Tuolumne River at Santa Fe Aggregates	6/25/12	--	37.1	1720	1830	119.1	126.0	--	122.5	122.5	-1.2	--
Waterford Main (MID)[f]	6/25/12	--	33	1800	2000	--	--	--	--	8		--
Hickman Spill (TID)[g]	6/25/12	--	33	0000	2345	--	--	--	--	0		--
Tuolumne River at Waterford	6/25/12	--	31.5	1834	1932	122.0	118.5	--	120.2	120.2	-0.4	--
Tuolumne River at Delaware Road[h]	6/29/12	--	30.5	1045	1230	138.7	138.1	--	138.4	138.4	18.2	--
Faith Home Spill (TID)[g]	6/25/12	--	20	0000	2345	--	--	--	--	0		--
Lateral No. 1 (MID)[f]	6/25/12	--	18	1115	1230	--	--	--	--	1		--
Tuolumne River at Legion Park	6/25/12	--	17.2	1115	1230	169.1	181.6	--	175.4	175.4	2.8	--
Dry Creek (CDEC DCM)[e,i]	6/25/12	5.3	16.4	0000	2345	--	--	--	--	38		--
Mouth of Dry Creek[j,k,l]	6/25/12	0.0	16.4	0915	1015	56.4	54.7	--	55.5	55.5		46[k]
Tuolumne River at Modesto 9th St. Bridge	6/25/12	--	16.2	1300	1400	204.2	212.1	--	208.2	208.2	32.8	--
Tuolumne River at Modesto (USGS 11290000)[d]	6/25/12	--	16.2	1300	1400	--	--	--	--	219		5
Tuolumne River at Modesto (CDEC MOD)[e]	6/25/12	--	16.2	0000	2345	--	--	--	--	216		4
Lateral 1 (TID)[g]	6/25/12	--	11	0000	2345	--	--	--	--	0		--
Tuolumne River at Shiloh Bridge	6/25/12	--	3.7	1530	1700	241.3	251.3	--	246.3	246.3	3.1	--
Lateral No. 5 (MID)[f]	6/25/12	--	2	0900	2000	--	--	--	--	26.5		--

-- not measured or not applicable

Grey is used to highlight inflow locations and flows.

Notes:

[a] Measurements collected by Stillwater Sciences using standard methods for collecting data in wadeable streams (Rantz 1982).

[b] Percent Difference = $|1 - Q_{measured}/Q_{gage}| * 100$, where $Q_{measured}$ is the measured flow and Q_{gage} is the gage flow.

[c] Q = flow. Q1, Q2, and Q3 are replicate measurements.

[d] Average data for measurement time interval, e.g. 9:45 to 11:30 am for USGS 11289650, downloaded from USGS NWIS website: **http://waterdata.usgs.gov/usa/nwis/sw**. Flows reflect a rating curve "shift" retroactively applied by USGS on or about June 28, 2012. The difference between flows reported under the old and new rating curves for that date and time is aproximately 30 cfs.

[e] Mean daily flow downloaded from CDEC website: **http://cdec.water.ca.gov/selectQuery.html**. Does not reflect La Grange gage's updated rating curve.

[f] Average flow for the time interval, e.g. 11:15 am to 12:30 pm for MID's Lateral 1, provided by MID (Ward, pers. comm. 2012)

[g] Daily flow provided by TID (Boyd, pers. comm. 2012)

[h] In Waterford downstream of Waterford Water Treatment Plant discharge. The current WWTP is rated to accommodate flows up to 1.0 mgd (RMC 2006). Data collected later than other sites; however, the temporary stage installed for the co-occuring IFIM study upstream at the Waterford site (RM 31.5) was within 1/100 ft between the two sample dates, indicating little change in flow between 6/29/12 versus 6/25/12.

[i] Dry Creek gage located upstream at Dry Creek RM 5.3 at Claus Rd., Modesto.

[j] Measurements taken in Dry Creek above confluence with Tuolumne River.

[k] Unlike the other locations, Dry Creek flow measurements were not taken at the gage. This number expresses how much flows increase below the gage. On June 25, flows increased almost 50% below the gage, accounting for 1/3 of the total flow.

Tuolumne River and Dry Creek Flow Measurements
October 3-4, 2012 (Revision 2 - 3/10/13)

Site	Date	Dry Creek River Mile	Tuolumne River Mile	Time (military)		Field Measurements[a] Measured Discharge (ft^3/sec)			Discharge (ft^3/sec)	Accretion per mile (ft^3/sec)	Difference between Gage & Measured[b] (%)	Stream Temp. (°C)
				Start	End	Q1[c]	Q2	AVG				
Tuolumne River at La Grange gage house	10/3/12	--	51.5	1330	1430	203.1	201.3	202.2	202.2		--	12.7
Tuolumne River at La Grange (USGS 11289650)[d]	10/3/12	--	51.5	1330	1430	--	--	--	179		13	--
Tuolumne River at La Grange (CDEC LGN)[e]	10/3/12	--	51.5	0000	2345	--	--	--	170		--	--
Tuolumne River at Basso Pool	10/3/12	--	49.1	1530	1700	185.1	196.8	191.0	191.0	-5	--	15.5
Tuolumne River at Zanker property	10/4/12	--	45.5	1020	1130	184.2	181.5	182.9	182.9	-2.2	--	14.9
Tuolumne River at Bobcat Flat	10/4/12	--	43.4	1245	1350	163.3	169.1	166.2	166.2	-7.9	--	16.2
Tuolumne River at Roberts Ferry Bridge	10/4/12	--	39.5	0900	1005	200.7	192.2	196.4	196.4	7.7	--	16.4
Tuolumne River at Santa Fe Aggregates	10/4/12	--	37.1	1032	1144	182.1	185.2	183.6	183.6	-5.3	--	17.8
Waterford Main (MID)[f]	10/3/12	--	33.0	0000	2300	--	--	--	1.0		--	--
Hickman Spill (TID)[g]	10/3/12	--	33.0	0000	2300	--	--	--	0		--	--
Tuolumne River at Waterford	10/3/12	--	31.5	1440	1620	194.0	189.4	191.7	191.7	1.4	--	21.6
Tuolumne River at Delaware Road[h]	10/3/12	--	30.5	1250	1400	183.0	185.7	184.4	184.4	-7.3	--	21.5
Tuolumne River at Fox Grove Park	10/4/12	--	26.0	1430	1520	207.8	206.6	207.2	207.2	5.1	--	23.0
Faith Home Spill (TID)[g]	10/3/12	--	20.0	0000	2300	--	--	--	0		--	--
Lateral No. 1 (MID)[f]	10/3/12	--	18.0	0000	2300	--	--	--	1.6		--	--
Tuolumne River at Legion Park	10/3/12	--	17.2	1330	1420	192.3	188.0	190.1	190.1	-1.9	--	24.8
Dry Creek (CDEC DCM)[e,i]	10/4/12	5.3	16.4	0830	0910	--	--	--	24		35	--
Dry Creek at gage	10/4/12	5.3	16.4	0830	0910	36.5	37.8	37.1	37.1		--	19.5
Dry Creek 2.0	10/4/12	2.0	16.4	0940	1030	30.8	31.6	31.2	31.2		--	19.5
Mouth of Dry Creek[j,k]	10/3/12	0.0	16.4	1440	1515	38.2	36.7	37.4	37.4		--	22.3
Tuolumne River at Modesto 9th St. Bridge	10/3/12	--	16.2	1110	1205	205.9	212.6	209.3	209.3	19.1	--	23.7
Tuolumne River at Modesto (USGS 11290000)[d]	10/3/12	--	16.2	1115	1200	--	--	--	227		8	--
Tuolumne River at Modesto (CDEC MOD)[e]	10/3/12	--	16.2	0000	2345	--	--	--	238		12	--
Lateral 1 (TID)[g]	10/3/212	--	11.0	0000	2300	--	--	--	0		--	--
Tuolumne River near Riverdale Park	10/3/12	--	10.0	0930	1100	250.0	249.2	249.6	249.6	6.5	--	21.2
Tuolumne River at Shiloh Bridge	10/3/12	--	3.7	0930	1020	219.3	220.5	219.9	219.9	-4.7	--	22.2
Lateral No. 5 (MID)[f]	10/3/12	--	2.0	0000	2300	--	--	--	14.3		--	--

-- not measured or not applicable

Grey is used to highlight inflow locations and flows.

Notes:

[a] Measurements collected by Stillwater Sciences using standard methods for collecting data in wadeable streams (Rantz 1982).

[b] Percent Difference = $|1 - Q_{measured}/Q_{gage}| * 100$, where $Q_{measured}$ is the measured flow and Q_{gage} is the gage flow.

[c] Q = flow. Q1 and Q2 are replicate measurements.

[d] Average data for measurement time interval, e.g. 13:30 to 14:30 pm for USGS 11289650, downloaded from USGS NWIS website: **http://waterdata.usgs.gov/usa/nwis/sw**.

[e] Mean daily flow downloaded from CDEC website: **http://cdec.water.ca.gov/selectQuery.html**. Does not reflect La Grange gage's updated rating curve.

[f] Daily flow provided by MID (Ward, pers. comm. 2012)

[g] TID recorded zero operational outflow on these dates (Boyd, pers. comm. 2012).

[h] In Waterford downstream of Waterford Water Treatment Plant discharge. The current WWTP is rated to accommodate flows up to 1.0 mgd (RMC 2006).

[i] Dry Creek gage located upstream at Dry Creek RM 5.3 at Claus Rd., Modesto.

[j] Measurements taken in Dry Creek at confluence with Tuolumne River.

Tuolumne River and Dry Creek Flow Measurements
February 11-12, 2013

Site	Date	Dry Creek River Mile	Tuolumne River Mile	Time (military)		Field Measurements[a] Measured Discharge (ft^3/sec)				Discharge (ft^3/sec)	Accretion per mile (ft^3/sec)	Difference between Gage & Measured[b] (%)	Stream Temp. (°C)
				Start	End	Q1[c]	Q2	Q3	AVG				
Tuolumne River at La Grange gage house	2/11/13	--	51.5	0945	1200	169.0	171.9	--	170.4	170.4		--	10.2
Tuolumne River at La Grange (USGS 11289650)[d]	2/11/13	--	51.5	0945	1200	--	--	--	--	182		6	--
Tuolumne River at La Grange (CDEC LGN)[e]	2/11/13	--	51.5	0000	2345	--	--	--	--	164		4	--
Tuolumne River at Basso Pool	2/11/13	--	49.1	1245	1415	161.9	159.4	--	160.6	160.6	-4	--	11.6
Tuolumne River at Zanker property	2/12/13	--	45.5	0920	1115	178.8	165.3	--	172.1	172.1	3.2	--	9.3
Tuolumne River at Bobcat Flat	2/12/13	--	43.4	1200	1248	167.1	173.0	--	170.1	170.1	-1.0	--	10.4
Tuolumne River at Roberts Ferry Bridge	2/11/13	--	39.5	1455	1720	176.6	161.2	164.3	167.3	167.3	-0.7	--	11.3
Tuolumne River at Santa Fe Aggregates	2/12/13	--	37.1	0905	1105	171.8	171.8	--	171.8	171.8	1.9	--	9.0
Waterford Main (MID)[f]	2/12/13	--	33.0	0000	2300	--	--	--	--	0		--	--
Hickman Spill (TID)[g]	2/12/13	--	33.0	0000	2300	--	--	--	--	0		--	--
Tuolumne River at Waterford	2/11/13	--	31.5	1000	1135	167.8	169.3	--	168.6	168.6	-0.6	--	9.5
Tuolumne River at Delaware Road[h]	2/11/13	--	30.5	1215	1405	180.3	179.6	176.2	178.7	178.7	10.2	--	10.3
Tuolumne River at Fox Grove Park	2/12/13	--	26.0	1413	1510	193.8	191.1	--	192.5	192.5	3.1	--	12.2
Faith Home Spill (TID)[g]	2/12/13	--	20.0	0000	2300	--	--	--	--	0		--	--
Lateral No. 1 (MID)[f]	2/12/13	--	18.0	0000	2300	--	--	--	--	0		--	--
Tuolumne River at Legion Park	2/11/13	--	17.2	1309	1450	190.9	185.9	--	188.4	188.4	-0.5	--	13.2
Dry Creek (CDEC DCM)[e,i]	2/12/13	5.3	16.4	0000	2345	--	--	--	--	2		293	--
Dry Creek at gage	2/12/13	5.3	16.4	1200	1330	0.5	0.6	--	0.5	0.5		--	6.7
Dry Creek 2.0	2/12/13	2.0	16.4	1047	1140	0.8	0.8	--	0.8	0.8		--	7.9
Mouth of Dry Creek[j,k]	2/12/13	0.0	16.4	0915	1030	0.6	0.7	--	0.6	0.6		--	9.3
Tuolumne River at Modesto 9th St. Bridge	2/11/13	--	16.2	1514	1700	189.2	195.9	--	192.6	192.6	4.1	--	13.3
Tuolumne River at Modesto (USGS 11290000)[d]	2/11/13	--	16.2	1514	1700	--	--	--	--	197		2	--
Tuolumne River at Modesto (CDEC MOD)[e]	2/11/13	--	16.2	1514	1700	--	--	--	--	197		2	--
Lateral 1 (TID)[g]	2/11/13	--	11.0	0000	2300	--	--	--	--	0		--	--
Tuolumne River near Riverdale Park	2/12/13	--	10.0	1200	1330	215.7	212.7	--	214.2	214.2	3.5	--	11.4
Tuolumne River at Shiloh Bridge	2/11/13	--	3.7	1030	1200	213.5	225.0	--	219.2	219.2	0.8	--	11.5
Lateral No. 5 (MID)[f]	2/11/13	--	2.0	0000	2300	--	--	--	--	0		--	--

-- not measured or not applicable

Grey is used to highlight inflow locations and flows.

Notes:

[a] Measurements collected by Stillwater Sciences using standard methods for collecting data in wadeable streams (Rantz 1982) during a time of no irrigation deliveries or rainfall.

[b] Percent Difference = $|1 - Q_{measured}/Q_{gage}| * 100$, where $Q_{measured}$ is the measured flow and Q_{gage} is the gage flow.

[c] Q = flow. Q1, Q2, and Q3 are replicate measurements.

[d] Average data for measurement time interval, e.g. 9:45 am to 12:00 pm for USGS 11289650, downloaded from USGS NWIS website: **http://waterdata.usgs.gov/usa/nwis/sw**.

[e] Mean daily flow downloaded from CDEC website: **http://cdec.water.ca.gov/selectQuery.html**.

[f] MID has NO recorded spills to contribute to the accretion data for the Tuolumne. Standard operating procedure for off season operations require draining the facilities and shutting off flow recorders (Ward, pers. comm. 2013).

[g] TID recorded zero operational outflow on these dates (Boyd, pers. comm. 2013).

[h] In Waterford downstream of Waterford Water Treatment Plant discharge. The current WWTP is rated to accommodate flows up to 1.0 mgd (RMC 2006).

[i] Dry Creek gage located upstream at Dry Creek RM 5.3 at Claus Rd., Modesto.

[j] Measurements taken in Dry Creek at confluence with Tuolumne River.

[k] MID's Lateral 2 was not spilling on February 11-12, 2013 (Loschke, pers. comm. 2013).

Modesto and Turlock Reservoir: Storage in reservoirs on Accretion Measurement Dates

Date	Modesto Reservoir[a]		Turlock Lake[b]	
	elevation (feet)	storage (acre-feet)	elevation (feet)	storage (acre-feet)
Irrigation Season				
6/25/2012	22.38	20160	234.02	26765
6/26/2012	22.65	20700	234.05	26833
Irrigation Season--Low Flow				
10/3/2012	19.19	14604	236.02	31703
10/4/2012	19.69	15404	235.91	31399
Non-Irrigation Season				
2/11/2013	19.15	14540	228.7	16658
2/12/2013	19.3	14780	228.7	16626

[a] Modesto Reservoir storage provided by MID (Loschke, pers. comm. 2013).

[b] Turlock Lake storage available at http//wiskiweb.tid.org.

STUDY REPORT W&AR-02
PROJECT OPERATIONS/WATER BALANCE MODEL

ATTACHMENT B

MODEL DESCRIPTION AND USER’S GUIDE

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1.0 INTRODUCTION

The Turlock Irrigation District (TID) and Modesto Irrigation District (MID) (collectively, the Districts) have developed a computerized Project Operations Model (Model) to assist in evaluating the relicensing of the Don Pedro Project (Project) (FERC Project 2299). On November 22, 2011, in accordance with the Integrated Licensing Process schedule for the relicensing of the Don Pedro Project, the Districts filed their Revised Study Plan containing 35 proposed studies with the Federal Energy Regulatory Commission (FERC) and relicensing participants. On December 22, 2011, FERC issued its Study Plan Determination approving, with modifications, the proposed studies, including Study Plan W&AR-2: Project Operations /Water Balance Model Study Plan. Consistent with the FERC-approved study plan, the objective of the Model is to provide a tool to compare current and potential future operations of the Project. Due to the fact that the geographic scope of the Model extends from the City and County of San Francisco's (CCSF) Hetch Hetchy system in the upper part of the watershed to the confluence of the Tuolumne and San Joaquin rivers, the Model is now entitled the Tuolumne River Daily Operations Model.

As fully described in this User's Guide, and consistent with the FERC-approved study plan, the Model includes numerous user-controlled parameters that allow the simulation of alternative Project operations, such as alternative flow regimes for the lower Tuolumne River. The Model performs a simulation of Project operations for a sequential period of years that covers a range of historical hydrologic conditions. The period of hydrologic record selected for the Model is Water Year 1971 through Water Year 2009, which includes extreme years of hydrology (1977 dry and 1983 wet) and multi-year periods of challenging water supply conditions such as 1976-1977, 1987-1992, and 2001-2004. The purpose of this User's Guide is to describe the structure of the Model, the interfaces available for operation of the Model, and methods available for the reviewing Model results. Procedures for development of input files for running alternative future operations are also described and illustrated. The data presented in this document are referenced to a "Test-Case" simulation of operations and are being incorporated for illustrative purposes.

As is the case with any model, the Tuolumne River Daily Operations Model is only a depiction of project operations, and is limited to representing CCSF and District operations to the extent that their operations can be described systematically by various equations and algorithms. Actual project operations may vary from those depicted by the Model due to circumstantial conditions of hydrology and weather, facility operation, and human intervention. The FERC-approved study plan has identified a number of user-controlled variables for running alternatives. The fact that the Model provides these user-controlled inputs is not an indication that either the Districts or CCSF endorse or support any specific alternative developed by manipulating these inputs.

2.0 GEOGRAPHICAL RANGE OF MODEL AND UNDERLYING SYSTEM OPERATION

As mentioned above, the geographic scope of the Model extends for CCSF's Hetch Hetchy system to the confluence of the Tuolumne and San Joaquin Rivers, as generally depicted in Figure 2.0-1. The Model comprises two primary subsystems -- the Districts' Don Pedro Project and CCSF's Hetch Hetchy Project, which are independently owned and operated by the respective parties. The Don Pedro Project includes the Don Pedro Reservoir and powerhouse. It provides water storage and flood control benefits. Water that flows into Don Pedro Reservoir is either stored or passed through to the lower Tuolumne River. Included in the model is the projected diversion of water at La Grange to serve irrigation and M&I customers of MID and TID. A model "node" (calculation point) is provided at the Districts' La Grange diversion dam, where the Model simulates flows to the Modesto Canal, the Turlock Canal, and the Tuolumne River below the La Grange diversion dam. The CCSF System is modeled as three physical reservoirs (Hetch Hetchy Reservoir, Lake Lloyd and Lake Eleanor), the San Joaquin Pipeline (SJPL), and an accounting for the Don Pedro Water Bank Account. All releases from the CCSF System, except those diverted to the SJPL enter Don Pedro Reservoir. A node is also provided to represent the location of the existing USGS stream flow gage entitled "Tuolumne River at Modesto" (Modesto). Additional nodes may be established above and/or below the Modesto gage node depending on the results of ongoing lower Tuolumne River accretion flow measurements.

The Model components operate with systematic algorithms that attempt to mimic operational decisions for reservoir and facility operations. For each subsystem, certain operation constraints can be user-controlled consistent with the FERC-approved study plan. Within each subsystem, each reservoir has the same underlying operation protocol. A daily mass balance is performed: change in reservoir storage = inflow, minus outflow (releases), minus reservoir losses. If the calculation results in a reservoir storage that is in excess of preferred/maximum capacity, an additional release is made.

Minimum releases for each modeled reservoir are in accordance with current stream flow requirements and diversion requirements. Each reservoir assumes a common "hold-unless-need-to-release" protocol, except as conditioned by minimum stream release requirements, diversions, preferred/maximum storage, snowmelt management releases, or other specified releases. In essence, each reservoir operates for its own "reservoir conservation" goal and retains storage as much as possible, only drawn down as needed to meet release requirements, diversions, or to achieve reservoir or flow management goals such as flood control or, in some cases hydropower.

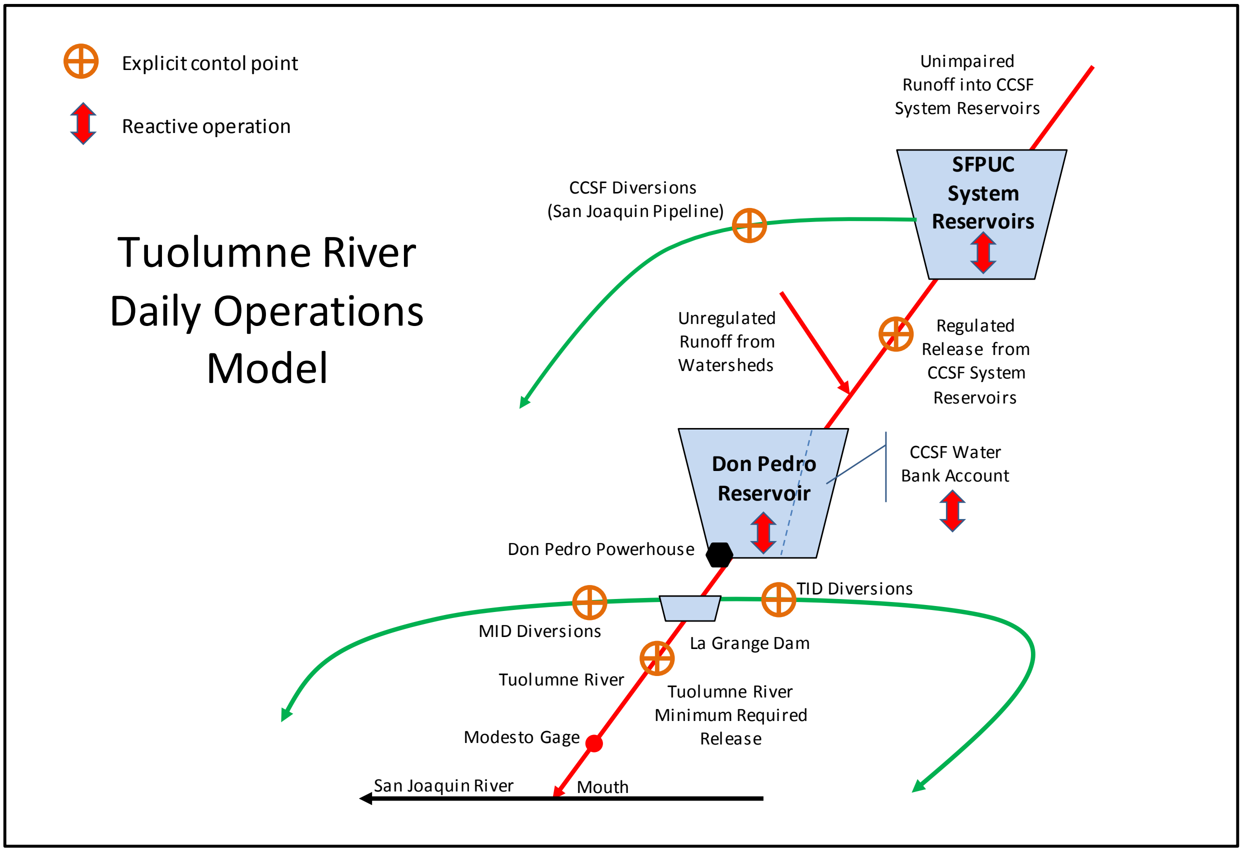


Figure 2.0-1. Tuolumne River Daily Operations Model.

3.0 DON PEDRO PROJECT AND LA GRANGE DIVERSION DAM

The Don Pedro Project and the La Grange diversion dam operations are modeled to represent current operations for irrigation and municipal water deliveries, fishery and instream flow requirements and flood control. Hydropower production is a function of the releases made for these other purposes. The following elements of hydrology and objectives guide the modeled operation.

3.1 Reservoir Inflow

Inflow to Don Pedro Reservoir is modeled as two components: 1) a fluctuating unregulated inflow to Don Pedro Reservoir, and 2) the regulated releases (regulated Don Pedro Reservoir inflow) from the CCSF System. The inflow will reflect a daily fluctuating pattern which is mostly associated with the unregulated component of runoff in the basin, which is approximately 40 percent of the total runoff in the basin. The unregulated component of inflow to Don Pedro Reservoir remains the same among all operation simulations. The regulated inflow to Don Pedro is based on a projected level of development and operation for the CCSF System. This component of Don Pedro Reservoir inflow may change among operation simulations due to changed assumptions for CCSF System demands and level of development, or due to user-controlled parameters.

3.2 MID and TID Canal Demand

Figure 3.2-1 is a schematic of the parameters used by modeling to create each District's diversion demand at La Grange diversion dam.

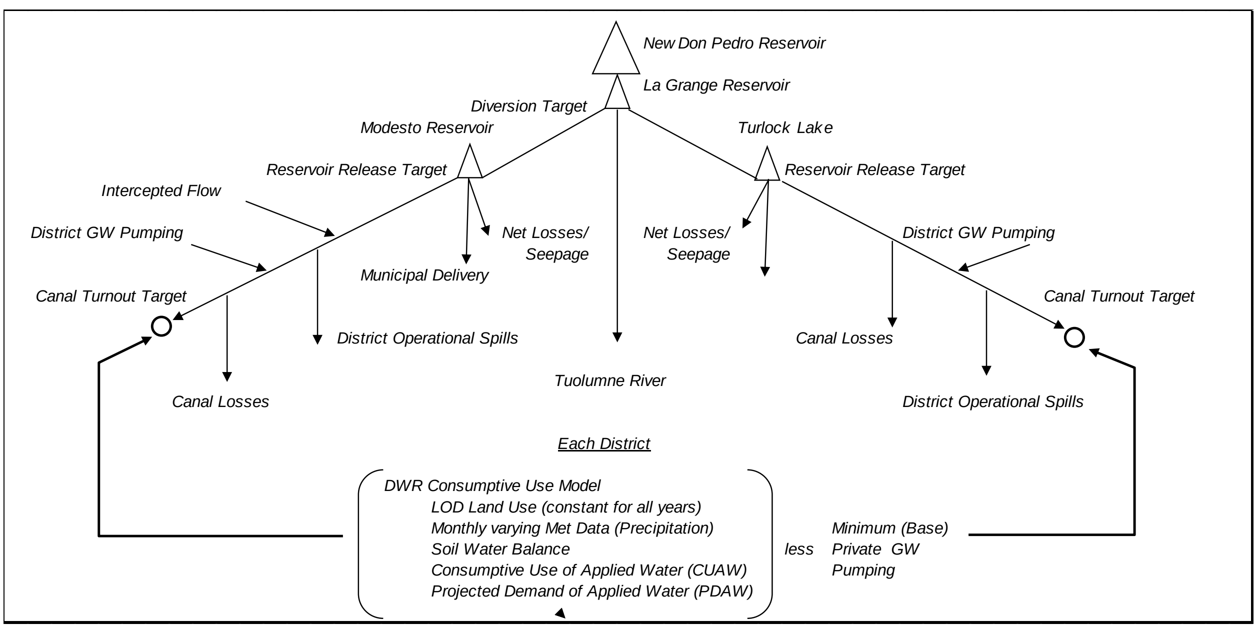


Figure 3.2-1. District Canal Demand Parameters.

Due to changing land use and cropping patterns, groundwater use and irrigation and canal management practices throughout history, the historical record of recorded diversions does not provide a consistent definition of water diversion needs. Similar to depicting inflow, the Model uses a projected level of development for establishing irrigation and canal diversion demand.

The canal diversions are assumed to be driven by three components: 1) a fluctuating customer component, the (P)rojected (D)emand of (A)pplied (W)ater (PDAW) that varies year to year and month to month, 2) a relatively constant depiction of District and land owner system losses and efficiencies, and 3) a water supply availability factor based on Don Pedro Reservoir storage and inflow.

The PDAW is developed through use of the California Department of Water Resources (CDWR) consumptive use model, and considers precipitation, ET rates, soil moisture criteria, rooting depth, irrigation indicators, and other factors along with land use to estimate the CUAW on a monthly basis. Monthly water use varies based on input ET rates, which are constant each year. CUAW will only vary each year based on variation in precipitation. The PDAW has been adjusted to reflect other routine irrigation practices not identifiable with strict ET, such as pre-irrigation. The estimate of monthly PDAW is distributed daily based on the historical (2009-2011) distribution of canal diversions within months.

In addition to the PDAW requirement, several canal operation and management components are incorporated into the projected diversion demand. The following tables provide the monthly estimates used for each component, Table 3.2-1 for MID and Table 3.2-2 for TID.

The turnout delivery factor is unique to each District and represents a modeling mechanism to adjust the PDAW for irrigation practices that are not included in the estimation of the CUAW, such as irrigation that provides for groundwater recharge.

Table 3.2-1. Canal Demand and Operation Components for MID.

Modesto Irrigation District

	Turnout Delivery Factor	Nominal Private GW Pumping	Canal Operational Spills Critical	Canal Operational Spills Non-crit	System Losses below Modesto Res	Intercepted Flows	Nominal MID GW Pumping	Modesto Res and Upper Canal Losses/Div	Municipal Delivery from Modesto Res	Modesto Res Target Storage
Month	%	TAF	TAF	TAF	TAF	TAF	TAF	TAF	TAF	TAF
January	35	0.0	2.0	2.0	0.1	0.0	0.0	0.0	2.3	17.0
February	35	0.0	2.0	2.0	0.1	0.0	0.0	0.0	2.3	18.0
March	65	1.0	1.0	3.0	0.6	0.9	1.0	2.0	2.7	18.0
April	70	2.0	3.0	6.0	0.6	0.9	2.3	2.9	2.7	19.0
May	85	3.0	4.0	6.5	0.6	1.2	2.3	3.9	3.0	20.0
June	85	4.0	3.5	6.5	0.6	1.0	2.3	4.3	3.2	20.0
July	77.5	4.0	3.5	6.5	0.6	1.0	2.6	4.9	3.3	21.0
August	70	4.0	4.9	7.0	0.6	1.4	2.4	4.9	3.3	22.0
September	65	2.0	5.0	7.0	0.6	1.2	2.3	4.2	3.3	20.0
October	40	1.0	2.8	6.9	0.6	0.9	2.1	2.0	3.2	17.0
November	30	0.0	2.0	2.0	0.1	0.0	0.0	2.0	2.7	15.0
December	35	0.0	2.0	2.0	0.1	0.0	0.0	0.0	2.5	15.0
Total		21.0	35.7	57.4	5.4	8.5	17.3	31.1	34.5	

Table 3.2-2. Canal Demand and Operation Components for TID.

Turlock Irrigation District

	Turnout Delivery Factor	Nominal Private GW Pumping	Canal Operational Spills Critical	Canal Operational Spills Non-crit	System Losses below Turlock Lk	Intercepted Flows	Nominal TID GW Pumping	Turlock Lk and Upper Canal Losses	Other Delivery from Turlock Lk	Turlock Lk Target Storage
Month	%	TAF	TAF	TAF	TAF	TAF	TAF	TAF	TAF	TAF
January	30	0.0	2.0	2.0	0.8	0.0	0.0	1.0	0.0	18.0
February	30	0.0	2.0	2.0	0.8	0.0	0.0	1.0	0.0	25.0
March	65	1.2	3.0	3.0	4.5	0.0	4.1	1.0	0.0	30.0
April	57.5	2.4	5.1	6.3	4.5	0.0	8.0	6.6	0.0	30.0
May	85	3.6	4.6	6.7	4.5	0.0	10.3	7.7	0.0	32.0
June	92.5	5.2	4.2	6.7	4.5	0.0	12.4	8.2	0.0	32.0
July	72.5	6.4	4.2	6.7	4.5	0.0	14.6	8.7	0.0	32.0
August	62.5	6.2	4.0	7.3	4.5	0.0	13.3	9.0	0.0	30.0
September	67.5	3.9	3.2	7.3	4.5	0.0	9.1	5.0	0.0	27.0
October	40	2.4	2.3	7.3	4.5	0.0	5.3	2.0	0.0	13.0
November	30	0.0	2.0	2.0	0.8	0.0	0.0	1.0	0.0	13.0
December	30	0.0	2.0	2.0	0.8	0.0	0.0	1.0	0.0	13.0
Total		31.3	38.6	59.3	39.2	0.0	77.1	52.2	0.0	

3.3 Required FERC flows at La Grange Bridge

The current FERC minimum flow requirements at La Grange Bridge are included in the Model. In the Model the terms “La Grange releases”, “flows at La Grange Bridge” or “releases at La Grange diversion dam” are used interchangeably to mean the minimum flow requirements under the Project’s current FERC license as measured at the USGS gage “Tuolumne River at La Grange, CA”. The annual flow requirement is established for the April-March flow year beginning April based on pre-knowledge of the final San Joaquin River Index (60-20-20) for the year. The annual volume including “interpolation water” is computed using the FERC Settlement Agreement procedures, which includes a revised year type distribution using a 1906-2011 population of historical years. The interpolation water is assumed to be spread among April and May volumes.

The Model assumes each month’s volume of the annual volume is spread evenly across the days of the months, except during April and May where the user can define the distribution of daily flows. The user can define the distribution as: 1) total monthly volume spread evenly across all days of a month, or 2) a user-specified daily distribution of monthly volume during April and May. Figure 3.3-1 illustrates the outcome of the two assumed flow distributions during April and May. The pulsing pattern option shown in Figure 3.3-1 is being used by the Model.

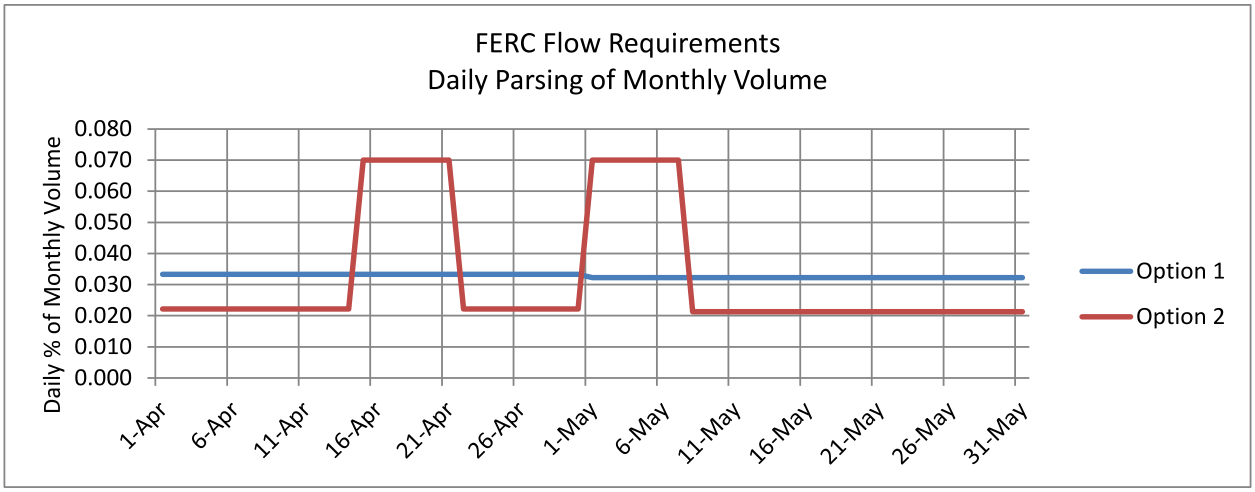


Figure 3.3-1. User-specified Distribution of April and May FERC Flow Requirements.

3.4 Reservoir and Release Management

Don Pedro Reservoir storage is initially checked against a preferred storage target. The Model allows the user to establish the preferred storage target. The preferred storage target is the Army Corps of Engineers (ACOE) rain flood reservation objective, except after July 1, when there is no required reservation space. The preferred storage target reflects a drawdown to evacuate storage during the summer in late and wet runoff years. The preferred target storage is again equal to the ACOE objective on October 7. Figure 3.4-1 illustrates the reservoir storage target used in the Model.

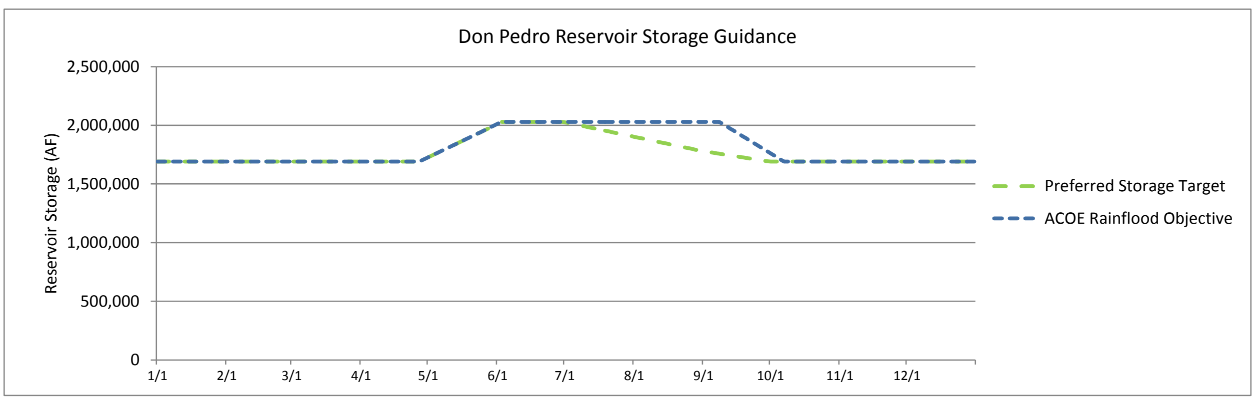


Figure 3.4-1. Reservoir Storage Guidance.

For a day of Don Pedro Reservoir operation, the day's inflow is a computed amount from upstream CCSF System operations and unregulated inflow. The stream flow requirements contained in the FERC license at La Grange Bridge and the MID and TID canal diversions are the release from Don Pedro Reservoir. The prior day's reservoir evaporation is included in the calculation. If the computation produces resulting Don Pedro Reservoir storage in excess (encroachment) of the preferred storage target, the encroachment is computed. Every 7th day the model checks for an encroachment, and if it exists a "check" release is computed. It is assumed that a constant supplemental release (in excess of minimum releases) will be initiated at a rate equal to the encroachment divided equally over the next 10 days. This protocol repeats itself every 7th day, reestablishing the level of check release each time. The end result of this procedure will allow encroachment of storage space above the preferred storage target and not require unrealistic “hard” releases of water to exactly conform to the target.

A second check release is made during the April through June period for management of anticipated snowmelt runoff. On the first day of each of these months a forecast is made of anticipated runoff into the reservoir and minimum releases and losses from the reservoir from the date of forecast through the end of June (the assumed target date of reservoir filling). These forecasts determine the volume of water (if any) that will require release in excess of minimum releases and losses and storage gain by the end of June. For April and May, the DWR “90 percent exceedence forecast” is used for anticipated runoff, along with known minimum releases and losses, and upstream impairment. The user defines the percentage of volume (of the total volume) to be additionally released during each month. For April, 30 percent of the 3-month volume is advised for release, and during May 50 percent of the 2-month volume is advised for released. For June, the historically reported unimpaired flow (UF) flow is assumed for the runoff computation. This assumes pre-knowledge of the runoff volume for the month, and 100 percent of the excess is spread across the month. The snowmelt check release is evenly distributed across the days of the month. The release made in a day is the greater of the two check releases or the minimum release. At no time is the maximum capacity of the reservoir (2,030,000 acre-feet) allowed to be exceeded, and if necessary a release, regardless of magnitude, will be made by the Model to not exceed maximum storage capacity.

A Modesto flood control objective is incorporated into the release logic. The objective is to maintain a flow at Modesto no greater than a user specified flow rate (assumed as 9,000 cfs). The logic checks against an “allowable” La Grange release considering the lower Tuolumne River accretions and Dry Creek flow. Model logic compares the La Grange allowable release to the other check releases. The La Grange release is then reduced if necessary to not exceed the Modesto flow target objective, even if it results in an encroachment in Don Pedro Reservoir. The exception is when the reservoir reaches full (2,030,000 AF). Any computed encroachment above a full reservoir is passed and the Modesto flow objective will be exceeded.

Consistent with the original FERC license filings for the new Don Pedro Project, the minimum operating reservoir level is established at elevation 600 feet, corresponding to a storage volume of 308,960 AF. Below this elevation is referred to as the “dead pool” storage.

3.5 Water Supply Factor

A constraint to the Districts’ canal diversions is recognized when there is a reduced water supply at Don Pedro Reservoir. The premise of the (W)ater (S)upply (F)actor (WSF) is to reduce the amount of water diverted to the canals during years when lack of carryover storage at Don Pedro Reservoir becomes a concern.

The modeling mechanism used to reduce canal diversions is a factor applied to the PDAW of the canal demand. This mechanism results in a reduction to the amount of water “turned out” to the customers while still recognizing the relatively constant efficiencies of canal operations.

The WSF is established by forecasting upcoming water supply, based on antecedent storage and anticipated inflow to Don Pedro Reservoir. The forecasting procedure begins in February and ends in April. The Factor Table is based on April forecast results. The February and March Forecasts act as adjustments to get to the April 1 state. The forecasts have the following protocol:

February Forecast (forecasting April 1 state):
End of January storage + Feb-Jul UF - Feb-Jul Upstream adjustment - Feb-Mar minimum river
March Forecast (forecasting April 1 state):
End of February storage + Mar-Jul UF - Mar-Jul Upstream adjustment - Mar minimum river
April Forecast: (final)
End of March storage + Apr-Jul UF - Apr-Jul Upstream adjustment

Pre-knowledge of unimpaired runoff for each forecast period is assumed, as well as knowledge of upcoming upstream impairment of the runoff.

The WSF factor / Don Pedro Storage + Inflow relationship is developed through iterations of multi-year system operation simulations. The WSF depicts actions that may be implemented during times of drought, and the projected canal diversions and reservoir storage operation during drought periods. The factors and index triggers were developed reviewing reservoir storage levels that occurred during the 1987-1992 drought.

3.6 Power Generation

Equations of Don Pedro powerhouse generation characteristics define capacity (MW) and efficiency (kWh/AF), based on reservoir storage. Capacity potential uses minimum storage of the day, while efficiency uses average storage of the day. The maximum flow through plant is assumed to be 5,400 cfs. Water that does not appear as passing through the generators is computed to be “spilled-bypassed”. The power generation “cutoff” also occurs at the reservoir storage of 308,960 acre-feet or the top of dead pool.

3.7 User-Interface Adjustments

The Model allows alternative user-specified data for two components of District operations: 1) user-specified assumptions for the La Grange Bridge minimum flow requirements, and 2) a user-specified diversion for the Districts’ canals. An alternative La Grange Bridge flow requirement can be incorporated by definition of required flows by periods within a year, based on year type. Entered in this protocol the input will result as a daily time series for the Model. Alternatively, a flow requirement can be entered as a daily time series. For an alternative canal diversion, an array has been provided to input a monthly by 39-year matrix of alternative canal diversions. The monthly array of data is parsed by the Model into daily distributions reflecting the current depicted daily distribution of canal diversions.

4.0 CITY AND COUNTY OF SAN FRANCISCO SYSTEM

The Model representation of the CCSF System on the Tuolumne River includes the three physical reservoirs (Hetch Hetchy Reservoir, Lake Lloyd and Lake Eleanor), diversions to the Bay Area through the San Joaquin Pipeline, and an accounting for the Don Pedro Water Bank Account. The CCSF System is illustrated in Figure 4.0-1, with detail provided for the components of explicitly modeled hydrologic parameters.

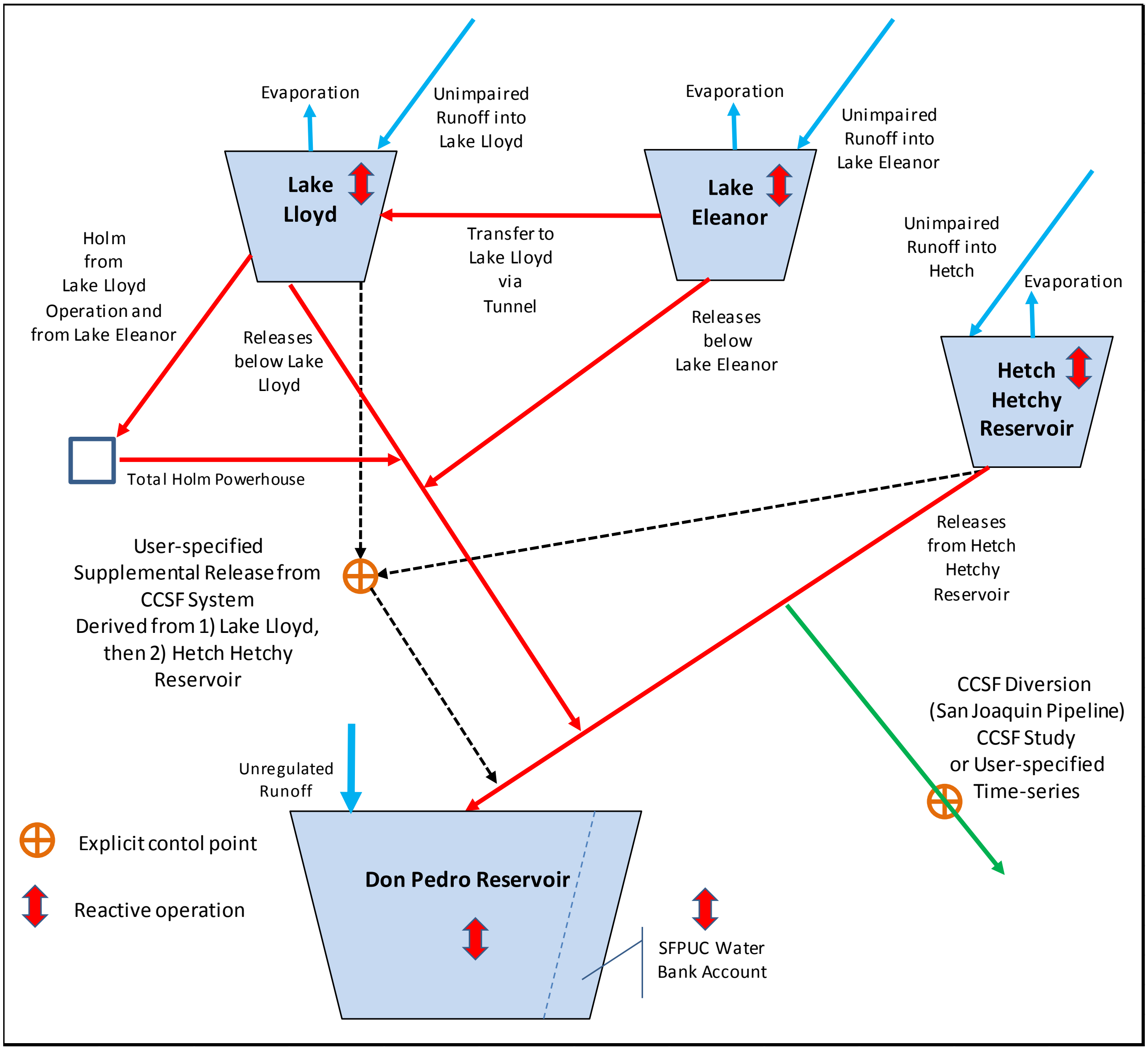


Figure 4.0-1. City and County of San Francisco System.

Each CCSF System reservoir has the same underlying operation protocol. A daily mass balance is performed: change in reservoir storage = inflow, minus outflow (releases), minus reservoir losses. If the calculation results in reservoir storage exceeding preferred/maximum capacity, an additional release of water is made.

Minimum releases from each reservoir are in accordance with current requirements for Hetch Hetchy Reservoir, Lake Lloyd and Lake Eleanor.

Each reservoir assumes a common "hold-unless-need-to-release" protocol, except as conditioned by minimum release requirements, diversions, preferred/maximum storage, snowmelt management releases, hydropower, or other flow or management objectives. In essence, each reservoir operates for its own "reservoir conservation" goal of retaining storage unless drawn down by demands or reservoir management objectives. CCSF is required by State law and its Charter to operate its system for "water first".

4.1 Hetch Hetchy Reservoir

Hetch Hetchy Reservoir storage is initially checked against a preferred storage target. The day's inflow is a given amount, and the SJPL diversion and minimum stream flow requirements below Hetch Hetchy Reservoir determine the release. The prior day's reservoir evaporation is included in the calculation. If the computation produces storage in excess (encroachment) of the preferred storage target, the encroachment is computed. Every 7th day the model checks for the encroachment, and if it exists a check release is computed. It is assumed that a constant supplemental release (in excess of minimum releases) will be initiated at a rate equal to the encroachment divided equally over the next 7 days. This protocol repeats itself every 7th day, reestablishing the level of check release each time. The end result of this procedure will allow encroachment of storage space above the preferred target storage and not require unrealistic releases of water to exactly conform to the target.

A second check release is made during the February through June period for management of anticipated snowmelt runoff. On the first day of each of these months a forecast is made of anticipated runoff into the reservoir and minimum releases and losses from the reservoir from the date of forecast through the end of June (assumed target of reservoir filling). These forecasts determine the volume of water (if any) that will require release in excess of minimum releases and losses and storage gain by the end of June. Pre-knowledge is used for anticipated runoff, minimum releases and losses. The user defines the percentage of volume (of the total volume for the period) to be additionally released during each month. For February through April, 10 percent of the additional release volume is advised for release, and may be additionally capped. This approach tends to hold Hetch Hetchy Reservoir releases for later release during May. The snowmelt check release is evenly distributed across the days of the month and can be capped in terms of rate (cfs) or minimum volume of the reservoir to which it can be drawn during the month. The particular release made in a day is the greater of the two check releases or the minimum release. At no time is the maximum capacity of the reservoir allowed to be exceeded, and if necessary a release, regardless of magnitude, will be made by the Model to not exceed maximum storage capacity.

For Hetch Hetchy Reservoir these two check releases typically guide the operation of the reservoir during the winter and spring. After reservoir filling, summer-time stream release requirements and the SJPL demand typically draw the reservoir down below the preferred storage targets.

Canyon Tunnel, Kirkwood Powerhouse, Mountain Tunnel and Moccasin Powerhouse are not explicitly modeled. The structure of the Model depicts the component of inflow to Don Pedro Reservoir that originates from the Hetch Hetchy Reservoir watershed. The detail of flow reaches below Hetch Hetchy Reservoir is not needed. Therefore, the simple gradation of flow between flow removed from the stream system by the SJPL and the remaining flow that will eventually reach Don Pedro Reservoir is sufficient for purposes related to the relicensing of the Districts' Don Pedro Project.

4.2 Lake Lloyd

The same underlying reservoir operation protocols of Hetch Hetchy Reservoir apply to Lake Lloyd, with a couple of modifications. Instead of the SJPL demand being assumed as an initial release requirement, a minimum Holm Powerhouse release during May through August is assumed from Lake Lloyd.

Both the initial check release for preferred storage encroachment and the snowmelt check release are computed and advised for reservoir operations. If supplemental releases above minimum releases are computed the Model routes the additional release through Holm Powerhouse up to its available capacity. The remainder of the supplemental release is routed to the stream below Lake Lloyd. A comparison is made between "Lloyd-only" use of Holm Powerhouse capacity and maximum capacity for passage to the Lake Eleanor model component.

The operation goal linkage between Lake Lloyd and Lake Eleanor assumes that Lake Eleanor will transfer water from its watershed to Lake Lloyd for the purpose of enhancing power generation at Holm Powerhouse. Thus, any available capacity at Holm Powerhouse after the Lloyd-only operation is assumed available and desired for use of a Lake Eleanor transfer. If water is transferred from Lake Eleanor the Model assumes the water to be directly routed to Holm Powerhouse which then becomes additional release from Lake Lloyd. The inclusion of the Holm Powerhouse logic in the Lloyd/Eleanor watershed logic is only done to facilitate the interaction between the two watersheds.

4.3 Lake Eleanor

Both the initial check release for preferred storage encroachment and the snowmelt check release are computed and employed into reservoir operations. In this instance of Lake Eleanor operations, the transfer "desire" for Holm Powerhouse generation is considered a disposition of the Lake Eleanor releases determined to be in excess of minimum stream requirements. To the extent that check (stream) releases are available from Lake Eleanor, they will be transferred. The amount transferred is limited by available Holm Powerhouse capacity and the assumed capacity of the Eleanor-Cherry Diversion Tunnel. The Lake Eleanor operation protocol will transfer water that would otherwise be released in excess of minimum flow requirements (largely dependent upon the preferred storage target and snowmelt releases) but it will not allow water to be "pulled" from Lake Eleanor to Lake Lloyd.

4.4 Don Pedro Inflow

The three components of regulated releases from Hetch Hetchy Reservoir (not including the SJPL), Lake Lloyd and Lake Eleanor are combined with the unregulated runoff below CCSF System reservoirs to provide the inflow data set for Don Pedro Reservoir.

4.5 Water Bank Account

A Water Bank Account calculation procedure is included in the Model. A running account of the Water Bank Account balance is computed daily, as limited by the Fourth Agreement and implementing agreement. The Model allows the computation of a "negative" balance. The accounting of the balance is incidental to model operations, and there is no auto-default feedback linkage to upstream operations if the balance is negative. To be consistent with current operations in the watershed, the user must employ the user-specified adjustment mechanism for supplemental CCSF System releases to remedy any negative balances.

For purposes of the FERC investigation, the protocols of Fourth Agreement Water Bank Accounting have been amended to incorporate a hypothetical implementation of "shared responsibility" for incremental increases in FERC-required flows for the Tuolumne River.[1] The incremental increase in FERC-required flows is determined by the daily difference between the current FERC requirements and scenario-required minimum flows. Approximately fifty-two percent (51.7121%) of the incremental difference between the flow schedules is assigned as CCSF's responsibility and counted as a debit within Water Bank Accounting.

4.6 User Interface Adjustments

The Model allows alternative user-specified data for two components of CCSF operations: 1) user-specified supplemental releases from the CCSF System, and 2) user-specified SJPL diversions.

The user-specified release from the CCSF System is to allow the user to "pull" additional water from the CCSF System as supplemental inflow to Don Pedro Reservoir. A single entry is established that will first pull water from Lake Lloyd so that water supply is preserved in the Hetch Hetchy Reservoir system for diversion to the SJPL. At a point when such supplemental releases strain Lake Lloyd storage, the supplemental releases are directed to Hetch Hetchy Reservoir. When employed, a daily flow release is directed from a reservoir at a point in logic after most of the previously described logic occurs. Thus, this release occurs in addition to what operation is already occurring by default. Such a release can affect the following day's default operation or previous periods' operations, thus results require review to determine if the user's desired result occurs. It is also necessary to determine at the end of each simulation whether the operations depicted are consistent with the keeping of the Water Bank Account Balance from being negative.

[1] The "shared responsibility" assumption is presented for the purpose of evaluating alternative operations. The assumption shall not be used as evidence in any proceeding relating to and shall not act as precedence for any allocation of Tuolumne River water between CCSF and the Districts for any purpose under the Fourth Agreement.

This adjustment capability is used to maintain the Water Bank Account Balance greater than zero. There is no auto-default logic to keep the Water Bank Account Balance from going negative. In a typical scenario of normal CCSF System operations during most years, for this level of modeling, the Water Bank Account would not affect CCSF upstream operations. The exception is during prolonged drought when the default reservoir operation of CCSF System reservoirs attempts to hold stream releases to a minimum. In the modeled WY 1971 to 2009, the period 1987 through 1992, and possibly other periods may drive the Water Bank Account to a negative condition. The release adjustment is used to provide additional releases from the CCSF System to avoid driving the Water Bank Account negative.

The second adjustment to SF System hydrology can be made to the pre-specified time series of monthly SJPL diversion. The user is provided a tool to enter an alternative time series of data. This capability can be used to adjust CCSF System diversions from the Tuolumne River.

5.0 MODEL STRUCTURE

The Model was constructed within the platform of a Microsoft Excel 2010 workbook. All Model logic is contained within cells of the workbook with no macros or calls to other forms of programming such as Visual Basic for Applications. Numerous worksheets within the workbook represent logical groupings of either sub-system facilities and operations, or input/output functionality. The worksheets of the Model are briefly described in Table 5.0-1. Some of the worksheets in the Model are fixed to prevent inadvertent changes to certain facility functions and operations. These aspects of the Model are consistent with the FERC-approved study plan.

Table 5.0-1. Model Worksheets.

Purpose	Worksheet Name	Description
Model Input	UserInput*	Contains user inputs for lower Tuolumne River flow requirements, Districts' canal diversions, CCSF SJPL and CCSF supplemental releases
Model Input/Operations	WaterBankRel*	Contains model logic and user input for CCSF supplemental releases (Model component worksheet) (preferred daily entry method)
Summarize Results	Review*	Provides summary of results and simulation warnings
Model Input	Control	Contains inputs for facility characteristics, system operation and configuration
Model Output	Output*	Results of scenario specific simulation in HEC-DSS format
Comparison Results	Test_Case	Results of Test Case simulation (HEC-DSS format)
Summarize Results	DSSAnyGroup*	Plots any group of parameters for a calendar year from HEC-DSS format
	DSSMonthTable*	Plots and tables up to four parameters, summarizing daily data by month from HEC-DSS format
	Switches*	Provides an echo of assumptions and values of UserInput and Control worksheets
	ModelYearofDaily*	Plots and tables any single parameter for a calendar or water year from Model component worksheets
	ModelAnyGroup*	Plots any group of parameters for a calendar year from Model component worksheets
	ModelMonthTable*	Plots and tables up to four parameters, summarizing daily data by month from Model component worksheets
Model Operations	DonPedro	Contains model logic for Don Pedro Reservoir operation (Model component worksheet)
	SFHetchHetchy	Contains model logic for Hetch Hetchy Reservoir operation (Model component worksheet)
	SFLloyd	Contains model logic for Lake Lloyd operation (Model component worksheet)
	SFEleanor	Contains model logic for Lake Eleanor operation (Model component worksheet)
	SFWaterBank	Contains model logic for Water Bank operation (Model component worksheet) (year type plus daily entry method)

Purpose	Worksheet Name	Description
Summarize Results	DPGroup*	Plots simulation of Don Pedro Reservoir operations and River flows (from Model component worksheets)
	DPGroup86_94*	Plots simulation of Don Pedro Reservoir operation during 1986-1994 (from Model component worksheets)
	HHGroup*	Plots simulation of Hetch Hetchy Reservoir operation (from Model component worksheets)
	LloydGroup*	Plots simulation of Lake Lloyd operation (from Model component worksheets)
	ELGroup*	Plots simulation of Lake Eleanor operation (from Model component worksheets)
	WBGroup*	Plots simulation of Water Bank Balance computation (from Model component worksheets)
	SFSysGroup*	Plots simulation of CCSF System reservoirs (from Model component worksheets)
	SFGroup86_94*	Plots simulation of CCSF System operation during 1986-1994 (from Model component worksheets)
Model Operations	LaGrangeSchedule	Contains model logic for 1995 FERC minimum flow requirements (Model component worksheet)
	DailyCanalsCompute	Contains model logic for computation of daily District canal demand (Model component worksheet)
	DailyCanals	Contains model logic for computation of user-defined canal demand (Model component worksheet)
	DPWSF	Contains model logic for computation of Don Pedro water supply factor (Model component worksheet)
	CCSF	Contains model logic for CCSF release and diversion requirements (Model component worksheet)
Model Input	Hydrology	Contains input data for hydrology
	602020	Contains input data for forecasting hydrology

"*" Identifies worksheets accessible as user interfaces.

5.1 UserInput Worksheet

This worksheet (UserInput) provides the interface for entering assumptions for minimum flow schedules for the lower Tuolumne River at La Grange Bridge, canal diversions by the Modesto Irrigation District and Turlock Irrigation District, supplemental releases to Don Pedro Reservoir from the CCSF System, and diversions by CCSF through the San Joaquin Pipeline. The worksheet is described below.

5.1.1 Contents Description and Study Name

This section (Figure 5.1-1) provides an index of the contents included in the worksheet, and identifies a named label for the particular study. An alpha numeric entry is entered (UI 1.00) for the study name, which is then incorporated into the DSS output interface tab (see worksheet Output description).

5.1.2 Section 1: Minimum Flow Requirements at La Grange Bridge

This section (Figure 5.1-2) provides an entry of the minimum flow schedule for the lower Tuolumne River. Switch UI 1.10 directs the use of the current 1995 FERC schedule (UI 1.10 = 0) or an alternative schedule (UI 1.10 = 1). If an alternative schedule is directed, Switch UI 1.20

directs the use of a user-defined daily times series (UI 1.20 = 0) or the use of a user-specified year type schedule (UI 1.20 = 1).

> Daily Time Series - If the daily time series is directed, a flow value (expressed in average daily flow – cfs) must be entered in Column BM of this worksheet for each day beginning October 1, 1970 through September 30, 2009.
>
> Year Type Schedule - If the year type schedule is directed, values must be entered into the matrix provided at UI 1.30. Values are entered as average daily flow (cfs) for 6 year types, for up to 24 discrete periods during the year. The periods are identified in MM.DD format. For instance, for a flow to be provided for January 1 through January 15 the flow would be identified with a period starting 01.01 (January [01], day 1) and ending with a different flow identified with a starting period of 01.16 (January [01], day 16). The year type has been established by the naming of 6 year types, wet, above normal, normal, below normal, dry and critical. Using the water year runoff for the years 1921 through 2011 (91 years), the years were rank ordered from wettest to driest. The wettest 20 percent of the years (18 years) are designated the wet year type. The next wettest 18 years are designated the above normal year type. And so on for the normal and below normal year types. The driest 20 percent of years are split between the dry and critical year types. After the demarcation occurs for each year the data set is reduced to only the 1971 through 2009 modeling period (39 years). The reduced set of years of the modeling period maintains a year type frequency distribution similar to the larger data set's 20/20/20/20/10/10 percent frequency. Switch UI 1.40 directs the monthly sequence of the flow requirement year. For instance, if the flow schedule is to be established for a year beginning February 1 of the year, UI 1.40 would be set to "Feb". The applicable year type schedule would be applied beginning February 1 of the year and continue through January 31 of the following year. Switch UI 1.40 can be set to any month February (Feb) through June (Jun).

The current 1995 FERC minimum flows to the lower Tuolumne River at La Grange Bridge are illustrated in this section for comparison purposes only, and the values are arranged in the context of the year type designations described above. The values reflect an assumption of two equal periods of flow requirements during each month. If Switch UI 1.10 directs the use of the current schedule, the 1995 FERC schedule as defined by the 1995 FERC Settlement Agreement is implemented including the use of its definition of year types and discrete periods of flow requirements during the year. The 1995 FERC schedule is computed in worksheet LaGrangeSchedule.

User Defined Input

Variables Affected by User Entered in Blue Shaded Cells

Contents:

(UI 1.00) Enter Study Reference: Test_Case *For Part 6 of DSS file (minimize length of name)*

Figure 5.1-1. Contents Description and Study Name.

Section 1 - Alternative Flow Requirements La Grange Bridge

This table is used to enter a user-specified minimum flow schedule at La Grange Bridge. Twenty-four time periods are available to define a flow rate. Six different water year types can be established.
The year types correspond to the Preliminary Relicensing Year Type which is based on Tuolumne River unimpaired flow.

(UI 1.10) Turn alterantive flow requirement on: 0 *(1) on, and use alternative flow requirement, or (0) off, use current FERC flow requirement*

(UI 1.20) Use year type table below, or time series: 0 *(1) for table below, or (0) for time series (Column BM)* N/A

Alternative Flow Requirements

Enter values in CFS

(UI 1.30)

CYMo Day MM.DD	W 1	AN 2	N 3	BN 4	D 5	C 6
1.01	300	300	233	150	157	150
1.16	300	300	233	150	157	150
2.01	1,287	994	729	419	409	359
2.15	1,287	994	729	419	409	359
3.01	1,627	1,172	912	931	627	421
3.16	1,627	1,172	912	931	627	421
4.01	1,960	1,533	1,508	1,211	1,075	785
4.16	1,960	1,533	1,508	1,211	1,075	785
5.01	2,767	2,744	2,476	1,696	1,258	905
5.16	2,767	2,744	2,476	1,696	1,258	905
6.01	2,857	2,200	1,619	924	566	382
6.16	2,857	2,200	1,619	924	566	382
7.01	250	250	150	61	56	50
7.16	250	250	150	61	56	50
8.01	250	250	150	61	56	50
8.16	250	250	150	61	56	50
9.01	250	250	150	61	56	50
9.16	250	250	150	61	56	50
10.01	397	397	295	143	152	126
10.16	397	397	295	143	152	126
11.01	300	300	233	150	158	150
11.16	300	300	233	150	158	150
12.01	300	300	233	150	157	150
12.16	300	300	233	150	157	150

(UI 1.40) Enter beginning month of annual flow requirement schedule: Feb-Jun / Feb / 2

Preliminary Relicensing Year Type is based on a rank-ordering of the water-year runoff for the years 1921-2011. Each water year type W, AN, N, and BN represent 20% of the years of ranking. D and C year types each represent 10% of the years.

CCSF Responsibility* for La Grange Minimum Flows

CCSF responsibility is applied as a daily debit in the computation of CCSF debit or credit in the Water Bank Account.

(UI 1.31) 0 *(0) not responsible, or (1) responsible for 51.7121% of difference between 1995 FERC and scenario requirement.*

If responsibility option is selected, user should go to Section 3 of UserInput and use supplemental CCSF releases to maintain Water Bank Account > zero.

Existing FERC Flow Requirements at La Grange Bridge

Values in CFS

CYMo Day MM.DD	W 1	AN 2	N 3	BN 4	D 5	C 6
1.01	300	300	225	150	157	150
1.16	300	300	225	150	157	150
2.01	300	300	225	150	158	150
2.15	300	300	225	150	158	150
3.01	300	300	225	150	157	150
3.16	300	300	225	150	157	150
4.01	300	300	225	150	158	150
4.15	1,762	1,762	1,562	776	655	461
5.01	1,762	1,762	1,562	776	655	461
5.16	300	300	225	150	157	150
6.01	250	250	150	61	56	50
6.16	250	250	150	61	56	50
7.01	250	250	150	61	56	50
7.16	250	250	150	61	56	50
8.01	250	250	150	61	56	50
8.16	250	250	150	61	56	50
9.01	250	250	150	61	56	50
9.16	250	250	150	61	56	50
10.01	397	397	284	143	152	126
10.16	397	397	284	143	152	126
11.01	300	300	225	150	158	150
11.16	300	300	225	150	158	150
12.01	300	300	225	150	157	150
12.16	300	300	225	150	157	150

Existing FERC flow requirements averaged within Preliminary Relicensing Year Type designations. Existing annual FERC schedules are assumed to begin April 1. Values shown for comparison purposes.

*The "shared responsibility" assumption is presented for the purpose of evaluating alternative operations. The assumption shall not be used as evidence in any proceeding relating to and shall not act as precedence for any allocation of Tuolumne River water between CCSF and the Districts for any purpose under the Fourth Agreement.

Figure 5.1-2. Minimum Flow Requirements at La Grange Bridge.

Shared responsibility for incremental increases in FERC-required flows for the Tuolumne River is enabled with Switch 1.31.[2] The incremental increase in FERC-required flows is determined by the daily difference between the current FERC requirements and scenario-required minimum flows. Approximately fifty-two percent (51.7121%) of the incremental difference between the flow schedules is assigned as CCSF's responsibility and counted as a debit within Water Bank Accounting. If enabled, shared responsibility will cause an effect in the CCSF Water Bank Account which requires review and possible revision to CCSF supplemental release.

5.1.3 Section 2: Canal Diversions of Modesto Irrigation District and Turlock Irrigation District

This section provides an entry of the diversions of the Modesto Irrigation District and Turlock Irrigation District. Switch UI 2.10 directs the use of Test Case diversions (UI 2.10 = 0) or user specified canal diversions (UI 2.10 = 1). If Test Case diversions are directed, a pre-processed daily time series of canal diversions is used. If directed to use user-specified canal diversions, the matrix tables shown at UI 2.30 (Figure 5.1-3) for Modesto Irrigation District) and at UI 2.40 (Figure 5.1-4) for Turlock Irrigation District) require input values for each month of each simulation year, beginning October 1970 (water year 1971) through September 2009. Values are entered as monthly volumes (acre-feet), which will be parsed by the Model into a daily distribution each month represented by the distribution pattern of the Test Case diversions. The Test Case diversions to the Modesto Canal and Turlock Canal are illustrated in this section for comparison purposes.

5.1.4 Section 3: Supplemental Releases of City and County of San Francisco

This section (Figure 5.1-5) provides entry of supplemental releases from CCSF upstream facilities. Switch UI 3.10 directs the use of a suggested method for defining daily supplemental releases (UI 3.10 = 1) or the use of a user-specified table of supplemental releases with or without consideration of Test Case supplemental releases (UI 3.10 = 0), other methods. If the suggested daily supplemental releases method is selected (UI 3.10 = 1) the user must go to worksheet WaterBankRel to complete Model input (see worksheet WaterBankRel description). If the "other methods" path is selected (UI 3.10 = 0) the user must provide additional direction. Switch UI 3.20 directs the use of Test Case supplemental releases (UI 3.20 = 0) or the use of a user-specified table of supplemental releases (UI 3.20 = 1). The user must also direct the consideration of Test Case supplemental releases. To only use the user-specified table of supplement releases, Switch UI 3.30 is set to 0. To add Test Case supplemental releases to the user-specified table of supplemental releases, Switch UI 3.30 is set to 1. The format and application of the user-specified table is the same as described for the entry of alternative flow requirements in Section 1. Values must be entered into the matrix provided at UI 3.40. Values are entered as a daily volume (acre-feet) for 6 year types, for up to 24 discrete periods during the year. The periods are identified in MM.DD format. The year type has been established by the naming of 6 year types, wet, above normal, normal, below normal, dry and critical. Switch UI 3.50 directs the monthly sequence of the supplemental release year. For instance, if the schedule

[2] The "shared responsibility" assumption is presented for the purpose of evaluating alternative operations. The assumption shall not be used as evidence in any proceeding relating to and shall not act as precedence for any allocation of Tuolumne River water between CCSF and the Districts for any purpose under the Fourth Agreement.

is to be established for a year beginning February 1 of the year, UI 3.50 would be set to “Feb”. The applicable year type schedule would be applied beginning February 1 of the year and continue through January 31 of the following year. Switch UI 3.50 can be set to any month February (Feb) through June (Jun). The Test Case supplemental release schedule is illustrated in this section for information purposes.

5.1.5 Section 4: San Joaquin Pipeline Diversions of City and County of San Francisco

This section (Figure 5.1-6) provides an entry for the diversions of the CCSF System to the San Joaquin Pipeline. Switch UI 4.10 directs the use of Test Case diversions (UI 4.10 = 0), or user-specified diversions (UI 4.10 = 1). If Test Case diversions are directed, a pre-processed time series of diversions is used. If directed to use user-specified diversions, the matrix table shown at UI 4.20 requires input values for each month of each simulation year, beginning October 1970 (water year 1971) through September 2009. Values are entered as monthly volumes (acre-feet), which will be parsed by the Model into an equal daily distribution each month.

Section 2 - Alternative Modesto and Turlock Canal Diversions

These tables are used to enter user-specified canal diversions for Modesto ID and Turlock ID. Enter a value for each month of each year.
The monthly volumes of canal diversions are distributed daily within a month based on the daily distribution used for the Base case.

(UI 2.10) Turn alterantive canal diversion on: 0 *(1) on, and use table below, or (0) off, use Test Case canal diversion*

(UI 2.20)

Alternative MID Canal Diversion

Enter values in acre-feet

Prelim Relicense Yr-Type	WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total WY
N	1971	20,952	2,700	2,500	4,300	3,300	14,746	30,656	42,917	47,253	54,987	49,086	32,192	305,589
BN	1972	20,952	5,130	2,500	4,300	5,679	24,844	46,800	46,544	46,542	54,987	49,086	30,637	338,001
N	1973	20,952	2,700	2,500	4,300	3,300	14,746	23,737	45,374	47,016	54,987	49,086	32,658	301,356
AN	1974	20,952	2,700	2,500	4,300	3,300	14,746	18,115	42,917	45,239	49,733	49,086	32,658	286,246
AN	1975	20,952	5,460	2,500	4,300	3,300	14,746	28,782	44,672	47,253	54,859	43,423	32,658	302,906
C	1976	20,952	6,451	2,500	4,300	6,350	30,232	34,676	38,540	38,163	44,939	35,682	24,524	287,308
C	1977	14,568	5,081	2,500	4,300	6,379	17,127	30,279	23,572	28,282	33,405	30,961	19,432	215,886
W	1978	10,761	2,700	2,500	4,300	3,300	14,746	10,143	39,642	47,253	54,987	49,086	25,506	264,924
N	1979	23,490	2,700	2,500	4,300	3,300	14,746	27,340	45,140	47,253	53,962	49,086	32,658	306,475
W	1980	20,952	2,700	2,500	4,300	3,300	14,746	24,602	43,034	47,253	50,758	49,086	32,658	295,889
D	1981	23,236	7,441	2,500	4,300	3,300	14,746	33,395	45,608	47,253	54,987	49,086	32,658	318,510
W	1982	20,952	2,700	2,500	4,300	3,300	14,746	12,687	42,917	45,476	54,987	49,086	17,265	270,916
W	1983	20,952	2,700	2,500	4,300	3,300	14,746	11,058	40,110	47,253	54,987	47,529	15,866	265,301
AN	1984	20,952	2,700	2,500	4,300	3,300	14,746	37,719	46,777	47,253	54,859	49,086	32,502	316,695
BN	1985	20,952	2,700	2,500	4,300	3,300	14,746	33,106	46,193	45,950	54,987	49,086	31,881	309,700
W	1986	20,952	2,700	2,500	4,300	3,300	14,746	19,701	42,215	47,253	54,987	49,086	32,192	293,932
C	1987	20,952	7,441	2,500	4,300	3,300	11,348	33,450	38,540	38,264	45,048	40,977	26,903	273,023
C	1988	14,568	5,081	2,500	4,300	3,300	10,522	20,959	28,485	29,064	35,631	32,822	21,807	209,039
BN	1989	13,109	2,700	2,500	4,300	5,631	11,348	37,004	38,341	38,264	45,048	40,375	15,537	254,156
D	1990	14,568	5,361	2,500	4,300	5,590	15,190	29,936	21,644	29,236	34,588	31,919	20,952	215,784
BN	1991	11,125	6,242	2,500	4,300	5,812	10,324	26,779	32,222	30,198	37,899	33,900	23,035	224,335
C	1992	12,215	6,407	2,500	4,300	3,300	9,811	16,590	29,752	29,193	35,255	32,639	21,693	203,656
AN	1993	11,399	2,700	2,500	4,300	3,300	14,746	23,160	36,951	44,528	54,987	49,086	32,658	280,315
D	1994	20,952	2,700	2,500	4,300	3,300	17,718	28,427	26,707	38,264	45,048	40,977	26,639	257,531
W	1995	14,568	2,700	2,500	4,300	3,300	14,746	15,953	32,974	43,936	54,987	49,086	32,658	271,707
AN	1996	23,490	7,441	2,500	4,300	3,300	14,746	24,746	30,868	47,134	54,987	49,086	32,658	295,257
W	1997	20,952	2,700	2,500	4,300	3,300	14,746	45,935	45,491	46,542	54,987	49,086	32,658	323,197
W	1998	21,967	2,700	2,500	4,300	3,300	14,746	20,421	19,404	43,462	54,987	49,086	32,502	269,376
AN	1999	20,952	2,700	2,500	4,300	3,300	14,746	31,232	43,619	47,134	54,987	49,086	32,347	306,904
N	2000	23,236	6,781	2,500	4,300	3,300	14,746	19,989	29,347	38,722	54,987	49,086	32,192	279,187
BN	2001	20,952	5,790	2,500	4,300	3,300	14,746	21,863	44,204	46,898	54,987	49,086	31,414	300,040
N	2002	21,713	2,700	2,500	4,300	3,300	14,746	36,133	45,959	47,253	54,987	49,086	32,658	315,335
N	2003	23,490	2,700	2,500	4,300	3,300	14,746	27,196	44,087	47,253	54,987	47,670	32,658	304,888
BN	2004	23,490	6,781	2,500	4,300	5,959	25,777	51,269	46,777	47,253	54,987	49,086	32,192	350,369
W	2005	20,952	2,700	2,500	4,300	3,300	14,746	36,422	46,193	47,134	54,987	49,086	30,792	313,112
W	2006	22,982	6,121	2,500	4,300	3,300	14,746	13,115	41,747	47,253	54,987	49,086	32,502	292,640
D	2007	20,952	2,700	2,500	4,300	5,672	22,068	36,391	38,142	38,264	45,048	40,977	25,317	282,330
BN	2008	14,568	5,923	2,500	4,300	3,300	11,348	31,368	38,540	38,264	45,048	40,977	26,903	263,037
N	2009	14,568	5,361	2,500	4,300	3,300	14,746	47,088	44,204	46,661	54,987	49,086	31,259	318,060
	Ave	19,262	4,197	2,500	4,300	3,830	15,412	28,160	38,984	42,875	50,662	45,333	28,663	284,177

Test Case MID Canal Diversion

Values in acre-feet

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total WY	Full Dem Total WY
1971	20,952	2,700	2,500	4,300	3,300	14,746	30,656	42,917	47,253	54,987	49,086	32,192	305,589	305,589
1972	20,952	5,130	2,500	4,300	5,679	24,844	46,800	46,544	46,542	54,987	49,086	30,637	338,001	338,001
1973	20,952	2,700	2,500	4,300	3,300	14,746	23,737	45,374	47,016	54,987	49,086	32,658	301,356	301,356
1974	20,952	2,700	2,500	4,300	3,300	14,746	18,115	42,917	45,239	49,733	49,086	32,658	286,246	286,246
1975	20,952	5,460	2,500	4,300	3,300	14,746	28,782	44,672	47,253	54,859	43,423	32,658	302,906	302,906
1976	20,952	6,451	2,500	4,300	6,350	30,232	34,676	38,540	38,163	44,939	35,682	24,524	287,308	324,478
1977	14,568	5,081	2,500	4,300	6,379	17,127	30,279	23,572	28,282	33,405	30,961	19,432	215,886	316,195
1978	10,761	2,700	2,500	4,300	3,300	14,746	10,143	39,642	47,253	54,987	49,086	25,506	264,924	271,015
1979	23,490	2,700	2,500	4,300	3,300	14,746	27,340	45,140	47,253	53,962	49,086	32,658	306,475	306,475
1980	20,952	2,700	2,500	4,300	3,300	14,746	24,602	43,034	47,253	50,758	49,086	32,658	295,889	295,889
1981	23,236	7,441	2,500	4,300	3,300	14,746	33,395	45,608	47,253	54,987	49,086	32,658	318,510	318,510
1982	20,952	2,700	2,500	4,300	3,300	14,746	12,687	42,917	45,476	54,987	49,086	17,265	270,916	270,916
1983	20,952	2,700	2,500	4,300	3,300	14,746	11,058	40,110	47,253	54,987	47,529	15,866	265,301	265,301
1984	20,952	2,700	2,500	4,300	3,300	14,746	37,719	46,777	47,253	54,859	49,086	32,502	316,695	316,695
1985	20,952	2,700	2,500	4,300	3,300	14,746	33,106	46,193	45,950	54,987	49,086	31,881	309,700	309,700
1986	20,952	2,700	2,500	4,300	3,300	14,746	19,701	42,215	47,253	54,987	49,086	32,192	293,932	293,932
1987	20,952	7,441	2,500	4,300	3,300	11,348	33,450	38,540	38,264	45,048	40,977	26,903	273,023	307,868
1988	14,568	5,081	2,500	4,300	3,300	10,522	20,959	28,485	29,064	35,631	32,822	21,807	209,039	288,428
1989	13,109	2,700	2,500	4,300	5,631	11,348	37,004	38,341	38,264	45,048	40,375	15,537	254,156	293,803
1990	14,568	5,361	2,500	4,300	5,590	15,190	29,936	21,644	29,236	34,588	31,919	20,952	215,784	304,883
1991	11,125	6,242	2,500	4,300	5,812	10,324	26,779	32,222	30,198	37,899	33,900	23,035	224,335	299,335
1992	12,215	6,407	2,500	4,300	3,300	9,811	16,590	29,752	29,193	35,255	32,639	21,693	203,656	285,286
1993	11,399	2,700	2,500	4,300	3,300	14,746	23,160	36,951	44,528	54,987	49,086	32,658	280,315	285,768
1994	20,952	2,700	2,500	4,300	3,300	17,718	28,427	26,707	38,264	45,048	40,977	26,639	257,531	287,956
1995	14,568	2,700	2,500	4,300	3,300	14,746	15,953	32,974	43,936	54,987	49,086	32,658	271,707	273,991
1996	23,490	7,441	2,500	4,300	3,300	14,746	24,746	30,868	47,134	54,987	49,086	32,658	295,257	295,257
1997	20,952	2,700	2,500	4,300	3,300	14,746	45,935	45,491	46,542	54,987	49,086	32,658	323,197	323,197
1998	21,967	2,700	2,500	4,300	3,300	14,746	20,421	19,404	43,462	54,987	49,086	32,502	269,376	269,376
1999	20,952	2,700	2,500	4,300	3,300	14,746	31,232	43,619	47,134	54,987	49,086	32,347	306,904	306,904
2000	23,236	6,781	2,500	4,300	3,300	14,746	19,989	29,347	38,722	54,987	49,086	32,192	279,187	279,187
2001	20,952	5,790	2,500	4,300	3,300	14,746	21,863	44,204	46,898	54,987	49,086	31,414	300,040	300,040
2002	21,713	2,700	2,500	4,300	3,300	14,746	36,133	45,959	47,253	54,987	49,086	32,658	315,335	315,335
2003	23,490	2,700	2,500	4,300	3,300	14,746	27,196	44,087	47,253	54,987	47,670	32,658	304,888	304,888
2004	23,490	6,781	2,500	4,300	5,959	25,777	51,269	46,777	47,253	54,987	49,086	32,192	350,369	350,369
2005	20,952	2,700	2,500	4,300	3,300	14,746	36,422	46,193	47,134	54,987	49,086	30,792	313,112	313,112
2006	22,982	6,121	2,500	4,300	3,300	14,746	13,115	41,747	47,253	54,987	49,086	32,502	292,640	292,640
2007	20,952	2,700	2,500	4,300	5,672	22,068	36,391	38,142	38,264	45,048	40,977	25,317	282,330	315,945
2008	14,568	5,923	2,500	4,300	3,300	11,348	31,368	38,540	38,264	45,048	40,977	26,903	263,037	299,996
2009	14,568	5,361	2,500	4,300	3,300	14,746	47,088	44,204	46,661	54,987	49,086	31,259	318,060	320,443
Ave	19,262	4,197	2,500	4,300	3,830	15,412	28,160	38,984	42,875	50,662	45,333	28,663	284,177	300,954

Figure 5.1-3. Canal Diversions of Modesto Irrigation District.

Alternative TID Canal Diversion

Enter values in acre-feet

	Prelim Relicense Yr-Type	WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total WY
(UI 2.30)	N	1971	31,487	1,000	1,000	6,000	8,000	42,220	71,385	79,506	96,454	118,397	101,372	51,350	608,171
	BN	1972	31,487	4,120	1,000	6,000	12,542	70,210	104,879	92,357	95,639	118,397	101,372	50,168	688,170
	N	1973	31,487	1,000	1,000	6,000	8,000	42,220	44,833	89,056	96,105	118,397	101,372	52,681	592,149
	AN	1974	31,487	1,000	1,000	6,000	8,000	42,220	39,626	82,689	92,845	106,930	101,372	52,681	565,851
	AN	1975	31,487	4,761	1,000	6,000	8,000	42,220	59,410	85,755	96,454	117,430	92,559	52,681	597,756
	C	1976	31,487	6,684	1,000	6,000	13,169	81,414	79,704	77,553	79,063	97,737	72,955	32,004	578,770
	C	1977	20,773	1,000	1,000	6,000	13,371	50,509	72,025	45,645	54,416	68,098	57,243	26,675	416,755
	W	1978	11,340	4,569	1,000	6,000	8,000	42,220	9,548	72,786	96,454	118,397	101,372	37,013	508,698
	N	1979	31,487	1,000	1,000	6,000	8,000	42,220	53,683	87,405	96,454	115,219	101,372	52,681	596,521
	W	1980	31,487	1,000	1,000	6,000	8,000	42,220	49,345	81,864	96,454	112,318	101,372	52,681	583,741
	D	1981	31,487	7,966	1,000	6,000	11,130	42,220	78,153	90,235	96,454	118,397	101,372	52,681	637,093
	W	1982	31,487	1,000	1,000	6,000	8,000	42,220	18,801	79,506	93,427	118,397	101,372	26,075	527,285
	W	1983	31,487	1,000	1,000	6,000	8,000	42,220	14,289	73,376	96,454	118,397	97,046	25,780	515,047
	AN	1984	31,487	1,000	1,000	6,000	8,000	42,220	89,260	92,475	95,173	118,120	101,372	51,794	637,901
	BN	1985	31,487	1,000	1,000	6,000	8,000	42,220	80,930	92,003	92,845	118,397	101,372	51,942	627,195
	W	1986	31,487	1,000	1,000	6,000	8,000	42,220	36,155	80,567	96,454	118,397	101,372	50,168	572,820
	C	1987	31,487	7,645	1,000	6,000	11,080	37,117	80,884	77,453	79,756	97,972	82,761	40,798	553,954
	C	1988	20,773	4,345	1,000	6,000	8,000	34,416	44,841	54,744	59,435	73,648	61,984	30,238	399,424
	BN	1989	13,087	1,000	1,000	6,000	11,360	37,117	89,292	76,551	79,756	97,972	80,991	19,063	513,190
	D	1990	20,773	4,889	1,000	6,000	11,491	42,592	67,733	41,090	58,355	70,954	59,683	28,700	413,261
	BN	1991	12,239	5,799	1,000	6,000	12,548	33,362	63,975	63,689	62,376	79,506	64,759	32,781	438,033
	C	1992	14,931	5,806	1,000	6,000	8,000	31,457	37,881	58,023	58,785	71,771	61,517	30,001	385,173
	AN	1993	12,915	5,034	1,000	6,000	8,000	42,220	43,271	70,428	88,770	118,397	101,372	52,681	550,087
	D	1994	31,487	4,441	1,000	6,000	8,000	42,220	67,460	54,104	79,756	97,972	82,761	39,040	514,241
	W	1995	20,773	1,000	1,000	6,000	8,000	42,220	25,049	58,874	87,023	118,120	101,372	52,681	522,113
	AN	1996	31,487	7,966	1,000	6,000	8,000	42,220	46,047	59,228	96,454	118,397	101,372	52,681	570,851
	W	1997	31,487	1,000	1,000	6,000	8,000	42,220	107,135	91,532	95,173	118,397	101,372	52,089	655,405
	W	1998	31,487	1,000	1,000	6,000	8,000	42,220	31,470	38,950	81,784	118,397	101,372	52,681	514,360
	AN	1999	31,487	1,000	1,000	6,000	8,000	42,220	75,897	88,702	96,454	118,397	101,372	52,681	623,209
	N	2000	31,487	5,723	1,000	6,000	8,000	42,220	36,503	56,634	83,065	118,397	101,372	52,681	543,081
	BN	2001	31,487	4,761	1,000	6,000	8,000	42,220	49,518	83,515	96,105	118,397	101,372	50,168	592,542
	N	2002	31,487	1,000	1,000	6,000	8,000	42,220	84,748	81,510	96,454	118,397	101,372	52,681	624,868
	N	2003	31,487	1,000	1,000	6,000	8,000	42,220	66,179	82,454	96,454	118,397	99,129	52,681	604,999
	BN	2004	31,487	6,363	1,000	6,000	8,000	42,220	111,474	89,763	91,215	112,042	96,725	52,681	648,970
	W	2005	31,487	1,000	1,000	6,000	8,000	42,220	54,725	81,275	96,454	118,397	100,731	48,099	589,386
	W	2006	31,487	6,363	1,000	6,000	8,000	42,220	29,387	71,607	96,454	118,397	101,372	52,681	564,968
	D	2007	31,487	1,000	1,000	6,000	12,448	70,365	85,162	76,852	79,756	97,972	82,761	36,904	581,706
	BN	2008	20,773	5,707	1,000	6,000	8,000	37,117	76,901	76,952	79,756	97,972	82,761	40,798	533,738
	N	2009	20,773	4,617	1,000	6,000	8,000	42,220	103,144	85,047	95,522	118,397	101,372	50,611	636,704
		Ave	27,456	3,271	1,000	6,000	8,952	43,791	61,044	74,917	87,340	108,669	92,511	44,747	559,697

Test Case TID Canal Diversion

Values in acre-feet

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total WY	Full Dem Total
1971	31,487	1,000	1,000	6,000	8,000	42,220	71,385	79,506	96,454	118,397	101,372	51,350	608,171	608,171
1972	31,487	4,120	1,000	6,000	12,542	70,210	104,879	92,357	95,639	118,397	101,372	50,168	688,170	688,170
1973	31,487	1,000	1,000	6,000	8,000	42,220	44,833	89,056	96,105	118,397	101,372	52,681	592,149	592,149
1974	31,487	1,000	1,000	6,000	8,000	42,220	39,626	82,689	92,845	106,930	101,372	52,681	565,851	565,851
1975	31,487	4,761	1,000	6,000	8,000	42,220	59,410	85,755	96,454	117,430	92,559	52,681	597,756	597,756
1976	31,487	6,684	1,000	6,000	13,169	81,414	79,704	77,553	79,063	97,737	72,955	32,004	578,770	669,740
1977	20,773	1,000	1,000	6,000	13,371	50,509	72,025	45,645	54,416	68,098	57,243	26,675	416,755	669,171
1978	11,340	4,569	1,000	6,000	8,000	42,220	9,548	72,786	96,454	118,397	101,372	37,013	508,698	524,472
1979	31,487	1,000	1,000	6,000	8,000	42,220	53,683	87,405	96,454	115,219	101,372	52,681	596,521	596,521
1980	31,487	1,000	1,000	6,000	8,000	42,220	49,345	81,864	96,454	112,318	101,372	52,681	583,741	583,741
1981	31,487	7,966	1,000	6,000	11,130	42,220	78,153	90,235	96,454	118,397	101,372	52,681	637,093	637,093
1982	31,487	1,000	1,000	6,000	8,000	42,220	18,801	79,506	93,427	118,397	101,372	26,075	527,285	527,285
1983	31,487	1,000	1,000	6,000	8,000	42,220	14,289	73,376	96,454	118,397	97,046	25,780	515,047	515,047
1984	31,487	1,000	1,000	6,000	8,000	42,220	89,260	92,475	95,173	118,120	101,372	51,794	637,901	637,901
1985	31,487	1,000	1,000	6,000	8,000	42,220	80,930	92,003	92,845	118,397	101,372	51,942	627,195	627,195
1986	31,487	1,000	1,000	6,000	8,000	42,220	36,155	80,567	96,454	118,397	101,372	50,168	572,820	572,820
1987	31,487	7,645	1,000	6,000	11,080	37,117	80,884	77,453	79,756	97,972	82,761	40,798	553,954	640,376
1988	20,773	4,345	1,000	6,000	8,000	34,416	44,841	54,744	59,435	73,648	61,984	30,238	399,424	595,199
1989	13,087	1,000	1,000	6,000	11,360	37,117	89,292	76,551	79,756	97,972	80,991	19,063	513,190	610,352
1990	20,773	4,889	1,000	6,000	11,491	42,592	67,733	41,090	58,355	70,954	59,683	28,700	413,261	632,968
1991	12,239	5,799	1,000	6,000	12,548	33,362	63,975	63,689	62,376	79,506	64,759	32,781	438,033	624,153
1992	14,931	5,806	1,000	6,000	8,000	31,457	37,881	58,023	58,785	71,771	61,517	30,001	385,173	586,401
1993	12,915	5,034	1,000	6,000	8,000	42,220	43,271	70,428	88,770	118,397	101,372	52,681	550,087	564,462
1994	31,487	4,441	1,000	6,000	8,000	42,220	67,460	54,104	79,756	97,972	82,761	39,040	514,241	588,710
1995	20,773	1,000	1,000	6,000	8,000	42,220	25,049	58,874	87,023	118,120	101,372	52,681	522,113	527,941
1996	31,487	7,966	1,000	6,000	8,000	42,220	46,047	59,228	96,454	118,397	101,372	52,681	570,851	570,851
1997	31,487	1,000	1,000	6,000	8,000	42,220	107,135	91,532	95,173	118,397	101,372	52,089	655,405	655,405
1998	31,487	1,000	1,000	6,000	8,000	42,220	31,470	38,950	81,784	118,397	101,372	52,681	514,360	514,360
1999	31,487	1,000	1,000	6,000	8,000	42,220	75,897	88,702	96,454	118,397	101,372	52,681	623,209	623,209
2000	31,487	5,723	1,000	6,000	8,000	42,220	36,503	56,634	83,065	118,397	101,372	52,681	543,081	543,081
2001	31,487	4,761	1,000	6,000	8,000	42,220	49,518	83,515	96,105	118,397	101,372	50,168	592,542	592,542
2002	31,487	1,000	1,000	6,000	8,000	42,220	84,748	81,510	96,454	118,397	101,372	52,681	624,868	624,868
2003	31,487	1,000	1,000	6,000	8,000	42,220	66,179	82,454	96,454	118,397	99,129	52,681	604,999	604,999
2004	31,487	6,363	1,000	6,000	8,000	42,220	111,474	89,763	91,215	112,042	96,725	52,681	648,970	648,970
2005	31,487	1,000	1,000	6,000	8,000	42,220	54,725	81,275	96,454	118,397	100,731	48,099	589,386	589,386
2006	31,487	6,363	1,000	6,000	8,000	42,220	29,387	71,607	96,454	118,397	101,372	52,681	564,968	564,968
2007	31,487	1,000	1,000	6,000	12,448	70,365	85,162	76,852	79,756	97,972	82,761	36,904	581,706	662,937
2008	20,773	5,707	1,000	6,000	8,000	37,117	76,901	76,952	79,756	97,972	82,761	40,798	533,738	625,483
2009	20,773	4,617	1,000	6,000	8,000	42,220	103,144	85,047	95,522	118,397	101,372	50,611	636,704	642,676
Ave	27,456	3,271	1,000	6,000	8,952	43,791	61,044	74,917	87,340	108,669	92,511	44,747	559,697	601,215

Figure 5.1-4. Canal Diversions of Turlock Irrigation District.

Section 3 - Supplemental Release from CCSF Upstream Reservoirs

This table is used to enter a user-specified supplemental release from CCSF upstream reservoirs. Twenty-four time periods are available to define the period and flow rate. Six different water year types can be established.
The year types correspond to the Preliminary Relicensing Year Type which is based on Tuolumne River unimpaired flow.
The supplemental release will be directed to Lake Lloyd until the reservoir storage reaches a defined limit, then the supplemental release is directed to Hetch Hetchy Reservoir.
User specifies whether or not Table supplemental releases are added to Test Case supplemental releases.
Alternatively, user can define a daily supplemental release from CCSF facilities. This option is the same method used to define Test Base supplemental releases to maintain the Water Bank Balance at or above zero. (Suggested method)

(UI 3.10) Use daily supplemental release option: 1 *(1) on, use daily defined option - go to worksheet WaterBankRel, or (0) off, use other supplemental release options*

If using other supplement release options, Switch UI 3.10 = 0, enter choices below.
(UI 3.20) Turn other user-specified supplemental releases on: 0 *(1) on, and use table below, or (0) off, use existing Test Case supplemental releases* N/A
(UI 3.30) If using table below, add to existing supplemental releases: 1 *(1) yes, add table to existing releases, or (0) no use table only*

Alternative Supplemental Releases
Enter values in acre-feet per day

(UI 3.40)

CYMo Day	W	AN	N	BN	D	C
MM.DD	1	2	3	4	5	6
1.01	0	0	0	0	0	0
1.16	0	0	0	0	0	0
2.01	0	0	0	0	2,000	2,000
2.15	0	0	0	0	2,000	2,000
3.01	0	0	0	0	2,000	2,000
3.16	0	0	0	0	2,000	2,000
4.01	0	0	0	0	2,000	2,000
4.16	0	0	0	0	2,000	2,000
5.01	0	0	0	0	2,000	2,000
5.16	0	0	0	0	2,000	2,000
6.01	0	0	0	0	2,000	2,000
6.16	0	0	0	0	2,000	2,000
7.01	0	0	0	0	0	0
7.16	0	0	0	0	0	0
8.01	0	0	0	0	0	0
8.16	0	0	0	0	0	0
9.01	0	0	0	0	0	0
9.16	0	0	0	0	0	0
10.01	0	0	0	0	0	0
10.16	0	0	0	0	0	0
11.01	0	0	0	0	0	0
11.16	0	0	0	0	0	0
12.01	0	0	0	0	0	0
12.16	0	0	0	0	0	0

Preliminary Relicensing Year Type is based on a rank-ordering of the water-year runoff for the years 1921-2011. Each water year type W, AN, N, and BN represent 20% of the years of ranking. D and C year types each represent 10% of the years.

(UI 3.50) Enter beginning month of annual supplemental release schedule: Feb-Jun / Jun / 6

Test Case Supplemental Releases (made to retain WB Balance above zero)

Prelim Relicense Yr-Type	WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
	Monthly Acre-feet													
N	1971	0	0	0	0	0	0	0	0	0	0	0	0	0
BN	1972	0	0	0	0	0	0	0	0	0	0	0	0	0
N	1973	0	0	0	0	0	0	0	0	0	0	0	0	0
AN	1974	0	0	0	0	0	0	0	0	0	0	0	0	0
AN	1975	0	0	0	0	0	0	0	0	0	0	0	0	0
C	1976	0	0	0	0	0	0	0	0	0	0	0	0	0
C	1977	0	0	0	0	0	0	0	0	0	0	0	0	0
W	1978	0	0	0	0	0	0	0	0	0	0	0	0	0
N	1979	0	0	0	0	0	0	0	0	0	0	0	0	0
W	1980	0	0	0	0	0	0	0	0	0	0	0	0	0
D	1981	0	0	0	0	0	0	0	0	0	0	0	0	0
W	1982	0	0	0	0	0	0	0	0	0	0	0	0	0
W	1983	0	0	0	0	0	0	0	0	0	0	0	0	0
AN	1984	0	0	0	0	0	0	0	0	0	0	0	0	0
BN	1985	0	0	0	0	0	0	0	0	0	0	0	0	0
W	1986	0	0	0	0	0	0	0	0	0	0	0	0	0
C	1987	0	0	0	0	0	0	0	0	0	0	0	0	0
C	1988	0	0	0	0	0	0	0	0	0	0	0	0	0
BN	1989	0	0	0	0	0	0	0	0	0	0	0	0	0
D	1990	0	0	0	0	0	0	0	0	0	0	0	0	0
BN	1991	0	0	0	0	0	0	0	0	0	0	0	0	0
C	1992	0	0	0	0	0	0	59,864	70,684	19,366	21,794	0	0	171,708
AN	1993	0	0	0	0	0	0	0	0	0	0	0	0	0
D	1994	0	0	0	0	0	0	0	0	0	0	0	0	0
W	1995	0	0	0	0	0	0	0	0	0	0	0	0	0
AN	1996	0	0	0	0	0	0	0	0	0	0	0	0	0
W	1997	0	0	0	0	0	0	0	0	0	0	0	0	0
W	1998	0	0	0	0	0	0	0	0	0	0	0	0	0
AN	1999	0	0	0	0	0	0	0	0	0	0	0	0	0
N	2000	0	0	0	0	0	0	0	0	0	0	0	0	0
BN	2001	0	0	0	0	0	0	0	0	0	0	0	0	0
N	2002	0	0	0	0	0	0	0	0	0	0	0	0	0
N	2003	0	0	0	0	0	0	0	0	0	0	0	0	0
BN	2004	0	0	0	0	0	0	0	0	0	0	0	0	0
W	2005	0	0	0	0	0	0	0	0	0	0	0	0	0
W	2006	0	0	0	0	0	0	0	0	0	0	0	0	0
D	2007	0	0	0	0	0	0	0	0	0	0	0	0	0
BN	2008	0	0	0	0	0	0	0	0	0	0	0	0	0
N	2009	0	0	0	0	0	0	0	0	0	0	0	0	0

Values are associated with Test Case scenario and are equal to daily supplemental releases made from CCSF facilities to maintain the Water Bank Account Balance at or above zero. Values are shown for comparison purposes.

Figure 5.1-5. Supplemental Releases of City and County of San Francisco.

Section 4 - Alternative CCSF San Joaquin Pipeline

This section specifies the CCSF San Joaquin Pipeline diversion. Use Test Case diversions, or user-specified values by entering a value for each month of each year.
The monthly volumes of pipeline diversions will be distributed daily within a month equally.

(UI 4.10) Turn alterantive pipeline diversion on: 0 *(0) off, use Test Case pipeline diversion, (1) on, use table below*

(UI 4.20)

Alternative SJPL Diversion — Enter values in acre-feet

Prelim Relicense Yr-Type	WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total WY
N	1971	19,027	11,969	6,660	6,660	6,015	25,782	24,950	25,782	24,950	29,778	29,778	23,937	235,286
BN	1972	21,881	16,572	12,368	17,124	15,467	25,782	25,779	25,782	24,950	29,778	29,778	24,950	270,211
N	1973	21,881	14,731	12,368	6,660	6,015	6,660	16,572	25,782	24,950	29,778	29,778	23,937	219,110
AN	1974	17,124	10,127	6,660	6,660	6,015	6,660	7,365	24,735	23,937	29,778	29,778	24,950	193,789
AN	1975	17,124	0	0	25,782	11,171	6,660	10,127	24,735	23,937	29,778	29,778	24,950	204,042
C	1976	17,124	13,810	12,368	19,027	17,186	25,782	26,699	25,782	24,950	29,778	29,778	24,950	267,234
C	1977	21,881	16,572	17,124	17,124	15,467	25,782	27,620	26,638	25,779	27,589	25,782	21,175	268,535
W	1978	19,027	16,572	12,368	6,660	6,015	6,660	9,023	22,833	22,096	29,778	29,778	23,937	204,745
N	1979	17,124	13,810	17,124	15,222	6,015	17,124	22,096	25,782	24,950	29,778	29,778	23,937	242,741
W	1980	17,124	0	0	14,270	6,015	6,660	19,334	25,782	24,950	29,778	29,778	23,937	197,628
D	1981	17,124	13,810	12,891	12,368	11,171	22,833	23,937	25,782	24,950	29,778	29,778	23,937	248,358
W	1982	17,124	11,969	9,323	6,660	6,015	6,660	6,445	19,979	19,334	29,778	29,778	26,239	189,302
W	1983	19,979	11,969	6,660	6,660	6,015	6,660	7,365	12,368	11,969	29,778	29,778	28,817	178,015
AN	1984	22,833	9,023	6,660	6,660	6,015	25,782	24,950	24,735	23,937	29,778	29,778	24,950	235,099
BN	1985	21,881	0	0	25,782	20,623	25,782	28,817	25,782	24,950	29,778	29,778	23,937	257,109
W	1986	21,881	18,413	12,368	19,027	6,015	6,660	14,731	25,782	24,950	29,778	29,778	23,937	233,319
C	1987	17,124	13,810	17,124	17,124	15,467	25,782	26,239	25,782	24,950	29,778	29,778	24,950	267,909
C	1988	21,881	16,572	12,368	19,027	17,186	25,782	27,620	25,782	24,950	27,589	26,638	21,175	266,571
BN	1989	19,027	16,572	15,222	15,222	13,749	25,782	23,937	22,833	22,096	28,541	25,782	21,175	249,937
D	1990	19,027	0	0	25,782	20,623	25,782	28,817	22,833	22,096	28,541	25,782	21,175	240,458
BN	1991	19,027	16,572	12,891	17,124	15,467	19,979	22,096	22,833	22,096	27,589	25,782	21,175	242,632
C	1992	19,027	16,572	15,222	15,222	6,015	21,881	21,175	22,833	22,096	27,589	25,782	21,175	234,590
AN	1993	19,027	16,572	12,368	6,660	6,015	6,660	16,572	21,881	21,175	29,778	29,778	24,950	211,435
D	1994	17,124	13,810	17,124	17,124	13,749	24,735	24,950	25,782	24,950	29,778	29,778	24,950	263,855
W	1995	19,979	0	0	12,368	6,874	6,660	13,810	22,833	22,096	29,778	29,778	24,950	189,124
AN	1996	17,124	13,810	12,891	6,660	6,015	6,660	18,413	24,735	23,937	29,778	29,778	24,950	214,751
W	1997	17,124	7,365	6,660	6,660	6,015	19,979	23,937	25,782	24,950	29,778	29,778	23,937	221,964
W	1998	21,881	11,969	12,368	6,660	6,015	6,660	6,445	19,979	19,334	29,778	29,778	24,950	195,814
AN	1999	17,124	13,810	15,222	14,270	6,015	12,368	13,810	24,735	23,937	29,778	29,778	23,937	224,785
N	2000	17,124	0	0	25,782	11,171	6,660	23,937	25,782	24,950	29,778	29,778	23,937	218,898
BN	2001	19,027	13,810	12,368	19,027	12,889	17,124	22,096	25,782	24,950	29,778	29,778	23,937	250,566
N	2002	17,124	13,810	9,323	15,222	13,749	24,735	23,937	25,782	24,950	29,778	29,778	24,950	253,138
N	2003	19,979	14,731	6,660	6,660	6,015	25,782	24,950	22,833	22,096	29,778	29,778	24,950	234,209
BN	2004	21,881	13,810	14,270	15,222	6,015	19,027	24,950	25,782	24,950	29,778	29,778	23,937	249,400
W	2005	19,979	0	0	12,368	6,874	6,660	13,810	24,735	23,937	29,778	29,778	24,950	192,868
W	2006	17,124	13,810	10,465	6,660	6,015	9,323	6,445	22,833	22,096	29,778	29,778	24,950	199,276
D	2007	19,027	13,810	15,222	17,124	15,467	24,735	23,937	25,782	24,950	29,778	29,778	24,950	264,561
BN	2008	21,881	16,572	12,368	9,323	6,015	21,881	23,937	25,782	24,950	29,778	29,778	24,950	247,215
N	2009	19,979	14,731	17,124	17,124	6,015	6,660	23,937	25,782	24,950	29,778	29,778	23,937	239,795
	Ave	19,174	11,586	10,056	13,763	9,761	16,390	19,886	24,296	23,512	29,490	29,185	24,138	231,238

Test Case SJPL Diversion — Values in acre-feet

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total WY	CCSF Sys Action
1971	19,027	11,969	6,660	6,660	6,015	25,782	24,950	25,782	24,950	29,778	29,778	23,937	235,286	0
1972	21,881	16,572	12,368	17,124	15,467	25,782	25,779	25,782	24,950	29,778	29,778	24,950	270,211	0
1973	21,881	14,731	12,368	6,660	6,015	6,660	16,572	25,782	24,950	29,778	29,778	23,937	219,110	0
1974	17,124	10,127	6,660	6,660	6,015	6,660	7,365	24,735	23,937	29,778	29,778	24,950	193,789	0
1975	17,124	0	0	25,782	11,171	6,660	10,127	24,735	23,937	29,778	29,778	24,950	204,042	0
1976	17,124	13,810	12,368	19,027	17,186	25,782	26,699	25,782	24,950	29,778	29,778	24,950	267,234	0
1977	21,881	16,572	17,124	17,124	15,467	25,782	27,620	26,638	25,779	27,589	25,782	21,175	268,535	1
1978	19,027	16,572	12,368	6,660	6,015	6,660	9,023	22,833	22,096	29,778	29,778	23,937	204,745	0
1979	17,124	13,810	17,124	15,222	6,015	17,124	22,096	25,782	24,950	29,778	29,778	23,937	242,741	0
1980	17,124	0	0	14,270	6,015	6,660	19,334	25,782	24,950	29,778	29,778	23,937	197,628	0
1981	17,124	13,810	12,891	12,368	11,171	22,833	23,937	25,782	24,950	29,778	29,778	23,937	248,358	0
1982	17,124	11,969	9,323	6,660	6,015	6,660	6,445	19,979	19,334	29,778	29,778	26,239	189,302	0
1983	19,979	11,969	6,660	6,660	6,015	6,660	7,365	12,368	11,969	29,778	29,778	28,817	178,015	0
1984	22,833	9,023	6,660	6,660	6,015	25,782	24,950	24,735	23,937	29,778	29,778	24,950	235,099	0
1985	21,881	0	0	25,782	20,623	25,782	28,817	25,782	24,950	29,778	29,778	23,937	257,109	0
1986	21,881	18,413	12,368	19,027	6,015	6,660	14,731	25,782	24,950	29,778	29,778	23,937	233,319	0
1987	17,124	13,810	17,124	17,124	15,467	25,782	26,239	25,782	24,950	29,778	29,778	24,950	267,909	0
1988	21,881	16,572	12,368	19,027	17,186	25,782	27,620	25,782	24,950	27,589	26,638	21,175	266,571	1
1989	19,027	16,572	15,222	15,222	13,749	25,782	23,937	22,833	22,096	28,541	25,782	21,175	249,937	1
1990	19,027	0	0	25,782	20,623	25,782	28,817	22,833	22,096	28,541	25,782	21,175	240,458	1
1991	19,027	16,572	12,891	17,124	15,467	19,979	22,096	22,833	22,096	27,589	25,782	21,175	242,632	1
1992	19,027	16,572	15,222	15,222	6,015	21,881	21,175	22,833	22,096	27,589	25,782	21,175	234,590	1
1993	19,027	16,572	12,368	6,660	6,015	6,660	16,572	21,881	21,175	29,778	29,778	24,950	211,435	0
1994	17,124	13,810	17,124	17,124	13,749	24,735	24,950	25,782	24,950	29,778	29,778	24,950	263,855	0
1995	19,979	0	0	12,368	6,874	6,660	13,810	22,833	22,096	29,778	29,778	24,950	189,124	0
1996	17,124	13,810	12,891	6,660	6,015	6,660	18,413	24,735	23,937	29,778	29,778	24,950	214,751	0
1997	17,124	7,365	6,660	6,660	6,015	19,979	23,937	25,782	24,950	29,778	29,778	23,937	221,964	0
1998	21,881	11,969	12,368	6,660	6,015	6,660	6,445	19,979	19,334	29,778	29,778	24,950	195,814	0
1999	17,124	13,810	15,222	14,270	6,015	12,368	13,810	24,735	23,937	29,778	29,778	23,937	224,785	0
2000	17,124	0	0	25,782	11,171	6,660	23,937	25,782	24,950	29,778	29,778	23,937	218,898	0
2001	19,027	13,810	12,368	19,027	12,889	17,124	22,096	25,782	24,950	29,778	29,778	23,937	250,566	0
2002	17,124	13,810	9,323	15,222	13,749	24,735	23,937	25,782	24,950	29,778	29,778	24,950	253,138	0
2003	19,979	14,731	6,660	6,660	6,015	25,782	24,950	22,833	22,096	29,778	29,778	24,950	234,209	0
2004	21,881	13,810	14,270	15,222	6,015	19,027	24,950	25,782	24,950	29,778	29,778	23,937	249,400	0
2005	19,979	0	0	12,368	6,874	6,660	13,810	24,735	23,937	29,778	29,778	24,950	192,868	0
2006	17,124	13,810	10,465	6,660	6,015	9,323	6,445	22,833	22,096	29,778	29,778	24,950	199,276	0
2007	19,027	13,810	15,222	17,124	15,467	24,735	23,937	25,782	24,950	29,778	29,778	24,950	264,561	0
2008	21,881	16,572	12,368	9,323	6,015	21,881	23,937	25,782	24,950	29,778	29,778	24,950	247,215	0
2009	19,979	14,731	17,124	17,124	6,015	6,660	23,937	25,782	24,950	29,778	29,778	23,937	239,795	0
Ave	19,174	11,586	10,056	13,763	9,761	16,390	19,886	24,296	23,512	29,490	29,185	24,138	231,238	

Figure 5.1-6. San Joaquin Pipeline Diversions of City and County of San Francisco.

5.2 WaterBankRel Worksheet

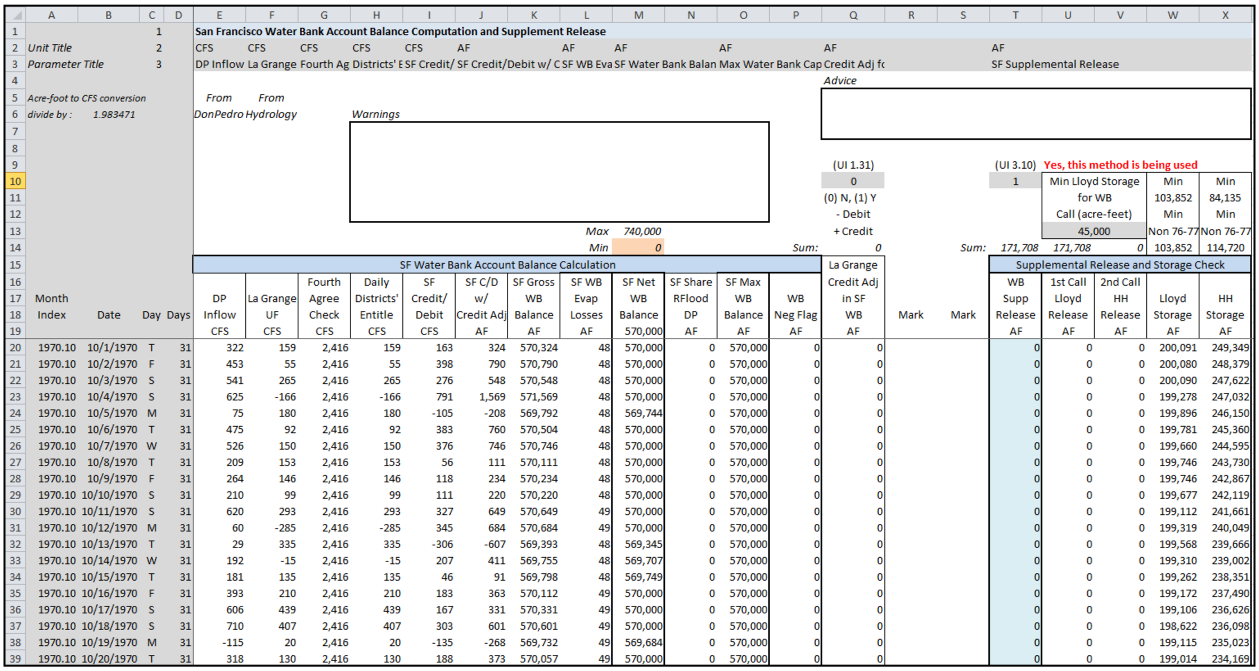
This worksheet (WaterBankRel) provides for entry of daily supplemental releases from the CCSF System. Without any other manual intervention the Model will direct releases from the CCSF System under a “hold-unless-need-to-release” protocol. Additional releases greater than provided by the default protocol may be needed. An example of such a need is during periods when CCSF System operations would otherwise deplete the Water Bank Account to a point of a “negative” balance.

The manual adjustment to releases from the CCSF System is provided to allow the user to “pull” additional water from the CCSF System as supplemental inflow to Don Pedro Reservoir. A single entry is established that will first pull water from Lake Lloyd so that water supply is preserved in the Hetch Hetchy Reservoir system for diversion to the SJPL. At a point when such supplemental releases strain Lake Lloyd storage, the supplemental releases are directed to Hetch Hetchy Reservoir. The supplemental release is directed from a reservoir at a point in logic after the default protocol releases occur. Thus, the release occurs in addition to what operation is already occurring by default. Such a release can affect the following day’s default operation or previous periods’ operations, thus results require review to determine if the user’s desired result occurs. This worksheet is employed when Switch UI 3.10 directs the use of this suggested method for defining daily supplemental releases (UI 3.10 = 1).

Shown in Figure 5.2-1 is a snapshot of the worksheet. The worksheet provides the daily accounting of the Water Bank Account Balance for the Model. Information ported from other worksheets of the Model into this worksheet is Don Pedro Reservoir inflow (Column E) and the unimpaired flow at La Grange (Column F). These data and the protocols associated with Fourth Agreement Water Bank Balance accounting (Columns G through Column O) derive the daily credit or debit of CCSF and then the daily balance of the Water Bank Account (Column M).

For purposes of the FERC investigation, the protocols of Fourth Agreement Water Bank Accounting have been amended to incorporate a hypothetical implementation of “shared responsibility” for incremental increases in FERC-required flows for the Tuolumne River. If running the option with shared responsibility has been selected (worksheet UserInput Switch UI 1.31 = 1), the incremental increase in FERC-required flows is determined by the daily difference between the current 1995 FERC Settlement requirements and scenario-required minimum flows. This computation occurs in worksheet LaGrangeSchedule with information regarding the scenario-required flows directed through worksheet UserInput. Approximately fifty-two percent (51.7121%) of the incremental difference between the flow schedules is assigned as CCSF’s responsibility and is ported into the worksheet in Column Q as a “debit”. This debit then enters the current protocols of Fourth Agreement Water Bank Accounting at Column J, and subsequently contributes to the determination of the daily Water Bank Account Balance (Column M).

Water Bank Account Balances which are less than zero (“negative”) are highlighted, and the minimum balance, whether negative or positive, is reported in Cell M14. When a negative balance occurs, the user is to enter into Column T (WB Supplemental Release) a volume of release needed to maintain the Water Bank Account Balance at, or greater than zero. The Model will first direct the supplemental release to Lake Lloyd, and continue releases until storage at Lake Lloyd is drawn to a specified 45,000 acre-feet minimum level (shown in Cell Q10 and entered at worksheet CCSF Switch 3.00). Subsequent supplemental releases will be drawn from Hetch Hetchy Reservoir any time storage is less than the Lake Lloyd minimum. The result of entering the supplemental release will cause a recalculation of the entire Model with results refreshed in the worksheet. Lake Lloyd, Hetch Hetchy Reservoir and Don Pedro Reservoir storage is ported from other worksheets to provide the status of their storage as supplemental releases are entered.



San Francisco Water Bank Account Balance Computation and Supplement Release

Unit Title: CFS, CFS, CFS, CFS, CFS, AF, AF, AF, AF, AF, AF

Parameter Title: DP Inflow, La Grange, Fourth Ag, Districts' E, SF Credit/, SF Credit/Debit w/ C, SF WB Eva, SF Water Bank Balan, Max Water Bank Cap, Credit Adj fc, SF Supplemental Release

Acre-foot to CFS conversion divide by : 1.983471

From DonPedro; From Hydrology

Warnings

Advice

Max 740,000
Min 0

(UI 1.31) 0 — (0) N, (1) Y; - Debit; + Credit; Sum: 0

(UI 3.10) 1 — Yes, this method is being used

Min Lloyd Storage for WB Call (acre-feet): 45,000

Min 103,852; Min; Non 76-77; 103,852

Min 84,135; Min; Non 76-77; 114,720

Sum: 171,708; 171,708; 0

SF Water Bank Account Balance Calculation; Supplemental Release and Storage Check

Row	Month Index	Date	Day	Days	DP Inflow CFS	La Grange UF CFS	Fourth Agree Check CFS	Daily Districts' Entitle CFS	SF Credit/ Debit CFS	SF C/D w/ Credit Adj AF	SF Gross WB Balance AF	SF WB Evap Losses AF	SF Net WB Balance 570,000	SF Share RFlood DP AF	SF Max WB Balance AF	WB Neg Flag AF	La Grange Credit Adj in SF WB AF	Mark	Mark	WB Supp Release AF	1st Call Lloyd Release AF	2nd Call HH Release AF	Lloyd Storage AF	HH Storage AF
20	1970.10	10/1/1970	T	31	322	159	2,416	159	163	324	570,324	48	570,000	0	570,000	0	0			0	0	0	200,091	249,349
21	1970.10	10/2/1970	F	31	453	55	2,416	55	398	790	570,790	48	570,000	0	570,000	0	0			0	0	0	200,080	248,379
22	1970.10	10/3/1970	S	31	541	265	2,416	265	276	548	570,548	48	570,000	0	570,000	0	0			0	0	0	200,090	247,622
23	1970.10	10/4/1970	S	31	625	-166	2,416	-166	791	1,569	571,569	48	570,000	0	570,000	0	0			0	0	0	199,278	247,032
24	1970.10	10/5/1970	M	31	75	180	2,416	180	-105	-208	569,792	48	569,744	0	570,000	0	0			0	0	0	199,896	246,150
25	1970.10	10/6/1970	T	31	475	92	2,416	92	383	760	570,504	48	570,000	0	570,000	0	0			0	0	0	199,781	245,360
26	1970.10	10/7/1970	W	31	526	150	2,416	150	376	746	570,746	48	570,000	0	570,000	0	0			0	0	0	199,660	244,595
27	1970.10	10/8/1970	T	31	209	153	2,416	153	56	111	570,111	48	570,000	0	570,000	0	0			0	0	0	199,746	243,730
28	1970.10	10/9/1970	F	31	264	146	2,416	146	118	234	570,234	48	570,000	0	570,000	0	0			0	0	0	199,746	242,867
29	1970.10	10/10/1970	S	31	210	99	2,416	99	111	220	570,220	48	570,000	0	570,000	0	0			0	0	0	199,677	242,119
30	1970.10	10/11/1970	S	31	620	293	2,416	293	327	649	570,649	49	570,000	0	570,000	0	0			0	0	0	199,112	241,661
31	1970.10	10/12/1970	M	31	60	-285	2,416	-285	345	684	570,684	49	570,000	0	570,000	0	0			0	0	0	199,319	240,049
32	1970.10	10/13/1970	T	31	29	335	2,416	335	-306	-607	569,393	48	569,345	0	570,000	0	0			0	0	0	199,568	239,666
33	1970.10	10/14/1970	W	31	192	-15	2,416	-15	207	411	569,755	48	569,707	0	570,000	0	0			0	0	0	199,310	239,002
34	1970.10	10/15/1970	T	31	181	135	2,416	135	46	91	569,798	48	569,749	0	570,000	0	0			0	0	0	199,262	238,351
35	1970.10	10/16/1970	F	31	393	210	2,416	210	183	363	570,112	49	570,000	0	570,000	0	0			0	0	0	199,172	237,490
36	1970.10	10/17/1970	S	31	606	439	2,416	439	167	331	570,331	49	570,000	0	570,000	0	0			0	0	0	199,106	236,626
37	1970.10	10/18/1970	S	31	710	407	2,416	407	303	601	570,601	49	570,000	0	570,000	0	0			0	0	0	198,622	236,098
38	1970.10	10/19/1970	M	31	-115	20	2,416	20	-135	-268	569,732	49	569,684	0	570,000	0	0			0	0	0	199,115	235,023
39	1970.10	10/20/1970	T	31	318	130	2,416	130	188	373	570,057	49	570,000	0	570,000	0	0			0	0	0	199,014	234,169

Figure 5.2-1. WaterBankRel Worksheet .

Warnings and advice are provided in the worksheet when several conditions occur. The snapshots below illustrate the occurrence of these conditions. A warning has been provided (Figure 5.2-2) that a reservoir has likely been depleted by the current operation assumptions. In this particular example, Tuolumne River minimum flows were increased with responsibility shared with CCSF, and a set of supplemental releases were established. In this iteration of results it is discovered in Column X (Hetch Hetchy Reservoir storage) an error (reported as "#N/A") on August 26, 1992 has occurred in the Model. By review of the previous day's storage results for Lake Lloyd (Column W), Hetch Hetchy Reservoir (Column X) and Don Pedro Reservoir (Column Y), and the rate of depletion for each of these reservoirs, it is concluded that Hetch Hetchy Reservoir likely drained on August 26 and thus crashed the Model. Although noted, a negative Water Bank Account Balance (Column M) will not cause the Model to crash. To remedy the condition, the user uses worksheet UserInput to revise (lower) SJPL diversions from Hetch Hetchy Reservoir (UI 4.10 and UI 4.20) and retain water in Hetch Hetchy Reservoir for release. If Don Pedro Reservoir storage was the culprit of causing the Model to crash, the user uses worksheet UserInput to revise (lower) MID and TID canal diversions (UI 2.10, UI 2.20 and UI 2.30 to retain water in Don Pedro Reservoir for release. Alternatively, the user could reduce the scenario's designated minimum flow requirement, which would change flow needed from the upstream systems.

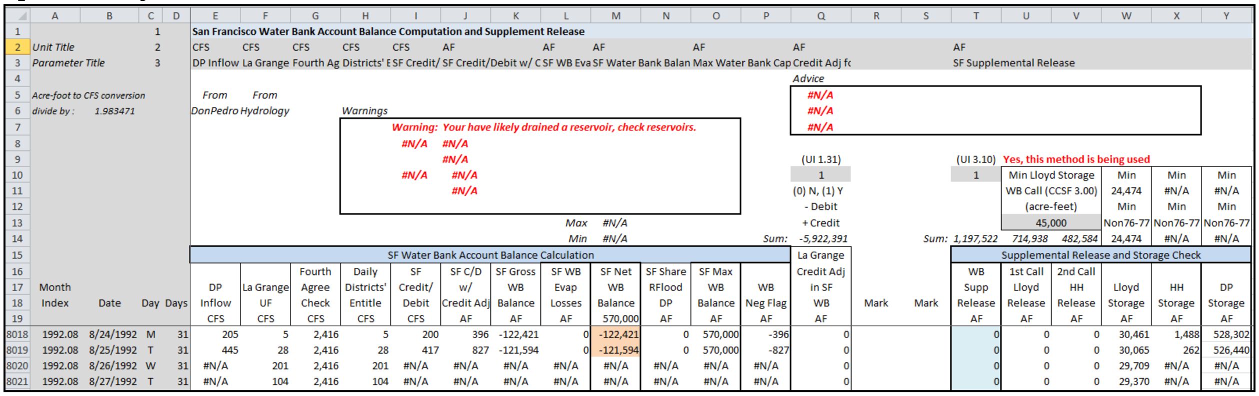


Figure 5.2-2. Example 1: A Reservoir Empties and the Model Crashes.

A second example of warning is shown in Figure 5.2-3, and advises that the Water Bank Account Balance is negative for one or more days of the scenario. In this instance, all Model reservoirs are operating within a viable operation (the Model did not crash due an emptying reservoir); however, the objective to maintain a positive Water Bank Account Balance has been violated. Upon inspection of the results the user can find the first instance of violation and remedy the violation by entry into Column T an amount of release that maintains at least a zero balance in the Water Bank Account Balance. For the first day of violation the reported negative balance (e.g., -3,253 acre-feet) is needed as a supplemental release. The ensuing days of supplemental release are informed by Column P.

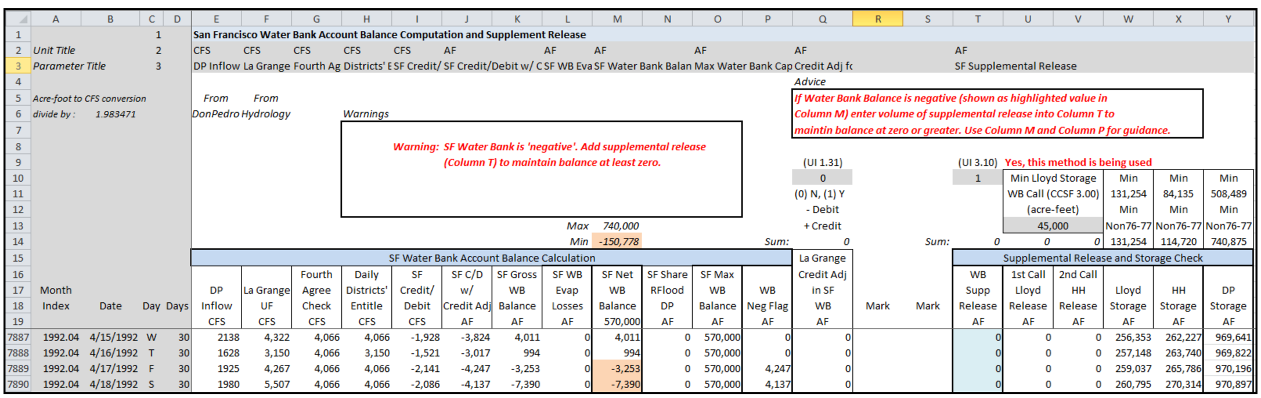


Figure 5.2-3. Example 2: Water Bank Balance is Negative.

It is possible that within the remedy of Example 2 the error exemplified by Example 1 may occur as Hetch Hetchy Reservoir may be drained through the efforts of maintaining a positive Water Bank Account Balance. At that point, the procedures of Example 1 will be required and the values already derived for supplemental releases may need to be revisited and possibly changed.

5.3 Control Worksheet

This worksheet (Control) provides an interface for entering assumptions for reservoir operations and several facility characteristics of District and CCSF facilities. The worksheet is described below.

5.3.1 Contents Description

This section (Figure 5.3-1) provides an index to the contents of this worksheet (Control).

5.3.2 Section 1: Don Pedro Reservoir and District Facilities -Reservoir Management, Preferred Storage Target and Drawdown, Modesto Flood Control Objective, Snowmelt Runoff, and Storage Constraints

This section (Figure 5.3-2) describes the parameters that provide guidance to the management of Don Pedro Reservoir storage and provides entry of several parameters that advise reservoir operations. ACOE and preferred reservoir storage guidance is described. User specified values for specific storage targets are input in Section 4 of this worksheet. The maximum targeted flood flow in the Tuolumne River at Modesto (below Dry Creek) is entered at C 1.00. Releases to the Tuolumne River will be constrained to not exceed this flow level when reservoir space is available in Don Pedro Reservoir to defer releases. Guidance is also provided for the release of anticipated runoff during the snowmelt runoff season. Values entered at C 1.10, C 1.11 and C 1.12 advise the amount of projected excess runoff (from the date of forecast through June) to be released during April, May and June. For instance, the value entered at C 1.10 (30 percent) advises the Model to release 30 percent of the excess runoff volume forecasted to occur during April through June during April. The Model estimates the total excess runoff volume as being the projected inflow to Don Pedro Reservoir less projected canal diversions, reservoir evaporation and minimum Tuolumne River flow requirements, with an objective to fill Don Pedro Reservoir at the end of June. An entry at C 1.20 directs the Model to cease the simulation of power generation at Don Pedro Powerhouse when reservoir storage is below the value. A warning occurs when Don Pedro Reservoir storage is less than the value. The warning informs the study that the reservoir is being simulated below dead pool. The study should be revised through inputs in worksheet UserInput to remedy reservoir storage that is less than dead pool. The entry at C 1.21 informs the Model of the maximum flow through the Don Pedro powerhouse. Releases from Don Pedro Dam in excess of this value is labeled spill or bypassed at the dam.

5.3.3 FERC Minimum Flows

This section (Figure 5.3-3) defines the 1995 FERC minimum flow requirements. Values are entered (C 1.30) for each defined flow period by year type, consistent with the FERC order issued July 31, 1996. Seven year types are defined based on the San Joaquin Basin 60-20-20 water supply index. The sequence year of the flow schedule begins in April and continues through the following March. The water supply index of each year of the simulation period is found in worksheet 602020, and the projection method of the index is defined at C 1.50. For the Test Case condition, the historical actual 60-20-20 index is used. The volume of water interpolated between annual schedules is distributed among April and May in proportion to the values provided at C 1.40 (April) and C 1.41 (May). The total volume of water designated for April and May is distributed daily during April and May is directed by C 1.60. If directed to use an equal distribution of the volume of flow during April and May, C 1.60 is set as 1. If C 1.60 is set as 2, two 7-day pulse flows will occur with the remaining volume evenly spread over the remaining days of the months. The pattern of these schedules can be modified in worksheet LaGrangeSchedule.

5.3.4 Test Case District Canal Demands

This section of parameters (Figure 5.3-4) contributes to the computation of District canal demands. The values entered at C 1.70 for Modesto Irrigation District and at C 1.80 for Turlock Irrigation District are utilized by worksheet DailyCanalsCompute in the projection of daily canal demands for the simulation period. These parameters represent various components of water supplies and disposition that result in the need for canal diversion. These components are combined with the projected demand for applied water associated with lands within the Districts. The projected demand for applied water is provided to the model in worksheet DailyCanalsCompute, and is adjusted by the turnout delivery factor entered in C 1.70 and C 1.80, which adjusts for applied water not associated with immediate consumptive use such as pre-irrigation and groundwater recharge. The computation of daily canal demand is processed by parsing the monthly values of C 1.70 and C 1.80 evenly across the days of a month and combining them with the monthly value of applied water that has been parsed daily in a pattern reflective of recent historical daily diversions for the canals.

5.3.5 Don Pedro Water Supply Factor

The Don Pedro Water Supply Factor directs the reduction of District canal diversions during periods of anticipated limited water supply. The values at C 1.90 (Figure 5.3-5) provide the model with a relationship between water availability at Don Pedro Reservoir and advised canal diversions. The parameters of the relationship is an index of water availability which is computed as the storage in Don Pedro Reservoir at the end of March plus the projected inflow into Don Pedro Reservoir for April through July, and the water supply factor which is applied to projected demand for applied water described above. A water supply factor of 1.00 will provide a diversion equal to projected canal demand (full demand). A water supply factor less than 1.00 will reduce the canal diversion to less than full canal demand.

Operation Control Parameters and Facility Characteristics
Variables Affecting Case and Facility Operation

Contents:

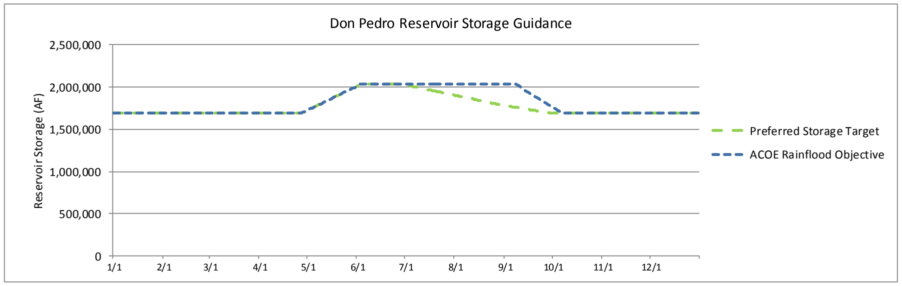
Figure 5.3-1. Contents Description.

Section 1 - Don Pedro Reservoir and District Facilities

Reservoir Management

Rainflood reservoir reservation space according to ACOE manual.

"Flood control reservoir increases uniformly at a rate of 11,700 acre-feet per day from zero requirement on September 8 to the maximum reservation of 340,000 acre-feet by October 7. The reservation is maintained at 340,000 acre-feet through April 27 after which, unless additional reservation is indicated by the snowmelt parameters, it will decrease uniformaly at a rate of 9,200 acre-feet per day to zero requirement by June 3."



Preferred Storage Targets

ACOE through June 30. Target 1,906,000 acre-feet for July 31, 1,782,000 acre-feet August 31, and 1,692,000 acre-feet for September 30. UCOE thereafter.

Modesto flood control objective

(C 1.00) *9,000 cfs. Target flow not to exceed in Tuolumne River below Modesto.*

Snowmelt release forecast parameters

90% exceedence DWR forecast of watershed runoff for April 1 and May 1
Historical watershed runoff for June 1

Release of forecasted excess runoff

(C 1.10)	*30*	*percent of April - June excess runoff during April*
(C 1.11)	*50*	*percent of May - June excess runoff during May*
(C 1.12)	*100*	*percent of June excess runoff during June*

Reservoir Storage Constraints/Objectives

	2,030,000	*acre-feet Maximum reservoir storage*
(C 1.20)	*308,960*	*acre-feet dead pool, cutoff of generation capability/no release**
(C 1.21)	*5,400*	*cfs maximum Don Pedro Powerhouse discharge*

** The Model will not crash upon simulating an operation below dead pool. However, to conform with operational limitations the user is to modify input assumptions to maintain reservoir storage at or above dead pool.*

Figure 5.3-2. Section 1: Don Pedro Reservoir and District Facilities -Reservoir Management, Preferred Storage Target and Drawdown, Modesto Flood Control Objective, Snowmelt Runoff, and Storage Constraints.

FERC Minimum Flow Requirements

FERC Flow Schedules

(C 1.30)

Year Type	1	2	3	4	5	6	7
Oct 1-15 (CFS)	100	100	150	150	180	200	300
Oct 16-31 (CFS)	150	150	150	150	180	175	300
Total Base (AF)	7,736	7,736	9,223	9,223	11,068	11,504	18,447
Attraction (AF)	0	0	0	0	1,676	1,736	5,950
Total Oct (AF)	7,736	7,736	9,223	9,223	12,744	13,240	24,397
Nov (CFS)	150	150	150	150	180	175	300
AF	8,926	8,926	8,926	8,926	10,711	10,413	17,852
Dec (CFS)	150	150	150	150	180	175	300
AF	9,223	9,223	9,223	9,223	11,068	10,760	18,447
Jan (CFS)	150	150	150	150	180	175	300
AF	9,223	9,223	9,223	9,223	11,068	10,760	18,447
Feb (CFS)	150	150	150	150	180	175	300
AF	8,331	8,331	8,331	8,331	9,997	9,719	16,661
Mar (CFS)	150	150	150	150	180	175	300
AF	9,223	9,223	9,223	9,223	11,068	10,760	18,447
Apr (CFS)	150	150	150	150	180	175	300
AF	8,926	8,926	8,926	8,926	10,711	10,413	17,852
May (CFS)	150	150	150	150	180	175	300
AF	9,223	9,223	9,223	9,223	11,068	10,760	18,447
Migration Flow							
AF	11,091	20,091	32,619	37,060	35,920	60,027	89,882
Jun (CFS)	50	50	50	75	75	75	250
AF	2,975	2,975	2,975	4,463	4,463	4,463	14,876
Jul (CFS)	50	50	50	75	75	75	250
AF	3,074	3,074	3,074	4,612	4,612	4,612	15,372
Aug (CFS)	50	50	50	75	75	75	250
AF	3,074	3,074	3,074	4,612	4,612	4,612	15,372
Sep (CFS)	50	50	50	75	75	75	250
AF	2,975	2,975	2,975	4,463	4,463	4,463	14,876
Total Annual	94,001	103,001	117,017	127,508	142,503	165,004	300,926

April - May distribution of spring migration volume

(C 1.40)	16	*parts (days) during April*
(C 1.41)	15	*parts (days) during May*
	31	*parts total during April and May*

Forecast of San Joaquin River Index

(C 1.50)	1	
	1	Actual
	2	90% Exc.
	3	75% Exc.
	4	Med.
	5	10% Exc.

April - May daily parsing of monthly volume of flow

(C 1.60)	2	
	1	Even
	2	2-Pulse

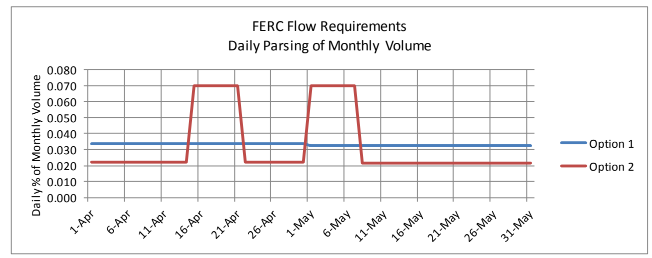


Figure 5.3-3. FERC Minimum Flows.

Test Case Canal Demands

Modesto Irrigation District

(C 1.70)

Month	Turnout Delivery Factor %	Nominal Private GW Pumping TAF	Canal Operation Spills Critical TAF	Canal Operation Spills Non-crit TAF	Canal Losses blw Modesto Reservoir TAF	Intercptd Flows TAF	Nominal MID GW Pumping TAF	Mod Res & Upper Canal Losses TAF	Modesto Reservoir: Municipal Delivery TAF	Modesto Reservoir: Target Storage TAF	Modesto Reservoir: Target Storage Change TAF
Jan	35.0	0.0	2.0	2.0	0.1	0.0	0.0	0.0	2.3	17.0	2.0
Feb	35.0	0.0	2.0	2.0	0.1	0.0	0.0	0.0	2.3	18.0	1.0
Mar	65.0	1.0	1.0	3.0	0.6	0.9	1.0	2.0	2.7	18.0	0.0
Apr	70.0	2.0	3.0	6.0	0.6	0.9	2.3	2.9	2.7	19.0	1.0
May	85.0	3.0	4.0	6.5	0.6	1.2	2.3	3.9	3.0	20.0	1.0
Jun	85.0	4.0	3.5	6.5	0.6	1.0	2.3	4.3	3.2	20.0	0.0
Jul	77.5	4.0	3.5	6.5	0.6	1.0	2.6	4.9	3.3	21.0	1.0
Aug	70.0	4.0	4.9	7.0	0.6	1.4	2.4	4.9	3.3	22.0	1.0
Sep	65.0	2.0	5.0	7.0	0.6	1.2	2.3	4.2	3.3	20.0	-2.0
Oct	40.0	1.0	2.8	6.9	0.6	0.9	2.1	2.0	3.2	17.0	-3.0
Nov	30.0	0.0	2.0	2.0	0.1	0.0	0.0	2.0	2.7	15.0	-2.0
Dec	35.0	0.0	2.0	2.0	0.1	0.0	0.0	0.0	2.5	15.0	0.0
Total		21.0	35.7	57.4	5.4	8.5	17.3	31.1	34.5		

March TO Factor

TO Del Fac Break Point	Factor %
0	65
9.9	65
13.2	65
20	65
9999	65

Turlock Irrigation District

(C 1.80)

Month	Turnout Delivery Factor %	Nominal Private GW Pumping TAF	Canal Operation Spills Critical TAF	Canal Operation Spills Non-crit TAF	Canal Losses blw Turlock Lake TAF	Intercptd Flows TAF	Nominal TID GW Pumping TAF	Turlock Lk & Upper Canal Losses TAF	Turlock Lake: Delivery TAF	Turlock Lake: Target Storage TAF	Turlock Lake: Target Storage Change TAF
Jan	30	0.0	2.0	2.0	0.8	0.0	0.0	1.0	0.0	18.0	5.0
Feb	30	0.0	2.0	2.0	0.8	0.0	0.0	1.0	0.0	25.0	7.0
Mar	65	1.2	3.0	3.0	4.5	0.0	4.1	1.0	0.0	30.0	5.0
Apr	57.5	2.4	5.1	6.3	4.5	0.0	8.0	6.6	0.0	30.0	0.0
May	85	3.6	4.6	6.7	4.5	0.0	10.3	7.7	0.0	32.0	2.0
Jun	92.5	5.2	4.2	6.7	4.5	0.0	12.4	8.2	0.0	32.0	0.0
Jul	72.5	6.4	4.2	6.7	4.5	0.0	14.6	8.7	0.0	32.0	0.0
Aug	62.5	6.2	4.0	7.3	4.5	0.0	13.3	9.0	0.0	30.0	-2.0
Sep	67.5	3.9	3.2	7.3	4.5	0.0	9.1	5.0	0.0	27.0	-3.0
Oct	40	2.4	2.3	7.3	4.5	0.0	5.3	2.0	0.0	13.0	-14.0
Nov	30	0.0	2.0	2.0	0.8	0.0	0.0	1.0	0.0	13.0	0.0
Dec	30	0.0	2.0	2.0	0.8	0.0	0.0	1.0	0.0	13.0	0.0
Total		31.3	38.6	59.3	39.2	0.0	77.1	52.2	0.0		

March TO Factor

TO Del Fac Break Point	Factor %
0	65
19.8	65
27.5	65
40	65
9999	65

Figure 5.3-4. Test Case District Canal Demands.

Don Pedro Water Supply Factor

(C 1.90)

Don Pedro Stor + Infl Index TAF	MTID WS Factor %
0	0.60
1,350	0.60
1,600	0.85
2,000	0.85
2,001	1.00
2,300	1.00
9,999	1.00

The reservoir index method adds the end-of-March Don Pedro Reservoir storage to the projected April through July inflow to assess water availability for diversion.

Figure 5.3-5. Don Pedro Water Supply Factor.

5.3.6 Section 2: City and County of San Francisco Facilities - Hetch Hetchy Reservoir

This section (Figure 5.3-6) provides parameters that direct or advise the operation of Hetch Hetchy Reservoir. Minimum flow releases below Hetch Hetchy Reservoir are directed by C 2.00, C 2.01 and C 2.02. These parameters and schedules are consistent with the stipulations for the Canyon Power Project and the modifications thereof for Kirkwood Powerhouse Unit No. 3. The application of these flow schedules and the addition of 64 cfs to the minimum flow schedule below Hetch Hetchy Reservoir are embedded in model logic in worksheet CCSF.

Values entered at C 2.10 advise the management of reservoir storage throughout a year. The hard limit entered into C 2.10 directs the maximum allowed storage in Hetch Hetchy Reservoir at the end of each month. Model logic will not allow exceedence of these values and will release addition water from the facility if needed to not exceed the values. The soft target, also representing a value at the end of each month, when exceeded advises the Model to make additional releases in order to not exceed that reservoir storage. Model logic computes the storage exceedence, if any, every seventh day and advises a release in addition to minimum releases. The rate of this additional release is equal to the exceedence volume spread over seven days. For transitional months when the soft target value at the end of a month differs from a previous month, the transition in storage target is parsed equally within the days of the month.

Entries at C 2.20 through C 2.24 advise the amount of projected excess runoff (from the date of forecast through June) to be released during February, March, April, May and June. For instance, the value entered at C 2.20 (10 percent) advises the Model to release 10 percent of the excess runoff volume forecasted to occur during the February through June during February. The Model estimates the total excess runoff volume as being the projected inflow to Hetch Hetchy Reservoir less projected San Joaquin Pipeline diversions, deliveries to Groveland and Moccasin Fish Hatchery, reservoir evaporation and minimum flow requirements below Hetch Hetchy Reservoir, with an objective to fill Hetch Hetchy Reservoir at the end of June.

Entries at C 2.25 through C 2.29 work in concert with the advised snowmelt runoff releases, and limit the rate at which those releases will be made. The functionality of the limit provides an ability to manage releases in recognition of downstream facility protection, the efficiency of releases through power generation facilities and reservoir storage goals. The example of C 2.25 being set as 1,200 cfs for February results in the advised snowmelt release being limited to no more than that value regardless of the rate of release advised by the projection of excess runoff. These releases are in addition to the already established minimum releases described previously. C 2.30 and C 2.31 also affect the advisement of snowmelt runoff releases. C 2.30 limits the drawdown of Hetch Hetchy Reservoir for snowmelt runoff, and its value will limit the release to not lower Hetch Hetchy reservoir storage below such value. C 2.31 directs the storage goal for Hetch Hetchy Reservoir at the assumed fill date of the end of June.

5.3.7 Lake Lloyd

The section of parameters that direct or advise the operation of Lake Lloyd (Figure 5.3-7) is very similar in content and structure as the section just described for Hetch Hetchy Reservoir.

Minimum flow releases below Lake Lloyd are directed by C 2.40 and C 2.41. A single schedule of flow requirements is provided for Lake Lloyd and is consistent with the stipulations for the Cherry River Project. The application of the flow schedule is embedded in Model logic in worksheet CCSF. Entry of a value at C 2.41 provides a release from Lake Lloyd through Holm Powerhouse during the months of May through August, established as 950 cfs for four hours per day. The entry at C 2.41 also advises the maximum flow rate through Holm Powerhouse.

Values entered at C 2.50 advise the management of reservoir storage throughout a year. The hard limit entered into C 2.50 directs the maximum allowed storage in Lake Lloyd at the end of each month. Model logic will not allow exceedence of these values and will release addition water from the facility if needed to not exceed the values. The soft target, also representing a value at the end of each month, when exceeded advises the Model to make additional releases in order to not exceed that reservoir storage. Model logic computes the storage exceedence, if any, every seventh day and advises a release in addition to minimum releases. The rate of this additional release is equal to the exceedence volume spread over seven days. For transitional months when the soft target value at the end of a month differs from a previous month, the transition in storage target is parsed equally within the days of the month.

Entries at C 2.60 through C 2.64 advise the amount of projected excess runoff (from the date of forecast through June) to be released during February, March, April, May and June. The model estimates the total excess runoff volume as being the projected inflow to Lake Lloyd less reservoir evaporation, minimum flow requirements below Lake Lloyd and releases to Holm Powerhouse, with an objective to fill Lake Lloyd at the end of June.

Entries at C 2.65 through C 2.69 work in concert with the advised snowmelt runoff releases, and limit the rate at which those releases will be made. C 2.70 and C 2.71 also affect the advisement of snowmelt runoff releases. These releases are in addition to the already established minimum releases described previously. C 2.70 limits the drawdown of Lake Lloyd for snowmelt runoff, and its value will limit the release to not lower Lake Lloyd storage below such value. C 2.71 directs the storage goal for Lake Lloyd at the assumed fill date of the end of June.

5.3.8 Lake Eleanor

This section (Figure 5.3-8) provides parameters that direct or advise the operation of Lake Eleanor. Minimum flow releases below Lake Eleanor are directed by C 2.80. These flow schedules are consistent with the stipulations for the Cherry-Eleanor Pumping Station. The application of these flow schedules are embedded in Model logic in worksheet CCSF, and always assume the schedule associated with pumping. An entry at C 2.81 directs the maximum flow rate through the Eleanor-Cherry Diversion Tunnel. This value may limit the rate at which water can be transferred from Lake Eleanor to Lake Lloyd.

Values entered at C 2.90 advise the management of reservoir storage throughout a year. The hard limit entered into C 2.90 directs the maximum allowed storage in Lake Eleanor at the end of each month. Model logic will not allow exceedence of these values and will release addition water from the facility if needed to not exceed the values. The soft target, also representing a value at the end of each month, when exceeded advises the Model to make additional releases in order to not exceed that reservoir storage. Model logic computes the storage exceedence, if any, every seventh day and advises a release in addition to minimum releases. The rate of this additional release is equal to the exceedence volume spread over seven days. For transitional months when the soft target value at the end of a month differs from a previous month, the transition in storage target is parsed equally within the days of the month.

Entries at C 2a.10 through C 2a.14 advise the amount of projected excess runoff (from the date of forecast through June) to be released during February, March, April, May and June. The model estimates the total excess runoff volume as being the projected inflow to Lake Eleanor less reservoir evaporation and minimum flow requirements below Lake Eleanor, with an objective to fill Lake Eleanor at the end of June.

Entries at C 2a.15 through C 2a.19 work in concert with the advised snowmelt runoff releases, and limit the rate at which those releases will be made. These releases are in addition to the already established minimum releases described previously. C 2a.20 and C 2a.21 also affect the advisement of snowmelt runoff releases. C 2a.20 limits the drawdown of Lake Eleanor for snowmelt runoff, and its value will limit the release to not lower Lake Eleanor storage below such value. C 2a.21 directs the storage goal for Lake Eleanor at the assumed fill date of the end of June.

5.3.9 CCSF Water Supply Parameters

The matrix describing the San Francisco water supply parameters (Figure 5.3-9) provides the model information to report the state of Test Case condition water supply action levels and the potential changes in the occurrence of action level due to alternative operations.

Entries at C 2a.30 represent the relationship between CCSF total system storage (at the end of June each year) and the advisement of water supply actions. Total system storage includes CCSF's local watershed reservoirs, its Hetch Hetchy Project reservoirs, and also the Don Pedro Water Bank Account Balance. Local watershed storage is provided from CCSF's system operation model (HHLSM) as pre-processed values for the simulation period. These values are combined with the Model's depiction of CCSF reservoir storage for the Tuolumne River system to depict total system storage. A water supply action level for each year of each study is determined by the matrix, relating total system storage thresholds to advised action levels. For instance, if total system storage at the end of June of a year is greater than 700,000 acre-feet and less than 1,100,000 acre-feet, an action level of 10 percent rationing is advised. The CCSF Test Case condition SJPL diversions include the effect of occasional water delivery shortages due to these water supply parameters.

Section 2 - CCSF Facilities

Hetch Hetchy Reservoir Control

Minimum releases below reservoir

(C 2.00)

Schedule Index - Accum Inches or Storage			
CY Month	*A (1)*	*B (2)*	*C (3)*
1	8.80	6.10	
2	14.00	9.50	
3	18.60	14.20	
4	23.00	18.00	
5	26.60	19.50	
6	28.45	21.25	
7	575,000	390,000	
8	640,000	400,000	

(C 2.01)

Below Dam Flow Requirement - CFS			
CY Month	*A (1)*	*B (2)*	*C (3)*
1	50	40	35
2	60	50	35
3	60	50	35
4	75	65	35
5	100	80	50
6	125	110	75
7	125	110	75
8	125	72.5	75
9	90	65	62.5
10	60	50	35
11	60	50	35
12	50	40	35

(C 2.02)

	15,000	6,500	4,400
Discretionary Schedule - Acre-feet			
CY Month	*A (1)*	*B (2)*	*C (3)*
1	0	0	0
2	0	0	0
3	0	0	0
4	0	0	0
5	0	0	0
6	0	0	0
7	0	0	0
8	0	0	0
9	0	0	0
10	0	0	0
11	0	0	0
12	0	0	0

Reservoir Management

(C 2.10)

Target Storage - Acre-feet		
CY Month	*Soft Trgt EOM*	*Hard Limit EOM*
1	320,000	360,360
2	320,000	360,360
3	320,000	360,360
4	320,000	360,360
5	360,360	360,360
6	360,360	360,360
7	360,360	360,360
8	360,360	360,360
9	360,360	360,360
10	330,000	360,360
11	320,000	360,360
12	320,000	360,360

Snowmelt release forecast parameters

Historical watershed runoff used for all forecasts of inflow (perfect foresight)

Release of forecasted excess runoff

(C 2.20)	10	*percent of Februay - June excess runoff during February*
(C 2.21)	10	*percent of March - June excess runoff during March*
(C 2.22)	10	*percent of April - June excess runoff during April*
(C 2.23)	100	*percent of May - June excess runoff during June*
(C 2.24)	100	*percent of June excess runoff during June*

Minimum storage of draw down for snowmelt release

(C 2.30) 100,000 *acre-feet*

Maximum advised release for snowmelt

(C 2.25)	1,200	*cfs - February*
(C 2.26)	1,150	*cfs - March*
(C 2.27)	1,200	*cfs - April*
(C 2.28)	100,000	*cfs - May*
(C 2.29)	100,000	*cfs - June*

Target storage for filling at end of June

(C 2.31) 360,360 *acre-feet*

Figure 5.3-6. Hetch Hetchy Reservoir.

Lake Lloyd Control

Minimum releases below reservoir

(C 2.40)

Blw Lake Lloyd - CFS	
CY Month	*Flow Req*
1	5
2	5
3	5
4	5
5	5
6	5
7	15.5
8	15.5
9	15.5
10	5
11	5
12	5

Holm Target Releases

May (Memorial Day) thru (C 2.41)
August (Labor Day)

Holm Capacity	950	*cfs*
Day	1,884	*acre-feet*
4-hours per day	314	*acre-feet*

Reservoir Management

(C 2.50)

Target Storage - Acre-feet		
CY Month	*Soft Trgt EOM*	*Hard Limit EOM*
1	238,000	273,300
2	238,000	273,300
3	238,000	273,300
4	273,300	273,300
5	273,300	273,300
6	273,300	273,300
7	268,000	273,300
8	258,000	273,300
9	248,000	273,300
10	248,000	273,300
11	238,000	273,300
12	238,000	273,300

Snowmelt release forecast parameters

Historical watershed runoff used for all forecasts of inflow (perfect foresight)

Release of forecasted excess runoff

(C 2.60)	20	*percent of Februay - June excess runoff during February*
(C 2.61)	25	*percent of March - June excess runoff during March*
(C 2.62)	33	*percent of April - June excess runoff during April*
(C 2.63)	50	*percent of May - June excess runoff during June*
(C 2.64)	100	*percent of June excess runoff during June*

Minimum storage of draw down for snowmelt release

(C 2.70) 100,000 *acre-feet*

Maximum advised release for snowmelt

(C 2.65)	1,000	*cfs - February*
(C 2.66)	1,000	*cfs - March*
(C 2.67)	1,000	*cfs - April*
(C 2.68)	1,000	*cfs - May*
(C 2.69)	1,000	*cfs - June*

Target storage for filling at end of June

(C 2.71) 273,300 *acre-feet*

Figure 5.3-7. Lake Lloyd.

Lake Eleanor Control

Minimum releases below reservoir

	Blw Lake Eleanor - CFS		
	CY Month	w/Pump Flow Req	w/o Flow Req
(C 2.80)	1	5	5
	2	5	5
	3	10	5
	4	15	5
	5	20	5
	6	20	5
	7	20	16
	8	20	16
	9	15	16
	10	10	5
	11	5	5
	12	5	5

Always uses w/Pump flow requirement

Eleanor to Lloyd tunnel capacity
(C 2.81) 400 cfs

Reservoir Management

	Target Storage - Acre-feet		
	CY Month	Soft Trgt EOM	Hard Limit EOM
(C 2.90)	1	21,495	27,100
	2	21,495	27,100
	3	21,495	27,100
	4	27,100	27,100
	5	27,100	27,100
	6	27,100	27,100
	7	27,100	27,100
	8	27,100	27,100
	9	15,000	27,100
	10	15,000	27,100
	11	15,000	27,100
	12	18,250	27,100

Snowmelt release forecast parameters

Historical watershed runoff used for all forecasts of inflow (perfect foresight)

Release of forecasted excess runoff

(C 2a.10)	20	percent of Februay - June excess runoff during February
(C 2a.11)	25	percent of March - June excess runoff during March
(C 2a.12)	33	percent of April - June excess runoff during April
(C 2a.13)	70	percent of May - June excess runoff during June
(C 2a.14)	100	percent of June excess runoff during June

Minimum storage of draw down for snowmelt release
(C 2a.20) 1,000 acre-feet

Maximum advised release for snowmelt

(C 2a.15)	2,000	cfs - February
(C 2a.16)	2,000	cfs - March
(C 2a.17)	2,000	cfs - April
(C 2a.18)	2,000	cfs - May
(C 2a.19)	2,000	cfs - June

Target storage for filling at end of June
(C 2a.21) 27,100 acre-feet

Figure 5.3-8. Lake Eleanor.

CCSF Water Supply Parameters

	Actions		
	Level	Trigger Tot Sys Stor	Action % Del Reduc
(C 2a.30)	0		0
	1	1,100,000	10
	2	1,100,000	10
	3	700,000	20

Figure 5.3-9. CCSF Water Supply Parameters.

5.3.10 Section 3: Don Pedro Reservoir and CCSF Elevation/Storage/Area and Evaporation Factors

The section (Figure 5.3-10) provides entry of the physical elevation/storage/area relationship for Don Pedro Reservoir and CCSF reservoirs. The values entered at C 3.00 for Hetch Hetchy Reservoir, Lake Lloyd, Lake Eleanor and Don Pedro Reservoir are currently being used by the Model. The Model employs a table lookup function to determine the area of a reservoir based on storage. The area is multiplied by a reservoir's evaporation factor for the estimation of reservoir evaporation. The monthly evaporation factor for CCSF reservoirs is entered at C 3.10 and Don Pedro Reservoir's evaporation factors are entered at C 3.20. These reservoir rating tables and evaporation factors are consistent with the daily accounting of Tuolumne River flows between the Districts and CCSF.

5.3.11 Section 4: Don Pedro Reservoir Flood Control Reservation and Discretionary Target

This section (Figure 5.3-11) provides for the entry of the preferred storage target for Don Pedro Reservoir. Values entered at C 4.00 and C 4.01 advises the management of reservoir storage throughout a year. A hard limit of 2,030,000 acre-feet directs the maximum allowed storage in Don Pedro Reservoir at the end of each month. Model logic will not allow exceedence of these values and will release addition water from the facility if needed to not exceed the values. The soft target ("Final Target Storage" at C 4.00), also representing a value at the end of each day, when exceeded advises the model to make additional releases in order to not exceed that reservoir storage. Model logic computes the storage exceedence, if any, every seventh day and advises a release in addition to minimum releases. The rate of this additional release is equal to the exceedence volume spread over ten days. For transitional months when the soft target value at the end of a month differs from a previous month, the transition in storage target is parsed equally within the days of the month.

The guidance provided by this parameter manages Don Pedro Reservoir storage throughout the year for both ACOE objectives during the season of rain flood reservation space and additional discretionary reservoir storage space or targets to manage reservoir storage from one year to another.

Section 3 - Don Pedro Reservoir and CCSF Reservoir Elevation/Storage/Area and Evaporation Factors

(C 3.00)

Hetch Hetchy Reservoir			Lake Lloyd			Lake Eleanor			Don Pedro Reservoir		
Elev - FT	Stor - AF	Area- Ac	Elev - FT	Stor - AF	Area- Ac	Elev - FT	Stor - AF	Area- Ac	Elev - FT	Stor - AF	Area- Ac
3520.0	410	124.0	4440.0	0.0	5.0	4605.0	0.0	0.0		0	0
3520.1	439	127.9	4440.1	1.0	5.1	4605.1	0.0	2.5		0	0
3520.2	468	131.8	4440.2	2.0	5.1	4605.2	0.0	5.0		0	0
3520.3	497	135.7	4440.3	2.0	5.2	4605.3	1.0	7.6		1	1
3520.4	526	139.6	4440.4	3.0	5.2	4605.4	1.0	10.1		1	1
3520.5	555	143.5	4440.5	4.0	5.3	4605.5	1.0	12.6		3	2
3520.6	583	147.4	4440.6	5.0	5.3	4605.6	2.0	15.1		5	3
3520.7	612	151.3	4440.7	5.0	5.4	4605.7	2.0	17.6		8	3
3520.8	641	155.2	4440.8	6.0	5.4	4605.8	2.0	20.2		12	4
3520.9	670	159.1	4440.9	7.0	5.5	4605.9	2.0	22.7		17	6
3521.0	699	163.0	4441.0	8.0	5.5	4606.0	2.0	25.2	300.0	35	7
3521.1	728	166.9	4441.1	8.0	5.6	4606.1	3.0	27.7		42	7
3521.2	757	170.8	4441.2	9.0	5.6	4606.2	3.0	30.2		50	8
3521.3	786	174.7	4441.3	10.0	5.7	4606.3	3.0	32.7		57	8
3521.4	815	178.6	4441.4	11.0	5.7	4606.4	3.0	35.3		65	8
3521.5	843	182.5	4441.5	11.0	5.8	4606.5	4.0	37.8		74	8
3521.6	872	186.4	4441.6	12.0	5.8	4606.6	4.0	40.3		82	9
3521.7	901	190.3	4441.7	13.0	5.9	4606.7	4.0	42.8		91	9
3521.8	930	194.2	4441.8	14.0	5.9	4606.8	4.0	45.3		100	9
3521.9	959	198.1	4441.9	14.0	6.0	4606.9	5.0	47.9		110	10
3522.0	988	202.0	4442.0	15.0	6.0	4607.0	5.0	50.4	310.0	120	10
3522.1	1017	205.9	4442.1	16.0	6.1	4607.1	5.0	52.9		130	10
3522.2	1046	209.8	4442.2	17.0	6.1	4607.2	5.0	55.4		140	10
3522.3	1075	213.7	4442.3	17.0	6.2	4607.3	6.0	57.9		150	11
3522.4	1104	217.6	4442.4	18.0	6.2	4607.4	6.0	60.4		161	11
3522.5	1133	221.5	4442.5	19.0	6.3	4607.5	6.0	63.0		172	11
3522.6	1161	225.4	4442.6	20.0	6.3	4607.6	6.0	65.5		183	11
3522.7	1190	229.3	4442.7	20.0	6.4	4607.7	7.0	68.0		194	11
3522.8	1219	233.2	4442.8	21.0	6.4	4607.8	7.0	70.5		206	12
3522.9	1248	237.1	4442.9	22.0	6.5	4607.9	7.0	73.0		218	12
3523.0	1277	241.0	4443.0	23.0	6.5	4608.0	7.0	75.6	320.0	229	12
3523.1	1306	244.9	4443.1	23.0	6.6	4608.1	8.0	78.1		242	13
3523.2	1335	248.8	4443.2	24.0	6.6	4608.2	8.0	80.6		255	13
3523.3	1364	252.7	4443.3	25.0	6.7	4608.3	8.0	83.1		268	14
3523.4	1393	256.6	4443.4	26.0	6.7	4608.4	8.0	85.6		283	15
3523.5	1422	260.5	4443.5	26.0	6.8	4608.5	9.0	88.2		297	15

Evaporation Factors

CCSF Reservoirs		(C 3.10)
		CFS/Ac/Day
Jan	1 =	-0.00325
Feb	2 =	-0.0036
Mar	3 =	0
Apr	4 =	0
May	5 =	0.003253
Jun	6 =	0.006722
Jul	7 =	0.009758
Aug	8 =	0.009758
Sep	9 =	0.006722
Oct	10 =	0.003253
Nov	11 =	0
Dec	12 =	0

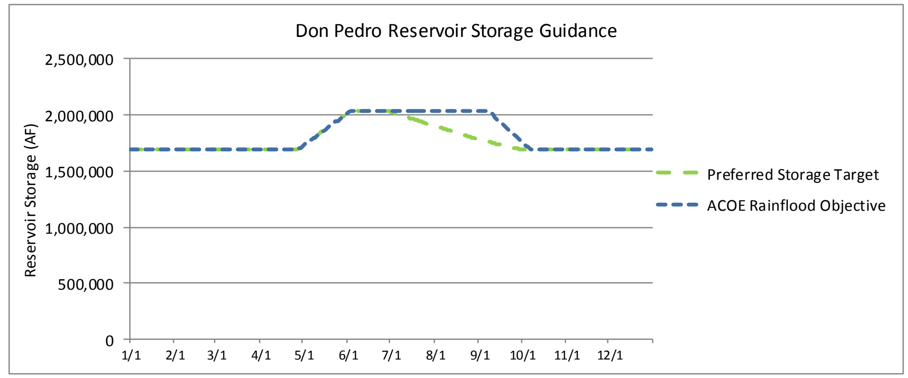
Evaporation Factors

Don Pedro Reservoir		(C 3.20)
		CFS/Ac/Day
Jan	1 =	-0.00088
Feb	2 =	-0.00026
Mar	3 =	0.001135
Apr	4 =	0.003081
May	5 =	0.007968
Jun	6 =	0.010947
Jul	7 =	0.013976
Aug	8 =	0.014109
Sep	9 =	0.01072
Oct	10 =	0.006395
Nov	11 =	0.001781
Dec	12 =	-0.00013

Figure 5.3-10. Don Pedro Reservoir and CCSF Reservoir Characteristics.

Section 4 - Don Pedro Reservoir Flood Control Reservation Space and Preferred Storage Target

	ACOE thru June
Full Res	*1,906,000*
(2,030,000)	*Jul 31*
Less	*1,782,000*
ACOE	*Aug 31*
RF Space	*1,692,000*
	Sep 30
	UCOE
	therefter



(C 4.00)

Don Pedro Reservoir FC/Discretionary/Drawdown Space							
Mo/Day	Mo/Day Index		ACOE RF Space AF	DP RF Storage AF	Add Descr Storage AF	Add Descr Modifier AF	Final Target Storage AF
1/1	1.01		340,000	1,690,000			1,690,000
1/2	1.02		340,000	1,690,000			1,690,000
1/3	1.03		340,000	1,690,000			1,690,000
1/4	1.04		340,000	1,690,000			1,690,000
1/5	1.05		340,000	1,690,000			1,690,000
1/6	1.06		340,000	1,690,000			1,690,000
1/7	1.07		340,000	1,690,000			1,690,000
1/8	1.08		340,000	1,690,000			1,690,000
1/9	1.09		340,000	1,690,000			1,690,000
1/10	1.10		340,000	1,690,000			1,690,000
1/11	1.11		340,000	1,690,000			1,690,000
1/12	1.12		340,000	1,690,000			1,690,000
1/13	1.13		340,000	1,690,000			1,690,000
1/14	1.14		340,000	1,690,000			1,690,000
1/15	1.15		340,000	1,690,000			1,690,000
1/16	1.16		340,000	1,690,000			1,690,000
1/17	1.17		340,000	1,690,000			1,690,000

ACOE Rainflood (AF) End-of-month

Jan	1,690,000	Jul	2,030,000
Feb	1,690,000	Aug	2,030,000
Mar	1,690,000	Sep	1,772,600
Apr	1,717,600	Oct	1,690,000
May	2,002,800	Nov	1,690,000
Jun	2,030,000	Dec	1,690,000

(C 4.01)

	Discretionar Guide AF
1 Jan	0
2 Feb	0
3 Mar	0
4 Apr	0
5 May	0
6 Jun	0
7 Jul	0
8 Aug	0
9 Sep	0
10 Oct	0
11 Nov	0
12 Dec	0

Figure 5.3-11. Don Pedro Reservoir Flood Control and Discretionary Target.

5.4 Output Worksheet

This worksheet (Output) provides an interface between Model computations and summary and analysis tools. It also provides a formatted set of information usable for exchange into an HEC-DSS database file, such as used to provide information to the temperature models used for this FERC investigation. Information concerning HEC-DSS can be found on the HEC web site at: http://www.hec.usace.army.mil/software/hec-dss/hecdss-dss.html

The structure and contents of worksheet Output accommodates the use of the HEC-DSS Excel Data Exchange Add-in which is an application for retrieving and storing interval time series data, in this circumstance the daily results of the Model.

Results provided in worksheet Output are directly linked to the computational and input worksheets of the Model. For instance, the daily inflow to Don Pedro Reservoir listed in worksheet Output is the value provided to worksheet DonPedro for its computations, which is dependent upon several other computation worksheets. As such, any change to model assumptions or data which causes a recalculation by the model will automatically update the values in worksheet Output. To preserve or store the results of a particular model study a copy of the worksheet should be created with a unique tab name and its contents converted to values. The HEC-DSS Add-in could also be used to create a unique database file for later use. Alternatively, but storage consuming, the entire Model could be saved as a unique study. However, this approach is not recommended as the worksheet Output will continue to be dynamically linked to the model's computational worksheets and any subsequent change to model assumptions will overwrite the results previously provided in the worksheet. More than 110 parameters are reported in the worksheet, representing salient information concerning the simulated operations and hydrology of the Tuolumne River and the Districts' and CCSF's facilities. Shown in Figure 5.4-1 is a snapshot of the content and format of the worksheet. Table 5.4-1 provides a listing of the parameters including their HEC-DSS name parts.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	1	TUOLUMNE	TUOLUMNE	TUOLUMNE	TUOLUMNE	TUOLUMNE	TUOLUMNE	TUOLUMNE	TUOLUMNE	TUOLUMNE	TUOLUMNE	TUOLUMNE	TUOLUMNE	TUOLUMNE
2	2	TUOLUMNEI	TUOLUMNEI	TUOLUMNEI	TUOLUMNEI	TUOLUMNEI	DONPEDRO	DONPEDRO	DONPEDRO	DONPEDRO	DONPEDRO	DONPEDRO	DONPEDRO	DONPEDRO
3	3	FLOW-LAGRANGEUNIMP	FLOW-HHUNIMP	FLOW-LLOYDUNIMP	FLOW-ELEANORUNIMP	FLOW-UNREGUNIMP	FLOW-TOTINFLOW	FLOW-SUP1INFLOWLL	FLOW-SUP2INFLOWHH	FLOW-INFLOWHH	FLOW-INFLOWLL	FLOW-INFLOWEL	STORAGE	EVAP
4	4	2	3	4	5	6	7	8	9	10	11	12	13	14
5	5	1DAY	1DAY	1DAY	1DAY	1DAY	1DAY	1DAY	1DAY	1DAY	1DAY	1DAY	1DAY	1DAY
6	6	Test_Base	Test_Base	Test_Base	Test_Base	Test_Base	Test_Base	Test_Base	Test_Base	Test_Base	Test_Base	Test_Base	Test_Base	Test_Base
7	7	1-Oct-70	1-Oct-70	1-Oct-70	1-Oct-70	1-Oct-70	1-Oct-70	1-Oct-70	1-Oct-70	1-Oct-70	1-Oct-70	1-Oct-70	1-Oct-70	1-Oct-70
8	8	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400
9	9	30-Sep-09	30-Sep-09	30-Sep-09	30-Sep-09	30-Sep-09	30-Sep-09	30-Sep-09	30-Sep-09	30-Sep-09	30-Sep-09	30-Sep-09	30-Sep-09	30-Sep-09
10	10	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400
11	11	CFS	CFS	CFS	CFS	CFS	CFS	AF	AF	CFS	CFS	CFS	AF	AF
12		PER_AVER	PER_AVER	PER_AVER	PER_AVER	PER_AVER	PER_AVER	PER_AVER	PER_AVER	PER_AVER	PER_AVER	PER_AVER	PER_AVER	PER_AVER
13	10/1/1970	159	79	56	25	-1	322	0	0	90	223	10	1,666,767	143
14	10/2/1970	55	-82	5	2	130	453	0	0	90	223	10	1,664,567	141
15	10/3/1970	265	25	15	7	218	541	0	0	90	223	10	1,662,719	141
16	10/4/1970	-166	110	-399	-179	302	625	0	0	90	223	10	1,659,892	141
17	10/5/1970	180	-38	322	144	-248	75	0	0	90	223	10	1,656,745	141
18	10/6/1970	92	9	-48	-21	152	475	0	0	90	223	10	1,654,119	141
19	10/7/1970	150	21	-51	-23	203	526	0	0	90	223	10	1,652,009	140
20	10/8/1970	153	-29	54	24	104	209	0	0	90	5	10	1,650,525	140
21	10/9/1970	146	-28	10	5	159	264	0	0	90	5	10	1,648,926	140
22	10/10/1970	99	30	-25	-11	105	210	0	0	90	5	10	1,647,059	140
23	10/11/1970	293	176	-275	-123	515	620	0	0	90	5	10	1,645,737	140

Figure 5.4-1. Sample Parameters Listed in Output Worksheet.

Table 5.4-1. Columnar Description for Parameters Listed in Output Worksheet.

Column	Col No	DSS - Part B	DSS - Part C	Units	Description
B	2	TUOLUMNERIVER	FLOW-LAGRANGEUNIMP	CFS	Unimpaired flow of Tuolumne River as computed at "La Grange"
C	3	TUOLUMNERIVER	FLOW-HHUNIMP	CFS	Unimpaired flow at Hetch Hetchy Reservoir (inflow)
D	4	TUOLUMNERIVER	FLOW-LLOYDUNIMP	CFS	Unimpaired flow at Lake Lloyd (inflow)
E	5	TUOLUMNERIVER	FLOW-ELEANORUNIMP	CFS	Unimpaired flow at Lake Eleanor (inflow)
F	6	TUOLUMNERIVER	FLOW-UNREGUNIMP	CFS	Unregulated inflow into Don Pedro Reservoir
G	7	DONPEDRO	FLOW-TOTINFLOW	CFS	Total inflow into Don Pedro Reservoir
H	8	DONPEDRO	FLOW-SUP1INFLOWLL	AF	Supplemental release from Lake Lloyd
I	9	DONPEDRO	FLOW-SUP2INFLOWHH	AF	Supplemental release from Hetch Hetchy Reservoir
J	10	DONPEDRO	FLOW-INFLOWHH	CFS	Total inflow into Don Pedro Reservoir from Hetch Hetchy Reservoir
K	11	DONPEDRO	FLOW-INFLOWLL	CFS	Total inflow into Don Pedro Reservoir from Lake Lloyd
L	12	DONPEDRO	FLOW-INFLOWEL	CFS	Total inflow into Don Pedro Reservoir from Lake Eleanor
M	13	DONPEDRO	STORAGE	AF	Don Pedro Reservoir storage
N	14	DONPEDRO	EVAP	AF	Don Pedro Reservoir evaporation
O	15	DONPEDRO	STORAGE-RFTRG	AF	Don Pedro Reservoir storage target assuming USCOE rainflood reservation space
P	16	DONPEDRO	STORAGE-SOFTTRG	AF	Don Pedro Reservoir storage target assuming USCOE rainflood reservation space and other guidance
Q	17	DONPEDRO	RELEASE-7DAYENCRADVISE	CFS	Don Pedro Reservoir advised release for target storage enchroachment
R	18	DONPEDRO	RELEASE-SNOWADVISE	CFS	Don Pedro Reservoir advised release for spring-time snowmelt release
S	19	DONPEDRO	RELEASE-TOTAL	CFS	Don Pedro Reservoir total release
T	20	DONPEDRO	POWR-MW	MW	Don Pedro Powerplant Capability
U	21	DONPEDRO	POWR-EFF	kWh/AF	Don Pedro Powerplant efficiency
V	22	DONPEDRO	POWR-MWh	MWh	Don Pedro Powerplant energy production
W	23	DONPEDRO	RELEASE-PH	AF	Don Pedro Powerplant release
X	24	DONPEDRO	RELEASE-BYPASS	AF	Don Pedro Powerplant bypass release
Y	25	DONPEDRO	FLOW-TOTCANALS	AF	Don Pedro Reservoir release for combined MID/TID canals
Z	26	LAGRANGE	RELEASE-MINQ	CFS	Minimum Tuolumne River release requirement (at La Grange)
AA	27	LAGRANGE	RELEASE-TOTAL	CFS	Total Tuolumne River Release below La Grange Dam
AB	28	LAGRANGE	RELEASE-MCANAL	CFS	Diversion to Modesto Canal
AC	29	LAGRANGE	RELEASE-TCANAL	CFS	Diversion to Turlock Canal
AD	30	LAGRANGE	FULLCANALREQ	AF	Full canal demand of combined MID/TID canals
AE	31	RIVER	FLOW-LTRACC1	CFS	Lower Tuolumne River accretion 1 (placeholder)
AF	32	RIVER	FLOW-LTRACC2	CFS	Lower Tuolumne River accretion 2 (placeholder)
AG	33	RIVER	FLOW-LTRACC3	CFS	Lower Tuolumne River accretion 3 (placeholder)
AH	34	RIVER	FLOW-LTRACC4	CFS	Lower Tuolumne River accretion 4 (currently contains synthetic record of accretion blw La Grange)
AI	35	RIVER	FLOW-DRYCK	CFS	Tuolumne River inflow from Dry Creek
AJ	36	RIVER	FLOW-LTRACC5	CFS	Lower Tuolumne River accretion 5 (placeholder)
AK	37	RIVER	FLOW-TR1	CFS	Lower Tuolume River flow at end of accretion reach 1 (placeholder)
AL	38	RIVER	FLOW-TR2	CFS	Lower Tuolume River flow at end of accretion reach 2 (placeholder)
AM	39	RIVER	FLOW-TR3	CFS	Lower Tuolume River flow at end of accretion reach 3 (placeholder)
AN	40	RIVER	FLOW-TR4	CFS	Lower Tuolume River flow at end of accretion reach 4 (placeholder)
AO	41	RIVER	FLOW-MODMAX	CFS	Target flow for Tuolumne River below Modesto
AP	42	RIVER	FLOW-MODMAXLG	CFS	Maximum target release from La Grange to not exceed target flow below Modesto
AQ	43	RIVER	FLOW-MODESTO	CFS	Flow of Tuolumne River below Modesto
AR	44	RIVER	FLOW-TR5	CFS	Lower Tuolume River flow at end of accretion reach 5 (placeholder)
AS	45	MIDCANAL	MIDAGPDAW	AF	Projected demand for applied water in MID
AT	46	MIDCANAL	MIDMI	AF	Projected demand for municipal and industrial uses from MID
AU	47	MIDCANAL	MIDFACT	PERCENT	Adjustment factor between MID PDAW and canal turnouts
AV	48	MIDCANAL	MIDNOMGWPRVT	AF	Nominal private groundwater pumping in MID
AW	49	MIDCANAL	MIDOPSPLS	AF	MID Canal operation spills
AX	50	MIDCANAL	MIDLOSS	AF	MID Canal losses
AY	51	MIDCANAL	MIDINTCP	AF	MID Canal intercepted other flows
AZ	52	MIDCANAL	MIDNOMGWDIST	AF	MID nominal district groundwater pumping
BA	53	MIDCANAL	MIDUPSYSLOSSDIV	AF	MID Canal upper system losses including seepage from Modesto Lake
BB	54	MIDCANAL	MIDLKDIV	AF	Modesto Lake diversions (water treatment plant)
BC	55	MIDCANAL	MIDLKSTORCHNG	AF	Modesto Lake change in storage
BD	56	MIDCANAL	MIDFULLREQ	AF	Full canal demand of MID

Column	Col No	DSS - Part B	DSS - Part C	Units	Description
BE	57	TIDCANAL	TIDAGPDAW	AF	Projected demand for applied water in TID
BF	58	TIDCANAL	TIDMI	AF	Projected demand for municipal and industrial uses from TID (placeholder)
BG	59	TIDCANAL	TIDFACT	PERCENT	Adjustment factor between TID PDAW and canal turnouts
BH	60	TIDCANAL	TIDNOMGWPRVT	AF	Nominal private groundwater pumping in TID
BI	61	TIDCANAL	TIDOPSPLS	AF	TID Canal operation spills
BJ	62	TIDCANAL	TIDLOSS	AF	TID Canal losses
BK	63	TIDCANAL	TIDINTCP	AF	TID Canal intercepted other flows
BL	64	TIDCANAL	TIDNOMGWDIST	AF	TID nominal district groundwater pumping
BM	65	TIDCANAL	TIDUPSYSLOSSDIV	AF	TID Canal upper system losses including seepage from Modesto Lake
BN	66	TIDCANAL	TIDLKDIV	AF	Turlock Lake diversions (placeholder)
BO	67	TIDCANAL	TIDLKSTORCHNG	AF	Turlock Lake change in storage
BP	68	TIDCANAL	TIDFULLREQ	AF	Full canal demand of TID
BQ	69	DONPEDRO	DPFACT	UNIT	Don Pedro water supply factor
BR	70	SANFRAN	SFSJPLBASE	AF	CCSF San Joaquin Pipeline diversion - Comparison base
BS	71	SANFRAN	SFLOCALSTOR	AF	CCSF Local Bay Area System reservoir storage
BT	72	SANFRAN	SFSJPL	AF	CCSF San Joaquin Pipeline diversion - scenario
BU	73	SANFRAN	SFTOTSYSSTOR	AF	CCSF total system reservoir storage
BV	74	SANFRAN	SFTOTTRSYSSTOR	AF	CCSF total Tuolumne River system reservoir storage
BW	75	SANFRAN	SFSUPPREL	UNIT	CCSF total supplemental release
BX	76	SANFRAN	SFSUPPTAB	UNIT	CCSF supplemental release directed by year type table
BY	77	SANFRAN	TRIGGER	UNIT	CCSF water supply action level
BZ	78	SANFRAN	WBBAL	UNIT	CCSF Water Bank Account balance
CA	79	HETCH	HATCH-GRVLND	CFS	Moccasin Hatchery and Groveland flow requirements
CB	80	HETCH	HATCH-RTRN	CFS	Return flow to Tuolumne River from Mocassin Hatchery
CC	81	HETCH	RELEASE-MINQ1	CFS	Hetch Hetchy Reservoir flow requirement (below dam) prior to Canyon Tunnel stipulation
CD	82	HETCH	RELEASE-TOTMINQ	CFS	Hetch Hetchy Reservoir flow requirement (below dam) after consideration of Canyon Tunnel flow
CE	83	HETCH	RELEASE-7DAYENCRADVISE	CFS	Hetch Hetchy Reservoir advised release for target storage enchroachment
CF	84	HETCH	RELEASE-SNOWADVISE	CFS	Hetch Hetchy Reservoir advised release for spring-time snowmelt release
CG	85	HETCH	RELEASE-TOTAL	CFS	Hetch Hetchy Reservoir total release
CH	86	HETCH	STORAGE	AF	Hetch Hetchy Reservoir storage
CI	87	HETCH	EVAP	AF	Hetch Hetchy Reservoir evaporation
CJ	88	HETCH	STORAGE-SOFTTRG	AF	Hetch Hetchy Reservoir storage target
CK	89	LLOYD	RELEASE-MINSTRMQ	CFS	Lake Lloyd flow requirement (below dam)
CL	90	LLOYD	RELEASE-MINHOLM	CFS	Minimum Lake Lloyd release to Holm Powerplant
CM	91	LLOYD	RELEASE-7DAYENCRADVISE	CFS	Lake Lloyd advised release for target storage enchroachment
CN	92	LLOYD	RELEASE-SNOWADVISE	CFS	Lake Lloyd advised release for snowmelt release
CO	93	LLOYD	RELEASE-LLOYDONLYHOLM	CFS	Lake Lloyd release to Holm Powerplant (Lake Lloyd operation)
CP	94	LLOYD	HOLMAVAILEL	CFS	Available capacity at Holm Powerplant for Eleanor transfer
CQ	95	LLOYD	RELEASE-TOTHOLM	CFS	Total Holm Powerplant flow
CR	96	LLOYD	RELEASE-TOTLLOYD	CFS	Lake Lloyd total release
CS	97	LLOYD	STORAGE	AF	Lake Lloyd storage
CT	98	LLOYD	EVAP	AF	Lake Lloyd evaporation
CU	99	LLOYD	STORAGE-SOFTTRG	AF	Lake Lloyd storage target
CV	100	ELEANOR	RELEASE-MINSTRMQ	CFS	Lake Eleanor flow requirement (below dam)
CW	101	ELEANOR	RELEASE-7DAYENCRADVISE	CFS	Lake Eleanor advised release for target storage enchroachment
CX	102	ELEANOR	RELEASE-SNOWADVISE	CFS	Lake Eleanor advised release for snowmelt release
CY	103	ELEANOR	TUNTRNSFCAP	CFS	Eleanor - Lloyd tunnel capacity
CZ	104	ELEANOR	FLOW-TUNNEL	CFS	Eleanor - Lloyd tunnel flow
DA	105	ELEANOR	RELEASE-STREAM	CFS	Lake Eleanor release to stream
DB	106	ELEANOR	RELEASE-TOTELEANOR	CFS	Lake Eleanor total release
DC	107	ELEANOR	STORAGE	AF	Lake Eleanor storage
DD	108	ELEANOR	EVAP	AF	Lake Eleanor evaporation
DE	109	ELEANOR	STORAGE-SOFTTRG	AF	Lake Eleanor storage target
DF	110	TUOLUMNERIVER	YEARMON	UNIT	Calendar year and month (YYYY.MM)
DG	111	LAGRANGE	CCSFLAGRANGERESP	AF	CCSF La Grange release responsibility
DH	112	TUOLUMNERIVER	SWITCHES	UNIT	Echo values of input from UserInput and Control worksheets

5.5 DSSAnyGroup Worksheet

This worksheet (DSSAnyGroup) provides plotting of up to ten parameters provided in worksheet Output or another equally formatted worksheet of results. One calendar year (the same year or different years) of data for a parameter can be plotted. The parameter(s) to be plotted are identified by reference worksheet name and column. Figure 5.5-1 is a snapshot of the identification parameters and result values.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	**DSSAnyGroup**													
2	This sheet illustrates a CY of daily results from Model sheets in graphic format.													
3	Axis Reference	1		1		2		2		2		2		1
4	Enter CY Graph Year:	1984		1984		1984		1984		1984		1984		1984
5	Enter Sheet Name:	OUTPUT1		OUTPUT2		OUTPUT2		OUTPUT1		OUTPUT		OUTPUT2		OUTPUT
6	Column:	#N/A		13		27		#N/A		26		26		#N/A
7	Enter Column:			M		AA				Z		Z		
8	Data Reference:	#REF!	Date	DONPEDRO STORAGE - AF (OUTPUT2)	Date	LAGRANGE RELEASE-TOTAL - CFS (OUTPUT2)	Date	#REF!	Date	LAGRANGE RELEASE-MINQ - CFS (OUTPUT)	Date	LAGRANGE RELEASE-MINQ - CFS (OUTPUT2)	Date	#REF!
9	Enter Scaler:	1		1		1		1		1		1		1
10	1-Jan-84	#REF!	1-Jan-84	1,765,400	1-Jan-84	8,681	1-Jan-84	#REF!	1-Jan-84	300	1-Jan-84	300	1-Jan-84	#REF!
11	2-Jan-84	#REF!	2-Jan-84	1,762,808	2-Jan-84	8,732	2-Jan-84	#REF!	2-Jan-84	300	2-Jan-84	300	2-Jan-84	#REF!
12	3-Jan-84	#REF!	3-Jan-84	1,759,443	3-Jan-84	8,758	3-Jan-84	#REF!	3-Jan-84	300	3-Jan-84	300	3-Jan-84	#REF!
13	4-Jan-84	#REF!	4-Jan-84	1,757,150	4-Jan-84	8,773	4-Jan-84	#REF!	4-Jan-84	300	4-Jan-84	300	4-Jan-84	#REF!
14	5-Jan-84	#REF!	5-Jan-84	1,749,651	5-Jan-84	8,683	5-Jan-84	#REF!	5-Jan-84	300	5-Jan-84	300	5-Jan-84	#REF!
15	6-Jan-84	#REF!	6-Jan-84	1,741,186	6-Jan-84	8,683	6-Jan-84	#REF!	6-Jan-84	300	6-Jan-84	300	6-Jan-84	#REF!
16	7-Jan-84	#REF!	7-Jan-84	1,735,636	7-Jan-84	8,683	7-Jan-84	#REF!	7-Jan-84	300	7-Jan-84	300	7-Jan-84	#REF!
17	8-Jan-84	#REF!	8-Jan-84	1,726,314	8-Jan-84	8,683	8-Jan-84	#REF!	8-Jan-84	300	8-Jan-84	300	8-Jan-84	#REF!
18	9-Jan-84	#REF!	9-Jan-84	1,718,101	9-Jan-84	8,683	9-Jan-84	#REF!	9-Jan-84	300	9-Jan-84	300	9-Jan-84	#REF!
19	10-Jan-84	#REF!	10-Jan-84	1,708,161	10-Jan-84	8,683	10-Jan-84	#REF!	10-Jan-84	300	10-Jan-84	300	10-Jan-84	#REF!
20	11-Jan-84	#REF!	11-Jan-84	1,696,327	11-Jan-84	8,683	11-Jan-84	#REF!	11-Jan-84	300	11-Jan-84	300	11-Jan-84	#REF!
21	12-Jan-84	#REF!	12-Jan-84	1,691,421	12-Jan-84	5,421	12-Jan-84	#REF!	12-Jan-84	300	12-Jan-84	300	12-Jan-84	#REF!
22	13-Jan-84	#REF!	13-Jan-84	1,686,396	13-Jan-84	5,421	13-Jan-84	#REF!	13-Jan-84	300	13-Jan-84	300	13-Jan-84	#REF!
23	14-Jan-84	#REF!	14-Jan-84	1,680,358	14-Jan-84	5,421	14-Jan-84	#REF!	14-Jan-84	300	14-Jan-84	300	14-Jan-84	#REF!
24	15-Jan-84	#REF!	15-Jan-84	1,674,328	15-Jan-84	5,421	15-Jan-84	#REF!	15-Jan-84	300	15-Jan-84	300	15-Jan-84	#REF!
25	16-Jan-84	#REF!	16-Jan-84	1,669,263	16-Jan-84	5,421	16-Jan-84	#REF!	16-Jan-84	300	16-Jan-84	300	16-Jan-84	#REF!

Figure 5.5-1. DSSAnyGroup Worksheet Input Interface.

Values are plotted to either the primary y-axis or secondary y-axis. The "axis reference" indicates to which axis the value will be plotted by default. The designation of y-axis assignment is not modified by this field, and the user must edit the series data within the plot to change the y-axis assignment, graph type or line or shape characteristics. The "enter graph year" is a user entry. The same year or different year of a parameter or multiple parameters can be plotted. "Sheet name" is a user entry, and identifies from which Output-formatted worksheet the parameter is to be acquired. The "enter column" entry identifies from which column the parameter occurs. Refer to Table 5.4-1 of the description for worksheet Output for the identification of the column associated with each parameter. Upon proper entry of a parameter a return of the parameter's label and source worksheet will occur in the "data reference" field. Values for the specified calendar year will also be returned in the data field. If a plotting position is not used, a "#VALUE!" or "#REF!" will be returned. The "scaler" field is provided to allow the conversion or scaling of the data returned from the result worksheet. For instance, if the daily data occurs in the result worksheet in units of daily average flow (cfs) it could be plotted in units of daily volume (acre-feet) by entering the conversion factor of 1.983471. The entry in the field acts as a multiplier to the value occurring in the result worksheet. This field can also be used to scale two different "order of magnitude" parameters to use the same y-axis.

The results of up to ten parameters will be plotted. An example of the several plotted parameters from two different studies is shown in Figure 5.5-2.

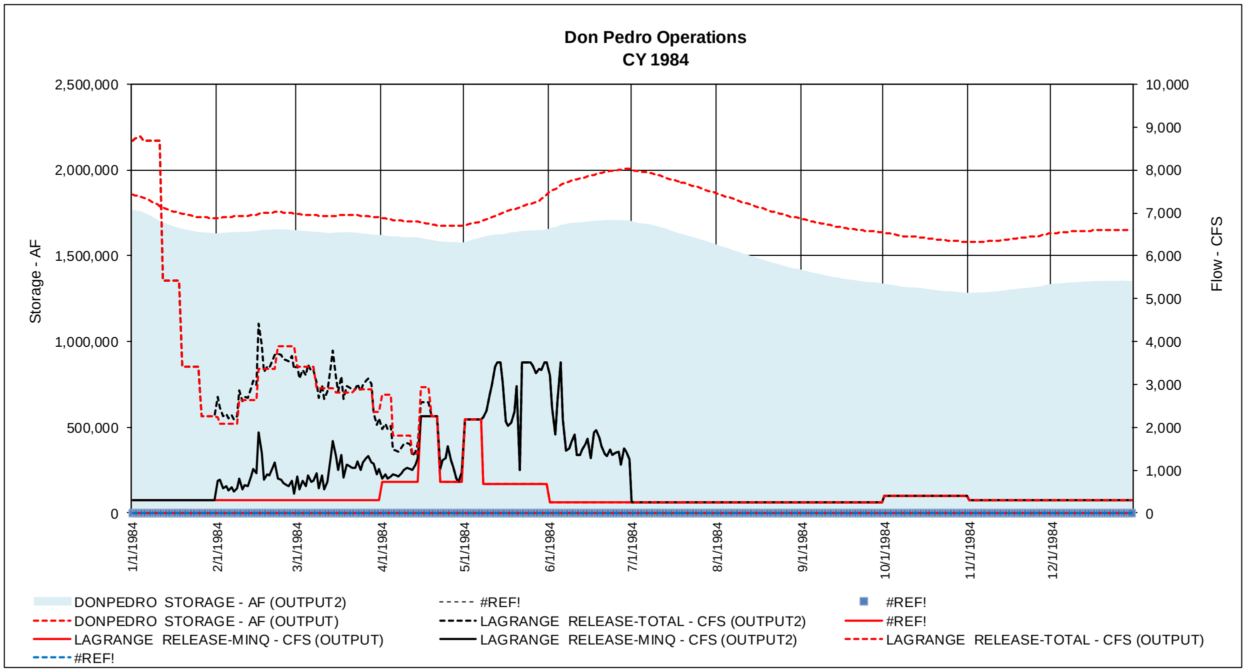


Figure 5.5-2. DSSAnyGroup Worksheet Plotting.

Unused plotting positions will appear with values plotted at "zero" and will have legends of "#VALUE!" or "#REF!". To create graphs without unused positions a copy of the plot can be made and positioned elsewhere in the worksheet. The unwanted positions can then be deleted from the plot.

5.6 DSSMonthTable Worksheet

This worksheet (DSSMonthTable) provides summation or averaging, and plotting of up to four parameters provided in worksheet Output or another equally formatted worksheet of results. The function of this worksheet is to provide a synthesis of the daily result data into monthly results thus reducing the handling and display of over 14,000 values for each parameter (39 years of days) to 468 values (39 years of months).

The parameter(s) to be plotted or tabled are identified by reference worksheet name and column, very similarly to the method identified for worksheet DSSAnyGroup. Figure 5.6-1 is a snapshot of the identification parameters and result values.

Each parameter is tabled and plotted separately for the entire 39-year simulation period. "Sheet name" is a user entry, and identifies from which Output-formatted worksheet the parameter is to be acquired. The "enter column letter" entry identifies from which column the parameter occurs. Refer to Table 5.4-2 of the description for worksheet Output for the identification of the column associated with each parameter. Upon proper entry of a parameter a return of the parameter's label, source worksheet and the native unit of the parameter will occur. Depending on need, the "conversion" entry is provided. This entry, a keyed value of 0 to 5, directs the worksheet on the handling of the daily data. An entry of 1 will direct the worksheet to sum the daily data into monthly increments in the parameter's native units (e.g., daily acre-feet into monthly volumes).

An entry of 1 will convert the daily data from a native unit of flow (cfs) into monthly volumes of acre-feet. An entry of 2 will convert the daily data from a native unit of volume (acre-feet) into a monthly sum of daily flow in units of cfs. An entry of 3 will act as an entry of 1 except convert the result into monthly volumes with units of 1,000 acre-feet. An entry of 4 will table and plot the daily value associated with the last day of each month in its native unit, and is primarily intended to analyze reservoir storage. An entry of 5 will report the average of daily values within a month. Depending on the entry in the conversion field, the converted unit will be returned to "converted unit" field. Values for the each month of the simulation period will also be returned in the data field. If a plotting position is not used, a "#VALUE!" or "#REF!" will be returned.
A "scaler" field is also provided for each parameter (in the row above the data fields) to allow the conversion or scaling of the data returned from the result worksheet. The results of up to four parameters will be tabled and plotted. Examples of the formats of reports are shown below.

5				Conversion Key:			
6				0	1 >> 1	Native	1
7				1	CFS >> AF	AF	1.9834700
8				2	AF >> CFS	CFS	0.5041669
9				3	CFS >> TAF	TAF	0.0019835
10				4	EOM Stor	AF	1
11				5	Ave Day	Native	1
12			Enter Conversion (0-5):	4	4	4	4
13			Enter Sheet Name:	Output	Output1	Output3c	Output2b
14			Enter Column Letter:	M	M	M	M
15			Column No:	13	13	13	13
16			Label:	O STORAG	D STORAGE	STORAGE	) STORAGE
17			Native Unit:	AF	AF	AF	AF
18			Convert Unit:	AF	AF	AF	AF
19	Index	Date	Day	1	1	1	1
20	1970.10	10/1/1970	T	1,666,767	1,666,767	1,666,767	1,666,969
21	1970.10	10/2/1970	F	1,664,567	1,664,567	1,664,567	1,664,971
22	1970.10	10/3/1970	S	1,662,719	1,662,719	1,662,719	1,663,323
23	1970.10	10/4/1970	S	1,659,892	1,659,892	1,659,892	1,660,699
24	1970.10	10/5/1970	M	1,656,745	1,656,745	1,656,745	1,657,753
25	1970.10	10/6/1970	T	1,654,119	1,654,119	1,654,119	1,655,329

Figure 5.6-1. DSSMonthTable Worksheet Input Interface.

5.6.1 Standardized Tables

An example of a standardized table for the illustration of results is shown in Table 5.6-1. (Table 1 Form). In this example the current minimum daily flow requirement at La Grange Bridge has been synthesized into monthly volumes for the simulation period, and water year totals and for the annual period February through January.

Conversion (0-5):	1
Sheet Name:	Output1
Column Letter:	Z
Column No:	26
Label:	ELEASE-MI
Native Unit:	CFS
Convert Unit:	AF

Table 5.6-1. Table 1 Form (units of volume).

Table 1
LAGRANGE RELEASE-MINQ (Output1)
AF

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total	Feb-Jan
1971	24,397	17,851	18,447	18,447	16,661	18,447	66,685	63,515	4,463	4,612	4,612	4,463	262,598	228,631
1972	13,240	10,413	10,760	10,760	9,719	10,760	30,288	29,251	2,975	3,074	3,074	2,975	137,292	128,713
1973	9,223	8,926	9,223	9,223	8,331	9,223	64,241	61,936	14,876	15,372	15,372	14,876	240,823	283,369
1974	24,397	17,851	18,447	18,447	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	300,923	300,923
1975	24,397	17,851	18,447	18,447	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	300,923	300,923
1976	24,397	17,851	18,447	18,447	16,661	18,447	20,153	19,749	2,975	3,074	3,074	2,975	166,250	122,217
1977	7,736	8,926	9,223	9,223	8,331	9,223	14,649	14,589	2,975	3,074	3,074	2,975	94,000	94,000
1978	7,736	8,926	9,223	9,223	8,331	9,223	64,241	61,936	14,876	15,372	15,372	14,876	239,336	283,369
1979	24,397	17,851	18,447	18,447	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	300,923	300,923
1980	24,397	17,851	18,447	18,447	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	300,923	300,923
1981	24,397	17,851	18,447	18,447	16,661	18,447	29,339	28,532	4,463	4,612	4,612	4,463	190,269	156,718
1982	12,744	10,711	11,068	11,068	9,997	11,068	64,241	61,936	14,876	15,372	15,372	14,876	253,329	286,880
1983	24,397	17,851	18,447	18,447	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	300,923	300,923
1984	24,397	17,851	18,447	18,447	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	300,923	300,923
1985	24,397	17,851	18,447	18,447	16,661	18,447	34,656	33,346	4,463	4,612	4,612	4,463	200,400	157,854
1986	9,223	8,926	9,223	9,223	8,331	9,223	64,241	61,936	14,876	15,372	15,372	14,876	240,823	283,369
1987	24,397	17,851	18,447	18,447	16,661	18,447	24,481	23,806	2,975	3,074	3,074	2,975	174,636	130,603
1988	7,736	8,926	9,223	9,223	8,331	9,223	14,649	14,589	2,975	3,074	3,074	2,975	94,000	94,000
1989	7,736	8,926	9,223	9,223	8,331	9,223	25,991	25,222	2,975	3,074	3,074	2,975	115,975	115,975
1990	7,736	8,926	9,223	9,223	8,331	9,223	19,362	19,008	2,975	3,074	3,074	2,975	103,131	103,131
1991	7,736	8,926	9,223	9,223	8,331	9,223	25,870	25,109	2,975	3,074	3,074	2,975	115,740	115,740
1992	7,736	8,926	9,223	9,223	8,331	9,223	19,995	19,601	2,975	3,074	3,074	2,975	104,357	104,357
1993	7,736	8,926	9,223	9,223	8,331	9,223	64,241	61,936	14,876	15,372	15,372	14,876	239,336	283,369
1994	24,397	17,851	18,447	18,447	16,661	18,447	25,903	25,140	2,975	3,074	3,074	2,975	177,391	134,846
1995	9,223	8,926	9,223	9,223	8,331	9,223	64,241	61,936	14,876	15,372	15,372	14,876	240,823	283,369
1996	24,397	17,851	18,447	18,447	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	300,923	300,923
1997	24,397	17,851	18,447	18,447	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	300,923	300,923
1998	24,397	17,851	18,447	18,447	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	300,923	300,923
1999	24,397	17,851	18,447	18,447	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	300,923	300,923
2000	24,397	17,851	18,447	18,447	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	300,923	300,923
2001	24,397	17,851	18,447	18,447	16,661	18,447	28,572	27,642	4,463	4,612	4,612	4,463	188,612	146,067
2002	9,223	8,926	9,223	9,223	8,331	9,223	32,729	31,539	4,463	4,612	4,612	4,463	136,567	136,567
2003	9,223	8,926	9,223	9,223	8,331	9,223	55,641	53,161	4,463	4,612	4,612	4,463	181,101	189,680
2004	13,240	10,413	10,760	10,760	9,719	10,760	28,696	27,758	4,463	4,612	4,612	4,463	140,257	131,678
2005	9,223	8,926	9,223	9,223	8,331	9,223	64,241	61,936	14,876	15,372	15,372	14,876	240,823	283,369
2006	24,397	17,851	18,447	18,447	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	300,923	300,923
2007	24,397	17,851	18,447	18,447	16,661	18,447	26,085	25,310	2,975	3,074	3,074	2,975	177,743	133,710
2008	7,736	8,926	9,223	9,223	8,331	9,223	27,470	26,609	2,975	3,074	3,074	2,975	118,840	120,328
2009	9,223	8,926	9,223	9,223	8,331	9,223	42,919	41,235	4,463	4,612	4,612	4,463	156,452	
Average	16,957	13,625	14,079	14,079	12,717	14,079	46,531	44,910	9,078	9,381	9,381	9,078	213,897	214,289
Min	7,736	8,926	9,223	9,223	8,331	9,223	14,649	14,589	2,975	3,074	3,074	2,975	94,000	94,000
Max	24,397	17,851	18,447	18,447	16,661	18,447	66,685	63,515	14,876	15,372	15,372	14,876	300,923	300,923

The values could also be tabled in the parameter's native unit of flow (cfs) representing the average daily flow requirement during each month. Annual totals are not included as the value is non-sensible. Table 5.6-2 illustrates the same parameter at before except the units are provided in average daily for a month.

Conversion (0-5):	5
Sheet Name:	Output1
Column Letter:	Z
Column No:	26
Label:	ELEASE-MI
Native Unit:	CFS
Convert Unit:	Native

Table 5.6-2. Table 1 Form (units of flow).

Table 1
LAGRANGE RELEASE-MINQ (Output1)
CFS — Average Daily Value

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1971	397	300	300	300	300	300	1,121	1,033	75	75	75	75
1972	215	175	175	175	169	175	509	476	50	50	50	50
1973	150	150	150	150	150	150	1,080	1,007	250	250	250	250
1974	397	300	300	300	300	300	1,080	1,007	250	250	250	250
1975	397	300	300	300	300	300	1,080	1,007	250	250	250	250
1976	397	300	300	300	290	300	339	321	50	50	50	50
1977	126	150	150	150	150	150	246	237	50	50	50	50
1978	126	150	150	150	150	150	1,080	1,007	250	250	250	250
1979	397	300	300	300	300	300	1,080	1,007	250	250	250	250
1980	397	300	300	300	290	300	1,080	1,007	250	250	250	250
1981	397	300	300	300	300	300	493	464	75	75	75	75
1982	207	180	180	180	180	180	1,080	1,007	250	250	250	250
1983	397	300	300	300	300	300	1,080	1,007	250	250	250	250
1984	397	300	300	300	290	300	1,080	1,007	250	250	250	250
1985	397	300	300	300	300	300	582	542	75	75	75	75
1986	150	150	150	150	150	150	1,080	1,007	250	250	250	250
1987	397	300	300	300	300	300	411	387	50	50	50	50
1988	126	150	150	150	145	150	246	237	50	50	50	50
1989	126	150	150	150	150	150	437	410	50	50	50	50
1990	126	150	150	150	150	150	325	309	50	50	50	50
1991	126	150	150	150	150	150	435	408	50	50	50	50
1992	126	150	150	150	145	150	336	319	50	50	50	50
1993	126	150	150	150	150	150	1,080	1,007	250	250	250	250
1994	397	300	300	300	300	300	435	409	50	50	50	50
1995	150	150	150	150	150	150	1,080	1,007	250	250	250	250
1996	397	300	300	300	290	300	1,080	1,007	250	250	250	250
1997	397	300	300	300	300	300	1,080	1,007	250	250	250	250
1998	397	300	300	300	300	300	1,080	1,007	250	250	250	250
1999	397	300	300	300	300	300	1,080	1,007	250	250	250	250
2000	397	300	300	300	290	300	1,080	1,007	250	250	250	250
2001	397	300	300	300	300	300	480	450	75	75	75	75
2002	150	150	150	150	150	150	550	513	75	75	75	75
2003	150	150	150	150	150	150	935	865	75	75	75	75
2004	215	175	175	175	169	175	482	451	75	75	75	75
2005	150	150	150	150	150	150	1,080	1,007	250	250	250	250
2006	397	300	300	300	300	300	1,080	1,007	250	250	250	250
2007	397	300	300	300	300	300	438	412	50	50	50	50
2008	126	150	150	150	145	150	462	433	50	50	50	50
2009	150	150	150	150	150	150	721	671	75	75	75	75
Average	276	229	229	229	227	229	782	730	153	153	153	153
Min	126	150	150	150	145	150	246	237	50	50	50	50
Max	397	300	300	300	300	300	1,121	1,033	250	250	250	250

For each parameter the sequential, the chronological annual values and associated monthly values are also grouped by water type, in descending order of annual runoff. The rank ordering of the years within the simulation period is established by the naming of 6 year types, wet, above normal, normal, below normal, dry and critical. Using the water year runoff for the years 1921 through 2011 (91 years), the years were rank ordered from wettest to driest. The wettest 20 percent of the years (18 years) are designated the wet year type. The next wettest 18 years are designated the above normal year type. And so on for the normal and below normal year types.

The driest 20 percent of years are split between the dry and critical year types. After the demarcation occurs for each year the data set is reduced to only the 1971 through 2009 modeling period (39 years). A switch at cell X216 directs the monthly sequence of the year. For instance, if the year is to begin February 1 of the year and continue through January of the following year, the switch would be set to "Feb". The switch can be set to any month February (Feb) through June (Jun). The first form of standardized table (Table 1a Form) (Figure 5.6-3) for this information follows, which identifies the year type associated with each chronologically-based listed year. Averages for each year type follow the listing.

Table 5.6-3. Table 1a Form (chronological).

	Table 1a													
Prelim	LAGRANGE RELEASE-MINQ (Output1)													
Relicense	AF													
Yr-Type	Yr Begin	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Total
3	1971	16,661	18,447	66,685	63,515	4,463	4,612	4,612	4,463	13,240	10,413	10,760	10,760	228,631
4	1972	9,719	10,760	30,288	29,251	2,975	3,074	3,074	2,975	9,223	8,926	9,223	9,223	128,713
3	1973	8,331	9,223	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	283,369
2	1974	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	300,923
2	1975	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	300,923
6	1976	16,661	18,447	20,153	19,749	2,975	3,074	3,074	2,975	7,736	8,926	9,223	9,223	122,217
6	1977	8,331	9,223	14,649	14,589	2,975	3,074	3,074	2,975	7,736	8,926	9,223	9,223	94,000
1	1978	8,331	9,223	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	283,369
3	1979	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	300,923
1	1980	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	300,923
5	1981	16,661	18,447	29,339	28,532	4,463	4,612	4,612	4,463	12,744	10,711	11,068	11,068	156,718
1	1982	9,997	11,068	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	286,880
1	1983	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	300,923
2	1984	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	300,923
4	1985	16,661	18,447	34,656	33,346	4,463	4,612	4,612	4,463	9,223	8,926	9,223	9,223	157,854
1	1986	8,331	9,223	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	283,369
6	1987	16,661	18,447	24,481	23,806	2,975	3,074	3,074	2,975	7,736	8,926	9,223	9,223	130,603
6	1988	8,331	9,223	14,649	14,589	2,975	3,074	3,074	2,975	7,736	8,926	9,223	9,223	94,000
4	1989	8,331	9,223	25,991	25,222	2,975	3,074	3,074	2,975	7,736	8,926	9,223	9,223	115,975
5	1990	8,331	9,223	19,362	19,008	2,975	3,074	3,074	2,975	7,736	8,926	9,223	9,223	103,131
4	1991	8,331	9,223	25,870	25,109	2,975	3,074	3,074	2,975	7,736	8,926	9,223	9,223	115,740
6	1992	8,331	9,223	19,995	19,601	2,975	3,074	3,074	2,975	7,736	8,926	9,223	9,223	104,357
2	1993	8,331	9,223	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	283,369
5	1994	16,661	18,447	25,903	25,140	2,975	3,074	3,074	2,975	9,223	8,926	9,223	9,223	134,846
1	1995	8,331	9,223	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	283,369
2	1996	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	300,923
1	1997	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	300,923
1	1998	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	300,923
2	1999	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	300,923
3	2000	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	300,923
4	2001	16,661	18,447	28,572	27,642	4,463	4,612	4,612	4,463	9,223	8,926	9,223	9,223	146,067
3	2002	8,331	9,223	32,729	31,539	4,463	4,612	4,612	4,463	9,223	8,926	9,223	9,223	136,567
3	2003	8,331	9,223	55,641	53,161	4,463	4,612	4,612	4,463	13,240	10,413	10,760	10,760	189,680
4	2004	9,719	10,760	28,696	27,758	4,463	4,612	4,612	4,463	9,223	8,926	9,223	9,223	131,678
1	2005	8,331	9,223	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	283,369
1	2006	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	300,923
5	2007	16,661	18,447	26,085	25,310	2,975	3,074	3,074	2,975	7,736	8,926	9,223	9,223	133,710
4	2008	8,331	9,223	27,470	26,609	2,975	3,074	3,074	2,975	9,223	8,926	9,223	9,223	120,328
3	2009	8,331	9,223	42,919	41,235	4,463	4,612	4,612	4,463					

LAGRANGE RELEASE-MINQ (Output1) - AF														
Water Year	Type	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Total
W	1	12,663	14,019	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	292,497
AN	2	15,273	16,909	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	297,997
N	3	11,901	13,176	55,814	53,608	8,926	9,223	9,223	8,926	18,149	13,884	14,347	14,347	240,016
BN	4	11,108	12,298	28,792	27,848	3,613	3,733	3,733	3,613	8,798	8,926	9,223	9,223	130,908
D	5	14,579	16,141	25,172	24,497	3,347	3,459	3,459	3,347	9,360	9,372	9,684	9,684	132,101
C	6	11,663	12,913	18,786	18,467	2,975	3,074	3,074	2,975	7,736	8,926	9,223	9,223	109,035
All		12,717	14,079	46,531	44,910	9,078	9,381	9,381	9,078	16,762	13,514	13,964	13,964	214,289

The second form of report (Table 1b Form) for the water year type based ranking is shown in Figure 5.6-4. This form rank orders the years according to descending volume of watershed runoff, named by the convention described above. The same averaging results occur for this format of report.

Table 5.6-4. Table 1a Form (year type ranking, descending order of wetness).

Table 1b
LAGRANGE RELEASE-MINQ (Output1)
AF

Prelim Relicense Yr-Type	Yr Begin	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Total
W	1983	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	300,923
W	1995	8,331	9,223	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	283,369
W	1982	9,997	11,068	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	286,880
W	1998	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	300,923
W	2006	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	300,923
W	1997	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	300,923
W	1980	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	300,923
W	1986	8,331	9,223	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	283,369
W	2005	8,331	9,223	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	283,369
W	1978	8,331	9,223	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	283,369
AN	1984	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	300,923
AN	1993	8,331	9,223	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	283,369
AN	1996	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	300,923
AN	1974	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	300,923
AN	1999	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	300,923
AN	1975	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	300,923
N	1973	8,331	9,223	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	283,369
N	2000	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	300,923
N	1979	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	300,923
N	1971	16,661	18,447	66,685	63,515	4,463	4,612	4,612	4,463	13,240	10,413	10,760	10,760	228,631
N	2009	8,331	9,223	42,919	41,235	4,463	4,612	4,612	4,463					
N	2003	8,331	9,223	55,641	53,161	4,463	4,612	4,612	4,463	13,240	10,413	10,760	10,760	189,680
N	2002	8,331	9,223	32,729	31,539	4,463	4,612	4,612	4,463	9,223	8,926	9,223	9,223	136,567
BN	1989	8,331	9,223	25,991	25,222	2,975	3,074	3,074	2,975	7,736	8,926	9,223	9,223	115,975
BN	2004	9,719	10,760	28,696	27,758	4,463	4,612	4,612	4,463	9,223	8,926	9,223	9,223	131,678
BN	1985	16,661	18,447	34,656	33,346	4,463	4,612	4,612	4,463	9,223	8,926	9,223	9,223	157,854
BN	1972	9,719	10,760	30,288	29,251	2,975	3,074	3,074	2,975	9,223	8,926	9,223	9,223	128,713
BN	2008	8,331	9,223	27,470	26,609	2,975	3,074	3,074	2,975	9,223	8,926	9,223	9,223	120,328
BN	1991	8,331	9,223	25,870	25,109	2,975	3,074	3,074	2,975	7,736	8,926	9,223	9,223	115,740
BN	2001	16,661	18,447	28,572	27,642	4,463	4,612	4,612	4,463	9,223	8,926	9,223	9,223	146,067
D	1981	16,661	18,447	29,339	28,532	4,463	4,612	4,612	4,463	12,744	10,711	11,068	11,068	156,718
D	2007	16,661	18,447	26,085	25,310	2,975	3,074	3,074	2,975	7,736	8,926	9,223	9,223	133,710
D	1990	8,331	9,223	19,362	19,008	2,975	3,074	3,074	2,975	7,736	8,926	9,223	9,223	103,131
D	1994	16,661	18,447	25,903	25,140	2,975	3,074	3,074	2,975	9,223	8,926	9,223	9,223	134,846
C	1992	8,331	9,223	19,995	19,601	2,975	3,074	3,074	2,975	7,736	8,926	9,223	9,223	104,357
C	1988	8,331	9,223	14,649	14,589	2,975	3,074	3,074	2,975	7,736	8,926	9,223	9,223	94,000
C	1976	16,661	18,447	20,153	19,749	2,975	3,074	3,074	2,975	7,736	8,926	9,223	9,223	122,217
C	1987	16,661	18,447	24,481	23,806	2,975	3,074	3,074	2,975	7,736	8,926	9,223	9,223	130,603
C	1977	8,331	9,223	14,649	14,589	2,975	3,074	3,074	2,975	7,736	8,926	9,223	9,223	94,000

LAGRANGE RELEASE-MINQ (Output1) - AF

Water Year	Type	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Total
W	1	12,663	14,019	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	292,497
AN	2	15,273	16,909	64,241	61,936	14,876	15,372	15,372	14,876	24,397	17,851	18,447	18,447	297,997
N	3	11,901	13,176	55,814	53,608	8,926	9,223	9,223	8,926	18,149	13,884	14,347	14,347	240,016
BN	4	11,108	12,298	28,792	27,848	3,613	3,733	3,733	3,613	8,798	8,926	9,223	9,223	130,908
D	5	14,579	16,141	25,172	24,497	3,347	3,459	3,459	3,347	9,360	9,372	9,684	9,684	132,101
C	6	11,663	12,913	18,786	18,467	2,975	3,074	3,074	2,975	7,736	8,926	9,223	9,223	109,035
All		12,717	14,079	46,531	44,910	9,078	9,381	9,381	9,078	16,762	13,514	13,964	13,964	214,289

5.6.2 Standardized Graphs

Several standardized graphs are also provided for each parameter. The first form of graph provides a trace of the monthly sequence of data developed for the standardized chronological table. Figure 5.6-2 illustrates the minimum flow requirement at La Grange Bridge synthesized as monthly volume during the simulation.

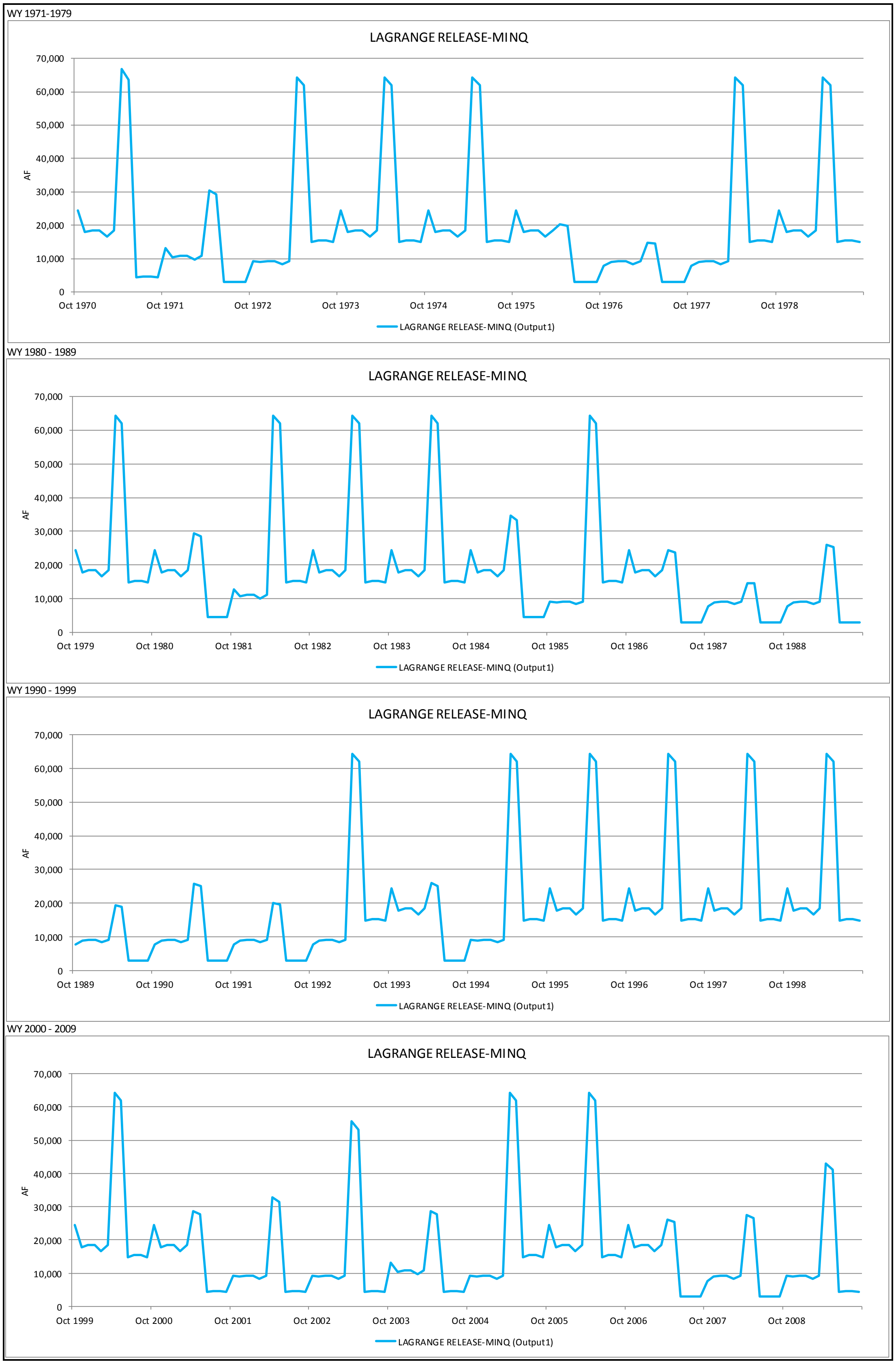


Figure 5.6-2. Chronological Illustration of Parameter.

A user-defined graph is also available to depict a particular column of data from the water year-based standardized table (Table 1 Form) described above. A column of interest within the Table 1 standardized table is selected (such as column AI representing a water year total volume) in cell AN116 to display the 39 annual values. Figure 5.6-3 illustrates this form of graphic.

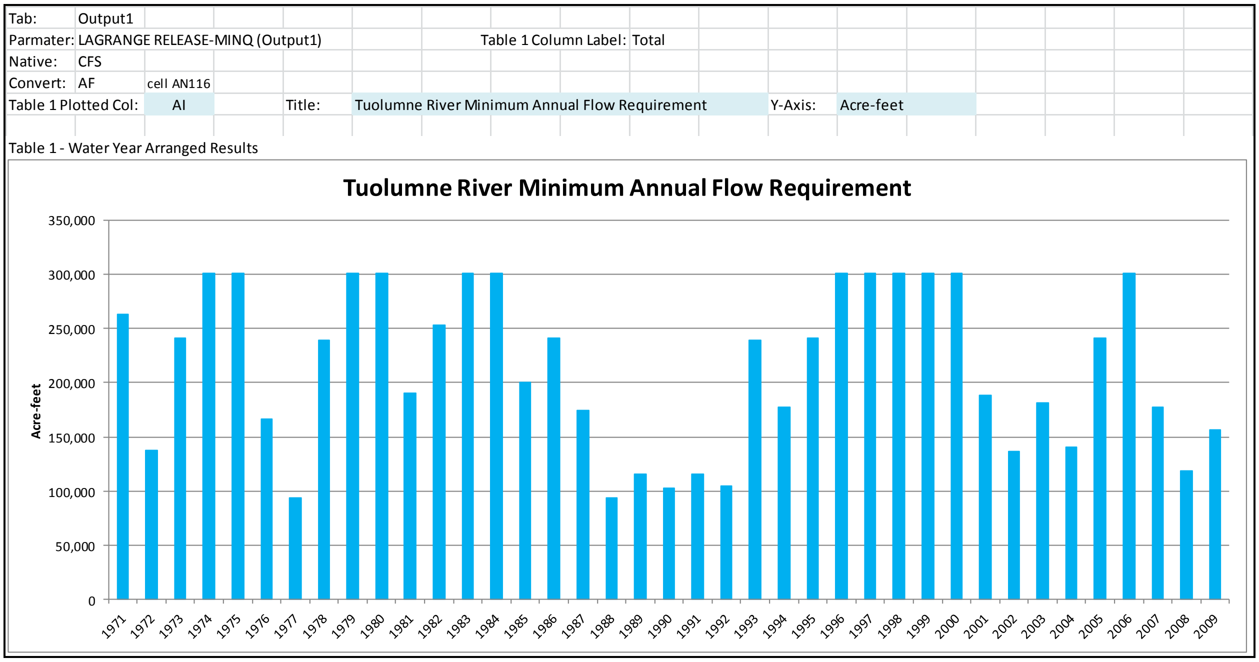


Figure 5.6-3. Annual Parameter Graphic – Tagged to Water Year Table.

A similar display of columnar results can be keyed to the chronological sequence year table described above. Entry of the desired column of information from the table (e.g., Table 1a) is done at cell AN143. Figure 5.6-4 illustrates this form of graphic.

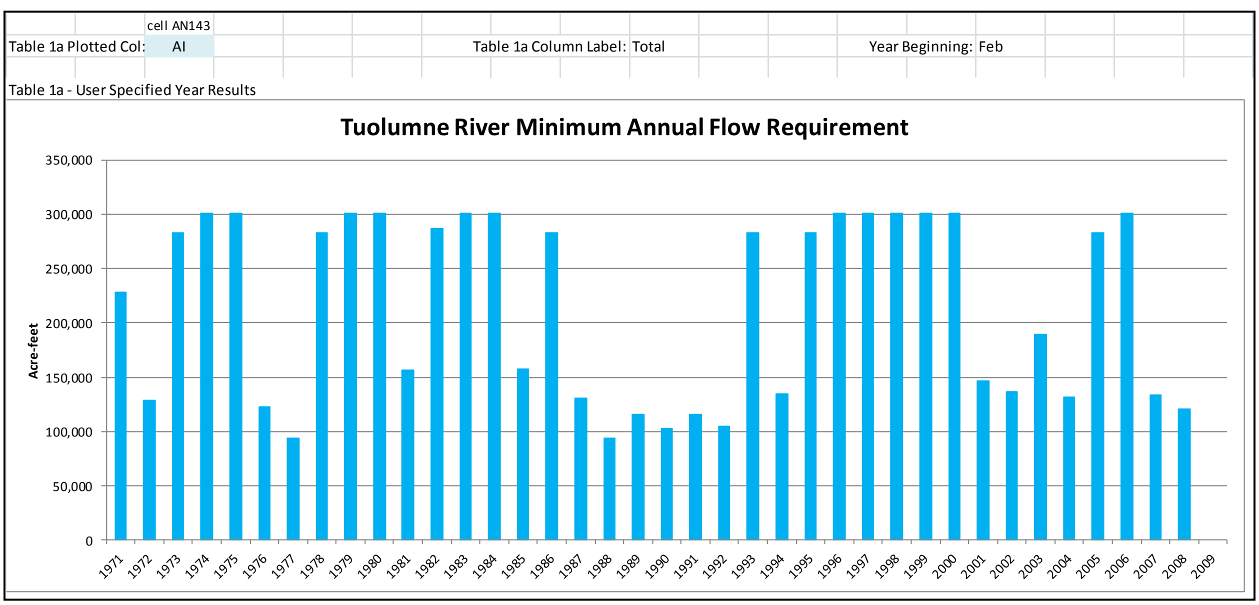


Figure 5.6-4. Annual Parameter Graphic – Tagged to Chronological Sequence Year Table.

The third version of standardized graph for the same information displays results from a column of a table that rank-ordered the years of simulation according to descending runoff (e.g., Table 1b). Entry of the desired column of information from that table is done at cell AN170, with results exemplified by the following graph. Figure 5.6-5 illustrates this form of graphic.

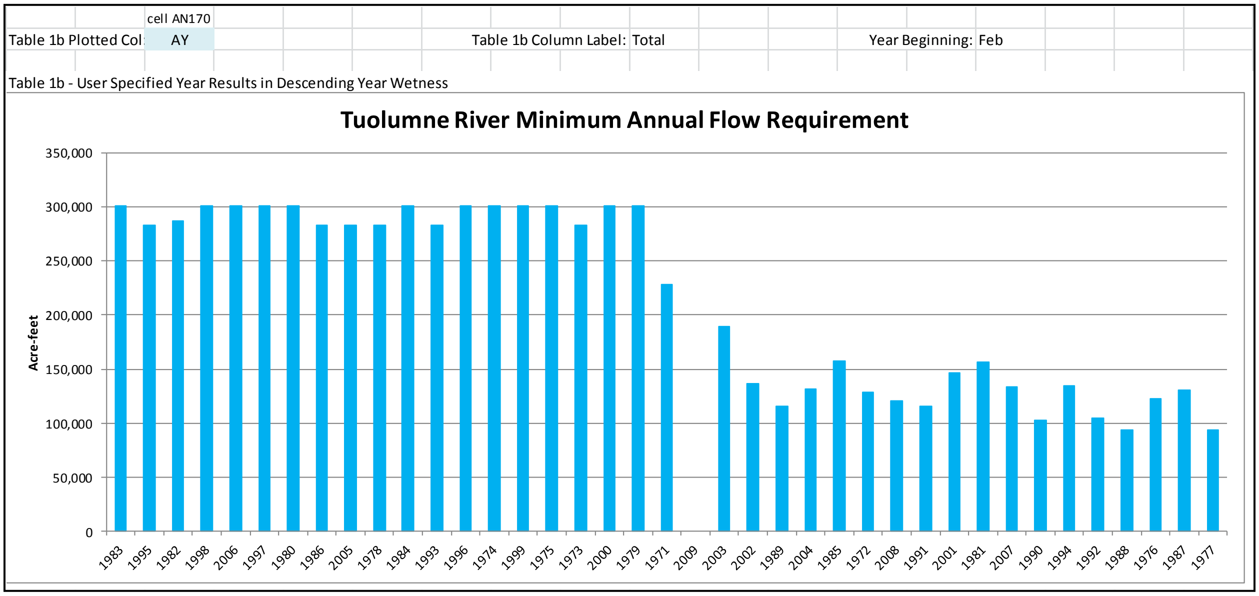


Figure 5.6-5. Annual Parameter Graphic–Tagged to Rank-ordering of Results by Year Wetness.

The same tables and graphics are provided for each of the three other parameters. Additionally, standardized graphics are provided for a columnar comparison of Table 1 and Table 2 values. An example of those graphics is shown below, with the column(s) of interest defined by the Table 1-specific and Table 2-specific entries. Figure 5.6-6 illustrates this form of graphic.

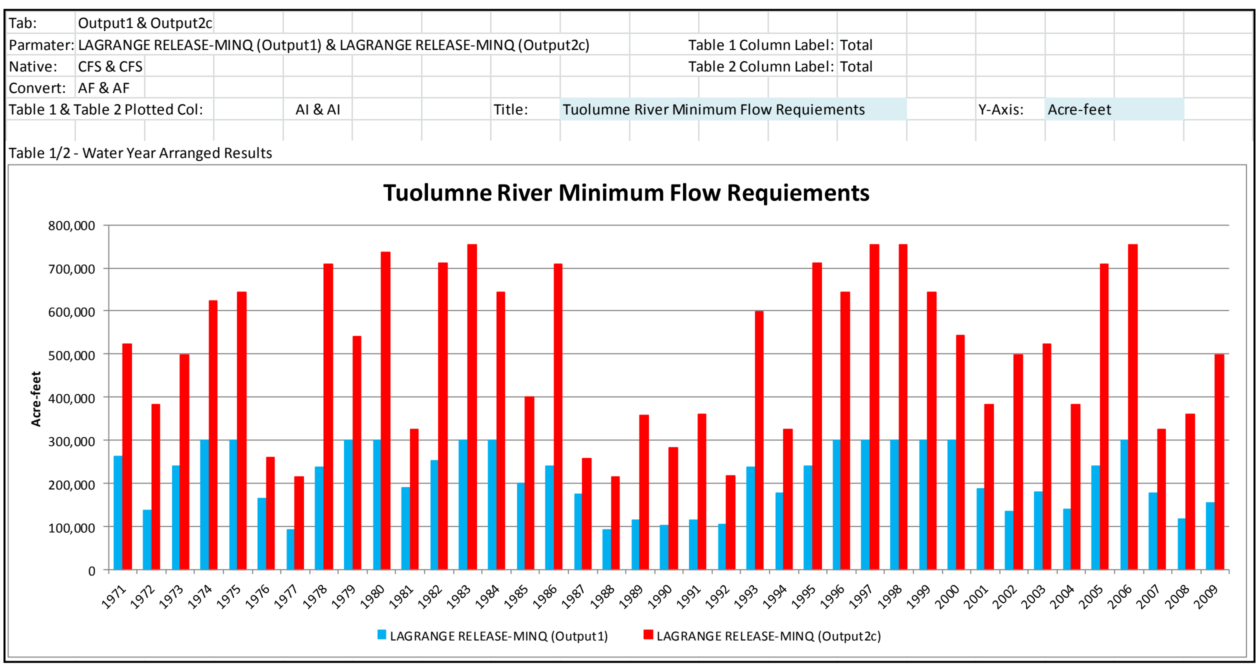


Figure 5.6-6. Annual Parameter Graphic – Comparison of 2 Tables.

A standardized graphic comparison of Table 1, Table 2, and Table 3, and all 4 tables of values is also provided. The four-way comparison graphs are shown in Figure 5.6-7.

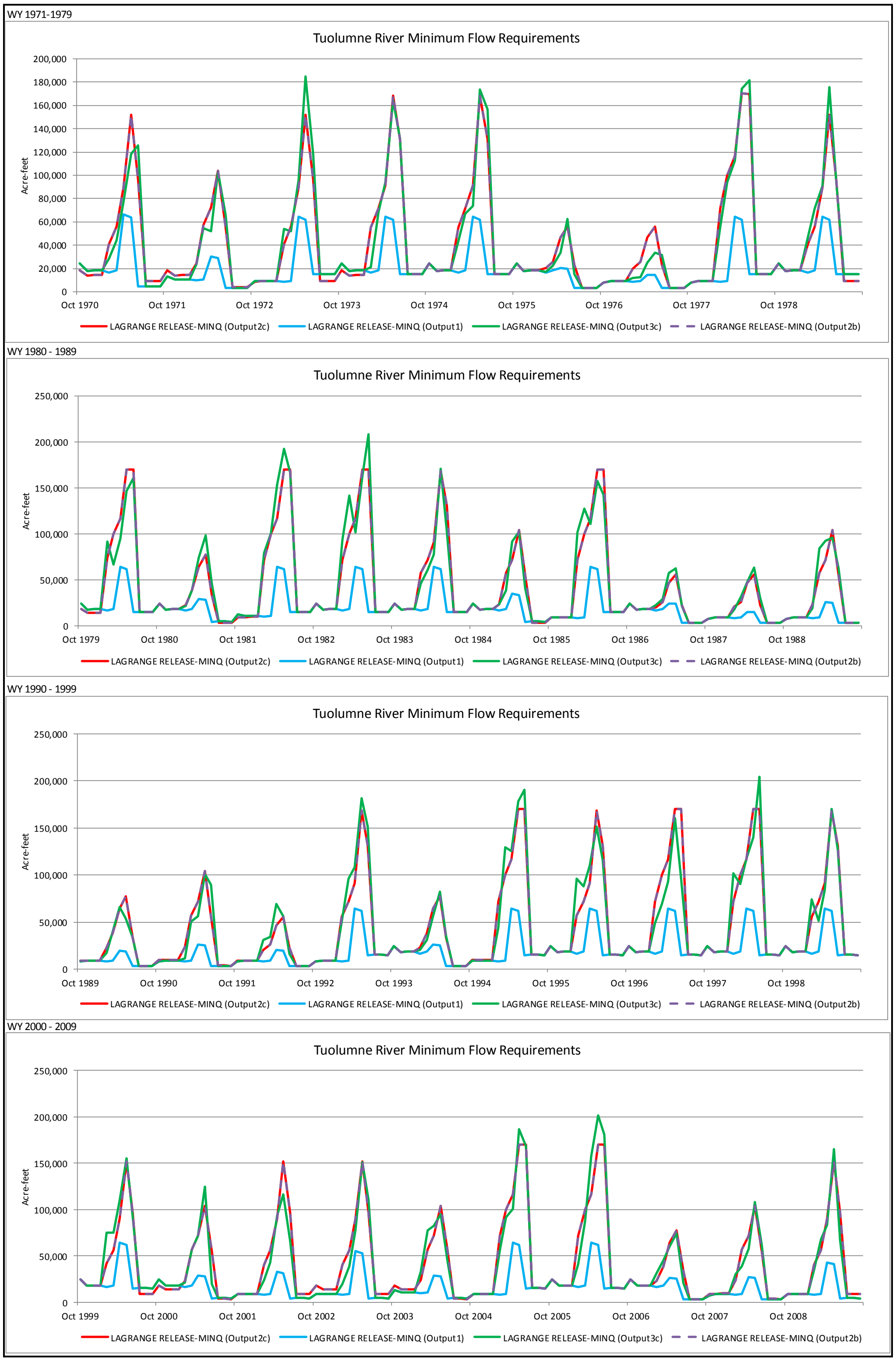


Figure 5.6-7. Comparison of 4 Tables.

5.7 Switches Worksheet

This worksheet (Switches) enables the documentation of all input assumptions and values of a particular study. Almost all user defined parameters entered into the UserInput and Control worksheets are provided as values to the Output worksheet. These parameters are echoed to the Switches worksheet upon identification of worksheet Output or another equally formatted worksheet of results. Figure 5.7-1 is a snapshot of the entry cell for the referenced output worksheet. The results shown in worksheet Switches mirror the formats of worksheet UserInput and Control.

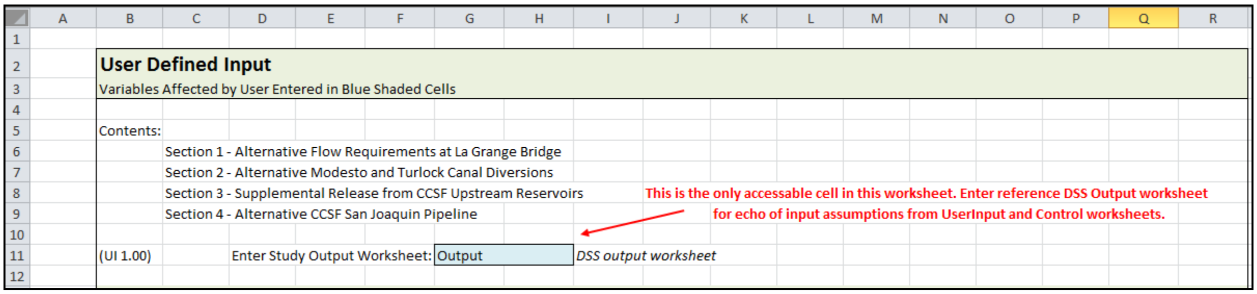


Figure 5.7-1. Switches Worksheet Input Interface.

5.8 XXGroup Worksheets

These worksheets provide graphical display of a single calendar year of operation for several model components. The model components represent groupings of physical features of the Tuolumne River system that make up logical components of operation. The model components are:

Don Pedro Reservoir, the Districts' facilities, and the Lower Tuolumne River
Modeled with computational worksheet DonPedro and displayed by worksheet DPGroup

Hetch Hetchy Reservoir, the San Joaquin Pipeline and downstream releases
Modeled with computational worksheet SFHetchHetchy and displayed by worksheet HHGroup

Lake Lloyd, Holm Powerhouse and its downstream releases
Modeled with computational worksheet SFLloyd and displayed by worksheet LloydGroup

Lake Eleanor, the Eleanor-Cherry Tunnel and its downstream releases
Modeled with computational worksheet SFEleanor and displayed by worksheet ELGroup

CCSF Water Bank and Supplemental Releases
Modeled with computational worksheet SFWaterBank and displayed by worksheet WBGroup

CCSF System Storage displayed by worksheet SFSysGroup.

Both the Districts' and CCSF's operations are additionally displayed for the 1986 through 1994, or any 9-year period by worksheets DPGroup86_94 and SFGroup86_94. These component-specific display worksheets provide plotting of numerous parameters provided in the computation worksheets. One calendar year (the same year) of data for all parameters can be plotted. These display worksheets are similar to worksheet DSSAnyGroup except they rely upon the data being computed by the current study within the computational worksheets. A comparison between the same parameter from two different studies is not possible. Those comparisons are intended to be made through the worksheet Output and its tools. The parameter(s) to be plotted are identified by reference worksheet name and column. Figure 5.8-1 is a snapshot of the identification parameters and result values is shown below for worksheet DPGroup.

Values are plotted to either the primary y-axis or secondary y-axis. The "axis reference" indicates to which axis the value will be plotted by default. The designation of y-axis assignment is not modified by this field, and the user must edit the series data within the plot to change the y-axis assignment, graph type or line or shape characteristics. The "enter graph year" is a user entry. The same year or different year of a parameter or multiple parameters can be plotted. "Sheet name" is a user entry, and identifies from which Output-formatted worksheet the parameter is to be acquired. The "enter column" entry identifies from which column the parameter occurs. Upon proper entry of a parameter a return of the parameter's label and source worksheet will occur in the "data reference" field. Values for the specified calendar year will also be returned in the data field. If a plotting position is not used, a "#VALUE" or "#REF" will be returned. The "scaler" field is provided to allow the conversion or scaling of the data returned from the result worksheet. For instance, if the daily data occurs in the result worksheet in units of daily average flow (cfs) it could be plotted in units of daily volume (acre-feet) by entering the conversion factor of 1.983471. The entry in the field acts as a multiplier to the value occurring in the result worksheet. This field can also be used to scale two different "order of magnitude" parameters to use the same y-axis. An example of the several plotted parameters from an active scenario study is shown in Figure 5.8-2.

	A	B	C	D	E	F	G	H
1	**DPGroup**							
2	This sheet illustrates a CY of daily results for Don Pedro operations in graphic format.							
3	Axis Reference	1	1	2	2	2	2	2
4	Enter CY Graph Year:	1983	1983	1983	1983	1983	1983	1983
5	Enter Sheet Name:	DonPedro	DonPedro	DonPedro	DonPedro	DonPedro	DonPedro	DonPedro
6	Column:	28	72	5	7	13	15	70
7	Enter Column:	AB	BT	E	G	M	O	BR
8	Data Reference:	COE Rainflood Space - AF	Don Pedro Storage - AF	Reservoir Inflow - CFS	Minimum La Grange Req Release - CFS	MID Canal - CFS	TID Canal - CFS	La Grange Release - CFS
9	Enter Scaler:	1	1	1	1	1	1	1
10	1-Jan-83	1,690,000	1,752,672	2,688	300	70	98	4,301
11	2-Jan-83	1,690,000	1,748,069	2,138	300	70	98	4,301
12	3-Jan-83	1,690,000	1,742,799	1,801	300	70	98	4,301
13	4-Jan-83	1,690,000	1,737,746	1,911	300	70	98	4,301
14	5-Jan-83	1,690,000	1,732,665	1,897	300	70	98	4,301
15	6-Jan-83	1,690,000	1,730,261	1,501	300	70	98	2,555
16	7-Jan-83	1,690,000	1,728,957	2,055	300	70	98	2,555
17	8-Jan-83	1,690,000	1,726,043	1,244	300	70	98	2,555
18	9-Jan-83	1,690,000	1,724,497	1,933	300	70	98	2,555

Figure 5.8-1. DPGroup Worksheet Input Interface.

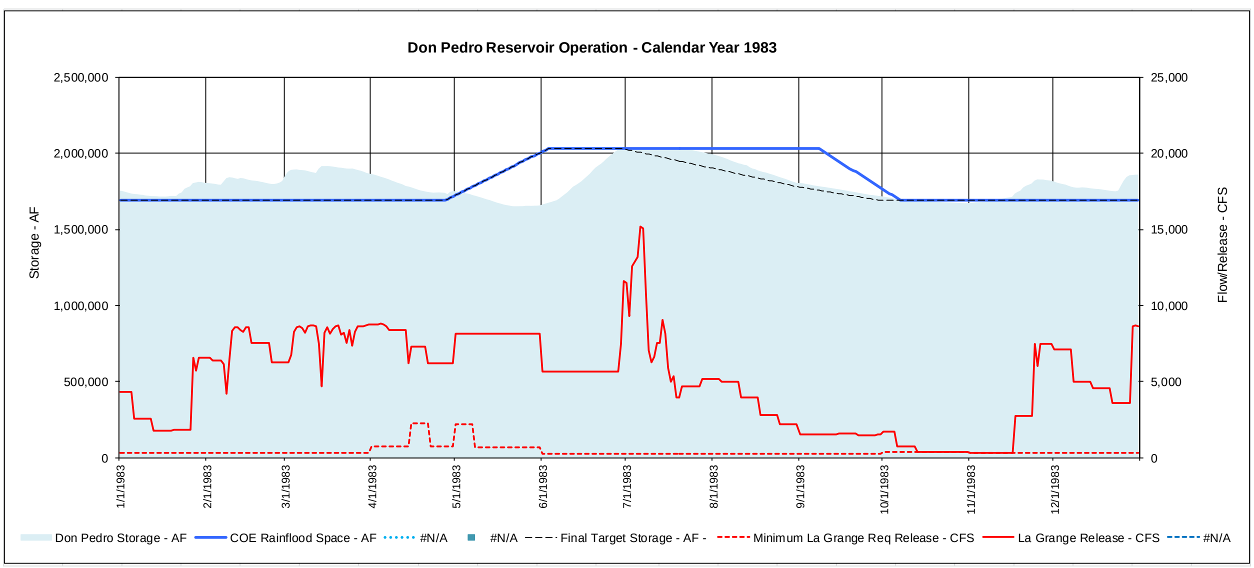


Figure 5.8-2. DPGroup Worksheet Plotting.

Unused plotting positions will appear with values plotted at “zero” and will have legends of “#VALUE!”, “#REF!” or “#N/A”. To create graphs without unused positions a copy of the plot can be made and positioned elsewhere in the worksheet. The unwanted positions can then be deleted from the plot.

5.9 ModelYearofDaily Worksheet

This worksheet (ModelYearofDaily) provides graphical and table display of the daily result for a single calendar or water year for any parameter within a Model component worksheet (e.g., worksheet DonPedro). A snapshot of the data entry interface and a sample of graphical display are shown in Figure 5.9-1.

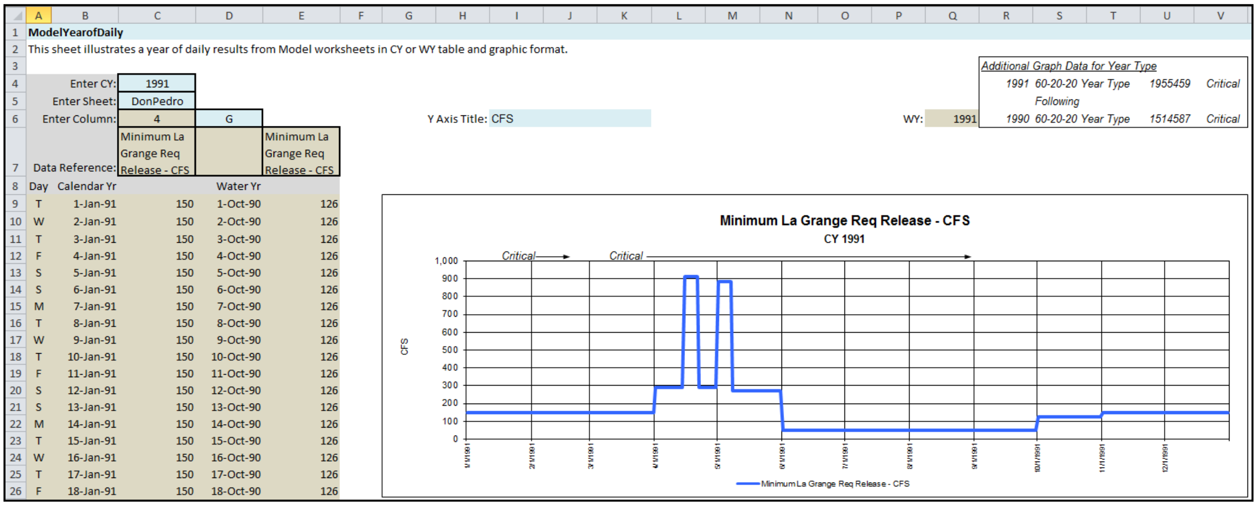


Figure 5.9-1. DPGroup Worksheet Input Interface.

The calendar year, Model worksheet, and column of interest are entered by the user. The result data are plotted by calendar year and water year. The result data are also tabled by calendar year (Figure 5.9-2) and water year.

Minimum La Grange Req Release - CFS												
CY 1991	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	150	150	150	289	886	50	50	50	50	126	150	150
2	150	150	150	289	886	50	50	50	50	126	150	150
3	150	150	150	289	886	50	50	50	50	126	150	150
4	150	150	150	289	886	50	50	50	50	126	150	150
5	150	150	150	289	886	50	50	50	50	126	150	150
6	150	150	150	289	886	50	50	50	50	126	150	150
7	150	150	150	289	886	50	50	50	50	126	150	150
8	150	150	150	289	269	50	50	50	50	126	150	150
9	150	150	150	289	269	50	50	50	50	126	150	150
10	150	150	150	289	269	50	50	50	50	126	150	150
11	150	150	150	289	269	50	50	50	50	126	150	150
12	150	150	150	289	269	50	50	50	50	126	150	150
13	150	150	150	289	269	50	50	50	50	126	150	150
14	150	150	150	289	269	50	50	50	50	126	150	150
15	150	150	150	913	269	50	50	50	50	126	150	150
16	150	150	150	913	269	50	50	50	50	126	150	150
17	150	150	150	913	269	50	50	50	50	126	150	150
18	150	150	150	913	269	50	50	50	50	126	150	150
19	150	150	150	913	269	50	50	50	50	126	150	150
20	150	150	150	913	269	50	50	50	50	126	150	150
21	150	150	150	913	269	50	50	50	50	126	150	150
22	150	150	150	289	269	50	50	50	50	126	150	150
23	150	150	150	289	269	50	50	50	50	126	150	150
24	150	150	150	289	269	50	50	50	50	126	150	150
25	150	150	150	289	269	50	50	50	50	126	150	150
26	150	150	150	289	269	50	50	50	50	126	150	150
27	150	150	150	289	269	50	50	50	50	126	150	150
28	150	150	150	289	269	50	50	50	50	126	150	150
29	150	---	150	289	269	50	50	50	50	126	150	150
30	150	---	150	289	269	50	50	50	50	126	150	150
31	150	---	150	---	269	---	50	50	---	126	---	150
Ave	150	150	150	435	408	50	50	50	50	126	150	150
AF	9,223	8,331	9,223	25,871	25,109	2,975	3,074	3,074	2,975	7,736	8,926	9,223
Annual	115,742 AF			160 Ave CFS								

Figure 5.9-2. ModelYearofDaily Output Table (calendar year).

5.10 ModelAnyGroup Worksheet

This worksheet (ModelAnyGroup) provides plotting of up to ten parameters provided in any Model component worksheet (e.g., worksheet DonPedro). One calendar year (the same year or different years) of data for a parameter can be plotted. The parameter(s) to be plotted are identified by reference worksheet name and column. A snapshot of the identification parameters and result values is shown in Figure 5.10-1. This worksheet performs the same function as the DSSAnyGroup worksheet except the source of its data are the Model component worksheets instead of DSS interface worksheets.

Values are plotted to either the primary y-axis or secondary y-axis. The "axis reference" indicates to which axis the value will be plotted by default. The designation of y-axis assignment is not modified by this field, and the user must edit the series data within the plot to change the y-axis assignment, graph type or line or shape characteristics. The "enter CY graph year" is a user entry. The same year or different year of a parameter or multiple parameters can be plotted. "Sheet name" is a user entry, and identifies from which Model component worksheet the parameter is to be acquired. The "enter column" entry identifies from which column the parameter occurs. Upon proper entry of a parameter a return of the parameter's label and source worksheet will occur in the "data reference" field. Values for the specified calendar year will also be returned in the data field. If a plotting position is not used, a "#VALUE!" or "#REF!" will be returned. The "scaler" field is provided to allow the conversion or scaling of the data returned from the result worksheet. For instance, if the daily data occurs in the result worksheet in units of daily average flow (cfs) it could be plotted in units of daily volume (acre-feet) by entering the conversion factor of 1.983471. The entry in the field acts as a multiplier to the value occurring in the result worksheet. This field can also be used to scale two different "order of magnitude" parameters to use the same y-axis.

The results of up to ten parameters will be plotted. An example of the several plotted parameters from an active scenario is shown in Figure 5.10-2.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	**ModelAnyGroup**													
2	This sheet illustrates a CY of daily results from Model worksheets in graphic format.													
3	Axis Reference	1		1		2		2		2		2		1
4	Enter CY Graph Year:	2004		2004		2004		2004		2004		2004		2004
5	Enter Sheet Name:	DonPedro		DonPedro		DonPedro		DonPedro		DonPedro		DonPedro		DonPedro
6	Column:	#N/A		72		6		7		#N/A		70		#N/A
7	Enter Column:			BT		F		G				BR		
8	Data Reference:	#N/A	Date	Don Pedro Storage - AF (DonPedro)	Date	Reservoir Inflow - AF (DonPedro)	Date	La Grange Req Release - CFS	Date	#N/A	Date	La Grange Release - CFS (DonPedro)	Date	#N/A
9	Enter Scaler:	1		1		1		1		1		1		1
10	1-Jan-04	#N/A	1-Jan-04	1,622,829	1-Jan-04	8,300	1-Jan-04	175	1-Jan-04	#N/A	1-Jan-04	175	1-Jan-04	#N/A
11	2-Jan-04	#N/A	2-Jan-04	1,625,102	2-Jan-04	2,934	2-Jan-04	175	2-Jan-04	#N/A	2-Jan-04	175	2-Jan-04	#N/A
12	3-Jan-04	#N/A	3-Jan-04	1,626,670	3-Jan-04	2,229	3-Jan-04	175	3-Jan-04	#N/A	3-Jan-04	175	3-Jan-04	#N/A
13	4-Jan-04	#N/A	4-Jan-04	1,628,860	4-Jan-04	2,850	4-Jan-04	175	4-Jan-04	#N/A	4-Jan-04	175	4-Jan-04	#N/A
14	5-Jan-04	#N/A	5-Jan-04	1,629,314	5-Jan-04	1,115	5-Jan-04	175	5-Jan-04	#N/A	5-Jan-04	175	5-Jan-04	#N/A
15	6-Jan-04	#N/A	6-Jan-04	1,630,546	6-Jan-04	1,892	6-Jan-04	175	6-Jan-04	#N/A	6-Jan-04	175	6-Jan-04	#N/A
16	7-Jan-04	#N/A	7-Jan-04	1,631,507	7-Jan-04	1,621	7-Jan-04	175	7-Jan-04	#N/A	7-Jan-04	175	7-Jan-04	#N/A
17	8-Jan-04	#N/A	8-Jan-04	1,632,196	8-Jan-04	1,349	8-Jan-04	175	8-Jan-04	#N/A	8-Jan-04	175	8-Jan-04	#N/A
18	9-Jan-04	#N/A	9-Jan-04	1,632,895	9-Jan-04	1,359	9-Jan-04	175	9-Jan-04	#N/A	9-Jan-04	175	9-Jan-04	#N/A
19	10-Jan-04	#N/A	10-Jan-04	1,634,514	10-Jan-04	2,279	10-Jan-04	175	10-Jan-04	#N/A	10-Jan-04	175	10-Jan-04	#N/A
20	11-Jan-04	#N/A	11-Jan-04	1,634,300	11-Jan-04	446	11-Jan-04	175	11-Jan-04	#N/A	11-Jan-04	175	11-Jan-04	#N/A
21	12-Jan-04	#N/A	12-Jan-04	1,636,320	12-Jan-04	2,680	12-Jan-04	175	12-Jan-04	#N/A	12-Jan-04	175	12-Jan-04	#N/A
22	13-Jan-04	#N/A	13-Jan-04	1,637,275	13-Jan-04	1,615	13-Jan-04	175	13-Jan-04	#N/A	13-Jan-04	175	13-Jan-04	#N/A
23	14-Jan-04	#N/A	14-Jan-04	1,638,581	14-Jan-04	1,967	14-Jan-04	175	14-Jan-04	#N/A	14-Jan-04	175	14-Jan-04	#N/A
24	15-Jan-04	#N/A	15-Jan-04	1,639,327	15-Jan-04	1,406	15-Jan-04	175	15-Jan-04	#N/A	15-Jan-04	175	15-Jan-04	#N/A
25	16-Jan-04	#N/A	16-Jan-04	1,640,134	16-Jan-04	1,466	16-Jan-04	175	16-Jan-04	#N/A	16-Jan-04	175	16-Jan-04	#N/A

Figure 5.10-1. ModelAnyGroup Worksheet Input Interface.

Unused plotting positions will appear with values plotted at "zero" and will have legends of "#VALUE!" or "#REF!". To create graphs without unused positions a copy of the plot can be made and positioned elsewhere in the worksheet. The unwanted positions can then be deleted from the plot.

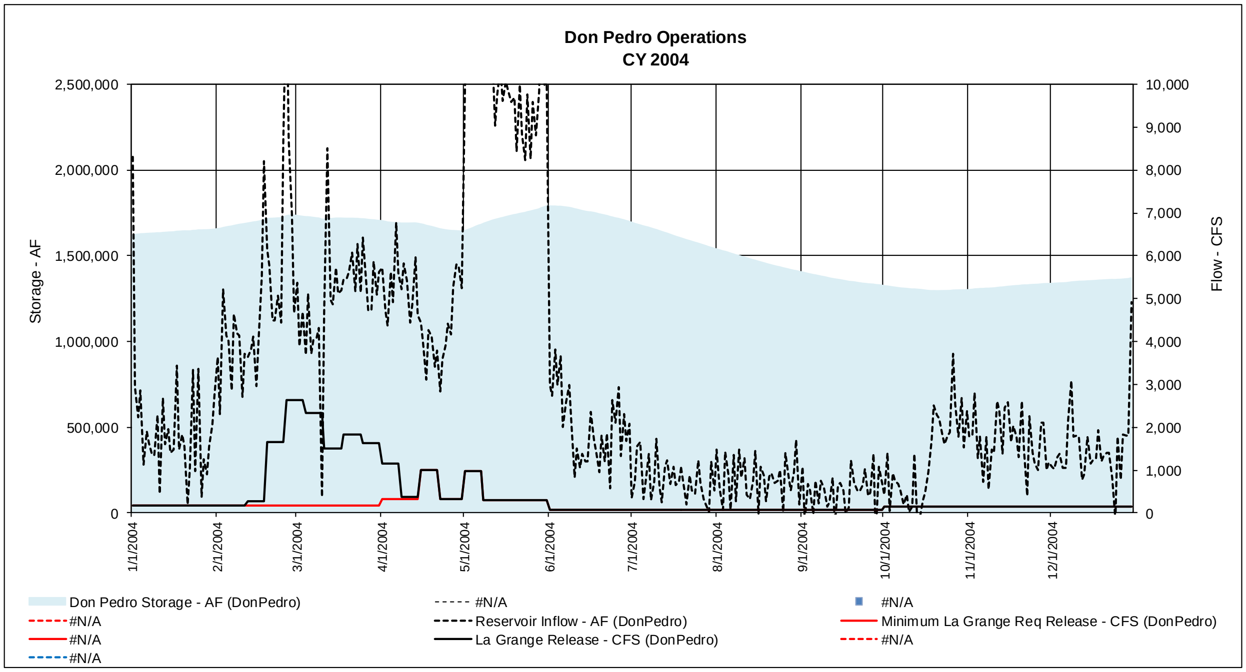


Figure 5.10-2. ModelAnyGroup Worksheet Plotting.

5.11 ModelMonthTable Worksheet

This worksheet (ModelMonthTable) provides summation or averaging, and plotting of up to four parameters provided in Model component worksheets (e.g., DonPedro worksheet). The function of this worksheet is to provide a synthesis of the daily result data into monthly results thus reducing the handling and display of over 14,000 values for each parameter (39 years of days) to 468 values (39 years of months). This worksheet and its functionality are identical to the DSSMonthTable worksheet except the source of its data are the Model component worksheets instead of DSS interface worksheets.

The parameter(s) to be plotted or tabled are identified by reference worksheet name and column, very similarly to the method identified for the ModelAnyGroup worksheet. A snapshot of the identification parameters and result values is shown in Figure 5.11-1.

Each parameter is tabled and plotted separately for the entire 39-year simulation period. "Sheet name" is a user entry, and identifies from which Model component worksheet the parameter is to be acquired. The "enter column letter" entry identifies from which column the parameter occurs. Upon proper entry of a parameter a return of the parameter's label, source worksheet and the native unit of the parameter will occur. Depending on need, the "conversion" entry is provided. This entry, a keyed value of 0 to 5, directs the worksheet on the handling of the daily data. An entry of 1 will direct the worksheet to sum the daily data into monthly increments in the parameter's native units (e.g., daily acre-feet into monthly volumes). An entry of 1 will convert the daily data from a native unit of flow (cfs) into monthly volumes of acre-feet. An entry of 2 will convert the daily data from a native unit of volume (acre-feet) into a monthly sum of daily flow in units of cfs. An entry of 3 will act as an entry of 1 except convert the result into monthly volumes with units of 1,000 acre-feet. An entry of 4 will table and plot the daily value associated with the last day of each month in its native unit, and is primarily intended to analyze reservoir storage. An entry of 5 will report the average of daily values within a month. Depending on the entry in the conversion field, the converted unit will be returned to “converted unit” field. Values for the each month of the simulation period will also be returned in the data field. If a plotting position is not used, a “#VALUE!” or “#REF!” will be returned.

A “scaler” field is also provided for each parameter (in the row above the data fields) to allow the conversion or scaling of the data returned from the result worksheet.

5				Conversion Key:			
6				0	1 >> 1	Native	1
7				1	CFS >> AF	AF	1.9834700
8				2	AF >> CFS	CFS	0.5041669
9				3	CFS >> TAF	TAF	0.0019835
10				4	EOM Stor	AF	1
11				5	Ave Day	Native	1
12	Enter Conversion (0-5):			4	1	1	1
13	Enter Sheet Name:			DonPedro	DonPedro	DonPedro	DonPedro
14	Enter Column Letter:			BT	F	BR	G
15	Column No:			72	6	70	7
16	Label:			ro Storage	oir Inflow (	ge Release	ange Req F
17	Native Unit:			AF	AF	CFS	CFS
18	Convert Unit:			AF	AF	AF	AF
19	Index	Date	Day	1	1	1	1
20	1970.10	10/1/1970	T	1,666,767	1,268	787	787
21	1970.10	10/2/1970	F	1,664,567	1,783	787	787
22	1970.10	10/3/1970	S	1,662,719	2,130	787	787
23	1970.10	10/4/1970	S	1,659,892	2,460	787	787
24	1970.10	10/5/1970	M	1,656,745	296	787	787
25	1970.10	10/6/1970	T	1,654,119	1,870	787	787

Figure 5.11-1. ModelMonthTable Worksheet Input Interface.

The results of up to four parameters will be tabled and plotted. The content formats of reports are identified below. Refer to section 5.6 DSSMonthTable for illustrations of each format.

Standardized Tables

- Data synthesized into monthly volumes for the simulation period.
- Chronological annual values and associated monthly values are also grouped by water type, in descending order of annual runoff.

Standardized Graphs

- Graphs providing a trace of the monthly sequence of data developed for the standardized chronological table.
- Graphs depicting a particular column of data from the water year-based standardized table.
- Graphs for the same information displayed rank-ordered according to descending runoff.
- Standardized graphics are provided for a columnar comparison of the four parameters.

5.12 DonPedro Worksheet

This Model component worksheet (DonPedro) simulates the operation of Don Pedro Reservoir. Several sections of logic provide a systematic operation of the reservoir based on inflow and forecasted hydrology and water demands. As described earlier, the Model will direct releases from the Don Pedro Project under a "hold-unless-need-to-release" protocol, except as conditioned by minimum release requirements, diversions, preferred/maximum storage, and snowmelt management releases. The several sections of logic are illustrated and discussed below.

5.12.1 Don Pedro Reservoir Release Demands.

The Don Pedro Reservoir release requirements section of logic (Figure 5.12-1) assembles the underlying water demands placed for Don Pedro Reservoir releases. Reservoir inflow is derived from other Model component worksheets and is the sum of unregulated inflow to Don Pedro Reservoir (Hydrology worksheet) and regulated releases from the CCSF System (SFHetchHetchy worksheet, SFLLoyd worksheet and SFEleanor worksheet). The minimum flow requirement for the Tuolumne River is provided by worksheet LaGrangeSchedule as directed by worksheet UserInput. The "Existing Level Full Diversion Demand" is a projection of canal diversion requirements if no water supply shortages occurred and full demands are provided. "Scenario Canal Diversion Demand" is the canal diversions of MID and TID for the active scenario. These diversions are determined by either pre-processed computations of diversions (e.g., fixed Test Case diversions), user specified diversions, or dynamic computations. "Total DP Demands" are the summation of minimum release requirements for the river and canal diversions. Other information is developed in this section concerning the difference between scenario diversions and full diversion demand, and an overall summary of water disposition for the entire simulation period.

	A	B	C	D	E	F	G	H	I	J	K	L
1			1		Don Pedro Model							
2	Unit Title		2		CFS	AF	CFS	AF	CFS	AF	CFS	AF
3	Parameter Title		3		DP Reserv	DP Reserv	Minimum La	Minimum	MID Full D	MID Full D	TID Full Di	TID Full Di
4												
5	Acre-foot to CFS conversion				This Scenario							
6	divide by :	1.983471			Check Sums		Sum AF	39-ave		Other	39-ave	
7						Inflow	65,915,187	1,690,133		MID Canal	284,177	
8						Evap	1,740,362	44,625		TID Canal	559,697	
9						River	31,532,459	808,525				
10						Canals	32,911,098	843,874		Minimum River	213,897	
11						Net	-268,732					
12						Chng Stor	-268,732					
13				39-year Ave or Max								
14				Min						Using WSF = 1.000 All Years		
15					Inflow		La Grange Require		Existing Level Full Diversion Demand			
16										300,954		601,215
17	Month				Reservoir	Reservoir	Minimum	Minimum	MID	MID	TID	TID
18	Index	Date	Day	Days	Inflow	Inflow	Req	Req	Canal	Canal	Canal	Canal
19					CFS	AF	CFS	AF	CFS	AF	CFS	AF
20	1970.10	10/1/1970	T	31	322	639	397	787	531	1,053	1,406	2,789
21	1970.10	10/2/1970	F	31	453	899	397	787	434	860	661	1,311
22	1970.10	10/3/1970	S	31	541	1,074	397	787	424	840	582	1,154
23	1970.10	10/4/1970	S	31	625	1,240	397	787	463	918	1,119	2,220
24	1970.10	10/5/1970	M	31	75	149	397	787	461	915	733	1,453
25	1970.10	10/6/1970	T	31	475	943	397	787	491	973	841	1,668

	M	N	O	P	Q	R	S	T	U	V	W	X
1												
2	CFS	AF	CFS	AF	CFS	AF					CFS	AF
3	MID Canal	MID Canal	TID Canal	TID Canal	Total Cana	Total Canals					Total Rese	Total Reser
4												
5						Difference from Base						
6		39-ave	39-ave				39-yr Ave	39-yr Ave				
7	Inflow	1,690,133	284,177	MID Canal		Inflow	0	0	MID Canal			
8	Evap	44,625	559,697	TID Canal		Evap	0	0	TID Canal			
9	River	808,525				River	0					
10	Canals	843,874	213,897	Minimum River		Canals	0	0	Minimum River			
11												
12												
13	1,257	284,177	2,404	559,697		843,874		16,777		41,518		1,057,771
14	41		1									
15	Scenario Canal Diversions						Diversion Shortage from Full Demand				Total DP Demands	
16											Total	Total
17	MID	MID	TID	TID	Total	Total	MID	MID	TID	TID	Res Rel	Res Rel
18	Canal	Canal	Canal	Canal	Canals	Canals	Canal	Canal	Canal	Canal	Demands	Demands
19	CFS	AF	CFS	AF	CFS	AF	CFS	AF	CFS	AF	CFS	AF
20	531	1,053	1,406	2,789	1,937	3,842	0	0	0	0	2,334	4,629
21	434	860	661	1,311	1,094	2,171	0	0	0	0	1,491	2,958
22	424	840	582	1,154	1,006	1,994	0	0	0	0	1,402	2,781
23	463	918	1,119	2,220	1,582	3,139	0	0	0	0	1,979	3,926
24	461	915	733	1,453	1,194	2,368	0	0	0	0	1,591	3,155
25	491	973	841	1,668	1,332	2,641	0	0	0	0	1,728	3,428

Figure 5.12-1. Don Pedro Reservoir Release Demands.

5.12.2 Reservoir Evaporation / Initial Storage Computation and Encroachment Release

This section (Figure 5.12-2) performs an initial check of reservoir storage assuming the previously described minimum releases for the river and canals. A daily mass balance is performed: *change in reservoir storage = inflow, minus outflow (releases), minus reservoir losses*. The prior day's reservoir evaporation is included in the calculation. If the computation produces resulting Don Pedro Reservoir storage in excess (encroachment) of the preferred storage target, the encroachment is computed. Every 7th day the model checks for an encroachment, and if it exists a check release is computed. It is assumed that a constant supplemental release (in excess of minimum releases) will be initiated at a rate equal to the encroachment divided equally over the next 10 days. This protocol repeats itself every 7th day, reestablishing the level of check release each time. The end result of this procedure will allow encroachment of storage space above the preferred storage target and not require unrealistic hard releases of water to exactly conform to the target.

	A	B	C	D	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH
1			1											
2	*Unit Title*		2					AF						
3	*Parameter Title*		3		rvoir Release Demands			COE Rainfl	Final Target Storage - AF					
4														
5	*Acre-foot to CFS conversion*													
6	*divide by :*	*1.983471*												
7														
8														
9														
10														
11														
12														
13		*39-year Ave or Max*												
14				*Min*										
15						Evap/loss	Initial Storage Computation and Encroachment Release							
16							Initial	COE				Spread	Spread	
17	Month					Net Res	DP	Rainflood	Target	Initial	Encroach	Encroach	7th Day	
18	Index	Date	Day	Days		Evap/Loss	Storage	Target	Stroage	Encroach	7th Day	10 days	10 days	7-day
19						AF	1,670,900	AF	AF	AF	AF	AF	CFS	Count
20	1970.10	10/1/1970	T	31		143	1,666,767	1,760,900	1,690,000	0	0	0	0	1
21	1970.10	10/2/1970	F	31		141	1,664,567	1,749,200	1,690,000	0	0	0	0	0
22	1970.10	10/3/1970	S	31		141	1,662,719	1,737,500	1,690,000	0	0	0	0	0
23	1970.10	10/4/1970	S	31		141	1,659,892	1,725,800	1,690,000	0	0	0	0	0
24	1970.10	10/5/1970	M	31		141	1,656,745	1,714,100	1,690,000	0	0	0	0	0
25	1970.10	10/6/1970	T	31		141	1,654,119	1,702,400	1,690,000	0	0	0	0	0

Figure 5.12-2. Reservoir Evaporation/Initial Storage Computation and Encroachment Release.

5.12.3 Snow-melt Management

A second check release is made during the April through June period for management of anticipated snowmelt runoff (Figure 5.12-3). On the first day of each of these months a forecast is made of anticipated runoff into the reservoir and minimum releases and losses from the reservoir from the date of forecast through the end of June (the assumed target date of reservoir filling). These forecasts determine the volume of water (if any) that will require release in excess of minimum releases and losses and storage gain by the end of June. For April and May, the DWR 90 percent exceedence forecast is used for anticipated runoff, along with known minimum releases and losses, and upstream impairment. The user defines the percentage of volume (of the total volume) to be additionally released during each month. For April, 30 percent of the 3-month volume is advised for release, and during May 50 percent of the 2-month volume is advised for released. For June, the historically reported UF flow is assumed for the runoff computation. This assumes pre-knowledge of the runoff volume for the month, and 100 percent of the excess is spread across the month. The snowmelt check release is evenly distributed across the days of the month. The release made in a day is the greater of the two check releases or the minimum release. At no time is the maximum capacity of the reservoir (2,030,000 acre-feet) allowed to be exceeded, and if necessary a release, regardless of magnitude, will be made by the model to not exceed maximum storage capacity.

Unit Title 2 — CFS; Parameter Title 3 — Target SM

Acre-foot to CFS conversion divide by: 1.983471

	April: Lookup of 1-Apr 90% Exc Apr-Jul Runoff	Est of Apr-Jun Portion of Apr-Jul	Uses Current Yr Canal + Min River +Typ Evap	Compute Upstream Adjust to UF	Compute Availble DP Stor through June	Compute Total Excess Apr-Jun Release	Amount to be Released during April	May: Lookup of 1-May 90% Exc Apr-Jul Runoff	Est of May-Jun Portion of Apr-Jul	Uses Current Yr Canal + Min River +Typ Evap	Compute Upstream Adjust to UF	Compute Availble DP Stor through June	Compute Total Excess May-Jun Release	Amount to be Released during May	June: Lookup of Actual June Runoff	Est of June Portion of June	Uses Current Yr Canal + Min River +Typ Evap	Compute Upstream Adjust to UF	Compute Availble DP Stor through June	Compute Total Excess Jun Release	Amount to be Released during June
39-year Ave or Max / Min	23 % Apr/Apr AJ; 35 % May/Apr AJ; 29 % Jun/Apr AJ			% of Apr-Jun excess rel in April			(C 1.10) 30	49 % May/May MJ; 38 % Jun/May MJ			% of May-Jun excess rel in May			(C 1.20) 50						% of June excess rel in June	(C 1.30) 100

				April Snow-melt Release Routine (April)							May Snow-melt Release Routine (May)							June Snow-melt Release Routine (June)							
Month Index	Date	Day	Days	1-Apr A-Jul Fcst AF	1-Apr A-Jun Fcst AF	A-Jun Can+Riv+E AF	A-Jun USAdj AF	A-Jun DP Avail AF	A-Jun Excess AF	April SM Rel CFS	1-May A-Jul Fcst AF	1-May MJune Fcst AF	M-Jun Can+Riv+E AF	M-Jun USAdj AF	M-Jun DP Avail AF	M-Jun Excess AF	May SM Rel CFS	1-Jun June UF AF	1-Jun June Fcst AF	June Can+Riv+E AF	June USAdj AF	June DP Avail AF	June Excess AF	June SM Rel CFS	Target SM Release CFS
1970.10	10/1/1970	T	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970.10	10/2/1970	F	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970.10	10/3/1970	S	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970.10	10/4/1970	S	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970.10	10/5/1970	M	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970.10	10/6/1970	T	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 5.12-3. Snow-melt Management.

5.12.4 Modesto Flow Objective, Don Pedro Reservoir, and Tuolumne River Release

A Modesto flood control objective is incorporated into release logic (Figure 5.12-4). The objective is to maintain a flow at Modesto no greater than a user-specified flow rate. The logic checks against an allowable river release that would not exceed the flood control objective after considering the lower Tuolumne River accretions and Dry Creek flow. The previous check releases are compared to the allowable release. The release is then reduced if necessary to not exceed the Modesto flow target objective, even if it results in an encroachment in Don Pedro Reservoir. The exception is when the reservoir reaches full (2,030,000 AF). Any computed encroachment above a full reservoir is passed and the Modesto flow objective is exceeded.

Unit Title 2: CFS, CFS, CFS, CFS, CFS, AF, CFS, AF, Acres, AF
Parameter Title 3: Re Dry Creek, LTR Accr, Tot Unreg, Trg Max L(, Modesto Flo\, La Grange, La Grange Release, Don Pedro Storage, DP Surface Area, DP Total Ev

Acre-foot to CFS conversion divide by: 1.983471

39-year Ave or Max: (C 1.00); 808,525; 508,489 Min 1976-77; 44,626
Min: Enter Modesto FC Target: 9,000 CFS; 785,605 Min 1987-92

				Modesto Flood Control Flow Objective					Final La Grange River		Don Pedro Reservoir			Net Don Pedro Loss Calculation			
Month Index	Date	Day	Days	Report Dry Creek Flow CFS	Est LTR Acc Flow CFS	Total Unreg Blw LG CFS	Target Max LaGrange CFS	Calc Modesto Flow CFS	Final La Grange Release AF	Final La Grange Release CFS	DP Storage Change AF	DP Storage	Encroach above 2,030,000	Area	Factor	CFS	AF
												1,670,900		11,156			
1970.10	10/1/1970	T	31	30	99	129	8,871	526	787	397	-4,133	1,666,767	0	11,139	0.006395	71.2	141.3
1970.10	10/2/1970	F	31	30	99	129	8,871	526	787	397	-2,200	1,664,567	0	11,127	0.006395	71.2	141.1
1970.10	10/3/1970	S	31	30	99	129	8,871	526	787	397	-1,849	1,662,719	0	11,116	0.006395	71.1	141.0
1970.10	10/4/1970	S	31	30	100	130	8,870	526	787	397	-2,826	1,659,892	0	11,099	0.006395	71.0	140.8
1970.10	10/5/1970	M	31	30	100	130	8,870	527	787	397	-3,147	1,656,745	0	11,082	0.006395	70.9	140.6
1970.10	10/6/1970	T	31	30	100	130	8,870	527	787	397	-2,626	1,654,119	0	11,071	0.006395	70.8	140.4

Figure 5.12-4. Modesto Flow Objective, Don Pedro Reservoir, and Tuolumne River Release.

The several advised releases, storage conditions and water demands all culminate in determining the "Final La Grange River" release. The "Don Pedro Reservoir" section of logic reports the final reservoir storage of a day and the computation of Don Pedro Reservoir losses. Reservoir losses are computed in accordance with procedures of the Fourth Agreement.

5.12.5 Don Pedro Project Generation and River Flows

Based on the hydrologic operation of Don Pedro Reservoir in the Model, power characteristics of the scenario are computed. Equations of Don Pedro powerhouse generation characteristics define capacity (MW) and efficiency (kWh/AF), based on reservoir storage. Capacity potential uses minimum storage of the day, while efficiency uses average storage of the day. The maximum water through plant is assumed to be 5,400 cfs. Water that does not appear as passing through the generators is computed to be “spilled-bypassed”. The power generation is “cutoff” at reservoir storage of 308,960 acre-feet, the top of the dead pool.

Flow in the river below La Grange diversion dam is computed and reported. The flow is a determined value by the Model. The same hydrologic information used within the Modesto flow objective logic is added to La Grange releases to estimate flow at downstream points in the river. Currently an estimate of total Tuolumne River accretion between La Grange Bridge and the confluence of Dry Creek is added to La Grange releases to provide an estimate of flow above the Dry Creek confluence. The estimated flow of Dry Creek is added to that estimate to provide an estimate of flow below the Dry Creek confluence at “Modesto”. Additional flow points can be added as information becomes available. Figure 5.12-5 is a snapshot of these sections of logic.

	A	B	C	D	BZ	CA	CB	CC	CD	CE	CF	CG	CH	CI	CJ	CK	CL	CM	CN	CO	CP
1			1																		
2	*Unit Title*		2					MW	kWh/AF	AF	AF	AF	MWh		CFS				CFS	CFS	
3	*Parameter Title*		3		vaporation			DP PH Cap	DP PH Eff	Total DP Re	DP Power I	DP Spill / I	Don Pedro Er		La Grange Release				TR abv Mc	TR blw Dry Creek	
4																					
5	*Acre-foot to CFS conversion*																				
6	*divide by :*	*1.983471*																			
7																					
8																					
9																					
10																					
11											(C 1.22)										
12							*39-yr Ave*	*191*	*392*	*1,652,399*	*1,488,570*	*163,829*	*607,705*								
13				*39-year Ave or Max*			*Max*	*198*	*440*	*154,471*	*10,711*	*143,760*	*4,710*								
14				*Min*			*Min*	*127*	*258*	*410*	*410*	*0*	*106*								
15						Don Pedro Power Operations									River Flows						
16						Per Ave	Per Min	(C 1.20)		Total	Thru		Don						LTR abv	LTR blw	
17	Month					DPStor	DPStor	308,960		DP	PH (cfs)	Spill/	Pedro		La Grange	Waterford	Hickman	Santa Fe	Modesto	Modesto	Mouth
18	Index	Date	Day	Days		(for Eff)	(for Cap)	Capability	Efficiency	Release	5,400	Bypass	Energy		RM 51.8	RM 42.0	RM 31.0	RM 21.6	RM 16.2	RM	RM 0.0
19						AF	AF	MW	kWh/AF	AF	AF	AF	MWh		CFS	CFS	CFS	CFS	CFS	CFS	CFS
20	1970.10	10/1/1970	T	31		1,668,834	1,666,767	195	408	4,629	4,629	0	1,888		397				496	526	
21	1970.10	10/2/1970	F	31		1,665,667	1,664,567	195	408	2,958	2,958	0	1,205		397				496	526	
22	1970.10	10/3/1970	S	31		1,663,643	1,662,719	195	407	2,781	2,781	0	1,133		397				496	526	
23	1970.10	10/4/1970	S	31		1,661,305	1,659,892	195	407	3,926	3,926	0	1,598		397				496	526	
24	1970.10	10/5/1970	M	31		1,658,319	1,656,745	195	407	3,155	3,155	0	1,284		397				497	527	
25	1970.10	10/6/1970	T	31		1,655,432	1,654,119	195	407	3,428	3,428	0	1,394		397				497	527	

Figure 5.12-5. Don Pedro Project Generation and River Flows.

5.12.6 Don Pedro Inflow Components

This section of logic (Figure 5.12-6) assembles the Don Pedro Reservoir inflow components from other Model component worksheets.

	A	B	C	D	CT	CU	CV	CW	CX	CY	CZ	DA	DB	DC	DD
1			1												
2	*Unit Title*		2			AF	CFS	AF	CFS	AF	CFS	AF	CFS	AF	CFS
3	*Parameter Title*		3			DP Inflow	DP Inflow	DP Inflow	DP Inflow	DP Inflow	DP Inflow	Unreg Infl	Unreg Infl	DP Inflow	DP Inflow
4															
5	*Acre-foot to CFS conversion*														
6	*divide by :*	*1.983471*				*Read*		*Read*		*Read*			*Read*		*Read by*
7						*from*		*from*		*from*			*from*		*Model*
8						*SFHetchHetchy*		*SFLloyd*		*SFEleanor*			*Hydrology*		
9						*Incl*									
10						*Return of*									
11						*Moc Hatch*									
12															
13		*39-year Ave or Max*				*39-year average*									
14				*Min*		*525,724*		*378,296*		*102,781*		*683,332*		*1,690,133*	
15						Inflow to Don Pedro Reservoir									
16						Inflow	Inflow	Inflow	Inflow	Inflow	Inflow				
17	Month					from	from	from	from	from	from	Unreg	Unreg	DP	DP
18	Index	Date	Day	Days		HH	HH	Lloyd	Lloyd	Eleanor	Eleanor	Inflow	Inflow	Inflow	Inflow
19						AF	CFS	AF	CFS	AF	CFS	AF	CFS	AF	CFS
20	1970.10	10/1/1970	T	31		179	90	443	223	20	10	-2	-1	639	322
21	1970.10	10/2/1970	F	31		179	90	443	223	20	10	258	130	899	453
22	1970.10	10/3/1970	S	31		179	90	443	223	20	10	433	218	1,074	541
23	1970.10	10/4/1970	S	31		179	90	443	223	20	10	599	302	1,240	625
24	1970.10	10/5/1970	M	31		179	90	443	223	20	10	-492	-248	149	75
25	1970.10	10/6/1970	T	31		179	90	443	223	20	10	302	152	943	475

Figure 5.12-6. Don Pedro Reservoir Inflow Components.

5.13 SFHetchHetchy Worksheet

This Model component worksheet (SFHetchHetchy) simulates the operation of Hetch Hetchy Reservoir. Several sections of logic provide a systematic operation of the reservoir based on inflow and forecasted hydrology and water demands. As described earlier, the Model will direct releases from Hetch Hetchy Reservoir under a "hold-unless-need-to-release" protocol, except as conditioned by minimum release requirements, diversions, preferred/maximum storage, and snowmelt management releases. The several sections of logic are illustrated and discussed below.

5.13.1 Hetch Hetchy Release Demands / Reservoir Evaporation / Initial Storage Computation and Encroachment Release

This section (Figure 5.13-1) of logic assembles the underlying water demands placed for Hetch Hetchy Reservoir releases. Reservoir inflow is derived from worksheet Hydrology and is the unimpaired flow entering the reservoir. The initial releases are comprised of the minimum flow requirement below Hetch Hetchy Reservoir (from the worksheet CCSF) and represent requirements prior to consideration of Canyon Tunnel flows, Mountain Tunnel flows that consist of diversions for the SJPL (from the worksheet CCSF), Moccasin Fish Hatchery releases and diversions by Groveland CSD from Mountain Tunnel.

This section also performs an initial check of reservoir storage assuming the previously described minimum releases for the river and Mountain Tunnel. A daily mass balance is performed: *change in reservoir storage = inflow, minus outflow (releases), minus reservoir* *losses*. The prior day's reservoir evaporation is included in the calculation. If the computation produces resulting Hetch Hetchy Reservoir storage in excess (encroachment) of the preferred storage target, the encroachment is computed. Every 7th day the model checks for an encroachment, and if it exists a check release is computed. For the preferred reservoir storage target encroachment it is assumed that a constant supplemental release (in excess of minimum releases) will be initiated at a rate equal to the encroachment divided equally over the next 7 days. This protocol repeats itself every 7th day, reestablishing the level of check release each time. The end result of this procedure will allow encroachment of storage space above the preferred storage target and not require unrealistic hard releases of water to exactly conform to the target.

5.13.2 Supplemental Releases and Final Reservoir and Release Computation

This section (Figure 5.13-2) of logic performs the final computation of reservoir storage and releases. Incorporated into the logic is inclusion of user specified supplemental releases (from WaterBankRel or SFWaterBank worksheets) and snowmelt management releases (described later). Reservoir losses are computed in accordance with procedures of the Fourth Agreement.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1			1		**Hetch Hetchy Reservoir Model**																	
2	*Unit Title*		2		CFS	AF		CFS	AF	CFS	AF	CFS	AF	AF								
3	*Parameter Title*		3		Hetch Het	Hetch Het		SJPL + Mo	SJPL + Mo	SJPL	SJPL	HH Req St	HH Req St	HH Net Evap								
4																						
5	*Acre-foot to CFS conversion*				*This scenario*								*Base*				*Difference from Base*					
6	*divide by :*	*1.983471*			*Check Sums*		*Sum AF*	*39-ave*		*Other Sums*		*Sum AF*		*39-ave*		*Sum AF*		*39-ave*		*Sum AF*		
7						*Inflow*	*29,761,289*	*763,110*			*Supplmtl*	*0*	*Inflow*	*763,110*	*Supplmtl*	*0*	*Inflow*	*0*	*Supplmtl*	*0*		
8						*Evap*	*149,655*	*3,837*					*Evap*	*3,837*			*Evap*	*0*				
9						*SJPL+*	*9,922,420*	*254,421*					*SJPL+*	*254,421*			*SJPL+*	*0*				
10						*Non-SJPL*	*19,655,587*	*503,989*					*Non-SJPL*	*503,989*			*Non-SJPL*	*0*				
11						*Net*	*33,627*															
12						*Chng Stor*	*33,627*															
13				*39-year Ave*		*763,110*			*254,421*		*231,238*			*3,837*								
14								*32*	*Moc Hatch + Groveland (CFS)*													
15					Inflow			Initial Releases						Evap/loss	Initial Storage Computation and Encroachment Release							
16					HH	HH		SJPL	SJPL			w/o 64	w/o 64		Initial	Target	Hard			Spread	Spread	
17	Month				Reservoir	Reservoir		+ Moc Hat	+ Moc Hat			Req	Req	Net Res	HH	HH	Limit	Initial	Encroach	Encroach	7th Day	
18	Index	Date	Day	Days	Inflow	Inflow		Grove	Grove	SJPL	SJPL	Blw HH	Blw HH	Evap/Loss	Storage	Storage	Storage	Encroach	7th Day	over 7	Enc over 7	7-day
19					CFS	AF		CFS	AF	CFS	AF	CFS	AF	AF	250,000	360,360	AF	AF	AF	AF	CFS	Count
20	1970.10	10/1/1970	T	31	79	157		341	677	309	614	60	119	11	249,349	359,381	360,360	0	0	0	0	1
21	1970.10	10/2/1970	F	31	-82	-163		341	677	309	614	60	119	11	248,379	358,401	360,360	0	0	0	0	0
22	1970.10	10/3/1970	S	31	25	50		341	677	309	614	60	119	11	247,622	357,422	360,360	0	0	0	0	0
23	1970.10	10/4/1970	S	31	110	218		341	677	309	614	60	119	11	247,032	356,443	360,360	0	0	0	0	0
24	1970.10	10/5/1970	M	31	-38	-75		341	677	309	614	60	119	11	246,150	355,463	360,360	0	0	0	0	0
25	1970.10	10/6/1970	T	31	9	18		341	677	309	614	60	119	11	245,360	354,484	360,360	0	0	0	0	0

Figure 5.13-1. Reservoir Evaporation/Initial Storage Computation and Encroachment Release.

	A	B	C	D	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG
1			1												
2	*Unit Title*		2			AF	CFS	AF	AF						CFS
3	*Parameter Title*		3			HH Supple	HH Releas	HH Releas	HH Storag						Total HH R
4															
5	*Acre-foot to CFS conversion*														
6	*divide by :*	*1.983471*													
7															
8															
9															
10															
11															
12															
13				*39-year Ave*				*503,989*							
14															
15					Final Release and Storage										
16							HH	HH		HH	Hetch Hetchy Reservoir Loss Calculation				HH
17	Month				Supplmtl	Supplmtl	Release	Release	HH	Storage	Area	Factor	CFS	AF	Total
18	Index	Date	Day	Days	Release	Release	abv Mnt	abv Mnt	Storage	Change					Release
19					CFS	AF	CFS	AF	250,000	AF					CFS
20	1970.10	10/1/1970	T	31	0	0	60	119	249,349	-651	1,722	0.003253	5.6	11.1	401
21	1970.10	10/2/1970	F	31	0	0	60	119	248,379	-970	1,721	0.003253	5.6	11.1	401
22	1970.10	10/3/1970	S	31	0	0	60	119	247,622	-758	1,718	0.003253	5.6	11.1	401
23	1970.10	10/4/1970	S	31	0	0	60	119	247,032	-589	1,716	0.003253	5.6	11.1	401
24	1970.10	10/5/1970	M	31	0	0	60	119	246,150	-883	1,714	0.003253	5.6	11.1	401
25	1970.10	10/6/1970	T	31	0	0	60	119	245,360	-789	1,711	0.003253	5.6	11.0	401

Figure 5.13-2. Supplemental Release, Reservoir Storage and Release.

5.13.3 Snow-melt Management

A second check release is made during the February through June period for management of anticipated snowmelt runoff. On the first day of each of these months a forecast is made of anticipated runoff into the reservoir and minimum releases and losses from the reservoir, from the date of forecast through the end of June (assumed target of reservoir filling). These forecasts (Figure 5.13-3) determine the volume of water (if any) that will require release in excess of minimum releases and losses and storage gain by the end of June.

Pre-knowledge is used for anticipated runoff, minimum releases and losses. The user defines the percentage of volume (of the total volume for the period) to be additionally released during each month. For February through April, 10 percent of the additional release volume is advised for release, and may be additionally capped. This approach tends to hold Hetch Hetchy Reservoir releases for later release during May. The snowmelt check release is evenly distributed across the days of the month and can be capped in terms of rate (cfs) or minimum volume of the reservoir to which it can be drawn during the month. The particular release made in a day is the greater of the two check releases or the minimum release. At no time is the maximum capacity of the reservoir allowed to be exceeded, and if necessary a release, regardless of magnitude, will be made by the model to not exceed maximum storage capacity.

Unit Title 2
Parameter Title 3
Acre-foot to CFS conversion
divide by : 1.983471
39-year Ave

June Storage Target (AF): 360,360 — *Max Rel Tgt (CFS)*
Minimum HH Storage for SM Drawdown (AF): 100,000
% Feb Release of Feb-June Excess: 10 — 1,200
% Mar Release of Mar-June Excess: 10 — *Max Rel Tgt (CFS)* 1,150
% Apr Release of Apr-June Excess: 10 — *Max Rel Tgt (CFS)* 1,200

				February Snow-melt Release Routine							March Snow-melt Release Routine							April Snow-melt Release Routine						
				February							March							April						
Month Index	Date	Day	Days	1-Feb AJ Fcst AF	1-Feb FJune Fcst AF	FJune SJPL+MRiv AF	FJune HH Avail AF	FJune Excess AF	Feb SM Rel CFS	Max Stor Draw CFS	1-Mar AJ Fcst AF	1-Mar MJune Fcst AF	MJune SJPL+MRiv AF	MJune HH Avail AF	MJune Excess AF	March SM Rel CFS	Max Stor Draw CFS	1-Apr AJ Fcst AF	1-Apr AJune Fcst AF	AJune SJPL+MRiv AF	AJune HH Avail AF	AJune Excess AF	April SM Rel CFS	Max Stor Draw CFS
1970.10	10/1/1970	T	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970.10	10/2/1970	F	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970.10	10/3/1970	S	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970.10	10/4/1970	S	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970.10	10/5/1970	M	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970.10	10/6/1970	T	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Unit Title 2
Parameter Title 3
Acre-foot to CFS conversion
divide by : 1.983471
39-year Ave

CFS HH Target — AF HH Target
% May Release of May-June Excess: 100 — *Max Rel Tgt (CFS)* 100,000
% Jun Release of June Excess: 100 — *Max Rel Tgt (CFS)* 100,000 — *Max Rel Tgt (CFS)* 100,000 — *Max*

				May Snow-melt Release Routine							June Snow-melt Release Routine								
				May							June								
Month Index	Date	Day	Days	1-May AJ Fcst AF	1-May MJune Fcst AF	MJune SJPL+MRiv AF	MJune HH Avail AF	MJune Excess AF	May SM Rel CFS	Max Stor Draw CFS	1-Jun June UF AF	1-Jun June Fcst AF	June SJPL+MRiv AF	June HH Avail AF	June Excess AF	June SM Rel CFS	Max Stor Draw CFS	Target SM Release CFS	Target SM Release AF
1970.10	10/1/1970	T	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970.10	10/2/1970	F	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970.10	10/3/1970	S	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970.10	10/4/1970	S	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970.10	10/5/1970	M	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970.10	10/6/1970	T	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 5.13-3. Snow-melt Management.

5.14 SFLloyd Worksheet

This Model component worksheet (SFLloyd) simulates the operation of Lake Lloyd. Several sections of logic provide a systematic operation of the reservoir based on inflow and forecasted hydrology and water demands. The Model will direct releases from Lake Lloyd under a “hold-unless-need-to-release” protocol, except as conditioned by minimum release requirements, diversions, preferred/maximum storage, snowmelt management releases and target releases for Holm Powerhouse. The several sections of logic are illustrated and discussed below.

5.14.1 Lake Lloyd Release Demands, Initial Storage Computation and Encroachment Release

This section of logic (Figure 5.14-1) assembles the underlying water demands placed for Lake Lloyd releases. Reservoir inflow is derived from the Hydrology worksheet and is the unimpaired flow entering the reservoir. The initial releases are comprised of the minimum flow requirement below Lake Lloyd (from worksheet CCSF) and target releases for Holm Powerhouse (from worksheet CCSF).

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1			1		**Lake Lloyd Model**																
2	*Unit Title*		2		CFS	AF	CFS	AF		AF	CFS	AF		AF		AF	AF				
3	*Parameter Title*		3		Lake Lloyc	Lake Lloyc	Min Holm Ta	Min Holm		Suppleme	Lloyd Req	Lloyd Req		Lloyd Net Evap		Lloyd Targe	Lloyd Limi				
4																					
5	*Acre-foot to CFS conversion*				*This scenario*								*Base*				*Difference from Base*				
6	*divide by :*	*1.983471*			*Check Sums*		*Sum AF*	*39-ave*		*Other Sums*		*Sum AF*		*39-ave*		*Sum AF*		*39-ave*		*Sum AF*	
7						*Inflow*	*11,743,646*	*301,119*			*Supplmtl*	*171,708*	*Inflow*	*301,119*	*Supplmtl*	*171,708*	*Inflow*	*0*	*Supplmtl*	*0*	
8						*Tun Inflow*	*3,196,266*	*81,956*					*Tun Inflow*	*81,956*			*Tun Inflow*	*0*			
9						*Evap*	*136,660*	*3,504*					*Evap*	*3,504*			*Evap*	*0*			
10						*Stream*	*1,298,823*	*33,303*					*Stream*	*33,303*			*Stream*	*0*			
11						*Holm*	*13,454,734*	*344,993*					*Holm*	*344,993*			*Holm*	*0*			
12						*Net*	*49,694*														
13						*Chng Stor*	*49,694*														
14		*39-year Ave*				*301,119*		*38,628*		*4,403*		*5,538*		*3,504*							
15					Inflow		Initial Release			Suppl	Initial Release			Evap/loss	Initial Storage and Encroachment Release						
16					Lake	Lake	Min	Min		171,708	Stream	Stream			Initial	Lloyd				Spread	Spread
17	Month				Lloyd	Lloyd	Holm	Holm		Supplmtl	Req	Req		Net Res	Lloyd	Target	Limit	Initial	Encroach	Encroach	7th Day
18	Index	Date	Day	Days	Inflow	Inflow	Target	Target		Release	Blw Lloyd	Blw Lloyd		Evap/Loss	Storage	Storage	Storage	Encroach	7th Day	over 7	Enc over 7
19					CFS	AF	CFS	AF		AF	CFS	AF		AF	200,000	200,000	AF	AF	AF	AF	CFS
20	1970.10	10/1/1970	T	31	56	111	0	0		0	5	10		10	200,091	248,000	273,300	0	0	0	0
21	1970.10	10/2/1970	F	31	5	10	0	0		0	5	10		10	200,080	248,000	273,300	0	0	0	0
22	1970.10	10/3/1970	S	31	15	30	0	0		0	5	10		10	200,090	248,000	273,300	0	0	0	0
23	1970.10	10/4/1970	S	31	-399	-791	0	0		0	5	10		10	199,278	248,000	273,300	0	0	0	0
24	1970.10	10/5/1970	M	31	322	638	0	0		0	5	10		10	199,896	248,000	273,300	0	0	0	0
25	1970.10	10/6/1970	T	31	-48	-94	0	0		0	5	10		10	199,781	248,000	273,300	0	0	0	0

Figure 5.14-1. Reservoir Evaporation/Initial Storage Computation and Encroachment Release.

This section also performs an initial check of reservoir storage assuming the previously described minimum releases for the river and Holm Powerhouse. A daily mass balance is performed: *change in reservoir storage = inflow, minus outflow (releases), minus reservoir losses*. The prior day's reservoir evaporation is included in the calculation. If the computation produces resulting Lake Lloyd storage in excess (encroachment) of the preferred storage target, the encroachment is computed. Every 7th day the model checks for an encroachment, and if it exists a check release is computed. It is assumed that a constant supplemental release (in excess of minimum releases) will be initiated at a rate equal to the encroachment divided equally over the next 7 days. This protocol repeats itself every 7th day, reestablishing the level of check release each time. The end result of this procedure will allow encroachment of storage space above the preferred storage target and not require unrealistic hard releases of water to exactly conform to the target. User specified supplemental releases are reported in this section but are not incorporated into the worksheet's logic until later.

5.14.2 Supplemental Releases, Lake Eleanor Transfers and Final Reservoir and Release Computation

This section of logic (Figure 5.14-2) performs the final computation of reservoir storage and releases, including consideration of snowmelt management releases (described later) and transfers from Lake Eleanor.

Both the initial check release for preferred storage encroachment and the snowmelt check release are computed and advised for reservoir operations. If supplemental releases above minimum releases are computed the Model routes the additional release through Holm Powerhouse up to its available capacity. The remainder of the supplemental release is routed to the stream below Lake Lloyd. A comparison is made between "Lloyd-only" use of Holm Powerhouse capacity and maximum capacity for passage to the Lake Eleanor model component.

The operation goal linkage between Lake Lloyd and Lake Eleanor assumes that Lake Eleanor will transfer water from its watershed to Lake Lloyd for the purpose of enhancing power generation at Holm Powerhouse. Thus, any available capacity at Holm Powerhouse after the

Lloyd-only operation is assumed available and desired for use of a Lake Eleanor transfer. If water is transferred from Lake Eleanor the Model assumes the water to be directly routed to Holm Powerhouse which then becomes additional release from Lake Lloyd.

Also incorporated into the logic is inclusion of user specified supplemental releases (from the WaterBankRel or SFWaterBank worksheets). Supplemental releases are added to any other release established for Lake Lloyd. Reservoir losses are compute in accordance with procedures of the Fourth Agreement.

	A	B	C	D	W	X	Y	Z	AA	AB	AC	AD	AE	AF
1			1											
2	*Unit Title*		2								CFS		CFS	AF
3	*Parameter Title*		3								Lloyd-only Holm		Final Strea	Final Strea
4														
5	*Acre-foot to CFS conversion*													
6	*divide by :*	*1.983471*												
7														
8														
9														
10														
11														
12					*Holm*	*(C 2.41)*								
13					*950*	*CFS Max*								
14				*39-year Ave*										
15					Prior to Eleanor								Final Routing	
16					Holm	Holm	Llyd-only	Llyd-only	Revised	Revised	Holm	Holm	Stream	Stream
17	Month				Capacity	Capacity	Rel w/o	Rel w/o	Routed	Routed	Prior to	Prior to	w/ Suppl	w/ Suppl
18	Index	Date	Day	Days	for Elnr	for Elnr	Suppl Rel	Suppl Rel	Holm	Holm	Tun Infl	Tun Infl	Release	Release
19					CFS	AF	CFS	AF	CFS	AF	CFS	AF	CFS	AF
20	1970.10	10/1/1970	T	31	950	1,884	5	10	0	0	0	0	5	10
21	1970.10	10/2/1970	F	31	950	1,884	5	10	0	0	0	0	5	10
22	1970.10	10/3/1970	S	31	950	1,884	5	10	0	0	0	0	5	10
23	1970.10	10/4/1970	S	31	950	1,884	5	10	0	0	0	0	5	10
24	1970.10	10/5/1970	M	31	950	1,884	5	10	0	0	0	0	5	10
25	1970.10	10/6/1970	T	31	950	1,884	5	10	0	0	0	0	5	10

	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR
1												
2	CFS	AF	CFS	AF	CFS	AF	AF					
3	Tunnel Inf	Tunnel Inf	Final Holn	Final Holn	Total Lloy	Total Lloy	Lake Lloyc					
15							Final Storage					
16			Final	Final	Lloyd	Lloyd	Lake	Lloyd	Lake Lloyd Loss Calculation			
17	Eleanor	Eleanor	Holm	Holm	Total	Total	Lloyd	Storage	Area	Factor	CFS	AF
18	to Holm	to Holm	Total	Total	Release	Release	Storage	Change				
19	CFS	AF	CFS	AF	CFS	AF	200,000	AF				
20	218	433	218	433	223	443	200,091	91	1,607	0.003253	5.2	10.4
21	218	433	218	433	223	443	200,080	-11	1,607	0.003253	5.2	10.4
22	218	433	218	433	223	443	200,090	10	1,607	0.003253	5.2	10.4
23	218	433	218	433	223	443	199,278	-811	1,607	0.003253	5.2	10.4
24	218	433	218	433	223	443	199,896	617	1,605	0.003253	5.2	10.4
25	218	433	218	433	223	443	199,781	-115	1,607	0.003253	5.2	10.4

Figure 5.14-2. Supplemental Releases, Lake Eleanor Transfers and Final Reservoir Operation.

5.14.3 Snow-melt Management

A second check release is made during the February through June period for management of anticipated snowmelt runoff. On the first day of each of these months a forecast is made of anticipated runoff into the reservoir and minimum releases and losses from the reservoir, from the date of forecast through the end of June (assumed target of reservoir filling). These forecasts (Figure 5.14-3) determine the volume of water (if any) that will require release in excess of minimum releases and losses and storage gain by the end of June. Pre-knowledge is used for anticipated runoff, minimum releases and losses. The user defines the percentage of volume (of the total volume for the period) to be additionally released during each month. For February through May, a varying percentage of the additional release volume is advised for release, and is capped in rate as a means to confine releases within the capacity of Holm Powerhouse. The snowmelt check release is evenly distributed across the days of the month. The release can also be capped in terms of minimum volume of the reservoir to which it can be drawn during the month.

Row	A	B	C	D
1			1	
2	*Unit Title*		2	
3	*Parameter Title*		3	
5	*Acre-foot to CFS conversion*			
6	*divide by :*	*1.983471*		
14		*39-year Ave*		

June Storage Target (AF): 273,300 *Max Rel*
Minimum HH Storage for SM Drawdown (AF): 100,000 *Tgt (CFS)*
% Feb Release of Feb-June Excess: 20 1,000
% Mar Release of Mar-June Excess: 25 1,000 (*Max Rel Tgt (CFS)*)
% Apr Release of Apr-June Excess: 33 1,000 (*Max Rel Tgt (CFS)*)

				February Snow-melt Release Routine (February)							March Snow-melt Release Routine (March)							April Snow-melt Release Routine (April)						
Month Index	Date	Day	Days	1-Feb AJ Fcst AF	1-Feb FJune Fcst AF	FJune Riv+Trg Holm AF	FJune Ch Avail AF	FJune Excess AF	Feb SM Rel CFS	Max Stor Draw CFS	1-Mar AJ Fcst AF	1-Mar MJune Fcst AF	MJune Riv+Trg Holm AF	MJune Ch Avail AF	MJune Excess AF	March SM Rel CFS	Max Stor Draw CFS	1-Apr AJ Fcst AF	1-Apr AJune Fcst AF	AJune Riv+Trg Holm AF	AJune Ch Avail AF	AJune Excess AF	April SM Rel CFS	Max Stor Draw CFS
1970.10	10/1/1970	T	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970.10	10/2/1970	F	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970.10	10/3/1970	S	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970.10	10/4/1970	S	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970.10	10/5/1970	M	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970.10	10/6/1970	T	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Row	A	B	C	D
1			1	
2	*Unit Title*		2	
3	*Parameter Title*		3	
5	*Acre-foot to CFS conversion*			
6	*divide by :*	*1.983471*		
14		*39-year Ave*		

% May Rlease of Ma y-June Excess: 50 1,000 (*Max Rel Tgt (CFS)*)
% Jun Release of June Excess: 100 1,000 (*Max Rel Tgt (CFS)*)
Max Rel Tgt (CFS) 1,000 *Max*
CFS AF
Lloyd Targ Lloyd Targ

				May Snow-melt Release Routine (May)							June Snow-melt Release Routine (June)								
Month Index	Date	Day	Days	1-May AJ Fcst AF	1-May MJune Fcst AF	MJune Riv+Trg Holm AF	MJune Ch Avail AF	MJune Excess AF	May SM Rel CFS	Max Stor Draw CFS	1-Jun June UF AF	1-Jun June Fcst AF	June Riv+Trg Holm AF	June Ch Avail AF	June Excess AF	June SM Rel CFS	Max Stor Draw CFS	Target SM Release CFS	Target SM Release AF
1970.10	10/1/1970	T	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970.10	10/2/1970	F	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970.10	10/3/1970	S	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970.10	10/4/1970	S	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970.10	10/5/1970	M	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970.10	10/6/1970	T	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 5.14-3. Snow-melt Management.

5.15 SFEleanor Worksheet

This Model component worksheet (SFEleanor) simulates the operation of Lake Eleanor. Several sections of logic provide a systematic operation of the reservoir based on inflow and forecasted hydrology and water demands. The Model will direct releases from Lake Eleanor under a "hold-unless-need-to-release" protocol, except as conditioned by minimum release requirements, diversions, preferred/maximum storage, snowmelt management releases. When advised releases exceed the minimum Model logic attempts to transfer water to Lake Lloyd. The several sections of logic are illustrated and discussed below.

5.15.1 Lake Eleanor Release Demands, Initial Storage Computation and Encroachment Release

This section of logic (Figure 5.15-1) assembles the underlying water demands placed for Lake Eleanor releases. Reservoir inflow is derived from the Hydrology worksheet and is the unimpaired flow entering the reservoir. The initial releases are comprised of the minimum flow requirement below Lake Eleanor (from the CCSF worksheet). An initial check of reservoir storage occurs assuming the minimum releases for the river. A daily mass balance is performed: *change in reservoir storage = inflow, minus outflow (releases), minus reservoir losses*. The prior day's reservoir evaporation is included in the calculation. If the computation produces resulting Lake Eleanor storage in excess (encroachment) of the preferred storage target, the encroachment is computed. Every 7th day the model checks for an encroachment, and if it exists a check release is computed. For the preferred reservoir storage target encroachment it is assumed that a constant supplemental release (in excess of minimum releases) will be initiated at a rate equal to the encroachment divided equally over the next 7 days. This protocol repeats itself every 7th day, reestablishing the level of check release each time. The end result of this procedure will allow encroachment of storage space above the preferred storage target and not require unrealistic hard releases of water to exactly conform to the target.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1			1		Lake Eleanor Model																	
2	Unit Title		2		CFS	AF					CFS	AF				AF	AF					
3	Parameter Title		3		Lake Elear	Lake Eleanor Inflow					Eleanor R	Eleanor Req Stream Rel				Eleanor T	Eleanor Limit Storage					
4																						
5	Acre-foot to CFS conversion				This scenario								Base				Difference from Base					
6	divide by :	1.983471			Check Sums		Sum AF	39-ave		Other Sums		39-yr Ave		39-ave		39-yr Ave		39-ave		39-yr Ave		
7						Inflow	7,276,607	186,580			Tunnel	81,956	Inflow	186,580	Tunnel	81,956	Inflow	0	Tunnel	0		
8						Evap	72,708	1,864					Evap	1,864			Evap	0				
9						Tun Out	3,196,266	81,956					Tun Out	81,956			Tun Out	0				
10						Stream	4,008,460	102,781					Stream	102,781			Stream	0				
11						Net	-826															
12						Chng Stor	-826															
13																						
14		39-year Ave				186,580						9,087		1,864								
15					Inflow						Initial Release			Evap/loss	Initial Storage and Encroachment Release							
16					Lake	Lake					Stream	Stream			Initial	Eleanor	Hard			Spread	Spread	
17	Month				Eleanor	Eleanor					Req	Req		Net Res	Eleanor	Target	Limit	Initial	Encroach	Encroach	7th Day	
18	Index	Date	Day	Days	Inflow	Inflow					Bl Eleanor	Bl Eleanor		Evap/Loss	Storage	Storage	Storage	Encroach	7th Day	over 7	Enc over 7	7-day
19					CFS	AF					CFS	AF		AF	18,000	AF	AF	AF	AF	AF	CFS	Count
20	1970.10	10/1/1970	T	31	25	50					10	20		6	18,030	15,000	27,100	3,030	3,030	433	218	1
21	1970.10	10/2/1970	F	31	2	4					10	20		6	17,576	15,000	27,100	2,576	3,030	433	218	0
22	1970.10	10/3/1970	S	31	7	14					10	20		6	17,131	15,000	27,100	2,131	3,030	433	218	0
23	1970.10	10/4/1970	S	31	-179	-355					10	20		6	16,317	15,000	27,100	1,317	3,030	433	218	0
24	1970.10	10/5/1970	M	31	144	287					10	20		6	16,145	15,000	27,100	1,145	3,030	433	218	0
25	1970.10	10/6/1970	T	31	-21	-42					10	20		6	15,644	15,000	27,100	644	3,030	433	218	0

Figure 5.15-1. Reservoir Evaporation/Initial Storage Computation and Encroachment Release.

5.15.2 Lake Eleanor Transfers and Final Reservoir and Release Computation

This section of logic (Figure 5.15-2) performs the final computation of reservoir storage and releases, including consideration of snowmelt management releases (described later) and transfers from Lake Eleanor to Lake Lloyd.

Both the initial check release for preferred storage encroachment and the snowmelt check release are computed and advised for reservoir operations. If excess releases above minimum releases are computed the Model routes the additional release through the tunnel up to the limit of its available capacity or the capacity available at Holm Powerhouse. The remainder of the supplemental release is routed to the stream below Lake Eleanor. The Lake Eleanor operation protocol will transfer water that would otherwise be released in excess of minimum flow requirements (largely dependent upon the preferred target storage and snowmelt releases) but it will not allow water to be "pulled" from Lake Eleanor to Lake Lloyd.

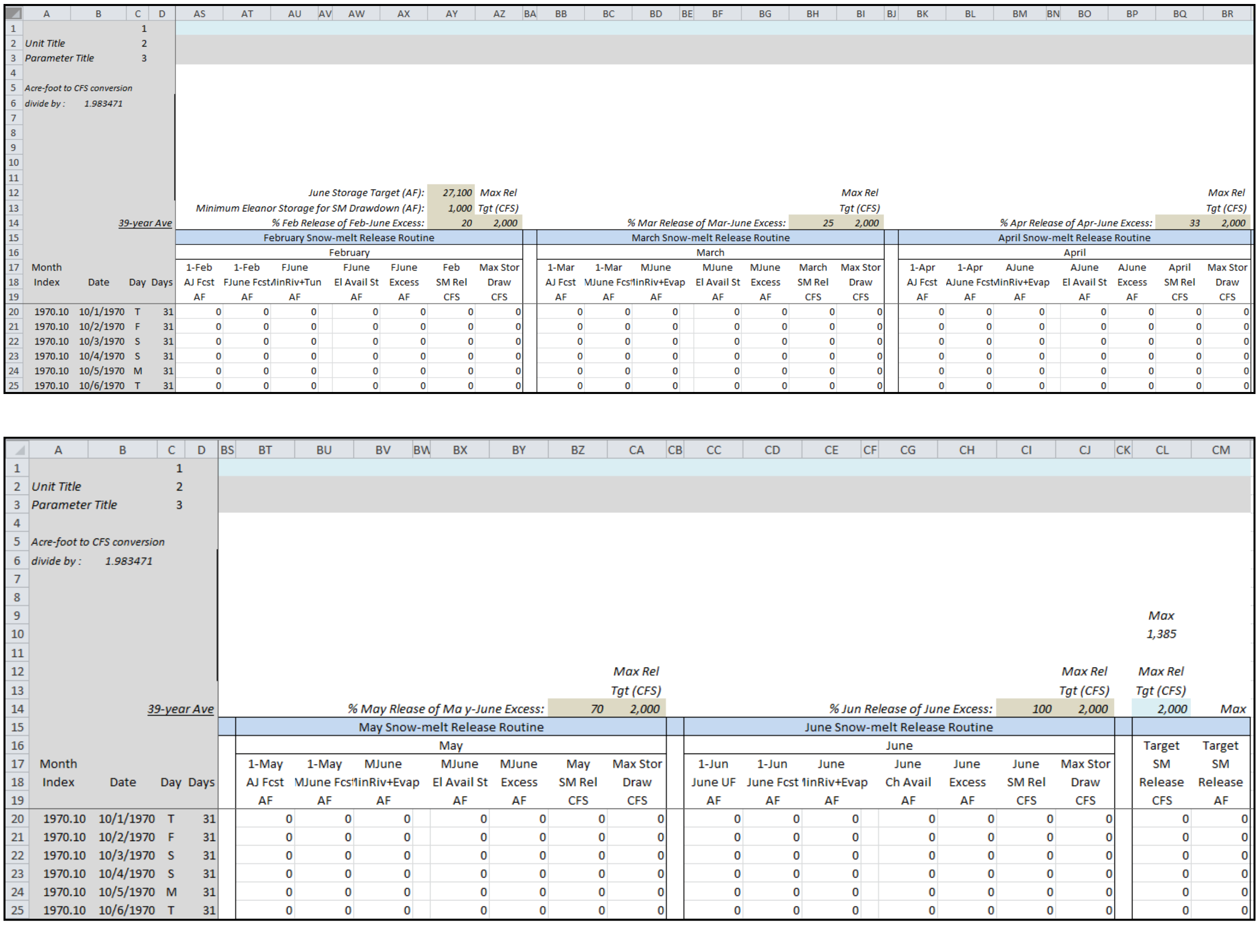
The operation goal linkage between Lake Lloyd and Lake Eleanor assumes that Lake Eleanor will transfer water from its watershed to Lake Lloyd for the purpose of enhancing power generation at Holm Powerhouse. Thus, any available capacity at Holm Powerhouse after the Lloyd-only operation is assumed available and desired for use of a Lake Eleanor transfer. If water is transferred from Lake Eleanor the model assumes the water to be directly routed to Holm Powerhouse which then becomes additional release from Lake Lloyd. Reservoir losses are computed in accordance with procedures of the Fourth Agreement.

	A	B	C	D	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR
1			1																							
2	*Unit Title*		2						CFS	AF	CFS	AF					CFS	AF	CFS	AF	AF					
3	*Parameter Title*		3						Tunnel	Tunnel	Eleanor St	Eleanor Stream Release					Tun Trans	Tun Trans	Total Elea	Total Elea	Lake Eleanor Storage					
4																										
5	*Acre-foot to CFS conversion*																									
6	*divide by :*	*1.983471*																								
7																										
8																										
9																										
10																										
11														*Tunnel Capacity*		*(C 2.81)*										
12															*400*	*CFS Max*										
13																										
14				*39-year Ave*						*81,956*		*102,781*								*184,737*						
15					Revised and Final Routing																Final Storage					
16					Revised	Revised	Excess	Excess	Put	Put			Avail	Avail	Limit by	Limit by			Total	Total	Revised	Eleanor	Lake Eleanor Loss Calculation			
17	Month				Stream	Stream	abv Min	abv Min	to	to	Final	Final	Holm Cap	Holm Cap	Tunnel	Tunnel	Transfer	Transfer	Eleanor	Eleanor	Eleanor	Storage	Area	Factor		
18	Index	Date	Day	Days	Release	Release	Stream	Stream	Tunnel	Tunnel	Stream	Stream	for El	for El	Available	Available	Capacity	Capacity	Release	Release	Storage	Change				
19					CFS	AF	CFS	AF	CFS	AF	CFS	AF	CFS	AF	CFS	AF	CFS	AF	CFS	AF	18,000	AF	Acres		CFS	AF
20	1970.10	10/1/1970	T	31	228	453	218	433	218	433	10	20	950	1,884	400	793	400	793	228	453	17,591	-409	896	0.003253	2.9	5.8
21	1970.10	10/2/1970	F	31	228	453	218	433	218	433	10	20	950	1,884	400	793	400	793	228	453	17,137	-454	893	0.003253	2.9	5.8
22	1970.10	10/3/1970	S	31	228	453	218	433	218	433	10	20	950	1,884	400	793	400	793	228	453	16,692	-445	890	0.003253	2.9	5.7
23	1970.10	10/4/1970	S	31	228	453	218	433	218	433	10	20	950	1,884	400	793	400	793	228	453	15,878	-814	885	0.003253	2.9	5.7
24	1970.10	10/5/1970	M	31	228	453	218	433	218	433	10	20	950	1,884	400	793	400	793	228	453	15,707	-172	876	0.003253	2.8	5.7
25	1970.10	10/6/1970	T	31	228	453	218	433	218	433	10	20	950	1,884	400	793	400	793	228	453	15,206	-501	874	0.003253	2.8	5.6

Figure 5.15-2. Lake Eleanor Transfers and Final Reservoir Operation.

5.15.3 Snow-melt Management

A second check release is made during the February through June period for management of anticipated snowmelt runoff. On the first day of each of these months a forecast is made of anticipated runoff into the reservoir and minimum releases and losses from the reservoir, from the date of forecast through the end of June (assumed target of reservoir filling). These forecasts (Figure 5.15-3) determine the volume of water (if any) that will require release in excess of minimum releases and losses and storage gain by the end of June. Pre-knowledge is used for anticipated runoff, minimum releases and losses. The user defines the percentage of volume (of the total volume for the period) to be additionally released during each month. For February through May, a varying percentage of the additional release volume is advised for release. The snowmelt check release is evenly distributed across the days of the month. The release can also be capped in terms of minimum volume of the reservoir to which it can be drawn during the month.



	A	B	C	D
1			1	
2	Unit Title		2	
3	Parameter Title		3	
5	Acre-foot to CFS conversion			
6	divide by :	1.983471		
14			39-year Ave	

June Storage Target (AF): 27,100 Max Rel
Minimum Eleanor Storage for SM Drawdown (AF): 1,000 Tgt (CFS)
% Feb Release of Feb-June Excess: 20 2,000
% Mar Release of Mar-June Excess: 25 Max Rel Tgt (CFS) 2,000
% Apr Release of Apr-June Excess: 33 Max Rel Tgt (CFS) 2,000

Month Index	Date	Day	Days	February Snow-melt Release Routine: 1-Feb AJ Fcst AF	1-Feb FJune Fcst AF	FJune MinRiv+Tun AF	FJune El Avail St AF	FJune Excess AF	Feb SM Rel CFS	Max Stor Draw CFS	March Snow-melt Release Routine: 1-Mar AJ Fcst AF	1-Mar MJune Fcst AF	MJune MinRiv+Evap AF	MJune El Avail St AF	MJune Excess AF	March SM Rel CFS	Max Stor Draw CFS	April Snow-melt Release Routine: 1-Apr AJ Fcst AF	1-Apr AJune Fcst AF	AJune MinRiv+Evap AF	AJune El Avail St AF	AJune Excess AF	April SM Rel CFS	Max Stor Draw CFS
1970.10	10/1/1970	T	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970.10	10/2/1970	F	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970.10	10/3/1970	S	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970.10	10/4/1970	S	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970.10	10/5/1970	M	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970.10	10/6/1970	T	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

% May Rlease of Ma y-June Excess: 70 Max Rel Tgt (CFS) 2,000
% Jun Release of June Excess: 100 Max Rel Tgt (CFS) 2,000
Max 1,385 Max Rel Tgt (CFS) 2,000 Max

Month Index	Date	Day	Days	May Snow-melt Release Routine: 1-May AJ Fcst AF	1-May MJune Fcst AF	MJune MinRiv+Evap AF	MJune El Avail St AF	MJune Excess AF	May SM Rel CFS	Max Stor Draw CFS	June Snow-melt Release Routine: 1-Jun June UF AF	1-Jun June Fcst AF	June MinRiv+Evap AF	June Ch Avail AF	June Excess AF	June SM Rel CFS	Max Stor Draw CFS	Target SM Release CFS	Target SM Release AF
1970.10	10/1/1970	T	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970.10	10/2/1970	F	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970.10	10/3/1970	S	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970.10	10/4/1970	S	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970.10	10/5/1970	M	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970.10	10/6/1970	T	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 5.15-3. Snow-melt Management.

5.16 SFWaterBank Worksheet

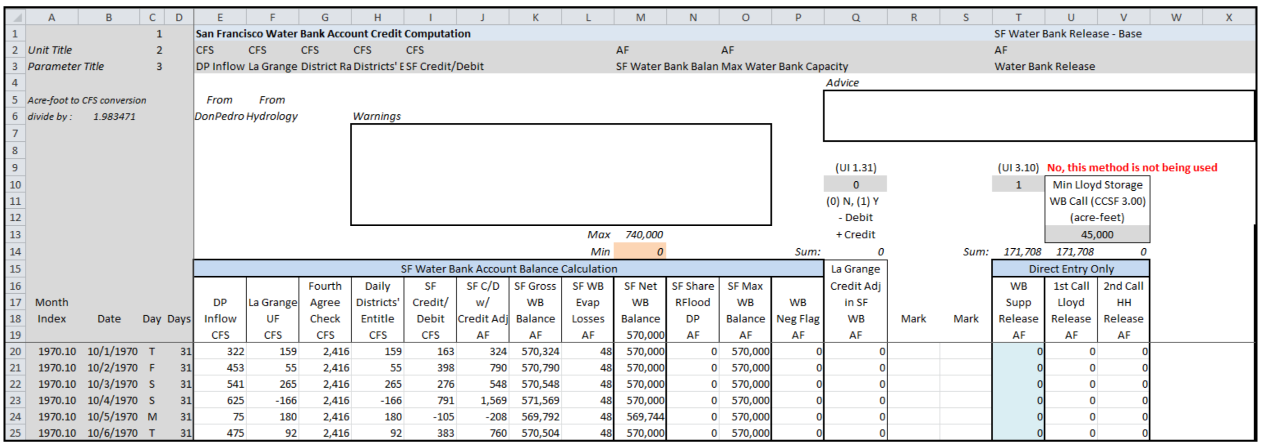
This worksheet (SFWaterBank) provides for entry of daily supplemental releases from the CCSF System. The worksheet is comparable to worksheet WaterBankRel except that this worksheet provides alternative methods of identifying supplemental releases (UI 3.10 = 0). Employing this option, the user can identify year type table-based supplemental flow, without or without addition of the pre-processed Test Case supplemental release.

Without any other manual intervention the Model will direct releases from the CCSF System under a “hold-unless-need-to-release” protocol. Additional releases greater than provided by the default protocol may be needed. An example of such a need is during periods when CCSF System operations would otherwise deplete the Water Bank Account to a point of a “negative” balance.

The manual adjustment to releases from the CCSF System is provided to allow the user to “pull” additional water from the CCSF System as supplemental inflow to Don Pedro Reservoir. An entry of supplemental release is established that will first pull water from Lake Lloyd so that water supply is preserved in the Hetch Hetchy Reservoir system for diversion to the SJPL. At a point when such supplemental releases strain Lake Lloyd storage, the supplemental releases are directed to Hetch Hetchy Reservoir. The supplemental release is directed from a reservoir at a point in logic after the default protocol releases occur. Thus, the release occurs in addition to what operation is already occurring by default. Such a release can affect the following day's default operation or previous periods' operations, thus results require review to determine if the user's desired result occurs.

5.16.1 CCSF Water Bank Account Balance Accounting, CCSF La Grange Flow Responsibility and Test Case Supplemental Releases

Figure 5.16-1 is a snapshot of the worksheet. The worksheet provides the daily accounting of the Water Bank Account Balance for the Model. Information ported from other worksheets of the Model into this worksheet is Don Pedro Reservoir inflow (Column E) and the unimpaired flow at La Grange (Column F). These data and the protocols associated with Fourth Agreement Water Bank Account Balance accounting (Columns G through Column O) derive the daily credit or debit of CCSF and then the daily balance of the Water Bank Account (Column M).



Month Index	Date	Day	Days	DP Inflow CFS	La Grange UF CFS	Fourth Agree Check CFS	Daily Districts' Entitle CFS	SF Credit/ Debit CFS	SF C/D w/ Credit Adj AF	SF Gross WB Balance AF	SF WB Evap Losses AF	SF Net WB Balance 570,000	SF Share RFlood DP AF	SF Max WB Balance AF	WB Neg Flag AF	La Grange Credit Adj in SF WB AF	Mark	Mark	WB Supp Release AF	1st Call Lloyd Release AF	2nd Call HH Release AF
1970.10	10/1/1970	T	31	322	159	2,416	159	163	324	570,324	48	570,000	0	570,000	0	0			0	0	0
1970.10	10/2/1970	F	31	453	55	2,416	55	398	790	570,790	48	570,000	0	570,000	0	0			0	0	0
1970.10	10/3/1970	S	31	541	265	2,416	265	276	548	570,548	48	570,000	0	570,000	0	0			0	0	0
1970.10	10/4/1970	S	31	625	-166	2,416	-166	791	1,569	571,569	48	570,000	0	570,000	0	0			0	0	0
1970.10	10/5/1970	M	31	75	180	2,416	180	-105	-208	569,792	48	569,744	0	570,000	0	0			0	0	0
1970.10	10/6/1970	T	31	475	92	2,416	92	383	760	570,504	48	570,000	0	570,000	0	0			0	0	0

Figure 5.16-1. CCSF Water Bank Balance Accounting.

For purposes of the FERC investigation, the protocols of Fourth Agreement Water Bank Accounting have been amended to incorporate a hypothetical implementation of "shared responsibility" for incremental increases in FERC-required flows for the Tuolumne River.[3] If running the scenario with shared responsibility has been selected (worksheet UserInput Switch UI 1.31 = 1), the incremental increase in FERC-required flows is determined by the daily difference between the current 1995 FERC Settlement requirements and scenario-required minimum flows. This computation occurs in worksheet LaGrangeSchedule with information regarding the scenario-required flows directed through worksheet UserInput. Approximately fifty-two percent (51.7121%) of the incremental difference between the flow schedules is assigned as CCSF's responsibility and shows in Column Q as a "debit". This debit then enters Fourth Agreement Water Bank Accounting at Column J, and subsequently contributes to the determination of the daily Water Bank Account Balance (Column M).

[3] The "shared responsibility" assumption is presented for the purpose of evaluating alternative operations. The assumption shall not be used as evidence in any proceeding relating to and shall not act as precedence for any allocation of Tuolumne River water between CCSF and the Districts for any purpose under the Fourth Agreement.

Water Bank Account Balances which are less than zero ("negative") are highlighted, and the minimum balance, whether negative or positive, is reported in Cell M14. By default, the base supplemental releases to maintain a positive Water Bank Account Balance at or above zero have been entered into Column T (WB Supplemental Release). An alternative time series can be used. The Model will first direct the supplemental release to Lake Lloyd, and continue releases until storage at Lake Lloyd is drawn to a specified 45,000 acre-feet minimum level (shown in Cell Q10 and entered at worksheet CCSF Switch 3.00). Subsequent supplemental releases will be drawn from Hetch Hetchy Reservoir any time storage is less than the Lake Lloyd minimum.

5.16.2 User Specified Table of Supplemental Releases and Reservoir Status Computation

Figure 5.16-2 illustrates the section of logic that incorporates a user Specified table of supplemental releases (UI 3.40) into the Model. A daily time series (Column Y) of supplemental releases is developed from the user specified table in worksheet UserInput. By selection, the user identifies whether or not the year type table-based supplemental release is added the preprocessed Test Case supplemental releases (Column T previously described). The Model then uses the selected supplemental release in its computation of operations.

	A	B	C	D	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI
1			1			User-defined SF Upstream Supplemental Release									
2	*Unit Title*		2							AF					
3	*Parameter Title*		3							Total SF Suppl Release					
4															
5	*Acre-foot to CFS conversion*														
6	*divide by :*	*1.983471*								*(UI 3.10)*	1	No, this method is not being used			
7					*2,704,000*	*2,875,708*	*2,875,708*	*0*							
8						Add Base									
9						Supp				Final Supplimental Release from Other Method					
10						1	N/A			0	*(UI 3.20)*				
11						*(0) no*	*(UI 3.30)*			*(0) Base*			Min	Min	Min
12						*(1) yes*				*(1) User-defined*			103,852	84,135	508,489
13					Supplemental Table Entry								Min	Min	Min
14						Supp							Non 76-77	Non 76-77	Non 76-77
15					Supp	Table	1st Call	2nd Call					103,852	114,720	785,605
16					Table	Only, or	To	To	*Sum:*	*171,708*	*171,708*	*0*			
17	Month				Release	Table +	Lloyd	HH			Lloyd	HH	Lloyd	HH	DP
18	Index	Date	Day	Days	Only	Existing	Release	Release		Total	Release	Release	Storage	Storage	Storage
19					AF	AF	AF	AF		AF	AF	AF	AF	AF	AF
20	1970.10	10/1/1970	T	31	0	0	0	0		0	0	0	200,091	249,349	1,666,767
21	1970.10	10/2/1970	F	31	0	0	0	0		0	0	0	200,080	248,379	1,664,567
22	1970.10	10/3/1970	S	31	0	0	0	0		0	0	0	200,090	247,622	1,662,719
23	1970.10	10/4/1970	S	31	0	0	0	0		0	0	0	199,278	247,032	1,659,892
24	1970.10	10/5/1970	M	31	0	0	0	0		0	0	0	199,896	246,150	1,656,745
25	1970.10	10/6/1970	T	31	0	0	0	0		0	0	0	199,781	245,360	1,654,119

Figure 5.16-2. CCSF Supplemental Release.

The result of entering the supplemental release will cause a recalculation of the entire Model with results refreshed in the worksheet. Lake Lloyd, Hetch Hetchy Reservoir and Don Pedro Reservoir storage is ported from other worksheets to provide the status of their storage as supplemental releases are entered.

Warnings and advice are provided in the worksheet when several conditions occur. The snapshots below illustrate the occurrence of these conditions. In this first example (Figure 5.16-3) a warning has been provided that a reservoir has likely been depleted by the current operation assumptions. In this particular example, Tuolumne River minimum flows were increased with responsibility shared with CCSF, and a set of supplemental releases were established. In this iteration of results it is discovered in Column X (Hetch Hetchy Reservoir storage) an error (reported as "#N/A") on August 26, 1992 has occurred in the Model.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
1			1		San Francisco Water Bank Account Balance Computation and Supplement Release																				
2	Unit Title		2		CFS	CFS	CFS	CFS	CFS	AF		AF	AF		AF		AF			AF					
3	Parameter Title		3		DP Inflow	La Grange	Fourth Ag	Districts' E	SF Credit/	SF Credit/Debit w/ C		SF WB Eva	SF Water Bank Balan		Max Water Bank Cap		Credit Adj fc			SF Supplemental Release					
4																	Advice								
5	Acre-foot to CFS conversion				From	From											#N/A								
6	divide by :	1.983471			DonPedro	Hydrology		Warnings									#N/A								
7									Warning: Your have likely drained a reservoir, check reservoirs.								#N/A								
8									#N/A	#N/A															
9										#N/A							(UI 1.31)			(UI 3.10)	Yes, this method is being used				
10									#N/A	#N/A							1			1	Min Lloyd Storage		Min	Min	Min
11										#N/A							(0) N, (1) Y				WB Call (CCSF 3.00)		24,474	#N/A	#N/A
12																	- Debit				(acre-feet)		Min	Min	Min
13												Max	#N/A				+ Credit				45,000		Non76-77	Non76-77	Non76-77
14												Min	#N/A			Sum:	-5,922,391		Sum:	1,197,522	714,938	482,584	24,474	#N/A	#N/A
15					SF Water Bank Account Balance Calculation												La Grange			Supplemental Release and Storage Check					
16							Fourth	Daily	SF	SF C/D	SF Gross	SF WB	SF Net	SF Share	SF Max		Credit Adj			WB	1st Call	2nd Call			
17	Month				DP	La Grange	Agree	Districts'	Credit/	w/	WB	Evap	WB	RFlood	WB	WB	in SF			Supp	Lloyd	HH	Lloyd	HH	DP
18	Index	Date	Day	Days	Inflow	UF	Check	Entitle	Debit	Credit Adj	Balance	Losses	Balance	DP	Balance	Neg Flag	WB	Mark	Mark	Release	Release	Release	Storage	Storage	Storage
19					CFS	CFS	CFS	CFS	CFS	AF	AF	AF	570,000	AF	AF	AF	AF			AF	AF	AF	AF	AF	AF
8018	1992.08	8/24/1992	M	31	205	5	2,416	5	200	396	-122,421	0	-122,421	0	570,000	-396	0			0	0	0	30,461	1,488	528,302
8019	1992.08	8/25/1992	T	31	445	28	2,416	28	417	827	-121,594	0	-121,594	0	570,000	-827	0			0	0	0	30,065	262	526,440
8020	1992.08	8/26/1992	W	31	#N/A	201	2,416	201	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0			0	0	0	29,709	#N/A	#N/A
8021	1992.08	8/27/1992	T	31	#N/A	104	2,416	104	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0			0	0	0	29,370	#N/A	#N/A

Note: This screen save is from the worksheet WaterBankRel description. Identical warnings are included in worksheet SFWaterBank.

Figure 5.16-3. Example 1: A Reservoir Empties and the Model Crashes.

By review of the previous day's storage results for Lake Lloyd (Column W), Hetch Hetchy Reservoir (Column X) and Don Pedro Reservoir (Column Y), and the rate of depletion for each of these reservoirs, it is concluded that Hetch Hetchy Reservoir likely drained on August 26 and thus crashed the Model. Although noted, a negative Water Bank Account Balance (Column M) will not cause the Model to crash. To remedy the condition, the user uses worksheet UserInput to revise (lower) SJPL diversions from Hetch Hetchy Reservoir (UI 4.10 and UI 4.20) and retain water in Hetch Hetchy Reservoir for release. If Don Pedro Reservoir storage was the culprit of causing the Model to crash, the user uses worksheet UserInput to revise (lower) MID and TID canal diversions (UI 2.10, UI 2.20 and UI 2.30 to retain water in Don Pedro Reservoir for release. Alternatively, the user could reduce the scenario's designated minimum flow requirement, which would change flow needed from the upstream systems.

In a second example (Figure 5.16-4), a warning has been provided that the Water Bank Account Balance is negative for one or more days of the scenario. In this instance, all Model reservoirs are operating within a viable operation (the Model did not crash due an emptying reservoir); however, the objective to maintain a positive Water Bank Account Balance has been violated. Upon inspection of the results the user can find the first instance of violation and remedy the violation by entry into Column T an amount of release that maintains at least a zero balance in the Water Bank Account Balance, and/or modify the year type table-based supplemental flows in worksheet UserInput. For the first day of violation the reported negative balance (e.g., -3,253 acre-feet) is needed as a supplemental release. The ensuing days of supplemental release are informed by Column P.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
1			1		San Francisco Water Bank Account Balance Computation and Supplement Release																				
2	Unit Title		2		CFS	CFS	CFS	CFS	CFS	AF		AF	AF		AF		AF			AF					
3	Parameter Title		3		DP Inflow	La Grange	Fourth Ag	Districts' E	SF Credit/	SF Credit/Debit w/ C		SF WB Eva	SF Water Bank Balan		Max Water Bank Cap		Credit Adj fc			SF Supplemental Release					
4																	Advice								
5	Acre-foot to CFS conversion				From	From											If Water Bank Balance is negative (shown as highlighted value in								
6	divide by :	1.983471			DonPedro	Hydrology		Warnings									Column M) enter volume of supplemental release into Column T to								
7																	maintin balance at zero or greater. Use Column M and Column P for guidance.								
8								Warning: SF Water Bank is 'negative'. Add supplemental release																	
9								(Column T) to maintain balance at least zero.									(UI 1.31)			(UI 3.10)	Yes, this method is being used				
10																	0			1	Min Lloyd Storage		Min	Min	Min
11																	(0) N, (1) Y				WB Call (CCSF 3.00)		131,254	84,135	508,489
12																	- Debit				(acre-feet)		Min	Min	Min
13												Max	740,000				+ Credit				45,000		Non76-77	Non76-77	Non76-77
14												Min	-150,778			Sum:	0		Sum:	0	0	0	131,254	114,720	740,875
15					SF Water Bank Account Balance Calculation												La Grange			Supplemental Release and Storage Check					
16							Fourth	Daily	SF	SF C/D	SF Gross	SF WB	SF Net	SF Share	SF Max		Credit Adj			WB	1st Call	2nd Call			
17	Month				DP	La Grange	Agree	Districts'	Credit/	w/	WB	Evap	WB	RFlood	WB	WB	in SF			Supp	Lloyd	HH	Lloyd	HH	DP
18	Index	Date	Day	Days	Inflow	UF	Check	Entitle	Debit	Credit Adj	Balance	Losses	Balance	DP	Balance	Neg Flag	WB	Mark	Mark	Release	Release	Release	Storage	Storage	Storage
19					CFS	CFS	CFS	CFS	CFS	AF	AF	AF	570,000	AF	AF	AF	AF			AF	AF	AF	AF	AF	AF
7887	1992.04	4/15/1992	W	30	2138	4,322	4,066	4,066	-1,928	-3,824	4,011	0	4,011	0	570,000	0	0			0	0	0	256,353	262,227	969,641
7888	1992.04	4/16/1992	T	30	1628	3,150	4,066	3,150	-1,521	-3,017	994	0	994	0	570,000	0	0			0	0	0	257,148	263,740	969,822
7889	1992.04	4/17/1992	F	30	1925	4,267	4,066	4,066	-2,141	-4,247	-3,253	0	-3,253	0	570,000	4,247	0			0	0	0	259,037	265,786	970,196
7890	1992.04	4/18/1992	S	30	1980	5,507	4,066	4,066	-2,086	-4,137	-7,390	0	-7,390	0	570,000	4,137	0			0	0	0	260,795	270,314	970,897

Note: This screen save is from the worksheet WaterBankRel description. Identical warnings are included in worksheet SFWaterBank.

Figure 5.16-4. Example 2: Water Bank is Negative.

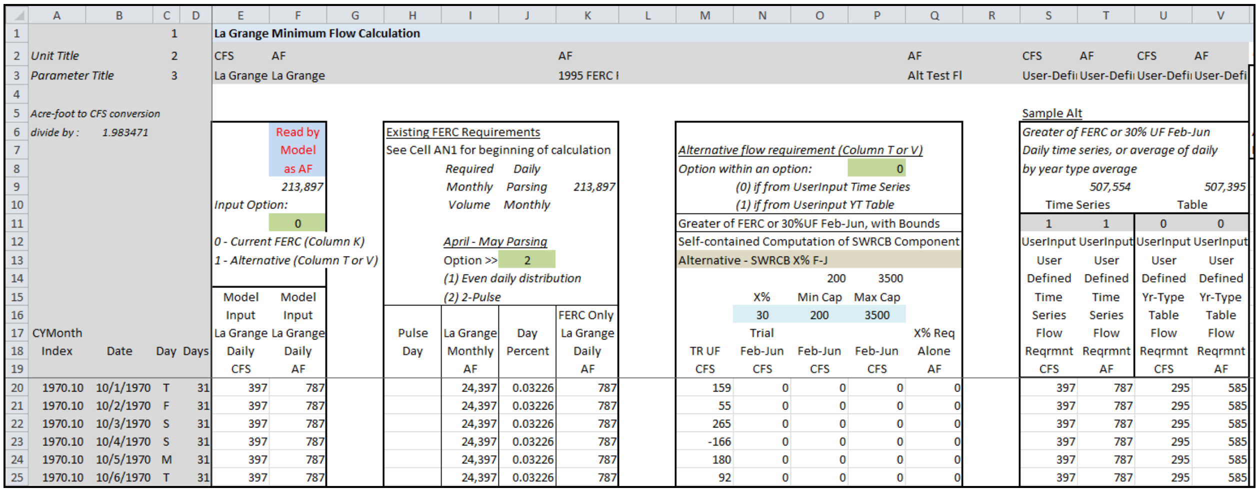
It is possible that within the remedy of Example 2 the error exemplified by Example 1 may occur as Hetch Hetchy Reservoir may be drained through the efforts of maintaining a positive Water Bank Account Balance. At that point, the procedures of Example 1 will be required and the values already derived for supplemental releases may need to be revisited and possibly changed.

5.17 LaGrangeSchedule Worksheet

This worksheet (LaGrangeSchedule) assembles the designation of the minimum flow requirement for the Tuolumne River. By user specification (UI 1.10) either the current 1995 FERC schedule is selected (UI 1.10 = 0) or the user defined minimum flow requirement is selected (UI 1.10 = 1). If the current 1995 FERC schedule is selected the computation of the schedule is computed in this worksheet (later described).

5.17.1 Minimum Flow Requirement Options

When using current 1995 FERC minimum flow requirements, the user can direct (worksheet Control, switch C 1.60) which shape of releases to assume for pulse flows during April and May. This section of the worksheet (Figure 5.17-1) performs the parsing the monthly flow requirements into daily flow requirements. If using the user specified flow schedule (identified and processed in worksheet UserInput), this section prepares the use of that data for use by the Model. Upon selection of the flow requirement, Column F is used to provide the minimum flow requirement to the rest of the Model. Although not directly linked through user switches, this section of the worksheet illustrates an example of developing an alternative flow requirement for testing. Columns M through Column Q perform a synthesis of an alternative flow requirement as has been suggested by the SWRCB. This particular flow requirement currently serves as the example alternative requirement for this documentation. The specifics of this component of flow requirement (February through June) in combination with the current 1995 FERC minimum flow requirement has been provided to worksheet UserInput for illustration purposes.

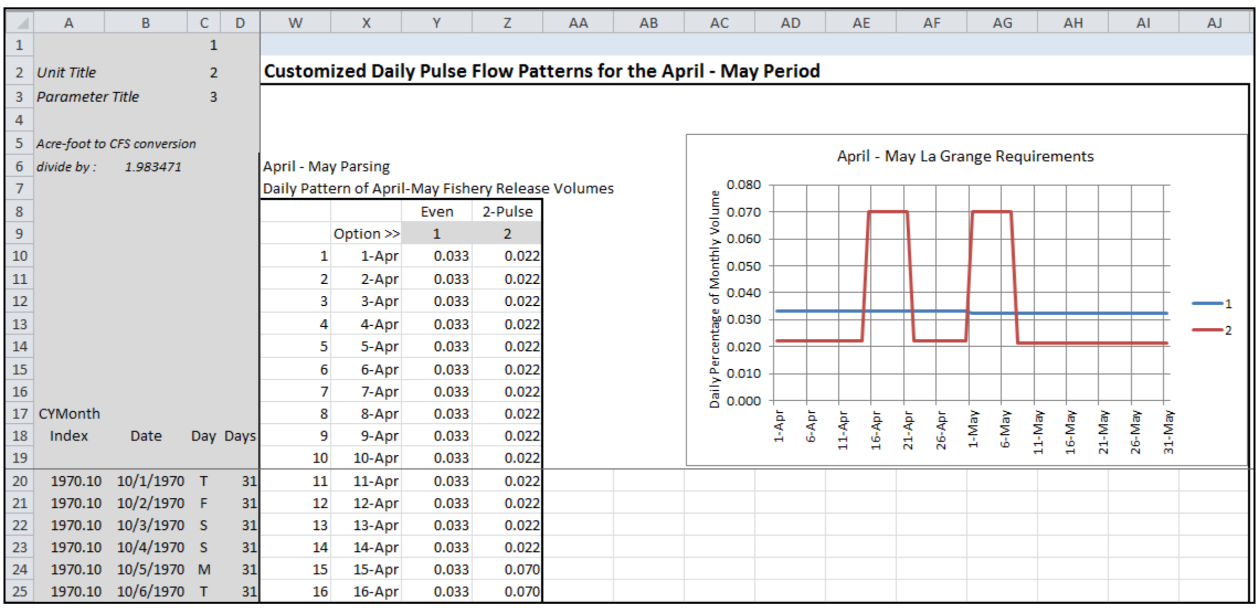


CYMonth Index	Date	Day	Days	Model Input La Grange Daily CFS	Model Input La Grange Daily AF	Pulse Day	La Grange Monthly AF	Day Percent	FERC Only La Grange Daily AF	TR UF CFS	X% 30 Trial Feb-Jun CFS	Min Cap 200 Feb-Jun CFS	Max Cap 3500 Feb-Jun CFS	X% Req Alone AF	UserInput User Defined Time Series Flow Reqrmnt CFS	UserInput User Defined Time Series Flow Reqrmnt AF	UserInput User Defined Yr-Type Table Flow Reqrmnt CFS	UserInput User Defined Yr-Type Table Flow Reqrmnt AF
1970.10	10/1/1970	T	31	397	787		24,397	0.03226	787	159	0	0	0	0	397	787	295	585
1970.10	10/2/1970	F	31	397	787		24,397	0.03226	787	55	0	0	0	0	397	787	295	585
1970.10	10/3/1970	S	31	397	787		24,397	0.03226	787	265	0	0	0	0	397	787	295	585
1970.10	10/4/1970	S	31	397	787		24,397	0.03226	787	-166	0	0	0	0	397	787	295	585
1970.10	10/5/1970	M	31	397	787		24,397	0.03226	787	180	0	0	0	0	397	787	295	585
1970.10	10/6/1970	T	31	397	787		24,397	0.03226	787	92	0	0	0	0	397	787	295	585

Figure 5.17-1. Daily Parsing of Minimum FERC Flow Requirement.

5.17.2 April – May Daily Parsing of Flow Requirements

This section of the worksheet (Figure 5.17-2) provides information to parse monthly-designated minimum flow requirements into daily patterns during April and May. Worksheet Control designates which parsing pattern is to be used.



	Option >>	Even 1	2-Pulse 2
1	1-Apr	0.033	0.022
2	2-Apr	0.033	0.022
3	3-Apr	0.033	0.022
4	4-Apr	0.033	0.022
5	5-Apr	0.033	0.022
6	6-Apr	0.033	0.022
7	7-Apr	0.033	0.022
8	8-Apr	0.033	0.022
9	9-Apr	0.033	0.022
10	10-Apr	0.033	0.022
11	11-Apr	0.033	0.022
12	12-Apr	0.033	0.022
13	13-Apr	0.033	0.022
14	14-Apr	0.033	0.022
15	15-Apr	0.033	0.070
16	16-Apr	0.033	0.070

Figure 5.17-2. April-May Daily Parsing of Minimum FERC Flow Requirement.

5.17.3 Computation of 1995 FERC Minimum Flow Requirement

This section of the worksheet (Figure 5.17-3) computes the current 1995 FERC flow requirement. Several elements of information provided in this worksheet and from worksheet Control provide the computation of flow requirement based on 1995 FERC Settlement procedures and flow rates. The basis of the year type flow requirements is the SWRCB San Joaquin River Basin 60-20-20 index. The annual flow schedules are assumed to be apply on a

April through March year, with the interpolation water of the schedules applied to April and May pulse flows.

Row	A	B	C	D	AN	AO	AP	AQ	AR	AS	AT	AU	AV	AW	AX	AY	AZ	BA
1			1		Current FERC Requirements													
2	*Unit Title*		2		Tuolumne River Flow Interpolation - Year 2011 Revised Distribution													
3	*Parameter Title*		3															
4					Flow Year Type			SJR Basin Index				Flow Requirement						
5	*Acre-foot to CFS conversion*																Base	
6	*divide by :*	*1.983471*			1		<	1510								94000	82,910	
7					2			1510	- <	2000		0.0286	x (Index -	1510	) +	103000	82,910	
8					3			2000	- <	2190		0.0552	x (Index -	2000	) +	117016	84,398	
9					4			2190	- <	2440		0.0600	x (Index -	2190	) +	127507	90,448	
10					5			2440	- <	2720		0.0804	x (Index -	2440	) +	142502	106,583	
11					6			2720	- <	3180		0.2955	x (Index -	2720	) +	165002	104,977	
12					7			3180	and Greater							300923	211,044	
13													Option >>	1	2	3	4	5
14					1	<<Option			Ave	219,421	149,274	70,146		Actual	90% Exc.	75% Exc.	Med.	10% Exc.
15					SJR					Tuolumne	Tuolumne	Pulse	Base	SJR	Apr SJR	Apr SJR	Apr SJR	Apr SJR
16					Index	Year		Water		River	River	Flow	Year	Index	Index	Index	Index	Index
17	CYMonth				602020	Class		Year		Require	Base	Calc	Type	602020	Fcast	Fcast	Fcast	Fcast
18	Index	Date	Day	Days	4,543,729	Wet		1922		300,923	211,044	89,879	7	4,543,729	2,424,373	2,561,322	2,674,495	2,921,846
19					3,549,358	Above		1923		300,923	211,044	89,879	7	3,549,358	1,765,568	1,897,976	2,007,411	2,246,643
20	1970.10	10/1/1970	T	31	1,419,746	Critical		1924		94,000	82,910	11,090	1	1,419,746	799,642	853,197	957,737	1,186,335
21	1970.10	10/2/1970	F	31	2,929,617	Below		1925		226,944	104,977	121,967	6	2,929,617	2,042,878	2,179,628	2,292,637	2,539,632
22	1970.10	10/3/1970	S	31	2,300,567	Dry		1926		134,141	90,448	43,693	4	2,300,567	1,256,470	1,387,014	1,494,917	1,730,818
23	1970.10	10/4/1970	S	31	3,558,955	Above		1927		300,923	211,044	89,879	7	3,558,955	2,147,110	2,284,156	2,397,408	2,644,932
24	1970.10	10/5/1970	M	31	2,632,407	Below		1928		157,972	106,583	51,388	5	2,632,407	1,934,163	2,068,826	2,180,117	2,423,380
25	1970.10	10/6/1970	T	31	2,004,815	Critical		1929		117,282	84,398	32,884	3	2,004,815	1,140,712	1,270,277	1,377,372	1,611,521
26	1970.10	10/7/1970	W	31	2,016,115	Critical		1930		117,906	84,398	33,508	3	2,016,115	1,270,167	1,401,445	1,509,950	1,747,161
27	1970.10	10/8/1970	T	31	1,200,755	Critical		1931		94,000	82,910	11,090	1	1,200,755	917,245	1,046,199	1,152,794	1,385,852
28	1970.10	10/9/1970	F	31	3,410,299	Above		1932		300,923	211,044	89,879	7	3,410,299	2,675,191	2,815,654	2,931,719	3,185,352
29	1970.10	10/10/1970	S	31	2,440,676	Dry		1933		142,556	106,583	35,973	5	2,440,676	1,770,057	1,901,889	2,010,851	2,249,053
30	1970.10	10/11/1970	S	31	1,440,719	Critical		1934		94,000	82,910	11,090	1	1,440,719	1,409,613	1,541,549	1,650,596	1,888,983
31	1970.10	10/12/1970	M	31	3,557,242	Above		1935		300,923	211,044	89,879	7	3,557,242	2,246,995	2,384,346	2,497,850	2,745,918
32	1970.10	10/13/1970	T	31	3,740,020	Above		1936		300,923	211,044	89,879	7	3,740,020	3,075,777	3,216,284	3,332,384	3,586,095
33	1970.10	10/14/1970	W	31	3,897,744	Wet		1937		300,923	211,044	89,879	7	3,897,744	3,466,677	3,608,402	3,725,505	3,981,393
34	1970.10	10/15/1970	T	31	5,894,485	Wet		1938		300,923	211,044	89,879	7	5,894,485	4,445,912	4,594,804	4,717,805	4,986,506
35	1970.10	10/16/1970	F	31	2,198,794	Dry		1939		128,035	90,448	37,587	4	2,198,794	1,767,445	1,899,140	2,007,989	2,245,946

FERC Flow Schedules

Year Type	1	2	3	4	5	6	7
Oct 1-15 (CFS)	100	100	150	150	180	200	300
Oct 16-31 (CFS)	150	150	150	150	180	175	300
Total Base (AF)	7,736	7,736	9,223	9,223	11,068	11,504	18,447
Attraction (AF)	0	0	0	0	1,676	1,736	5,950
Total Oct (AF)	7,736	7,736	9,223	9,223	12,744	13,240	24,397
Nov (CFS)	150	150	150	150	180	175	300
AF	8,926	8,926	8,926	8,926	10,711	10,413	17,852
Dec (CFS)	150	150	150	150	180	175	300
AF	9,223	9,223	9,223	9,223	11,068	10,760	18,447
Jan (CFS)	150	150	150	150	180	175	300
AF	9,223	9,223	9,223	9,223	11,068	10,760	18,447
Feb (CFS)	150	150	150	150	180	175	300
AF	8,331	8,331	8,331	8,331	9,997	9,719	16,661
Mar (CFS)	150	150	150	150	180	175	300
AF	9,223	9,223	9,223	9,223	11,068	10,760	18,447
Apr (CFS)	150	150	150	150	180	175	300
:AF	8,926	8,926	8,926	8,926	10,711	10,413	17,852
May (CFS)	150	150	150	150	180	175	300
AF	9,223	9,223	9,223	9,223	11,068	10,760	18,447
Migration Flow							
AF	11,091	20,091	32,619	37,060	35,920	60,027	89,882
Jun (CFS)	50	50	50	75	75	75	250
AF	2,975	2,975	2,975	4,463	4,463	4,463	14,876
Jul (CFS)	50	50	50	75	75	75	250
AF	3,074	3,074	3,074	4,612	4,612	4,612	15,372
Aug (CFS)	50	50	50	75	75	75	250
AF	3,074	3,074	3,074	4,612	4,612	4,612	15,372
Sep (CFS)	50	50	50	75	75	75	250
AF	2,975	2,975	2,975	4,463	4,463	4,463	14,876
Total Annual	94,001	103,001	117,017	127,508	142,503	165,004	300,926

Figure 5.17-3. 1995 FERC Minimum Flow Requirement.

5.17.4 CCSF La Grange Release Responsibility

Also performed in this worksheet is the computation of the hypothetical responsibility of CCSF for Tuolumne River incremental flow requirements.[4] Figure 5.17-4 is a snapshot of the computation.

Row	A	B	C	D	BV	BW	BX	BY	BZ	CA	CB	CC
1			1			SF La Grange Responsibility Computation						
2	*Unit Title*		2									
3	*Parameter Title*		3									
4												
5	*Acre-foot to CFS conversion*											
6	*divide by :*	*1.983471*										
7												
8												
9												
10						*Approach - SF 52% Responsibility Scenario*						
11												
12						*Compute difference between existing FERC minimum flow requirement and test scenario*						
13						*Test scenario: SWRCB 30% UF February-June w/ 200/3,500 cfs bounds on SWRCB component, or existing FERC whichever is greater*						
14							213,897		213,897		0	0
15											Total Diff	
16								Scenario	Scenario		Alt	
17	CYMonth					Exsiting	Exsiting	SWRCB	SWRCB		minus	51.7121
18	Index	Date	Day	Days		FERC	FERC	30%	30%		FERC	SF Debit
19						CFS	AF	CFS	AF		AF	AF
20	1970.10	10/1/1970	T	31		397	787	397	787		0	0
21	1970.10	10/2/1970	F	31		397	787	397	787		0	0
22	1970.10	10/3/1970	S	31		397	787	397	787		0	0
23	1970.10	10/4/1970	S	31		397	787	397	787		0	0
24	1970.10	10/5/1970	M	31		397	787	397	787		0	0
25	1970.10	10/6/1970	T	31		397	787	397	787		0	0

Figure 5.17-4. CCSF La Grange Release Responsibility.

[4] The "shared responsibility" assumption is presented for the purpose of evaluating alternative operations. The assumption shall not be used as evidence in any proceeding relating to and shall not act as precedence for any allocation of Tuolumne River water between CCSF and the Districts for any purpose under the Fourth Agreement.

The 1995 FERC flow requirement and the scenario flow requirement are compared on a daily basis to identify the difference between the two schedules. The CCSF 52% responsibility factor is applied to the total difference, which values are then provided to the WaterBankRel and SFWaterBank worksheets for use if selected.

5.18 DailyCanalsCompute Worksheet

This worksheet (DailyCanalsCompute) performs the computation of the daily canal demands of the MID and TID. The computation of canal demands incorporate the PDAW and canal operations practices of the districts. This worksheet also incorporates the application of a Water Supply Factor (from worksheet DPWSF) that reduces canal diversions during limited water supply conditions. The results from this worksheet have been provided to the Model for the Test Case scenario.

5.18.1 Projected Demand for Applied Water and Don Pedro Water Supply Factor

This section of logic (Figure 5.18-1) incorporates two components of information into the computation of canal demands. The PDAW for each District is a pre-processed Model entry based on an estimate developed by the CDWR consumptive use model. The monthly time series for PDAW for the simulation period is modified prior to use in the computation to refine the demand to recognize the local districts' delivery records. The second component of information is the Don Pedro Water Supply Factor (WSF). This fraction is computed in worksheet DPWSF and reflects limited water supplies during periods of drought. The factor is used to reduce canal diversions, based on antecedent reservoir storage and forecasted inflow to Don Pedro Reservoir. There are several versions of the WSF available for use in the Model if user access is allowed. The "full demand" WSF will produce a canal demand/diversion equal to full needs, as if the available water supply is sufficient to meet the full canal demands. The WSF table included in the Model represents canal demands including reductions from full diversions, and manages water supplies to produce a reservoir operation similar to that occurred during the 1987-1992 drought.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1			1		District Canal Diversion Computed by Canal Assumptions and Don Pedro Water Supply Factor									
2	*Unit Title*		2		Factor		Factor	Factor			AF	AF	AF	AF
3	*Parameter Title*		3		DP WSF Full		DP WSF	Dynamic WSF			MID Daily	TID Daily /	MID Daily	TID Daily N
4														
5	*Acre-foot to CFS conversion*													
6	*divide by :*	*1.983471*			*Pre-Proc*	*Pre-Proc*	*Active*	*Read*	*Read*	*Read*				
7					*Full*	*Base*	*Factor*	*from*	*from*	*from*				
8					*Factor*	*Factor*	*Used in*	*DPWSF*	*BU20:487*	*BV20:487*				
9					*1*		*Scenario*							
10				*39-yr Ave*							*170,364*	*406,025*	*34,500*	*0*
11				*Max*	*1.0000*	*1.0000*	*1.0000*	*1.0000*	*36,100*		*1,822*	*4,116*	*110*	*0*
12				*Min*	*1.0000*	*0.6000*	*0.6000*	*0.6000*	*0*		*0*	*0*	*74*	*0*
13					DP Water Supply Factor				District Projected Demand of Applied Water					
14						*10-4-2012*								
15					DP	DP								
16					WS Factor	WS Factor	Model	DP	MID	TID	MID	TID	MID	TID
17	Month				Full	Base	DP	WS Factor	PDAW	PDAW	Daily	Daily	Daily	Daily
18	Index	Date	Day	Days	Demand	Case	WS Factor	Dynamic	Monthly	Monthly	PDAW	PDAW	M&I	M&I
19									AF	AF	AF	AF	AF	AF
20	1970.10	10/1/1970	T	31	1.0000	1.0000	1.0000	1.0000	6,000	16,000	347	1,217	103	0
21	1970.10	10/2/1970	F	31	1.0000	1.0000	1.0000	1.0000	6,000	16,000	270	626	103	0
22	1970.10	10/3/1970	S	31	1.0000	1.0000	1.0000	1.0000	6,000	16,000	262	564	103	0
23	1970.10	10/4/1970	S	31	1.0000	1.0000	1.0000	1.0000	6,000	16,000	293	990	103	0
24	1970.10	10/5/1970	M	31	1.0000	1.0000	1.0000	1.0000	6,000	16,000	292	683	103	0
25	1970.10	10/6/1970	T	31	1.0000	1.0000	1.0000	1.0000	6,000	16,000	315	769	103	0

Figure 5.18-1. Projected Demand for Applied Water and Don Pedro Water Supply Factor.

5.18.2 District Canal Demand Calculation

The sections of logic (Figure 5.18-2 and Figure 5.18-3) compute the components of District canal operations that factor into the daily canal demands/diversions of the Districts. These components build on top of the PDAW to develop a daily canal demand from Don Pedro Reservoir. The PDAW is represented as a daily varying demand based on recent historical daily diversion shapes while the canal operation parameters are generally represented by an even distribution pattern within each month.

	A	B	C	D	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE
1			1																		
2	*Unit Title*		2			AF	AF	AF	AF	AF	AF	AF	AF	AF	AF	AF		AF		CFS	
3	*Parameter Title*		3		M&I	MID Turnc	MID Nom	MID Turnc	MID Canal	MID Canal	MID Canal	MID Lwr C	MID Nom	MID Lwr C	MID M&I [	MID Upper Sys Losse		MID La Grange Diver		MID La Grange Divers	
4																					
5	*Acre-foot to CFS conversion*				*Override for DailyCanals*		*(UI 2.10)*		0	*(1) on, use user-defined table, (0) off, use Base Case canal diversion*									*Capacity Check*	*2,000*	*cfs*
6	*divide by :*	*1.983471*				0			0	*(0) off, use UserInput option (UI 2.10), or (2) use calculated canal diversion*									*Max*	*1,257*	
7					*If <> 2, use UserInput or Base*				1	*If using calculated canal diversion, (1) Base, (2) Full Demand, or (3) Dynamic*											
8					*If = 2, use calculated*																*Pre-Proc*
9																					*Factor*
10				*39-yr Ave*		*215,775*	*20,995*	*194,780*	*44,510*	*5,059*	*8,492*	*235,857*	*17,280*	*218,577*	*34,500*	*31,100*	*0*	*284,177*			
11				*Max*		*2,323*	*133*	*2,291*	*233*	*21*	*45*	*2,314*	*84*	*2,282*	*110*	*158*	*65*	*2,492*			
12				*Min*		*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*74*	*0*	*-97*	*81*			
13					MID Canal Demand Calculation																
14															MID		MID				MID
15						MID					MID	MID			M&I Div	MID	Modesto		MID		7-day
16						Turnout	MID	MID	MID	MID	Canal	Lwr Canal		MID	frm	Upper	Lake	MID	Monthly	MID	3-yr Ave
17	Month				MID	w/o	Nom Prvt	Turnout	Canal	Canal	Intercpt	bfr MID	MID	Lwr Canal	Modesto	System	Daily	La Grange	Sum	La Grange	Day
18	Index	Date	Day	Days	Factor	Prvt Pmp	Pmp	Delivery	Op Spills	Losses	Flow	Nom Pmp	Nom Pmp	Diversion	Lake	Losses	Change	Diversion	Diversion	Diversion	Percent
19					%	AF	AF	AF	AF	AF	AF	AF	AF	AF	AF	AF	AF	AF	AF	CFS	% of Mo
20	1970.10	10/1/1970	T	31	40	869	32	836	223	20	29	1,050	68	982	103	65	-97	1,053	20,952	531	0.06
21	1970.10	10/2/1970	F	31	40	676	32	643	223	20	29	857	68	789	103	65	-97	860	20,952	434	0.05
22	1970.10	10/3/1970	S	31	40	656	32	623	223	20	29	837	68	769	103	65	-97	840	20,952	424	0.04
23	1970.10	10/4/1970	S	31	40	734	32	701	223	20	29	915	68	847	103	65	-97	918	20,952	463	0.05
24	1970.10	10/5/1970	M	31	40	730	32	698	223	20	29	911	68	844	103	65	-97	915	20,952	461	0.05
25	1970.10	10/6/1970	T	31	40	789	32	756	223	20	29	970	68	902	103	65	-97	973	20,952	491	0.05

Figure 5.18-2. District Canal Demand Components - MID.

	A	B	C	D	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AU	AV
1			1																		
2	Unit Title		2			AF	AF	AF	AF	AF	AF	AF	AF	AF	AF	AF		AF		CFS	
3	Parameter Title		3		sion	TID Turno	TID Nom F	TID Turno	TID Canal	MID Canal	TID Canal	TID Lwr Ca	TID Nom F	TID Lwr Ca	TID M&I D	TID Upper Sys Losses		TID La Grange Divers		TID La Grange Diversi	
4																					
5	Acre-foot to CFS conversion																		Capacity Check	3,400	cfs
6	divide by :	1.983471																	Max	2,404	
7																					
8																					Pre-Proc
9																					Factor
10				39-yr Ave		532,337	31,298	501,039	46,871	36,555	0	584,465	77,066	507,399	0	52,200	0	559,697			
11				Max		4,535	206	4,455	243	150	0	4,815	471	4,548	0	290	250	4,768			
12				Min		0	0	0	0	0	0	0	0	0	0	32	-452	1			
13					TID Canal Demand Calculation																
14															TID						TID
15						TID					TID	TID			M&I Div	TID	Turlock		TID		7-day
16						Turnout	TID	TID	TID	TID	Canal	Lwr Canal		TID	frm	Upper	Lake	TID	Monthly	TID	3-yr Ave
17	Month				TID	w/o	Nom Prvt	Turnout	Canal	Canal	Intercpt	bfr TID	TID	Lwr Canal	Turlock	System	Daily	La Grange	Sum	La Grange	Day
18	Index	Date	Day	Days	Factor	Prvt Pmp	Pmp	Delivery	Op Spills	Losses	Flow	Nom Pmp	Nom Pmp	Diversion	Lake	Losses	Change	Diversion	Diversion	Diversion	Percent
19					%	AF	AF	AF	AF	AF	AF	AF	AF	AF	AF	AF	AF	AF	AF	CFS	% of Mo
20	1970.10	10/1/1970	T	31	40	3,044	77	2,966	235	145	0	3,347	171	3,176	0	65	-452	2,789	31,487	1,406	0.08
21	1970.10	10/2/1970	F	31	40	1,565	77	1,488	235	145	0	1,869	171	1,698	0	65	-452	1,311	31,487	661	0.04
22	1970.10	10/3/1970	S	31	40	1,409	77	1,332	235	145	0	1,712	171	1,541	0	65	-452	1,154	31,487	582	0.04
23	1970.10	10/4/1970	S	31	40	2,475	77	2,398	235	145	0	2,779	171	2,608	0	65	-452	2,220	31,487	1,119	0.06
24	1970.10	10/5/1970	M	31	40	1,708	77	1,631	235	145	0	2,011	171	1,841	0	65	-452	1,453	31,487	733	0.04
25	1970.10	10/6/1970	T	31	40	1,923	77	1,845	235	145	0	2,226	171	2,055	0	65	-452	1,668	31,487	841	0.05

Figure 5.18-3. District Canal Demand Components - TID.

5.18.3 District Canal Operation Assumptions

The canal operation assumptions, e.g., regulating reservoir operation, seepage and losses and canal operation spills, are identified in this worksheet (entered into worksheet Control). These parameters are provided to the computations shown above. The canal operation assumptions for each District are shown Figure 5.18-4 and Figure 5.18-5.

Modesto Irrigation District

Month	Turnout Delivery Factor %	Nominal Private GW Pumping TAF	Canal Operational Spills Critical TAF	Canal Operational Spills Non-crit TAF	System Losses below Modesto Res TAF	Intercepted Flows TAF	Nominal MID GW Pumping TAF	Modesto Res and Upper Canal Losses/Div TAF	Municipal Delivery from Modesto Res TAF	Modesto Res Target Storage TAF	Modesto Res Target Storage Change TAF
January	35.0	0.0	2.0	2.0	0.1	0.0	0.0	0.0	2.3	17.0	2.0
February	35.0	0.0	2.0	2.0	0.1	0.0	0.0	0.0	2.3	18.0	1.0
March	65.0	1.0	1.0	3.0	0.6	0.9	1.0	2.0	2.7	18.0	0.0
April	70.0	2.0	3.0	6.0	0.6	0.9	2.3	2.9	2.7	19.0	1.0
May	85.0	3.0	4.0	6.5	0.6	1.2	2.3	3.9	3.0	20.0	1.0
June	85.0	4.0	3.5	6.5	0.6	1.0	2.3	4.3	3.2	20.0	0.0
July	77.5	4.0	3.5	6.5	0.6	1.0	2.6	4.9	3.3	21.0	1.0
August	70.0	4.0	4.9	7.0	0.6	1.4	2.4	4.9	3.3	22.0	1.0
September	65.0	2.0	5.0	7.0	0.6	1.2	2.3	4.2	3.3	20.0	-2.0
October	40.0	1.0	2.8	6.9	0.6	0.9	2.1	2.0	3.2	17.0	-3.0
November	30.0	0.0	2.0	2.0	0.1	0.0	0.0	2.0	2.7	15.0	-2.0
December	35.0	0.0	2.0	2.0	0.1	0.0	0.0	0.0	2.5	15.0	0.0
Total		21.0	35.7	57.4	5.4	8.5	17.3	31.1	34.5		

Figure 5.18-4. Canal Demand and Operation Components for MID.

Turlock Irrigation District											
	Turnout Delivery Factor	Nominal Private GW Pumping	Canal Operational Spills Critical	Canal Operational Spills Non-crit	System Losses below Turlock Lk	Intercepted Flows	Nominal TID GW Pumping	Turlock Lk and Upper Canal Losses	Other Delivery from Turlock Lk	Turlock Lk Target Storage	Turlock Lk Target Storage Change
Month	%	TAF	TAF	TAF	TAF	TAF	TAF	TAF	TAF	TAF	TAF
January	30.0	0.0	2.0	2.0	0.8	0.0	0.0	1.0	0.0	18.0	5.0
February	30.0	0.0	2.0	2.0	0.8	0.0	0.0	1.0	0.0	25.0	7.0
March	65.0	1.2	3.0	3.0	4.5	0.0	4.1	1.0	0.0	30.0	5.0
April	57.5	2.4	5.1	6.3	4.5	0.0	8.0	6.6	0.0	30.0	0.0
May	85.0	3.6	4.6	6.7	4.5	0.0	10.3	7.7	0.0	32.0	2.0
June	92.5	5.2	4.2	6.7	4.5	0.0	12.4	8.2	0.0	32.0	0.0
July	72.5	6.4	4.2	6.7	4.5	0.0	14.6	8.7	0.0	32.0	0.0
August	62.5	6.2	4.0	7.3	4.5	0.0	13.3	9.0	0.0	30.0	-2.0
September	67.5	3.9	3.2	7.3	4.5	0.0	9.1	5.0	0.0	27.0	-3.0
October	40.0	2.4	2.3	7.3	4.5	0.0	5.3	2.0	0.0	13.0	-14.0
November	30.0	0.0	2.0	2.0	0.8	0.0	0.0	1.0	0.0	13.0	0.0
December	30.0	0.0	2.0	2.0	0.8	0.0	0.0	1.0	0.0	13.0	0.0
Total		31.3	38.6	59.3	39.2	0.0	77.1	52.2	0.0		

Figure 5.18-5. Canal Demand and Operation Components for TID.

5.19 DailyCanals Worksheet

This worksheet (DailyCanals) assembles the appropriate canal demands for the scenario. While worksheet DailyCanalsCompute is capable of providing several versions of canal demands, worksheet DailyCanals readies either those selected demands or alternatively defined demands for the Model.

5.19.1 Model (scenario) Canal Demands

The section of logic (Figure 5.19-1) shows two columns of data used by the Model (worksheet DonPedro) for canal diversions by MID and TID. The version of demand used is user specified. If using the worksheet UserInput interface, UI 2.10 selects whether pre-processed Test Case diversions are used or a user specified table of diversions are used. If access to worksheet DailyCanalsCompute is granted, a time series of canal diversions from worksheet DailyCanalsCompute is used.

	A	B	C	D	E	F	G	H	I	J
1			1		District Canal Diversion Read by Model					
2	*Unit Title*		2							
3	*Parameter Title*		3							
4										
5	*Acre-foot to CFS conversion*									
6	*divide by :*	*1.983471*			MID and TID Canal Diversion Assumption					
7					*Read*		*Read*			
8					*by*		*by*			
9					*DP Model*		*DP Model*		*Sum*	
10				*39-yr Ave*	*284,177*		*559,697*		*843,874*	
11					*Option (0) is using Base Case Canal Diversion*					
12					*Option (1) is using Alt from UserInput Canal Diversion*					
13					Option>>	0	Switch 2.10 or Override			
14					*Option (2) is using Calculated Canal Diversion*					
15					Model	Model	Model	Model	Model	Model
16					MID	MID	TID	TID	Total	Total
17	Month				Canal	Canal	Canal	Canal	Canal	Canal
18	Index	Date	Day	Days	Diversion	Diversion	Diversion	Diversion	Diversion	Diversion
19					AF	CFS	AF	CFS	AF	CFS
20	1970.10	10/1/1970	T	31	1,053	531	2,789	1,406	3,842	1,937
21	1970.10	10/2/1970	F	31	860	434	1,311	661	2,171	1,094
22	1970.10	10/3/1970	S	31	840	424	1,154	582	1,994	1,006
23	1970.10	10/4/1970	S	31	918	463	2,220	1,119	3,139	1,582
24	1970.10	10/5/1970	M	31	915	461	1,453	733	2,368	1,194
25	1970.10	10/6/1970	T	31	973	491	1,668	841	2,641	1,332

Figure 5.19-1. District Canal Demands.

5.19.2 Test Case and Alternative Canal Diversions

This section of logic (Figure 5.19-2) provides the Model either a pre-processed time series of canal diversions (Test Case) or a time series of canal diversions that has been specified by the user in worksheet UserInput (UI 2.20 and UI 2.30) as monthly canal demands for the simulation period. A snapshot of the worksheet is shown below. This section of logic also parses the user specified monthly table of canal diversions into a daily diversion pattern based on the Test Case scenario's daily pattern of diversions.

	A	B	C	D	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA
1			1																	
2	*Unit Title*		2																	
3	*Parameter Title*		3																	
4																				
5	*Acre-foot to CFS conversion*																			
6	*divide by :*	*1.983471*			*Enter*		*Enter*		*Pre-Processed*		Alternative Canal Diversion				*Enter*		*Enter*		*Derived from*	
7					*Time*		*Time*		*as base scenario*						*Data in*		*Data in*		*UserInput*	
8					*Series*		*Series*				Daily Distribution of User Supplied				*Matrix*		*Matrix*			
9					*Here*		*Here*		*Sum*		Monthly Alternative District Canal				*AI66:AU103*		*AX66:BJ103*		*Sum*	
10				*39-yr Ave*	*284,177*		*559,697*		*843,874*		Diversion				*284,177*		*559,697*		*843,874*	
11						*1,257*		*2,404*			Distributed as Daily Percentage of					*1,257*		*2,404*		
12						*41*		*1*			Monthly Total District Base Diversion					*41*		*1*		
13					0	0	0	0	0	0				*Option>>*	1	1	1	1	1	1
14					*Values of Base Case - October 4, 2012*															
15					Base	Base	Base	Base	Base	Base	Base	MID %	Base	TID %	Alt	Alt	Alt	Alt	Alt	Alt
16					MID	MID	TID	TID	Total	Total	MID Mon	Day of	TID Mon	Day of	MID	MID	TID	TID	Total	Total
17	Month				Canal	Canal	Canal	Canal	Canal	Canal	Canal	Month	Canal	Month	Canal	Canal	Canal	Canal	Canal	Canal
18	Index	Date	Day	Days	Diversion	Diversion	Diversion	Diversion	Diversion	Diversion	Diversion	Diversion	Diversion	Diversion	Diversion	Diversion	Diversion	Diversion	Diversion	Diversion
19					AF	CFS	AF	CFS	AF	CFS	AF		AF		AF	CFS	AF	CFS	AF	CFS
20	1970.10	10/1/1970	T	31	1,053	531	2,789	1,406	3,842	1,937	20,952	0.05	31,487	0.09	1,053	531	2,789	1,406	3,842	1,937
21	1970.10	10/2/1970	F	31	860	434	1,311	661	2,171	1,094	20,952	0.04	31,487	0.04	860	434	1,311	661	2,171	1,094
22	1970.10	10/3/1970	S	31	840	424	1,154	582	1,994	1,006	20,952	0.04	31,487	0.04	840	424	1,154	582	1,994	1,006
23	1970.10	10/4/1970	S	31	918	463	2,220	1,119	3,139	1,582	20,952	0.04	31,487	0.07	918	463	2,220	1,119	3,139	1,582
24	1970.10	10/5/1970	M	31	915	461	1,453	733	2,368	1,194	20,952	0.04	31,487	0.05	915	461	1,453	733	2,368	1,194
25	1970.10	10/6/1970	T	31	973	491	1,668	841	2,641	1,332	20,952	0.05	31,487	0.05	973	491	1,668	841	2,641	1,332

Figure 5.19-2. Test Case and Alternative Canal Diversions.

Adjacent to the above illustrated area of computations are several components of data assemblage (Figure 5.19-3). The monthly time series columns serve to summarize daily Test

Case diversions assumptions and provide user specified monthly diversions for daily parsing. The chronological matrices provide an alternative listing of the monthly data.

Row	A	B	C	D
1			1	
2	*Unit Title*		2	
3	*Parameter Title*		3	
4				
5	*Acre-foot to CFS conversion*			
6	*divide by :*	*1.983471*		
10			*39-yr Ave*	
17	Month			
18	Index	Date	Day	Days
20	1970.10	10/1/1970	T	31
21	1970.10	10/2/1970	F	31
22	1970.10	10/3/1970	S	31
23	1970.10	10/4/1970	S	31
24	1970.10	10/5/1970	M	31
25	1970.10	10/6/1970	T	31

Monthly Time Series Data

AC	AD	AE	AF	AG
	Monthly from Daily Input Pre-Proc	*Enter Data in Matrix AI66:AU103 UserInput*	*Monthly from Daily Input Pre-Proc*	*Enter Data in Matrix AX66:BJ103 UserInput*
39-yr Ave	*284,177*	*284,177*	*559,697*	*559,697*
	1	2	1	2
Yr-Month	MID Base Assumpt Monthly Volume AF	MID Alt Assumpt Monthly Volume AF	TID Base Assumpt Monthly Volume AF	TID Alt Assumpt Monthly Volume AF
1970.10	20,952	20,952	31,487	31,487
1970.11	2,700	2,700	1,000	1,000
1970.12	2,500	2,500	1,000	1,000
1971.01	4,300	4,300	6,000	6,000
1971.02	3,300	3,300	8,000	8,000
1971.03	14,746	14,746	42,220	42,220

Monthly Matrix Time Series Data

User-defined District Canal Diversions at AI66:AU103 and AX66:BJ103

Test_Base MID Canal Assumption - Read from Time Series in Column AD
Acre-feet

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total WY
1971	20,952	2,700	2,500	4,300	3,300	14,746	30,656	42,917	47,253	54,987	49,086	32,192	305,589
1972	20,952	5,130	2,500	4,300	5,679	24,844	46,800	46,544	46,542	54,987	49,086	30,637	338,001
1973	20,952	2,700	2,500	4,300	3,300	14,746	23,737	45,374	47,016	54,987	49,086	32,658	301,356
1974	20,952	2,700	2,500	4,300	3,300	14,746	18,115	42,917	45,239	49,733	49,086	32,658	286,246
1975	20,952	5,460	2,500	4,300	3,300	14,746	28,782	44,672	47,253	54,859	43,423	32,658	302,906
1976	20,952	6,451	2,500	4,300	6,350	30,232	34,676	38,540	38,163	44,939	35,682	24,524	287,308

Figure 5.19-3. Assemblage of Canal Diversions.

5.20 DPWSF Worksheet

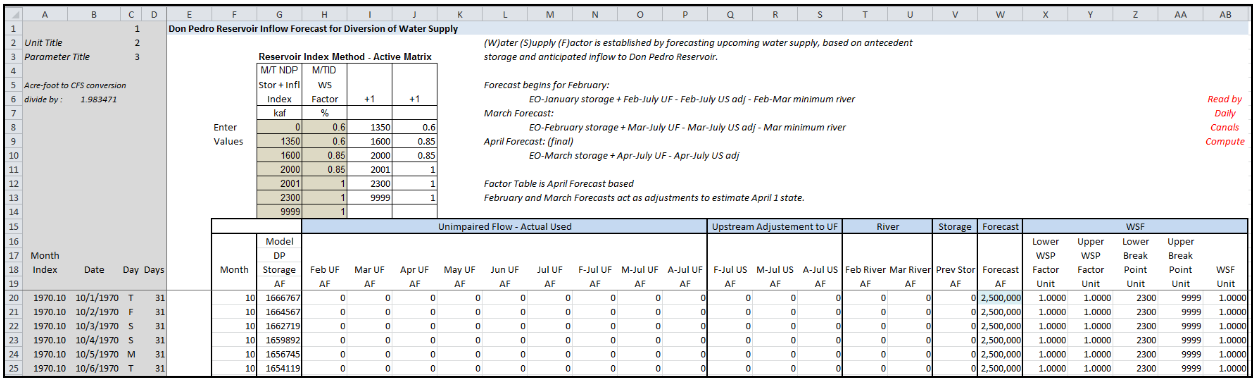
This worksheet (DPSWF) computes the Don Pedro Water Supply Factor (WSF). The premise of the WSF factor is to reduce the amount of water diverted to the canals during years when lack of carryover storage at Don Pedro Reservoir becomes a concern. The modeling mechanism used to reduce canal diversions is a factor applied to the PDAW of the canal demand. This mechanism results in a reduction to the amount of water "turned out" to the customers while still recognizing the relatively constant efficiencies of canal operations.

The WSF is established by forecasting upcoming water supply, based on antecedent storage and anticipated inflow to Don Pedro Reservoir. The forecasting procedure begins in February and ends in April. The Factor Table is based on April forecast results. The February and March Forecasts act as adjustments to get to the April 1 state. The forecasts have the following protocol:

February Forecast (forecasting April 1 state):
End of January storage + Feb-Jul UF - Feb-Jul US adjustment - Feb-Mar minimum river
March Forecast (forecasting April 1 state):
End of February storage + Mar-Jul UF - Mar-Jul US adjustment - Mar minimum river
April Forecast: (final)
End of March storage + Apr-Jul UF - Apr-July US adjustment

Pre-knowledge of unimpaired runoff for each forecast period is assumed, as well as knowledge of upcoming upstream impairment of the runoff. *The WSF factor / Don Pedro Storage + Inflow* relationship is developed through iterations of multi-year system operation simulations. The WSF depicts actions that may be implemented during times of drought, and the projected canal diversions and reservoir storage operation during drought periods. The factors and index triggers were developed reviewing reservoir storage levels that occurred during the 1987-1992 drought.

Figure 5.20-1 is a snapshot of the worksheet computation area.



Don Pedro Reservoir Inflow Forecast for Diversion of Water Supply

Unit Title 2
Parameter Title 3

Acre-foot to CFS conversion
divide by : 1.983471

(W)ater (S)upply (F)actor is established by forecasting upcoming water supply, based on antecedent storage and anticipated inflow to Don Pedro Reservoir.

Forecast begins for February:
EO-January storage + Feb-July UF - Feb-July US adj - Feb-Mar minimum river
March Forecast:
EO-February storage + Mar-July UF - Mar-July US adj - Mar minimum river
April Forecast: (final)
EO-March storage + Apr-July UF - Apr-July US adj

Factor Table is April Forecast based
February and March Forecasts act as adjustments to estimate April 1 state.

Read by Daily Canals Compute

Reservoir Index Method - Active Matrix

	M/T NDP Stor + Infl Index kaf	M/TID WS Factor %	+1	+1
Enter Values	0	0.6	1350	0.6
	1350	0.6	1600	0.85
	1600	0.85	2000	0.85
	2000	0.85	2001	1
	2001	1	2300	1
	2300	1	9999	1
	9999	1		

Month Index	Date	Day	Days	Month	Model DP Storage AF	Feb UF AF	Mar UF AF	Apr UF AF	May UF AF	Jun UF AF	Jul UF AF	F-Jul UF AF	M-Jul UF AF	A-Jul UF AF	F-Jul US AF	M-Jul US AF	A-Jul US AF	Feb River AF	Mar River AF	Prev Stor AF	Forecast AF	Lower WSP Factor Unit	Upper WSP Factor Unit	Lower Break Point Unit	Upper Break Point Unit	WSF Unit
1970.10	10/1/1970	T	31	10	1666767	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,500,000	1.0000	1.0000	2300	9999	1.0000
1970.10	10/2/1970	F	31	10	1664567	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,500,000	1.0000	1.0000	2300	9999	1.0000
1970.10	10/3/1970	S	31	10	1662719	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,500,000	1.0000	1.0000	2300	9999	1.0000
1970.10	10/4/1970	S	31	10	1659892	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,500,000	1.0000	1.0000	2300	9999	1.0000
1970.10	10/5/1970	M	31	10	1656745	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,500,000	1.0000	1.0000	2300	9999	1.0000
1970.10	10/6/1970	T	31	10	1654119	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,500,000	1.0000	1.0000	2300	9999	1.0000

(Column groups: Unimpaired Flow - Actual Used; Upstream Adjustement to UF; River; Storage; Forecast; WSF)

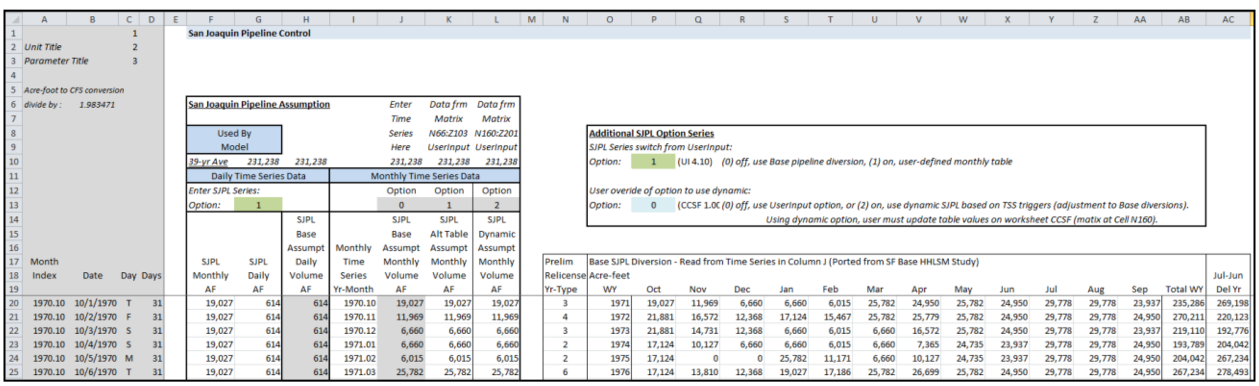
Figure 5.20-1. Don Pedro Water Supply Factor Computation.

5.21 CCSF Worksheet

This worksheet (CCSF) identifies, assembles and directs several elements of CCSF System operations, and provides input to other Model component worksheets.

5.21.1 San Joaquin Pipeline Diversions

The first section of logic concerns the identification of SJPL diversions. Figure 5.21-1 is a snapshot of this section. By user selection (UI 4.10) either pre-processed Test Case SJPL diversions are used, or a user specified table of monthly diversions for the simulation period are used. This section assembles the user selected version of diversions for use by the Model. These two versions of SJPL diversions are available for selection through worksheet UserInput. If access is granted, a third version of SJPL diversions is provided which revises Test Case diversions based on circumstances of the scenario that changes CCSF's operation. Procedures are described below the monthly diversion matrix describing how to employ this third version of SJPL diversions.



San Joaquin Pipeline Control

Unit Title 2
Parameter Title 3

Acre-foot to CFS conversion
divide by : 1.983471

San Joaquin Pipeline Assumption

Used By Model

39-yr Ave 231,238 231,238 — Enter Time Series Here 231,238 — Data frm Matrix N66:Z103 UserInput 231,238 — Data frm Matrix N160:Z201 UserInput 231,238

Daily Time Series Data — *Enter SJPL Series: Option:* 1

Monthly Time Series Data — Option 0, Option 1, Option 2

Month Index	Date	Day	Days	SJPL Monthly AF	SJPL Daily AF	SJPL Base Assumpt Daily Volume AF	Monthly Time Series Yr-Month	SJPL Base Assumpt Monthly Volume AF	SJPL Alt Table Assumpt Monthly Volume AF	SJPL Dynamic Assumpt Monthly Volume AF
1970.10	10/1/1970	T	31	19,027	614	614	1970.10	19,027	19,027	19,027
1970.10	10/2/1970	F	31	19,027	614	614	1970.11	11,969	11,969	11,969
1970.10	10/3/1970	S	31	19,027	614	614	1970.12	6,660	6,660	6,660
1970.10	10/4/1970	S	31	19,027	614	614	1971.01	6,660	6,660	6,660
1970.10	10/5/1970	M	31	19,027	614	614	1971.02	6,015	6,015	6,015
1970.10	10/6/1970	T	31	19,027	614	614	1971.03	25,782	25,782	25,782

Additional SJPL Option Series
SJPL Series switch from UserInput:
Option: 1 (UI 4.10) *(0) off, use Base pipeline diversion, (1) on, user-defined monthly table*

User overide of option to use dynamic:
Option: 0 (CCSF 1.0(*(0) off, use UserInput option, or (2) on, use dynamic SJPL based on TSS triggers (adjustment to Base diversions).*
Using dynamic option, user must update table values on worksheet CCSF (matix at Cell N160).

Base SJPL Diversion - Read from Time Series in Column J (Ported from SF Base HHLSM Study)
Acre-feet

Prelim Relicense Yr-Type	WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total WY	Jul-Jun Del Yr
3	1971	19,027	11,969	6,660	6,660	6,015	25,782	24,950	25,782	24,950	29,778	29,778	23,937	235,286	269,198
4	1972	21,881	16,572	12,368	17,124	15,467	25,782	25,779	25,782	24,950	29,778	29,778	24,950	270,211	220,123
3	1973	21,881	14,731	12,368	6,660	6,015	6,660	16,572	25,782	24,950	29,778	29,778	23,937	219,110	192,776
2	1974	17,124	10,127	6,660	6,660	6,015	6,660	7,365	24,735	23,937	29,778	29,778	24,950	193,789	204,042
2	1975	17,124	0	0	25,782	11,171	6,660	10,127	24,735	23,937	29,778	29,778	24,950	204,042	267,234
6	1976	17,124	13,810	12,368	19,027	17,186	25,782	26,699	25,782	24,950	29,778	29,778	24,950	267,234	278,493

Figure 5.21-1. CCSF San Joaquin Pipeline Diversions and Assemblage of Data.

5.21.2 CCSF System Storage and Action Levels

This section of logic (Figure 5.21-2) provides reporting and computational functions. The CCSF System action level computation analyzes scenario results concerning CCSF's reservoir storage and extrapolates that information into advised action levels within the CCSF System. Germane to the FERC investigation is the potential effect that flow responsibility placed upon CCSF may have upon its water system and deliveries. The relationship between CCSF System reservoir storage and action levels (translated to increased delivery rationing) is incorporated into this worksheet. Upon changed conditions within a scenario (as compared to Test Case conditions), the change in action levels is identified. This change is also provided the SJPL diversion logic described above, and if allowed to be selected this worksheet will perform an adjustment to SJPL diversions.

	A	B	C	D	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AU
1			1			San Francisco System Storage and Action Levels																
2	Unit Title		2			Level	AF	AF	AF	AF	AF	AF	AF	AF								
3	Parameter Title		3			Plng Mod	Hetch Het	Lake Lloyc	Lake Eleanor Storage			Total HH S	Local Stor	Total Syst	Model Action Level							
4																	SF System Action Level Computation					
5	Acre-foot to CFS conversion																Actions	C2a.30	C2a.30			
6	divide by :	1.983471															Level	BaseTrigger	BaseAction	ScenarioT	ScenarioA	
7						SF System Storage and Action Level Status - Daily Time Series Data											0		0			
8													Linked to	Use Only			1	1,100,000	10	1,100,000	10	CCSF 2.00
9													SF Base	Last Day			2	1,100,000	10	1,100,000	10	
10													HHLSM	of Month			3	700,000	20	700,000	20	
11													Study	Plotting			Action Level Count			Base		Scenario
12													"Hydrology"				Level			Count		Count
13							Scenario Model Results plus SF Base HHLSM Study Local System Storage										0			33		33
14													Base	Total			1			0		0
15							Scenario	Scenario	Scenario	Scenario	Scenario	Scenario	Local	System			2			6		6
16						Base	Hetch	Lake	Lake	Water	Total	Total	Storage	Storage	Scenario		3			0		0
17	Month					Action	Hetchy	Lloyd	Eleanor	Bank	Upcountry	HH System	Incl GW	Incl GW	Action		Total			39		39
18	Index	Date	Day	Days		Level	Storage	Storage	Storage	Balance	Storage	Storage	EOM	EOM	Level							
19							AF	AF	AF	AF	AF	AF	AF	AF								
20	1970.10	10/1/1970	T	31		0	249,349	200,091	17,591	570,000	467,031	1,037,031	211,136	3,000,000	0		SF Action Level & SJPL Adjustment					
21	1970.10	10/2/1970	F	31		0	248,379	200,080	17,137	570,000	465,596	1,035,596	211,136	3,000,000	0				"Hydrology"			
22	1970.10	10/3/1970	S	31		0	247,622	200,090	16,692	570,000	464,404	1,034,404	211,136	3,000,000	0				SF Base	SF Base	Scenario	Scenario
23	1970.10	10/4/1970	S	31		0	247,032	199,278	15,878	570,000	462,189	1,032,189	211,136	3,000,000	0				June 30	Action	June 30	Action
24	1970.10	10/5/1970	M	31		0	246,150	199,896	15,707	569,744	461,752	1,031,496	211,136	3,000,000	0				TSS	Level	TSS	Level
25	1970.10	10/6/1970	T	31		0	245,360	199,781	15,206	570,000	460,347	1,030,347	211,136	3,000,000	0		EO-Jun	Year	AF	(0-3)	AF	(0-3)

Figure 5.21-2. CCSF System Storage and Action Levels.

5.21.3 Hetch Hetchy Reservoir Control

This section of logic (Figure 5.21-3) identifies several underlying operation constraints for Hetch Hetchy Reservoir. The minimum stream release below Hetch Hetchy Reservoir is computed in this section. Also identified in this section are reservoir storage targets and limits. This information is used in worksheet SFHetchHetchy for several operational constraints and objectives.

	A	B	C	D	AV	AW	AX	AY	AZ	BA	BB	BC	BD	BE	BF	BG	BH	BI	BJ
1			1			Hetch Hetchy Reservoir Control											15,000	6,500	4,400
2	Unit Title		2			Schedule Index - Accum Inches or Storage					Below Hetch Hetchy Requirement - CFS					Discretionary Schedule - Acre-feet			
3	Parameter Title		3			Cal Mon	A (1)	B (2)	C (3)		Cal Mon	A (1)	B (2)	C (3)		Cal Mon	A (1)	B (2)	C (3)
4						1	8.80	6.1			1	50	40	35		1	0	0	0
5	Acre-foot to CFS conversion					2	14	9.5			2	60	50	35		2	0	0	0
6	divide by :	1.983471				3	18.6	14.2			3	60	50	35		3	0	0	0
7						4	23	18			4	75	65	35		4	0	0	0
8						5	26.6	19.5			5	100	80	50		5	0	0	0
9						6	28.45	21.25			6	125	110	75		6	0	0	0
10						7	575,000	390,000			7	125	110	75		7	0	0	0
11						8	640,000	400,000			8	125	72.5	75		8	0	0	0
12											9	90	65	62.5		9	0	0	0
13											10	60	50	35		10	0	0	0
14							Sum of WY	Trigger			11	60	50	35		11	0	0	0
15						HH Accum	HH Inflow	Due to	Schedule	Schedule	12	50	40	35		12	0	0	0
16						Precip	To	Inflow	Due to	Due to							10	11	12
17	Month					beginning	Date	Jul-Dec	Inflow	Inflow	Jan	Feb	Mar	Apr	May	Jun	Oct	Nov	Dec
18	Index	Date	Day	Days		Oct 1	AF	AF	Jul	Aug - Dec	Schedule	Schedule	Schedule	Schedule	Schedule	Schedule	Schedule	Schedule	Schedule
19						Inches		709,538		1							CFS	CFS	CFS
20	1970.10	10/1/1970	T	31		0.73	157	709,538	0	1	0	0	0	0	0	0	60	0	0
21	1970.10	10/2/1970	F	31		0.73	-6	709,538	0	1	0	0	0	0	0	0	60	0	0
22	1970.10	10/3/1970	S	31		0.73	44	709,538	0	1	0	0	0	0	0	0	60	0	0
23	1970.10	10/4/1970	S	31		0.73	262	709,538	0	1	0	0	0	0	0	0	60	0	0
24	1970.10	10/5/1970	M	31		0.73	186	709,538	0	1	0	0	0	0	0	0	60	0	0
25	1970.10	10/6/1970	T	31		0.73	204	709,538	0	1	0	0	0	0	0	0	60	0	0

	A	B	C	D	BK	BL	BM	BN	BO	BP	BQ	BR	BS
1			1										
2	*Unit Title*		2										
3	*Parameter Title*		3										
4													
5	*Acre-foot to CFS conversion*												
6	*divide by :*	*1.983471*											
7													
8													
9													
10													
11													
12													
13													
14													
15													
16					1	2	3	4	5	6	7	8	9
17	Month				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
18	Index	Date	Day	Days	Schedule	Schedule	Schedule	Schedule	Schedule	Schedule	Schedule	Schedule	Schedule
19					CFS	CFS	CFS	CFS	CFS	CFS	CFS	CFS	CFS
20	1970.10	10/1/1970	T	31	0	0	0	0	0	0	0	0	0
21	1970.10	10/2/1970	F	31	0	0	0	0	0	0	0	0	0
22	1970.10	10/3/1970	S	31	0	0	0	0	0	0	0	0	0
23	1970.10	10/4/1970	S	31	0	0	0	0	0	0	0	0	0
24	1970.10	10/5/1970	M	31	0	0	0	0	0	0	0	0	0
25	1970.10	10/6/1970	T	31	0	0	0	0	0	0	0	0	0

	BT	BU	BV	BW	BX	BY	BZ	CA	CB
1									
2					AF	CFS	Target Storage - Acre-feet		
3					Total Mini	Total Mini		Target	Limit
4							Cal Mon	EOM	EOM
5							0	320000	
6		Month					1	320,000	360,360
7		on					2	320,000	360,360
8		5					3	320,000	360,360
9		*Does not*	*Does not*	*Lagged*			4	320,000	360,360
10		*include*	*include*	*by 1 day*			5	360,360	360,360
11		*offramp*	*Canyon*	*to avoid*			6	360,360	360,360
12		*of Discret*	*64 cfs*	*circular*			7	360,360	360,360
13		*"C" Sch*		*reference*			8	360,360	360,360
14		*due to*					9	360,360	360,360
15		*HH Stor*	Min HH		w/ 64 cfs	w/ 64 cfs	10	330,000	360,360
16			Basic +	Canyon	Total	Total	11	320,000	360,360
17	Basic	Discret	Discret	64 cfs	Min HH	Min HH	12	320,000	360,360
18	Schedule	Schedule	Schedule	Schedule	Schedule	Schedule		Day Chg	Target
19	AF	AF	AF	AF	AF	CFS		Target	360,360
20	119	0	119		119	60		-979	359,381
21	119	0	119	0	119	60		-979	358,401
22	119	0	119	0	119	60		-979	357,422
23	119	0	119	0	119	60		-979	356,443
24	119	0	119	0	119	60		-979	355,463
25	119	0	119	0	119	60		-979	354,484

Figure 5.21-3. Hetch Hetchy Reservoir Controls.

5.21.4 Lake Lloyd Control

This section of logic identifies several underlying operation constraints for Lake Lloyd. Figure 5.21-4 is a snapshot of this section. The minimum stream release below Lake Lloyd is computed in this section. Also identified in this section are reservoir storage targets and limits, and the target release objective for Holm Powerhouse. The maximum drawdown of Lake Lloyd due to supplemental releases is identified. This information is used in worksheet SFLloyd for several operational constraints and objectives.

	A	B	C	D	CF	CG	CH
1			1		**Lake Lloyd and Lake Eleanor Control**		
2	*Unit Title*		2		Lloyd Target Storage - Acre-feet		
3	*Parameter Title*		3			Soft Trgt	Hard Limit
4					Cal Mon	EOM	EOM
5	*Acre-foot to CFS conversion*				0	238,000	
6	*divide by :*	*1.983471*			1	238,000	273,300
7					2	238,000	273,300
8					3	238,000	273,300
9					4	273,300	273,300
10					5	273,300	273,300
11					6	273,300	273,300
12					7	268,000	273,300
13					8	258,000	273,300
14					9	248,000	273,300
15					10	248,000	273,300
16					11	238,000	273,300
17	Month				12	238,000	273,300
18	Index	Date	Day	Days	Day Chg	Target	
19					Target	248,000	
20	1970.10	10/1/1970	T	31	0	248,000	
21	1970.10	10/2/1970	F	31	0	248,000	
22	1970.10	10/3/1970	S	31	0	248,000	
23	1970.10	10/4/1970	S	31	0	248,000	
24	1970.10	10/5/1970	M	31	0	248,000	
25	1970.10	10/6/1970	T	31	0	248,000	

	CJ	CK	CL	CM	CN
2	Lake Lloyd/Lake Eleanor Split of Combined Inflow				
3		Lloyd	Eleanor		
4	Cal Mon	%	%	*Note:*	
5	1	53	47	*Watershed*	
6	2	52	48	*proportions*	
7	3	52	48	*were developed*	
8	4	57	43	*from the record*	
9	5	65	35	*of runoff each basin*	
10	6	72	28	*basin prior to 1960.*	
11	7	72	28		
12	8	56	44		
13	9	52	48		
14	10	69	31		
15	11	58	42		
16	12	57	43		
17	Total	Lloyd	Lloyd	Eleanor	Eleanor
18	Inflow	Inflow	Inflow	Inflow	Inflow
19	CFS	CFS	AF	CFS	AF
20	81	56	111	25	50
21	7	5	10	2	4
22	22	15	30	7	14
23	-578	-399	-791	-179	-355
24	466	322	638	144	287
25	-69	-48	-94	-21	-42

	CP	CQ	CS	CT	CU	CV
2	Blw Lake Lloyd - CFS		Holm Target Releases			
3	Cal Mon	Req				
4	1	5	May (Memorial Day) thru			
5	2	5	August (Labor Day)			
6	3	5	Holm Capacity		950	cfs
7	4	5		Day	1,884	acre-feet
8	5	5		4-hours per day	314	acre-feet
9	6	5				
10	7	15.5	Minimum Lloyd Storage to Draw			
11	8	15.5	for Water Bank/Supplemental Release			
12	9	15.5	Release:	45,000	acre-feet	CCSF 3.00
13	10	5				
14	11	5		May-Aug		
15	12	5		Min		
16				Holm		
17	Min Req	Min Req		Target		
18	Release	Release		Release		
19	CFS	AF	CFS	AF		
20	5	10	0	0		
21	5	10	0	0		
22	5	10	0	0		
23	5	10	0	0		
24	5	10	0	0		
25	5	10	0	0		

Figure 5.21-4. Lake Lloyd Controls.

5.21.5 Lake Eleanor Control

This section of logic identifies several underlying operation constraints for Lake Eleanor. Figure 5.21-5 is a snapshot of this section. The minimum stream release below Lake Lloyd is computed in this section. Also identified in this section are reservoir storage targets and limits. This information is used in worksheet SFEleanor for several operational constraints and objectives.

	A	B	C	D	CW	CX	CY	CZ	DA	DB	DC	DD
1			1									
2	*Unit Title*		2			Blw Lake Eleanor - CFS				Eleanor Target Storage - Acre-fe		
3	*Parameter Title*		3				w/Pump	w/o			Soft Trgt	Hard Limit
4						Cal Mon	Req	Req		Cal Mon	EOM	EOM
5	*Acre-foot to CFS conversion*					1	5	5		0	18,250	
6	*divide by :*	*1.983471*				2	5	5		1	21,495	27,100
7						3	10	5		2	21,495	27,100
8						4	15	5		3	21,495	27,100
9						5	20	5		4	27,100	27,100
10						6	20	5		5	27,100	27,100
11						7	20	16		6	27,100	27,100
12						8	20	16		7	27,100	27,100
13						9	15	16		8	27,100	27,100
14						10	10	5		9	15,000	27,100
15						11	5	5		10	15,000	27,100
16						12	5	5		11	15,000	27,100
17	Month					Min Req	Min Req	*Always*		12	18,250	27,100
18	Index	Date	Day	Days		Release	Release	*Assume*		Day Chg	Target	
19						CFS	AF	*Pump*		Target	15,000	
20	1970.10	10/1/1970	T	31		10	20			0	15,000	
21	1970.10	10/2/1970	F	31		10	20			0	15,000	
22	1970.10	10/3/1970	S	31		10	20			0	15,000	
23	1970.10	10/4/1970	S	31		10	20			0	15,000	
24	1970.10	10/5/1970	M	31		10	20			0	15,000	
25	1970.10	10/6/1970	T	31		10	20			0	15,000	

Figure 5.21-5. Lake Eleanor Controls.

5.22 Hydrology Worksheet

This worksheet (Hydrology) identifies and assembles underlying watershed hydrologic data necessary for Model operation. Required elements of historical hydrology include inflows to CCSF System reservoirs and the unregulated inflow to Don Pedro Reservoir. Also necessary are certain Test Case conditions for the CCSF System, namely Test Case SJPL diversions and water delivery (action levels) associated with Test Case conditions. Also needed is the status of local watershed reservoir storage associated with the Test Case condition.

5.23 602020 Worksheet

This worksheet (602020) identifies and assembles underlying watershed hydrologic data necessary for Model operation. Included is the computation of the San Joaquin River Index. Also included are published results of CDWR runoff forecasts.

6.0 EXAMPLES OF MODEL USE

As part of the Model training during W&AR-02 Workshop #3, October 23, 2012, a set of example scenarios was provided, described and illustrated to attending Representative Participants. The following describes those examples.[5]

6.1 Example 1

Modify lower Tuolumne River flow requirements. Assume a 10 percent increase in current FERC requirements. Assume no CCSF responsibility for additional flow.

Advice: the workbook may be running in an auto-recalculation mode. To avoid a recalculation following an entry of each item the user may want to change the workbook settings to recalculate in the "manual" mode, and then apply a recalculation (F9) after multiple entries have been made. Also, worksheet Review is extremely processor time intensive. It is recommended that the worksheet be set in the "No" recalculation mode at all times except when necessary to review results.

Enter a study reference name in UserInput (UI 1.00), indicative of the scenario. In this example the study reference will be "Alt_10%".

An alternative flow requirement for the lower Tuolumne River is entered in worksheet UserInput, Section 1. The alternative flow requirement can be entered by two methods: 1) a daily time series (Column BM) reflective of a computation made external to this worksheet, or 2) a modified schedule entered as a year type schedule at UI 1.30.

Choose the table option. The current FERC requirements have been equated to the year type schedule format for UI 1.30, and are listed in the area to the right of the input matrix. One method of providing entry to the matrix is to write an equation for each cell of the matrix to increase the current schedule by 10 percent (e.g., the matrix cell could be represented as [Current FERC * 1.1]).

To employ the table, enter option (1) for UI 1.10 to use an alternative flow schedule. Also, enter option (1) for UI 1.20 to use the year type schedule. The month of "Apr" is selected for UI 1.40 to engage the flow schedule on an April through following year March flow year.

At this point Don Pedro Reservoir will have attempted to provide the additional flow requirement from reservoir storage and reoperation of releases which otherwise were released in excess of minimum releases in other periods. Worksheet Review is viewed to identify changes that have occurred and for warnings. Viewing the worksheet Review summary shows that river requirements have increased, and releases to the river have increased but by not as much. This circumstance indicates that some of the increases in requirements have been met with releases that were previously released in excess of minimum requirements and possibly from reservoir storage. The review summary also shows differences in reservoir minimum storage that occurred

[5] The examples described in this document are examples only and not alternatives endorsed or supported by the Districts and CCSF.

in the simulation. A warning has also been indicated for CCSF Water Bank Account operations. Additional detail of the monthly results for the simulation and a comparison to the Test Base is found in the summary matrices. Differences between the two scenarios are can also be viewed in worksheets DSSAnyGroup and DSSMonthTable.

The scenario should be refined by eliminating the "negative Water Bank Account" warning. To remedy the circumstance the user could employ two methods: 1) the preferred daily adjustment method, or 2) a year type table approach, with or without a combination of daily adjustments. To use the preferred daily adjustment method option (1) is selected for UI 3.10, and the user is directed to worksheet WaterBankRel.

Upon selection of worksheet WaterBankRel, the user will see the same warning and the value of negative balance (Cell M14). Column T is provided to enter daily supplemental releases to remedy negative Water Bank Account Balances. The column will be populated with the time series last entered into the worksheet. By scrolling down the column the user will find previously entered values. In this example, entries began in 1992 which is associated with the Test Case scenario. It is seen that with the alternative flow requirement of this example the Water Bank Account Balance (Column M) is shown as a negative 161 acre-feet, and continues to be negative for numerous subsequent days. Under the Test Case scenario the Water Bank Account Balance remained at or above zero during this period as the result of the Test Case supplemental releases.

Advice: Set worksheet Review in the "No" recalculation mode prior to entering daily supplemental releases.

To remedy the new resultant negative Water Bank Account Balance an additional 161 acre-feet of supplemental release is added to the previously entered amount, and the "negatives" go away.

If the user is satisfied that this set of results represents an alternative simulation of future operations, the study is completed. The output worksheet could be saved as a unique result named Alt_10 or some other more explicit title.

6.2 Example 2

Same alternative flow requirements as Example 1; however, CCSF is to share in responsibility for the change in flow requirements.

Enter a study reference name in UserInput (UI 1.00), indicative of the scenario. In this instance the study reference will be "Alt_10%_Shared".

The alternative flow schedule entered at UI 1.30 remains the same. To invoke the CCSF responsibility logic the switch at UI 1.31 is set to option (1). The model will recalculate and provide a new set of results. Viewing worksheet Review shows that results for Don Pedro Reservoir operations remain the same as Example 1. However, the results for CCSF Water Bank Account operations have changed, and indicate that a negative balance again occurs (maximum of -43,000 acre-feet). However, review of other CCSF reservoir and diversion results will show no change from Example 1. This circumstance illustrates how invoking the CCSF responsibility logic (UI 1.31) will affect the Water Bank Account Balance, but it alone will not change the Model's CCSF's operation. Review of the detailed monthly summary results for the Water Bank Account Balance (shown in the worksheet Review matrix beginning at Row 423) negative balances begin in the simulation in June 1990 and intermittently occur through December 1993.

The scenario should be refined by eliminating the "negative Water Bank Account" warning. To use the preferred daily adjustment method option (1) is selected for UI 3.10, and the user is directed to worksheet WaterBankRel.

Advice: Set worksheet Review in the "No" recalculation mode prior to entering daily supplemental releases.

Upon selection of worksheet WaterBankRel, the user will see the same warning and the value of negative balance (Cell M14). Column T will be used to remedy negative Water Bank Account Balances. The column is currently populated with the time series for Example 1. By scrolling down the column the user will find negative balances will begin to occur in June 1990 (-3,348 acre-feet on June 9). To remedy the new resultant negative Water Bank Account Balance an additional 3,348 acre-feet of supplemental release is entered in Column T. The worksheet will recalculate and show a revised balance for the day as zero. Subsequent balances will also change. The user will continue to make daily entries to eliminate the negative balances. Supplemental releases are needed through the later part of July for 1990. The exercise of entering supplemental releases is required again beginning June 28, 1991, and ends during July. Supplemental releases are also required beginning March 1992. It is recommended that the previously entered supplemental releases entered for 1992 for Example 1 be deleted. Completing the supplemental releases for 1992 should result in the negative balance warning going away.

At this juncture of Model input and adjustment the results are reflective of an increase of 10 percent in minimum Tuolumne River requirements, with the Districts providing the flows from Don Pedro Reservoir. CCSF is responsible for a share of the differences in flow requirements and its Water Bank Account Balance is affected by that computed responsibility. CCSF operates its system as usual, and due to the affect at the Water Bank Account makes additional supplemental releases when needed to maintain a positive Water Bank Account Balance.

If the user accepts this set of results as an acceptable simulation of operations the study is completed. The output worksheet could be saved as a unique result named Alt_10_Shared.

6.3 Example 3

Modify lower Tuolumne River flow requirements. Assume a minimum flow regime that is the current FERC requirement, except the minimum flow requirement is 300 cfs. Assume no CCSF responsibility for additional flow.

Choose the table option for flow requirements. The existing FERC requirements have been equated to the year type schedule format for UI 1.30, and are listed in the area to the right of the input matrix. One method of providing entry to the matrix is to write an equation for each cell of the matrix to provide the current FERC release but maintain at least a 300 cfs requirement (e.g., the matrix cell could be represented as [Max(Current FERC,300)].

At this point Don Pedro Reservoir will have attempted to provide the additional flow requirement from reservoir storage and reoperation of releases which otherwise were released in excess of minimum releases in other periods. Worksheet Review is viewed to identify changes that have occurred and for warnings. Viewing the worksheet Review summary shows that river requirements have increased, and releases to the river have increased but by not as much. This circumstance indicates that some of the increases in requirements have been met with releases that were previously released in excess of minimum requirements and possibly from reservoir storage. The review summary also shows differences in reservoir minimum storage that occurred in the simulation. A warning has also been indicated for CCSF Water Bank Account operations, and a warning indicates that Don Pedro Reservoir storage has been simulated below dead storage as a result of both the 1976-1977 and 1987-1992 droughts. Additional detail of the monthly results for the simulation and a comparison to the other scenarios is found in the summary matrices. Differences between two scenarios are also viewed in worksheets DSSAnyGroup and DSSMonthTable.

In the circumstance of this example where there is no shared responsibility with CCSF, prior to developing a remedy for the negative Water Bank Account Balance it is recommended that the dead storage warning be corrected. The user can either reduce the minimum flow requirements or the canal diversions, either resulting in retaining additional storage in Don Pedro Reservoir.

By choosing reduced canal diversions the user will use option (1) at UI 2.10, and enter an alternative monthly diversion for the Districts at UI 2.20 and UI 2.30. The simulated diversions for the Test Base are shown to the right of the matrices of UI 2.20 and UI 2.30.

The volume and pattern of canal reduction is entered at the user’s discretion. For merely illustrative purposes this example assumes that WY 1976 diversions of both MID and TID are reduced from the already reduced values of the Test Case by an additional 10 percent. For the WY 1987-1992 period, it is assumed each District’s already reduced diversions are additionally reduced by 5 percent.

The Model will recalculate the simulation and the results are viewed in worksheet Review. It is shown that the Don Pedro Reservoir dead pool storage warning has been remedied, with resultant storage after selective diversion reductions are now greater than 308,960 acre-feet. The warning for negative Water Bank Account Balances still occurs. To complete the study the negative balances need to be eliminated, which would require adjustment as described in Example 1 and Example 2.

6.4 Additional Example

Example 3 could be amended to include a CCSF responsibility for the incremental flow requirements. The process described in Example 2 would be executed by switching CCSF responsibility “on” and then providing supplemental releases to maintain a positive balance in the Water Bank Account. If CCSF storage in Lake Lloyd and Hetch Hetchy becomes depleted an adjustment (reduction) to CCSF's SJPL would be required which requires a similar process as used to reduce the Districts' canal diversions.

Don Pedro Project
Project Operations/Water Balance Model Study Report
Attachment B – Model Description and User's Guide, Addendum 1
Revised 5-20-2013

1.0 INTRODUCTION

The Turlock Irrigation District (TID) and Modesto Irrigation District (MID) (collectively, the Districts) have developed a computerized Tuolumne River Daily Operations Model (Model) to assist in the relicensing of the Don Pedro Project (Project) (FERC Project 2299). The Model is fully described in the User's Guide submitted to FERC as part of the Initial Study Report (ISR), January 2013 (Model version 1.01). The purpose of the User's Guide is to describe the structure of the Model, the interfaces available for operation of the Model, and methods available for reviewing Model results. Procedures for development of input files for running scenarios for alternative future Project operations are also described and illustrated. The data presented in the ISR document referenced a "Test Case" simulation of operations for illustrative purposes. The test case was presented at a Workshop held with relicensing participants on December 7, 2012 for the purpose of training interested relicensing participants in the use of the Model.

Subsequent to the ISR submittal, the Districts proceeded to develop the "Base Case" which depicts the operation of the Don Pedro Project in accordance with the current FERC license, ACOE flood control management guidelines, and the Districts' irrigation and M&I water management practices. Under FERC policy, the Base Case represents the "No Action" alternative for purposes of evaluating future operation scenarios under NEPA. Future scenarios are compared to the Base Case to assess their impacts. As a result of the effort, including a collaborative refinement of the underlying hydrology of the Model completed at a Workshop held on March 27, 2013, several refinements and modifications to the Model have been implemented. The purpose of this Addendum 1 is to describe the refinements and modifications that have been made to the revised Model (Model Version 2.0) since the ISR submittal.

The Tuolumne River Daily Operations Model provides a depiction of the Don Pedro Project and City and County of San Francisco water operations consistent with the FERC-approved W&AR-02 study plan. The Model portrays operations that can be described systematically by various equations and algorithms. Actual project operations may vary from those depicted by the Model due to circumstantial and real-time conditions of hydrology and weather, facility operation, and human intervention. The FERC-approved study plan has identified a number of user-controlled variables. The fact that the Model provides these user-controlled inputs is not an indication that either the Districts or CCSF endorse or support any specific operational alternative developed by manipulating these inputs.

2.0 MODEL LOGIC AND EXECUTION MODIFICATIONS

Several Model logic routines were modified to provide a better or more adaptable depiction of Project operations. The specific areas of Project operations that were modified included the depiction of the current minimum flow requirements of the Don Pedro Project for the lower Tuolumne River and the reservoir operation logic during June and early July when Don Pedro Reservoir is filling. The simulation of power generation from the Project has also been revised as mentioned in the December 7, 2012 Workshop.

2.1 Don Pedro Reservoir Snow-melt Management

User's Guide reference: Section 5.12: "DonPedro" Worksheet, Section 5.12.3 Snow-melt Management

The Model computes a daily operation of Don Pedro Reservoir. Each day Don Pedro Reservoir inflow is computed from upstream CCSF System operations and unregulated inflow. The minimum stream flow requirements and the MID and TID canal diversions are assumed as the release from Don Pedro Reservoir. The prior day's reservoir evaporation is included in the calculation. If the computation produces a Don Pedro Reservoir storage value in excess of a preferred storage target, an "encroachment" is computed. If an encroachment occurs, a "check" release is computed. It is assumed that a constant supplemental "check" release (in excess of minimum releases) will be initiated. This protocol repeats itself periodically, reestablishing the level of check release each time. The end result of this procedure will allow encroachment of storage space above the preferred storage target and not require unrealistic "hard" releases of water to exactly conform to the target reservoir level.

A second check release is made during the April through June period for management of anticipated snow-melt runoff. Model Version 1.01 provided logic that on the first day of each of these months a forecast is made of anticipated runoff into the reservoir and minimum releases and losses from the reservoir from the date of forecast through the end of June (the assumed target date of reservoir filling). These forecasts determine the snow-melt "check" release volume of water (if any) that will require release in excess of minimum releases and losses and storage gain by the end of June. The snow-melt check release is evenly distributed across the days of the month. The release made in a day is the greater of the two check releases or the minimum release. At no time is the maximum capacity of the reservoir (2,030,000 acre-feet, elevation 830 ft) allowed to be exceeded, and if necessary a release, regardless of magnitude, will be made by the Model to not exceed this storage capacity.

Through testing of alternative Model scenarios it was discovered that Version 1.01 logic could produce erratic reservoir release results during early July, whereby a relatively constant release through the end of June could be followed by an erratic large release during the first part of July. The cause of the circumstance was the result of requiring the "filling" date of the reservoir to be the end of June. The assumption could lead to a full reservoir at the end of June while substantial inflow could subsequently occur. With no empty reservoir space remaining the Model would essentially pass inflow without modulation and in some circumstances large releases in excess of downstream flood control objectives. To remedy this outcome the Model was modified to extend the June snow-melt release check logic through July 7. All computational procedures for June remained the same except the time period upon which hydrologic information was known or assumed extends through July 7. Figure 2.1-1 illustrates the location of the revised logic within the DonPedro Worksheet, within the June computation section and designated by notes concerning the June through July 7 computational period.

Also newly incorporated into the snow-melt logic routine for the entire April through July 7 period is release change “smoothing” logic which can lessen the occurrence of modeled erratic release reductions that would otherwise sometimes occur during the transition from one month’s computed release to the next month’s computed release. During periods when the snow-melt release computation is controlling reservoir releases, user-defined values can be specified for a threshold and a rate of change that can occur from one day to the next. The threshold (C 1.13, “Control” Worksheet) defines the level of flow of the previous day for which a constraint to a next-day release reduction will occur, and the fraction (C 1.14, “Control” Worksheet) defines the reduced flow rate that can occur the next day. By illustration, if a previous day’s flow is 2,500 cfs or greater, the next day’s flow cannot be less than 0.75 of the previous day’s flow. This logic does not represent any known “ramping” constraints, but the protocol provides additional guidance to Model release decisions and produces reasonable results.

	A	B	C	D	AR	AS	AT	AU	AV	AW	AX	AY
1			1									
2	Unit Title		2									
3	Parameter Title		3									
4												
5	Acre-foot to CFS conversion											
6	divide by :	1.983471				Lookup of	Est of	Uses	Compute	Compute	Compute	Amount
7						1-May	May-Jun	Current Yr	Upstream	Availble	Total	to be
8						90% Exc	Portion	Canal +	Adjust	DP Stor	Excess	Released
9						Apr-Jul	of	Min River	to	through	May-Jun	during
10						Runoff	Apr-Jul	+Typ Evap	UF	June	Release	May
11												
12												
13		39-year Ave or Max				49	% May/May MJ					(C 1.20)
14		Min				38	% Jun/May MJ				% of May-Jun excess rel in May	50
15						May Snow-melt Release Routine						
16						May						
17	Month					1-May	1-May	M-Jun	M-Jun	M-Jun	M-Jun	May
18	Index	Date	Day	Days		A-Jul Fcst	MJune Fcst	Can+Riv+E	USAdj	DP Avail	Excess	SM Rel
19						TAF	TAF	AF	AF	AF	AF	CFS
20	1970.10	10/1/1970	T	31		0	0	0	0	0	0	0
21	1970.10	10/2/1970	F	31		0	0	0	0	0	0	0
22	1970.10	10/3/1970	S	31		0	0	0	0	0	0	0
23	1970.10	10/4/1970	S	31		0	0	0	0	0	0	0
24	1970.10	10/5/1970	M	31		0	0	0	0	0	0	0
25	1970.10	10/6/1970	T	31		0	0	0	0	0	0	0
26	1970.10	10/7/1970	W	31		0	0	0	0	0	0	0
27	1970.10	10/8/1970	T	31		0	0	0	0	0	0	0
28	1970.10	10/9/1970	F	31		0	0	0	0	0	0	0
29	1970.10	10/10/1970	S	31		0	0	0	0	0	0	0

	AZ	BA	BB	BC	BD	BE	BF	BG	BH	BI
1										
2										CFS
3										Target SM Re
4										
5										
6		Lookup of	Est of	Uses	Compute	Compute	Compute	Amount		
7		Actual	Actual	Current Yr	Upstream	Availble	Total	to be		
8		Jun-Jul 7	Jun-Jul 7	Canal +	Adjust	DP Stor	Excess	Released		0
9		Runoff	Runoff	Min River	to	through	Jun-Jul 7	during		2,500
10				+Typ Evap	UF	7-Jul	Release	Period		0.75
11										
12										
13								(C 1.30)		
14							% of June excess rel in June-Jul 7	100		
15		June - July 7 Snow-melt Release Routine								
16		June - July 7								Target
17		June -	June -	Period	Period	Period	Period	Period		SM
18		July 7 UF	July 7 UF	Can+Riv+E	USAdj	DP Avail	Excess	SM Rel		Release
19		TAF	TAF	AF	AF	AF	AF	CFS		CFS
20		0	0	0	0	0	0	0		0
21		0	0	0	0	0	0	0		0
22		0	0	0	0	0	0	0		0
23		0	0	0	0	0	0	0		0
24		0	0	0	0	0	0	0		0
25		0	0	0	0	0	0	0		0
26		0	0	0	0	0	0	0		0
27		0	0	0	0	0	0	0		0
28		0	0	0	0	0	0	0		0
29		0	0	0	0	0	0	0		0

	BJ	BK	BL	BM	BN	BO
1						
2		CFS	CFS	CFS	CFS	CFS
3		Dry Creek	LTR Accr	Tot Unreg	Trg Max L(	Modesto F
4						
5						
6						
7						
8	Original equation w/o release ramping constraint					
9	Prior day ramping threshold (C 1.13)					
10	Fraction of prior day flow for ramping (C 1.14)					
11						
12						
13					(C 1.00)	
14				Enter Modesto FC Target:	9,000	CFS
15		Modesto Flood Control Flow Objective				
16		Report	Est	Total	Target	Calc
17		Dry Creek	LTR Acc	Unreg	Max	Modesto
18		Flow	Flow	Blw LG	LaGrange	Flow
19		CFS	CFS	CFS	CFS	CFS
20		30	80	110	8,890	410
21		30	80	110	8,890	410
22		30	80	110	8,890	410
23		30	80	110	8,890	410
24		30	80	110	8,890	410
25		30	80	110	8,890	410
26		30	80	110	8,890	410
27		30	80	110	8,890	410
28		30	80	110	8,890	410
29		30	80	110	8,890	410

Figure 2.1-1. Snow-melt management section.

2.2 Don Pedro Current Minimum Flow Requirement

User’s Guide reference: Section 5.17: “LaGrangeSchedule” Worksheet, Section 5.17.1 Minimum Flow Requirement Options, Section 5.17.2 April-May Daily Parsing of Flow Requirements, and Section 5.17.3 Computation of 1995 FERC Minimum Flow Requirement

The FERC license for the Don Pedro Project requires flow releases from Don Pedro Reservoir to the lower Tuolumne River. These flows are measured at the USGS gage downstream of the La Grange diversion dam. To keep the Don Pedro Reservoir required flow releases distinct from Don Pedro Reservoir releases in general the model designates “LaGrangeSchedule” Worksheet for assemblage of the minimum flow requirement for the lower Tuolumne River. By user specification (UI 1.10) either the current 1995 FERC schedule is selected (UI 1.10 = 0) or the user defined minimum flow requirement is selected (UI 1.10 = 1). If the current 1995 FERC schedule is selected the computation of the schedule is computed in this worksheet.

When using current 1995 FERC minimum flow requirements, Version 1.01 (Switch C 1.60, "Control" Worksheet) allowed the user to direct the daily shape of release for pulse flows during April and May. Version 2.0 continues to allow the shaping of April-May migration flows to the lower Tuolumne River and also allows a shaping of October attraction flows. Figure 2.2-1 illustrates the parsing of the monthly flow requirements into daily flow requirements. The structure of this section of the worksheet is mostly the same as before, except the monthly/daily flow requirements have now been defined by "base" and "pulse" components. Also, a computational procedure has been added for October to prescribe current FERC-defined attraction flows.

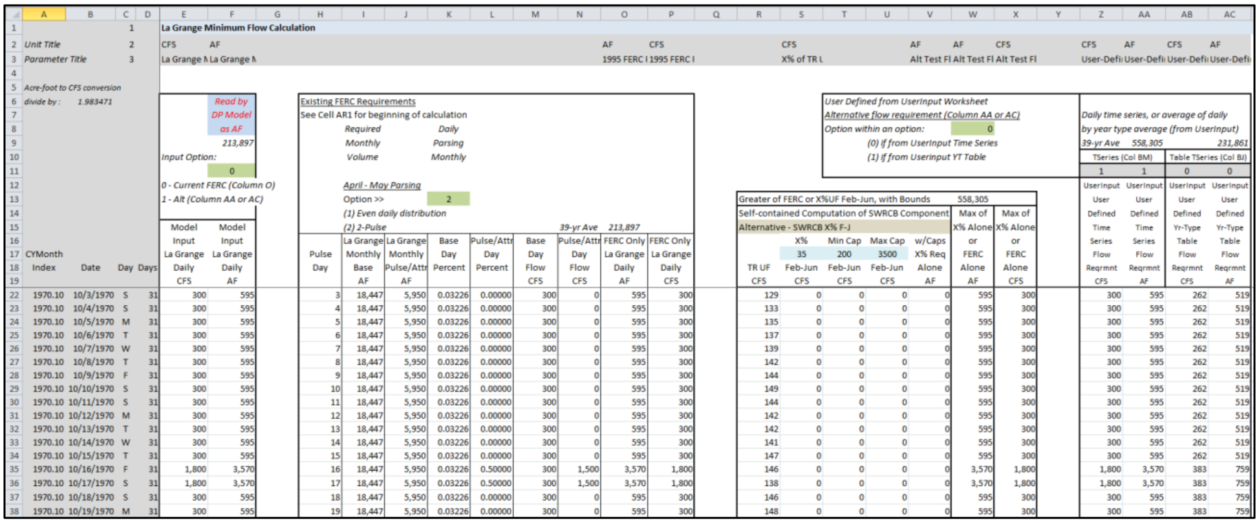


Figure 2.2-1. Daily parsing of FERC flow requirement from Don Pedro Reservoir.

Figure 2.2-2 illustrates the area for entry of data to parse monthly-designated migration and attraction flow requirements into daily patterns during April, May and October. The "Control" Worksheet designates which parsing pattern is to be used for April and May. The examples illustrate the entry for an evenly distributed pattern of migration flow volume during the April-May 61-day period, and a pattern for which the migration flow volume (by daily fraction of the volume) has been divided between April (16 days) and May (15 days). The migration flow volume for each month has been evenly distributed during each day of the partial month period. These daily migration flows are added to the base flow component of each month. The parsing of the attraction flow volume during the month of October is similarly defined. In this example the attraction flow volume (by daily fraction of the volume) for October is distributed evenly over a two-day period beginning October 15.

Figure 2.2-3 illustrates the section of the worksheet that defines the current 1995 FERC flow requirement from Don Pedro Reservoir. Several elements of information provided in this worksheet and from the "Control" Worksheet provide the computation of flow requirement based on 1995 FERC Settlement procedures and flow rates. The basis of the year type flow requirements is the SWRCB San Joaquin River Basin 60-20-20 index. The annual flow schedules are assumed to be on an April through March year, with the interpolation water of the schedules applied to April and May pulse flows. For modeling convenience the explicit FERC requirements for October base and attraction flows have been slightly modified to adapt into the evenly daily distributed base flow component of the Model.

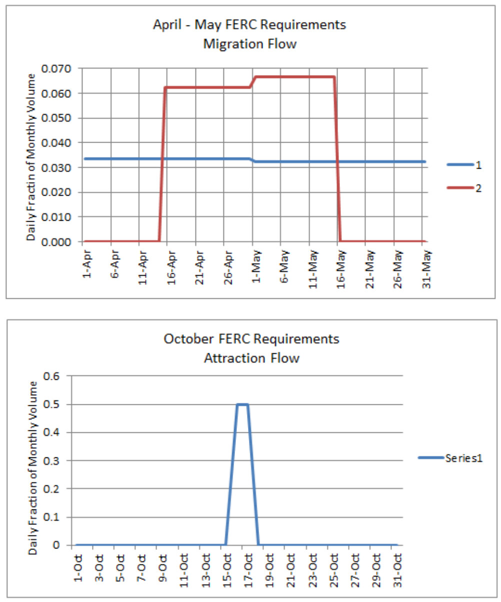
AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR

Customized Daily Pulse Flow Patterns for the April - May and October Period

April - May Parsing

Daily Pattern of April-May Pulse Fishery Volumes

		Even	2-Pulse
	Option >>	1	2
1	1-Apr	0.033	0.000
2	2-Apr	0.033	0.000
3	3-Apr	0.033	0.000
4	4-Apr	0.033	0.000
5	5-Apr	0.033	0.000
6	6-Apr	0.033	0.000
7	7-Apr	0.033	0.000
8	8-Apr	0.033	0.000
9	9-Apr	0.033	0.000
10	10-Apr	0.033	0.000
11	11-Apr	0.033	0.000
12	12-Apr	0.033	0.000
13	13-Apr	0.033	0.000
14	14-Apr	0.033	0.000
15	15-Apr	0.033	0.063
16	16-Apr	0.033	0.063
17	17-Apr	0.033	0.063
18	18-Apr	0.033	0.063
19	19-Apr	0.033	0.063
20	20-Apr	0.033	0.063
21	21-Apr	0.033	0.063
22	22-Apr	0.033	0.063
23	23-Apr	0.033	0.063
24	24-Apr	0.033	0.063
25	25-Apr	0.033	0.063
26	26-Apr	0.033	0.063
27	27-Apr	0.033	0.063
28	28-Apr	0.033	0.063
29	29-Apr	0.033	0.063
30	30-Apr	0.033	0.063
31	1-May	0.032	0.067
32	2-May	0.032	0.067
33	3-May	0.032	0.067
34	4-May	0.032	0.067



October Parsing

Daily Pattern of October Attraction Fishery Volume

		Day Frac
1	1-Oct	0
2	2-Oct	0
3	3-Oct	0
4	4-Oct	0
5	5-Oct	0
6	6-Oct	0

Figure 2.2-2. Daily parsing of FERC migration and attraction flow.

FERC Flow Schedules

Year Type	1	2	3	4	5	6	7	Adapted October 6	
Oct 1-15 (CFS)	100	100	150	150	180	200	300	188	*October has been modified from*
Oct 16-31 (CFS)	150	150	150	150	180	175	300	188	*explicit FERC Schedule for modeling*
Total Base (AF)	7,736	7,736	9,223	9,223	11,068	11,504	18,447	11,560	*simplicity. Split-month base flow has*
Attraction (AF)	0	0	0	0	1,676	1,736	5,950	1,680	*been levelized.*
Total Oct (AF)	7,736	7,736	9,223	9,223	12,744	13,240	24,397	13,240	
Nov (CFS)	150	150	150	150	180	175	300		
AF	8,926	8,926	8,926	8,926	10,711	10,413	17,852		
Dec (CFS)	150	150	150	150	180	175	300		
AF	9,223	9,223	9,223	9,223	11,068	10,760	18,447		
Jan (CFS)	150	150	150	150	180	175	300		
AF	9,223	9,223	9,223	9,223	11,068	10,760	18,447		
Feb (CFS)	150	150	150	150	180	175	300		
AF	8,331	8,331	8,331	8,331	9,997	9,719	16,661		
Mar (CFS)	150	150	150	150	180	175	300		
AF	9,223	9,223	9,223	9,223	11,068	10,760	18,447		
Apr (CFS)	150	150	150	150	180	175	300		
AF	8,926	8,926	8,926	8,926	10,711	10,413	17,852		
May (CFS)	150	150	150	150	180	175	300		
AF	9,223	9,223	9,223	9,223	11,068	10,760	18,447		
Migration Flow									
AF	11,091	20,091	32,619	37,060	35,920	60,027	89,882		
Jun (CFS)	50	50	50	75	75	75	250		
AF	2,975	2,975	2,975	4,463	4,463	4,463	14,876		
Jul (CFS)	50	50	50	75	75	75	250		
AF	3,074	3,074	3,074	4,612	4,612	4,612	15,372		
Aug (CFS)	50	50	50	75	75	75	250		
AF	3,074	3,074	3,074	4,612	4,612	4,612	15,372		
Sep (CFS)	50	50	50	75	75	75	250		
AF	2,975	2,975	2,975	4,463	4,463	4,463	14,876		
Total Annual	94,001	103,001	117,017	127,508	142,503	165,004	300,926		

Figure 2.2-3. 1995 FERC minimum flow requirement schedule.

Figure 2.2-4 illustrates the revised computational section of the "LaGrangeSchedule" Worksheet that computes the components of base and total required schedule annual volumes, October attraction flow volume, and April-May migration flow volume. Other sections of the worksheet have been revised to define the monthly distribution of annual volumes for incorporation into the daily parsing routines shown above.

AU	AV	AW	AX	AY	AZ	BA	BB	BC	BD	BE	BF	BG	BH	BI
Current FERC Requirements														
	Tuolumne River Flow Interpolation - Year 2011 Revised Distribution													
	Flow Year Type			SJR Basin Index				Flow Requirement						October
													Base	Attraction
	1		<	1510								94000	82,910	0
	2			1510	- <	2000		0.0286	x (Index -	1510	) +	103000	82,910	0
	3			2000	- <	2190		0.0552	x (Index -	2000	) +	117016	84,398	0
	4			2190	- <	2440		0.0600	x (Index -	2190	) +	127507	90,448	0
	5			2440	- <	2720		0.0804	x (Index -	2440	) +	142502	104,907	1,676
	6			2720	- <	3180		0.2955	x (Index -	2720	) +	165002	103,297	1,680
	7			3180	and Greater							300923	205,094	5,950
									Option >>	1	2	3	4	5
	1	<<Option			Ave	219,421	146,114	70,146		Actual	90% Exc.	75% Exc.	Med.	10% Exc.
	SJR				TR	Tuolumne	Tuolumne	Pulse	Base	SJR	Apr SJR	Apr SJR	Apr SJR	Apr SJR
	Index	Year			October	River	River	Flow	Year	Index	Index	Index	Index	Index
	602020	Class		Year	Attraction	Require	Base	Calc	Type	602020	Fcast	Fcast	Fcast	Fcast
	4,543,729	Wet		1922	5,950	300,923	205,094	89,879	7	4,543,729	2,424,373	2,561,322	2,674,495	2,921,846
	3,549,358	Above		1923	5,950	300,923	205,094	89,879	7	3,549,358	1,765,568	1,897,976	2,007,411	2,246,643
	1,419,746	Critical		1924	0	94,000	82,910	11,090	1	1,419,746	799,642	853,197	957,737	1,186,335
	2,929,617	Below		1925	1,680	226,944	103,297	121,967	6	2,929,617	2,042,878	2,179,628	2,292,637	2,539,632
	2,300,567	Dry		1926	0	134,141	90,448	43,693	4	2,300,567	1,256,470	1,387,014	1,494,917	1,730,818
	3,558,955	Above		1927	5,950	300,923	205,094	89,879	7	3,558,955	2,147,110	2,284,156	2,397,408	2,644,932
	2,632,407	Below		1928	1,676	157,972	104,907	51,388	5	2,632,407	1,934,163	2,068,826	2,180,117	2,423,380
	2,004,815	Critical		1929	0	117,282	84,398	32,884	3	2,004,815	1,140,712	1,270,277	1,377,372	1,611,521

Figure 2.2-4. 1995 FERC flow requirements from Don Pedro Reservoir.

2.3 Don Pedro Project Generation

User's Guide reference: Section 5.12: "DonPedro" Worksheet, Section 5.12.5 Don Pedro Project Generation and River Flows

The hydroelectric generation characteristics of any modeled Project operation scenario are modeled incidental to Project hydrologic operations. The power generation of the Project is computed from the simulation of daily time step operations and is incoporated into the "DonPedro" Worksheet. Input to the power component includes daily average flow past Don Pedro Dam (flow through the dam and through the spillway, if any) and Don Pedro Reservoir storage. The power component computes gross and net head, flow through turbines, efficiency and power output based on a group of reservoir rating, tailwater rating and manufacturer's performance characteristic curves, and generalized equations for head losses.

Figure 2.3-1 illustrates the components of computational procedure that derives power output of the Project. The power characteristics of the turbine generators are defined for a range of head and flow combinations. "Cutoff" of generation that would otherwise be indicated by the performance curves is provided through user defined switches entered in the "Control" Worksheet. Switch C 1.20 defines the minimum reservoir storage level at which generation occurs, and Switch C 1.22 defines the maximum flow through the powerplant. In this illustration generation will not occur when Don Pedro Reservoir storage is less than 308,960 acre-feet (elevation 600 ft). The performance curves indicate that generation may occur up to a flow rate of approximately 5,500 cfs. Switch C 1.22 has been set higher than this value to not impede the computation.

	A	B	C	D	DK	DL	DM	DN	DO	DP	DQ	DR	DS	DT	DU	DV	DW	DX	DY	DZ
1			1																	
2	*Unit Title*		2			CFS														
3	*Parameter Title*		3			Total Dam Release														
4																				
5	*Acre-foot to CFS conversion*																			
6	*divide by :*	*1.983471*																		
7																				
8					*TEST*															
9					*11/21/1977*	*289*	*361,955*	*614.3*	*298.0*	*316.3*	*316.2*	*310*	*325*	*0*		*3*	*1*	*10*	*4550*	*289*
10																				
11							*308,960*	*(C 1.20) Cutoff of generation, DP Storage (sets available units to zero)*												
12						*Penstock Loss:*	*9.66E-07*	*ft/cfs²*	*Scheduled Maintenance? (1) Yes, (0) No:*					*0*					*6,000*	
13		*39-year Ave or Max*			*Max*	*67,039*		*830*	*298*	*532*	*527*	*530*	*525*			*3*	*1*	*10*	*5,655*	*5,500*
14		*Min*			*Min*	*207*		*614*	*298*	*316*	*316*	*310*	*325*			*3*	*1*	*10*	*4,550*	*207*
15					**Don Pedro Power Generation**															
16						Don	Don	Don	Approx			Net H	Net H		Unsched	Number	Number	Min	Max	Potential
17	Month					Pedro	Pedro	Pedro	Tailwater	Gross	Approx	Look-up	Look-up	Sched	Outage /	Available	Available	Plant	Plant	Plant
18	Index	Date	Day	Days		Release	Storage	Elevation	Elevation	Head	Net H	Units 1-3	Unit 4	Outage	Bypass	Units 1-3	Unit 4	Flow	Flow	Flow
19						CFS	Ave-AF	FT elev	FT elev	FT	FT	FT	FT	unit #	unit #			CFS	CFS	CFS
20	1970.10	10/1/1970	T	31		2,037	1,669,232	800.0	298.0	502.0	498.0	490	500	0		3	1	10	5500	2,037
21	1970.10	10/2/1970	F	31		1,288	1,666,644	799.7	298.0	501.7	500.1	510	500	0		3	1	10	5500	1,288
22	1970.10	10/3/1970	S	31		1,209	1,664,882	799.6	298.0	501.6	500.2	510	500	0		3	1	10	5500	1,209
23	1970.10	10/4/1970	S	31		1,718	1,662,698	799.4	298.0	501.4	498.6	490	500	0		3	1	10	5500	1,718
24	1970.10	10/5/1970	M	31		1,378	1,660,351	799.2	298.0	501.2	499.4	490	500	0		3	1	10	5500	1,378
25	1970.10	10/6/1970	T	31		1,502	1,658,222	799.0	298.0	501.0	498.8	490	500	0		3	1	10	5500	1,502
26	1970.10	10/7/1970	W	31		1,322	1,656,151	798.8	298.0	500.8	499.1	490	500	0		3	1	10	5500	1,322
27	1970.10	10/8/1970	T	31		728	1,654,638	798.7	298.0	500.7	500.2	510	500	0		3	1	10	5500	728
28	1970.10	10/9/1970	F	31		827	1,653,407	798.5	298.0	500.5	499.8	490	500	0		3	1	10	5500	827
29	1970.10	10/10/1970	S	31		898	1,652,016	798.4	298.0	500.4	499.6	490	500	0		3	1	10	5500	898

	A	B	C	D	EA	EB	EC	ED	EE	EF	EG	EH	EI	EJ	EK	EL
1			1													
2	*Unit Title*		2						CFS							kWh
3	*Parameter Title*		3						Total Plant Flow							Modeled D
4																
5	*Acre-foot to CFS conversion*															
6	*divide by :*	*1.983471*														
7																
8																
9					*1*	*289*	*0*	*0*	*289*	*315.9*	*60.0%*	*0.0%*	*4,648*	*0*	*4,648*	*111,544*
10																
11																
12								*39-yr Annual Ave (AF):*	*1,501,380*						*39-yr Annual Ave (MWh):*	*603,718*
13		*39-year Ave or Max*			*3*		*1*	*1,000*	*5,500*	*525*	*0.90*	*0.92*	*172,991*	*38,653*	*208,219*	*4,997,256*
14		*Min*			*1*		*0*	*0*	*207*	*316*	*0.60*	*0.00*	*3,333*	*0*	*3,333*	*80,003*
15																
16						Flow		Flow			Plant	Plant				Plant
17	Month				Operation	Through	Operation	Through	Plant	Net	Effic	Effic	Power	Power	Plant	Daily
18	Index	Date	Day	Days	Units 1-3	Units 1-3	Unit 4	Unit 4	Flow	Head	Units 1-3	Unit 4	Units 1-3	Unit 4	Power	Generation
19					Count	CFS		CFS	CFS	FT	%	%	kW	kW	kW	kWh
20	1970.10	10/1/1970	T	31	3	679	0	0	2037	495.0	77.2%	0.0%	65,942	0	65,942	1,582,609
21	1970.10	10/2/1970	F	31	3	429	0	0	1288	498.2	65.2%	0.0%	35,423	0	35,423	850,156
22	1970.10	10/3/1970	S	31	3	403	0	0	1209	498.3	63.9%	0.0%	32,602	0	32,602	782,449
23	1970.10	10/4/1970	S	31	3	573	0	0	1718	496.0	73.4%	0.0%	53,001	0	53,001	1,272,019
24	1970.10	10/5/1970	M	31	3	459	0	0	1378	497.3	67.8%	0.0%	39,381	0	39,381	945,135
25	1970.10	10/6/1970	T	31	3	501	0	0	1502	496.5	70.3%	0.0%	44,432	0	44,432	1,066,359
26	1970.10	10/7/1970	W	31	3	441	0	0	1322	497.1	67.0%	0.0%	37,296	0	37,296	895,105
27	1970.10	10/8/1970	T	31	2	364	0	0	728	499.0	60.0%	0.0%	18,467	0	18,467	443,214
28	1970.10	10/9/1970	F	31	3	276	0	0	827	498.5	60.0%	0.0%	20,971	0	20,971	503,311
29	1970.10	10/10/1970	S	31	3	299	0	0	898	498.3	60.0%	0.0%	22,759	0	22,759	546,222

Figure 2.3-1. Project power computational procedure.

A validation of the computational process was made by comparing Model-produced generation to historically reported generation. Table 2.3-1 shows a comparison between computed and reported generation for a 2002 – 2009 period of record. The results show that Project generation is well depicted with the computational procedures, with minimal annual differences. This period of record includes a dry (reduced reservoir and releases) to wet (full reservoir and large releases) range of hydrologic conditions. Figure 2.3-2 illustrates the comparison of Model-produced daily generation and historically reported generation for calendar year 2003, which had a range of reservoir storage and release conditions.

Table 2.3-1. Modeled and reported Project power.

	Reported Generation (MWh)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2002	5,079	4,259	38,044	61,819	54,412	54,341	66,448	52,811	28,790	18,760	6,073	7,005	397,840
2003	5,395	11,275	25,076	39,599	51,964	68,313	75,800	61,667	32,692	33,135	8,343	6,261	419,520
2004	7,509	12,122	62,985	72,157	58,301	58,788	68,904	54,145	25,452	23,118	4,565	4,402	452,449
2005	12,339	48,759	98,233	137,057	143,777	137,291	122,689	84,793	43,861	22,203	9,831	33,044	893,877
2006	111,669	72,155	125,741	110,498	131,217	124,759	97,387	80,643	46,356	26,152	11,631	8,204	946,413
2007	12,597	15,207	45,088	48,189	54,255	57,216	64,531	53,546	22,957	15,461	7,032	3,780	399,859
2008	3,184	5,562	37,289	43,158	58,312	45,852	54,811	46,690	22,417	11,467	4,647	6,114	339,501
2009	4,912	5,326	21,733	41,084	55,267	56,222	67,625	53,082	28,388	18,051	7,781	5,495	364,965
Average	20,335	21,833	56,774	69,195	75,938	75,348	77,274	60,922	31,364	21,043	7,488	9,288	526,803
Ann Dist	4%	4%	11%	13%	14%	14%	15%	12%	6%	4%	1%	2%	100%

	Modeled Generation (MWh)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2002	4,692	4,343	36,119	63,521	54,701	56,249	69,864	53,614	27,334	17,457	5,765	6,422	400,081
2003	5,104	10,231	23,762	39,691	51,839	67,021	80,295	64,791	31,953	31,070	7,742	5,434	418,932
2004	6,696	11,128	62,972	75,770	60,036	59,137	70,224	55,786	24,403	21,785	5,131	4,488	457,555
2005	13,839	50,180	109,404	139,619	146,930	147,343	132,278	89,284	44,552	21,561	10,306	35,026	940,321
2006	102,499	71,293	130,498	108,499	113,092	111,410	102,790	82,253	45,051	24,484	11,237	7,320	910,425
2007	11,023	13,343	43,437	47,548	54,298	59,601	67,647	56,301	22,600	14,898	6,724	4,165	401,585
2008	3,820	5,733	37,688	43,469	59,007	45,476	56,320	49,154	21,603	10,833	4,542	6,150	343,795
2009	4,985	5,740	21,720	40,985	55,636	58,102	72,166	56,015	28,577	16,255	7,465	5,421	373,066
Average	19,082	21,499	58,200	69,888	74,443	75,542	81,448	63,400	30,759	19,793	7,364	9,303	530,720
Generation	4%	4%	11%	13%	14%	14%	15%	12%	6%	4%	1%	2%	100%

	% Deviation ((Reported-Actual)/Actual)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2002	-8%	2%	-5%	3%	1%	4%	5%	2%	-5%	-7%	-5%	-8%	1%
2003	-5%	-9%	-5%	0%	0%	-2%	6%	5%	-2%	-6%	-7%	-13%	0%
2004	-11%	-8%	0%	5%	3%	1%	2%	3%	-4%	-6%	12%	2%	1%
2005	12%	3%	11%	2%	2%	7%	8%	5%	2%	-3%	5%	6%	5%
2006	-8%	-1%	4%	-2%	-14%	-11%	6%	2%	-3%	-6%	-3%	-11%	-4%
2007	-12%	-12%	-4%	-1%	0%	4%	5%	5%	-2%	-4%	-4%	10%	0%
2008	20%	3%	1%	1%	1%	-1%	3%	5%	-4%	-6%	-2%	1%	1%
2009	1%	8%	0%	0%	1%	3%	7%	6%	1%	-10%	-4%	-1%	2%
Average	-6%	-2%	3%	1%	-2%	0%	5%	4%	-2%	-6%	-2%	0%	1%

Modeled generation includes assumptions for historical outages of units.

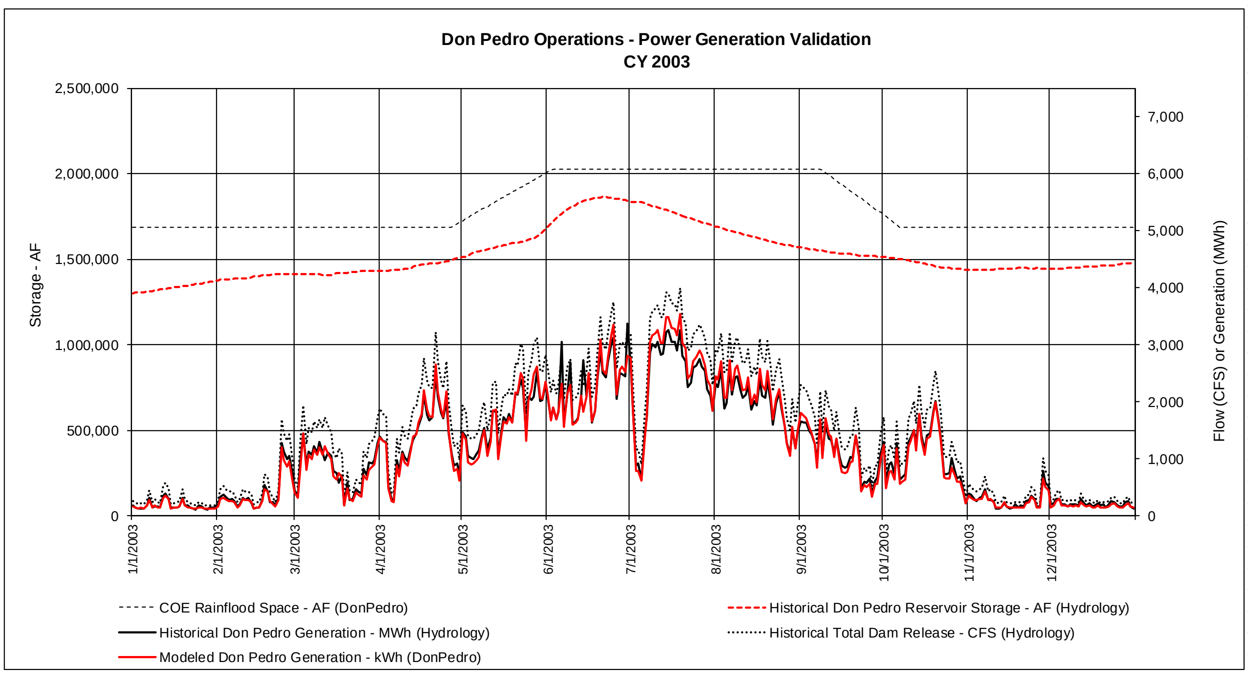


Figure 2.3-2. Project power daily generation.

3.0 INPUT AND HYDROLOGY MODIFICATIONS

Several changes to underlying hydrology and data assumptions have been implemented in the Model (Version 2.0).

3.1 Unimpaired Runoff

User's Guide reference: Section 5.22: "Hydrology" Worksheet

Concern was raised regarding the sometimes erratic daily pattern of computed unimpaired runoff for various components of the historical record, and the occassional computation of a "negative" value of flow. Although the use of the historically computed data are known to not adversely affect Model results, the Districts forwarded an approach to developing a hybrid gauge summation/gage proration hydrologic record for Tuolumne River unimpaired flow that would provide a "smoother" hydrograph. At a Workshop on March 27, 2013, RPs and the Districts worked through the approach and came to a consensus on an acceptable record of unimpaired flow for the Tuolumne River. It was clearly stated that the Districts and CCSF will not change their historical methods for calculating their respective water supplies from the Tuolumne River or the historical record of water bank operations. This modified data set will only be used to estimate unimpaired flow for the FERC relicensing.

Modified sub-basin hydrology was implemented for Hetch Hetchy Reservoir inflow, Cherry/Eleanor inflow, and the unregulated inflow to Don Pedro Reservoir. With only one month of exception, the historically computed monthly volumes of total runoff above La Grange were maintained in the modified data set. However, the daily shaping of the sub-basin runoff was modified, and on occasion rebalanced between the sub-basins to rectify historically computed negative volumes. Figure 3.1-1 illustrates the location and an example of the modified hydrology implemented in the "Hydrology" Worksheet.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1			1		Hydrology								
2			2		CFS	CFS	CFS	CFS	CFS		CFS	CFS	CFS
3			3		Unimpaire	Unimpaire	Unimpaire	Revised Ur	Unregulated Inflow tc		Dry Creek	Total LTR Ac	Modesto to
4													
5													
6					*Read by*	*Read by*	*Read by*		*Read by*		*Read by*	*Read by*	*Read by*
7					*Model*	*Model*	*Model*		*Model*		*Model*	*Model*	*Model*
8													
9													
10													
11													
12											LTR Accretions		
13					*March 26, 2013 Prorated Hydrology*						Nov 2012	Nov 2012	
14											Dry Creek	Lower	Modesto
15					1,934,193	762,930	487,867		683,396		Flow @	Tuolumne	to
16					Unimpaired Flow				Computed Flow		Modesto	River	Confluence
17	Month					Hetch	Cherry/		Unregul		HDR est.	Acc abv	
18	Index	Date	Day		La Grange	Hetchy	Eleanor		blw SF			Modesto	
19					CFS	CFS	CFS		CFS		CFS	CFS	CFS
20	1970.10	10/1/1970	T		125	4	14		107		30	80	32
21	1970.10	10/2/1970	F		130	4	14		111		30	80	32
22	1970.10	10/3/1970	S		129	4	14		111		30	80	32
23	1970.10	10/4/1970	S		133	4	15		115		30	80	32
24	1970.10	10/5/1970	M		135	4	15		117		30	80	32
25	1970.10	10/6/1970	T		137	4	15		118		30	80	32
26	1970.10	10/7/1970	W		139	4	15		119		30	80	32
27	1970.10	10/8/1970	T		142	4	15		122		30	80	32
28	1970.10	10/9/1970	F		144	4	15		124		30	80	32
29	1970.10	10/10/1970	S		149	4	16		130		30	80	32

Figure 3.1-1. Unimpaired runoff data set.

3.2 District Canal Operation Assumptions

User's Guide reference: Section 5.18: "DailyCanalsCompute" Worksheet, Section 5.18.3 Daily Canal Operation Assumptions

The "DailyCanalsCompute" Worksheet performs the computation of the daily canal demands of the MID and TID. The computation of canal demands incorporate the PDAW and canal operations practices of the Districts. Canal operation assumptions include regulating reservoir operation, seepage and losses, nominal groundwater pumping and canal operational spills. Since the initial development of data for the Model, a recent review of the Districts' operation records associated with the Districts' preparation and filing of their 5-year Agricultural Water Management Plans has led to the refinement of certain canal operations assumptions. Model (Version 2.0) assumptions for each District are shown Figure 3.2-1.

Modesto Irrigation District

Month	Turnout Delivery Factor %	Nominal Private GW Pumping TAF	Canal Operational Spills Critical TAF	Canal Operational Spills Non-crit TAF	System Losses below Modesto Res TAF	Intercepted Flows TAF	Nominal MID GW Pumping TAF	Modesto Res and Upper Canal Losses/Div TAF	Municipal Delivery from Modesto Res TAF	Modesto Res Target Storage TAF	Modesto Res Target Storage Change TAF
January	35.0	0.0	2.0	2.0	0.1	0.0	0.0	0.0	2.3	17.0	2.0
February	35.0	0.0	2.0	2.0	0.1	0.0	0.0	0.0	2.3	18.0	1.0
March	65.0	1.0	1.0	3.0	0.6	0.9	1.0	2.0	2.7	18.0	0.0
April	70.0	2.0	3.0	6.0	0.6	0.9	2.3	2.9	2.7	19.0	1.0
May	85.0	3.0	4.0	6.5	0.6	1.2	2.3	3.9	3.0	20.0	1.0
June	85.0	4.0	3.5	6.5	0.6	1.0	2.3	4.3	3.2	20.0	0.0
July	77.5	4.0	3.5	6.5	0.6	1.0	2.6	4.9	3.3	21.0	1.0
August	70.0	4.0	4.9	7.0	0.6	1.4	2.4	4.9	3.3	22.0	1.0
September	65.0	2.0	5.0	7.0	0.6	1.2	2.3	4.2	3.3	20.0	-2.0
October	40.0	1.0	2.8	6.9	0.6	0.9	2.1	2.0	3.2	17.0	-3.0
November	30.0	0.0	2.0	2.0	0.1	0.0	0.0	2.0	2.7	15.0	-2.0
December	35.0	0.0	2.0	2.0	0.1	0.0	0.0	0.0	2.5	15.0	0.0
Total		21.0	35.7	57.4	5.4	8.5	17.3	31.1	34.5		

MID March TO Factor

Factor Break Pnt (PDAW-TAF)	Factor %
0.0	65.0
9.9	65.0
13.2	65.0
20.0	65.0
9999.0	65.0

TID March TO Factor

Factor Break Pnt (PDAW-TAF)	Factor %
0.0	65.0
19.8	65.0
27.5	65.0
40.0	65.0
9999.0	65.0

MID April TO Factor

Factor Break Pnt (PDAW-TAF)	Factor %
0.0	70.0
10.0	70.0
17.5	70.0
25.0	80.0
9999.0	80.0

TID April TO Factor

Factor Break Pnt (PDAW-TAF)	Factor %
0.0	57.5
20.0	57.5
35.0	70.0
50.0	80.0
9999.0	80.0

Turlock Irrigation District

Month	Turnout Delivery Factor %	Nominal Private GW Pumping TAF	Canal Operational Spills Critical TAF	Canal Operational Spills Non-crit TAF	System Losses below Turlock Lk TAF	Intercepted and Other Flows TAF	Nominal TID GW Pumping TAF	Turlock Lk and Upper Canal Losses TAF	Other Delivery from Turlock Lk TAF	Turlock Lk Target Storage TAF	Turlock Lk Target Storage Change TAF
January	30.0	0.0	2.0	2.0	0.8	0.0	0.0	1.0	0.0	18.0	5.0
February	30.0	0.0	2.0	2.0	0.8	0.0	0.0	1.0	0.0	25.0	7.0
March	65.0	1.2	3.0	3.0	4.5	0.5	4.1	1.0	0.0	30.0	5.0
April	57.5	2.4	5.1	6.3	4.5	1.0	8.0	6.6	0.0	30.0	0.0
May	85.0	3.6	4.6	6.7	4.5	1.3	10.3	7.7	0.0	32.0	2.0
June	92.5	5.2	4.2	6.7	4.5	1.3	12.4	8.2	0.0	32.0	0.0
July	75.0	6.4	4.2	6.7	4.5	1.5	14.6	8.7	0.0	32.0	0.0
August	65.0	6.2	4.0	7.3	4.5	1.5	13.3	9.0	0.0	30.0	-2.0
September	67.5	3.9	3.2	7.3	4.5	1.0	9.1	5.0	0.0	27.0	-3.0
October	40.0	2.4	2.3	7.3	4.5	0.5	5.3	2.0	0.0	13.0	-14.0
November	30.0	0.0	2.0	2.0	0.8	0.0	0.0	1.0	0.0	13.0	0.0
December	30.0	0.0	2.0	2.0	0.8	0.0	0.0	1.0	0.0	13.0	0.0
Total		31.3	38.6	59.3	39.2	8.5	77.1	52.2	0.0		

Figure 3.2-1. Districts' canal demand components.

The change that has occurred to the data set is the estimation of “intercepted and other flows” for the TID canal system. The change reflects the addition of a component of canal water supply that was previously not recognized in the data set. Also refined in the data set and computational process for both Districts were several of the monthly turnout delivery factors. The turnout delivery factors are unique to each District and represent a modeling mechanism to adjust the PDAW for irrigation practices that are not included in the estimation of the CUAW, such as irrigation that provides for groundwater recharge. Data identified in this worksheet are entered through the Control Worksheet.

3.3 Don Pedro Water Supply Factor

User’s Guide reference: Section 5.20: “DPWSF” Worksheet

The “DPSWF” Worksheet computes the Don Pedro Water Supply Factor (WSF). The premise of the WSF factor is to reduce the amount of water diverted to the canals during years when lack of carryover storage at Don Pedro Reservoir becomes a concern. The modeling mechanism used to reduce canal diversions is a factor applied to the PDAW of the canal demand. This mechanism results in a reduction to the amount of water “turned out” to the customers. Changes to estimated canal demands and underlying hydrology, in combination with the review of projected operations has led to a change in the WSF to be used for the Base Case. Figure 3.3-1 illustrates the Base Case WSF components in the Model (Version 2.0). The values are entered in the “Control” Worksheet.

Don Pedro Reservoir Inflow Forecast for Diversion of Water Supply

Reservoir Index Method - Active Matrix

	M/T NDP Stor + Infl Index	M/TID WS Factor	+1	+1
	kaf	%		
Enter	0	0.75	1090	0.75
Values	1090	0.75	1090	0.875
From	1090	0.875	1700	0.875
C1.90	1700	0.875	1700	1
	1700	1	2300	1
	2300	1	9999	1
	9999	1		

(W)ater (S)upply (F)actor is established by forecasting upcoming water supply, based on antecedent storage and anticipated inflow to Don Pedro Reservoir.

Forecast begins for February:
EO-January storage + Feb-July UF - Feb-July US adj - Feb-Mar minimum river
March Forecast:
EO-February storage + Mar-July UF - Mar-July US adj - Mar minimum river
April Forecast: (final)
EO-March storage + Apr-July UF - Apr-July US adj

Factor Table is April Forecast based
February and March Forecasts act as adjustments to estimate April 1 state.

Figure 3.3-1. Don Pedro water supply forecast factors.

3.5 Lower Tuolumne River Accretions below Modesto

The Model (Version 1.0) incorporated a synthesized data set for lower Tuolumne River accretions above the “Modesto” gage and estimated flow from Dry Creek. These data sets inform the Model of flow that could influence Don Pedro Reservoir releases during flood control operations. Recent, actual field measurements for flow in the Tuolumne River and for Dry Creek have confirmed general assumptions of the data sets. Also acquired during these field measurements has been flow data for the reach of the lower Tuolumne River below the “Modesto” gage and above the confluence with the San Joaquin River. Based on these measurements, an accretion of 32 cfs has been assumed to occur below the USGS “Modesto” gage. This data set has been added to the “Hydrology” Worksheet, Column M (“Modesto to Confluence”), incorporated into computations of river flow in the “DonPedro” Worksheet, Column CP ("TR at Confluence"), and the projected flow at the confluence is reported in the "Output" Worksheet, Column AR ("Flow-Confluence").

3.5 Miscellaneous Reference Case Data Revisions

As the result of defining a Base Case in the Model (Version 2.0), several data sets required update or revision to facilitate automated comparisons between the Base Case results and alternative scenario results. Changes to Base Case reference values occurred in table values or time series sets for:

"UserInput" Worksheet

- Existing FERC Flow Requirements at La Grange Bridge Gage
- Base Case MID Canal Diversion
- Base Case TID Canal Diversion
- Base Case Supplemental Releases

"WaterBankRel" Worksheet

- Water Bank Supplemental Release (Column T)

"DonPedro" Worksheet

- Base Case Full Diversion Demand (Column I – Column L)

"SFWaterBankRel" Worksheet

- Water Bank Supplemental Release (Column AN)

"DailyCanalsCompute" Worksheet

- DP Water Supply Factor Base Case (Column F)

"DailyCanals" Worksheet

- Base MID Canal Diversion (Column L)
- Base TID Canal Diversion (Column N)

4.0 MODEL EXECUTION

To aid in the execution, completion and recording of an alternative operation scenario, several "macro" tools have been incorporated into the Model.

4.1 Water Bank Supplemental Release Macro

A variation from Base Case Don Pedro Reservoir operation assumptions will normally cause a change in results to the CCSF Water Bank Account Balance. If needing revision from Base Case conditions (e.g., revised supplemental releases to maintain a positive Water Bank Account Balance) supplemental releases can be automatically computed by use of a macro implemented for the "WaterBankRel" Worksheet. This macro will replicate the manual action of the user to provide the day-by-day supplemental release exactly needed to maintain no less than a zero Water Bank Balance.

Figure 4.1-1 illustrates the location of the macro button in the "WaterBankRel" Worksheet. To "run" the macro the user simply "clicks" on the button identified by the label "Supplemental Release". By invoking the macro, values will be automatically placed into Column T to maintain a positive Water Bank Account Balance. The macro will iterate computations up to 24 times to complete the process. It is advised to initialize Column T with zeroes prior to invoking the macro. It is also advised to set the Excel worksheet "Options" to a manual calculation mode prior to invoking the macro.

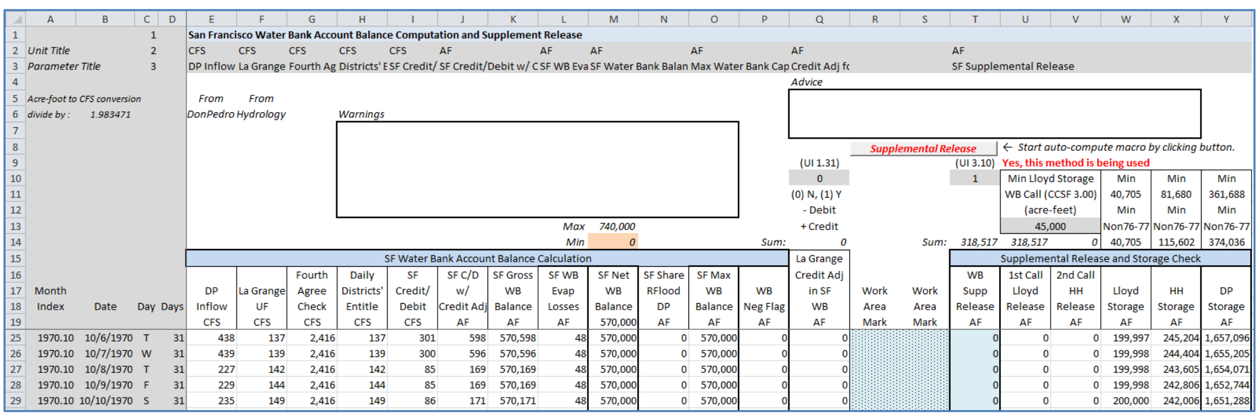


Figure 4.1-1. Water bank supplemental release macro.

4.2 Copy Output Worksheet Macro

The "Output" Worksheet provides an interface between Model computations and summary and analysis tools. It also provides a formatted set of information usable for exchange into an HEC-DSS database file. Results provided in the worksheet are directly linked to the computational and input worksheets of the Model. As such, any change to model assumptions or data which causes a recalculation by the Model will automatically update the values in the worksheet. To preserve or store the results of a particular study a copy of the worksheet should be created with a unique tab name and its contents converted to values. The user can either use Excel keystroke or menu commands to create the worksheet copy, or can invoke a macro. Figure 4.2-1 illustrates the location of the macro button in the “Output” Worksheet. To “run” the macro the user simply “clicks” on the button identified by the label “Copy Sheet / Values”. By invoking the macro, the worksheet will be “copied” as “values” into an adjacent worksheet and given a name identified by Switch UI 1.00 in the “UserInput” Worksheet. The user must save the entire workbook to not lose the new worksheet.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	1	TUOLUMNE	TUOLUMNE	TUOLUMNE	TUOLUMNE	TUOLUMNE	TUOLUMNE	TUOLUMNE	TUOLUMNE	TUOLUMNE	TUOLUMNE	TUOLUMNE	TUOLUMNE
2	2	TUOLUMNEI	TUOLUMNEI	TUOLUMNEI	TUOLUMNEI	TUOLUMNEI	DONPEDRO	DONPEDRO	DONPEDRO	DONPEDRO	DONPEDRO	DONPEDRO	DONPEDRO
3	3	FLOW- LAGRANGE UNIMP	FLOW- HHUNIMP	FLOW- LLOYDUNI MP	FLOW- ELEANORU NIMP	FLOW- UNREGUNI MP	FLOW- TOTINFLO W	FLOW- SUP1INFLO WLL	FLOW- SUP2INFLO WHH	FLOW- INFLOWHH	FLOW- INFLOWLL	FLOW- INFLOWEL	STORAGE
4	4	2	3	4	5	6	7	8	9	10	11	12	13
5	5	1DAY	1DAY	1DAY	1DAY	1DAY	1DAY	1DAY	1DAY	1DAY	1DAY	1DAY	1DAY
6	6	Base_Case 4	Base_Case 4	Base_Case 4	Base_Case 4	Base_Case 4	Base_Case 4	Base_Case 4	Base_Case 4	Base_Case 4	Base_Case 4	Base_Case 4	Base_Case 4
7	*Save study results* 7	1-Oct-70	1-Oct-70	1-Oct-70	1-Oct-70	1-Oct-70	1-Oct-70	1-Oct-70	1-Oct-70	1-Oct-70	1-Oct-70	1-Oct-70	1-Oct-70
8	*as unique* 8	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400
9	*worksheet by* 9	30-Sep-09	30-Sep-09	30-Sep-09	30-Sep-09	30-Sep-09	30-Sep-09	30-Sep-09	30-Sep-09	30-Sep-09	30-Sep-09	30-Sep-09	30-Sep-09
10	*clicking button* 10	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400
11	↓ 11	CFS	CFS	CFS	CFS	CFS	CFS	AF	AF	CFS	CFS	CFS	AF
12	*Copy Sheet / Values*	PER_AVER	PER_AVER	PER_AVER	PER_AVER	PER_AVER	PER_AVER	PER_AVER	PER_AVER	PER_AVER	PER_AVER	PER_AVER	PER_AVER
13	10/1/1970	125	4	10	4	107	427	0	0	90	220	10	1,667,564
14	10/2/1970	130	4	10	4	111	431	0	0	90	220	10	1,665,724
15	10/3/1970	129	4	10	4	111	431	0	0	90	220	10	1,664,041
16	10/4/1970	133	4	10	5	115	435	0	0	90	220	10	1,661,355
17	10/5/1970	135	4	10	5	117	437	0	0	90	220	10	1,659,348
18	10/6/1970	137	4	10	5	118	438	0	0	90	220	10	1,657,096
19	10/7/1970	139	4	10	5	119	439	0	0	90	220	10	1,655,205
20	10/8/1970	142	4	10	5	122	227	0	0	90	5	10	1,654,071
21	10/9/1970	144	4	10	5	124	229	0	0	90	5	10	1,652,744
22	10/10/1970	149	4	11	5	130	235	0	0	90	5	10	1,651,288

Figure 4.2-1. “Output” Worksheet copy values macro.

Don Pedro Project
Project Operations/Water Balance Model
Attachment B – Model Description and User's Guide, Addendum 1
Base Case Description
5-20-2013

1.0 INTRODUCTION

The Turlock Irrigation District ("TID") and Modesto Irrigation District ("MID") (collectively, the "Districts") have developed a computerized Tuolumne River Daily Operations Model ("Model") to assist in the relicensing of the Don Pedro Project ("Project") (FERC Project 2299). The Model is fully described in the User's Guide submitted to FERC as part of the Initial Study Report ("ISR"), January 2013 (Model version 1.01) and supplemented by Addendum 1, May 2013 regarding the currently used version of the Model (Version 2.0).

The Districts have proceeded to develop the "Base Case" which depicts the operation of the Don Pedro Project in accordance with the current FERC license, ACOE flood management guidelines, and the Districts' irrigation and M&I water management practices. Under FERC policy, the Base Case represents the "No Action" alternative for purposes of evaluating future operating scenarios under NEPA. Future scenarios are compared to the Base Case to assess their impacts. For purposes of representing the City and County of San Francisco ("CCSF") operations, the Base Case also includes changes that are permitted under CEQA, approved by CCSF, and authorized (funded), but not yet fully implemented. This document provides a description of the assumptions and results of the modeled simulation of the Base Case as depicted by the Tuolumne River Daily Operations Model.

2.0 BASE CASE MODEL AND ASSUMPTIONS

The Tuolumne River Daily Operations Model (Version 2.0) has been developed to depict the Base Case water management operations of CCSF facilities and the Don Pedro Project, providing a tool to simulate and compare alternative operation scenarios. The Model was constructed within the platform of a Microsoft Excel 2010 workbook, and allows alternative user-specified data and assumptions for numerous components of Don Pedro Project operations in accordance with the Districts Study Plan W&AR-02 as approved by FERC's December 2011 Study Plan Determination. A brief description of Model assumptions and data for the Base Case follows.

2.1 Reservoir Inflows

The Model requires several records of estimated unimpaired flow. These records are (1) unimpaired flow (inflow) at Hetch Hetchy Reservoir, (2) unimpaired flow (inflow) at Lake Lloyd Reservoir and Eleanor Reservoir, (3) flow which depicts the runoff entering Don Pedro Reservoir that is not affected by upstream CCSF facilities, and (4) unimpaired flow at the La Grange USGS gage.

The estimated unimpaired flow of the Tuolumne River has been computed for various locations within the basin for decades. The hydrologic data set developed by the Districts and CCSF was provided in Study Report W&AR-02: Project Operations/Water Balance Model Attachment A, January 2013. Subsequently during March 2013, the Districts and the RPs developed a consensus-based revised data set of unimpaired daily hydrology. The revised data set generally provides a "smoother" daily sequence of flows while maintaining the overall monthly volumes of runoff from the watershed contained in the January 2013 report. The revised data set for the four components of unimpaired flow described above was agreed to during the March 27, 2013 Workshop concerning unimpaired flow hydrology.

Inflow to Don Pedro Reservoir is modeled as two components: (1) a fluctuating unregulated inflow to Don Pedro Reservoir, and (2) the regulated releases (regulated Don Pedro Reservoir inflow) from the CCSF System. The unregulated component of inflow to Don Pedro Reservoir remains the same among all operation simulations. The regulated inflow to Don Pedro is based on the operation of the CCSF System. The latter component of Don Pedro Reservoir inflow may change among operation simulations due to user-controlled parameters. The Base Case operation for the CCSF System is based on current facilities, operational plans and objectives, regulatory requirements in place, and operational plans and facilities that have been approved under CEQA and authorized for funding by CCSF, but not yet fully implemented.

Projected[1] annual inflow to Don Pedro Reservoir under the Base Case is illustrated in Figure 2.1-1, representing the regulated and unregulated components of total inflow to Don Pedro Reservoir. Average annual inflow to Don Pedro Reservoir is projected to be 1,690,100 acre-feet,

[1] The terms "projected" and "modeled" are used as qualifiers of an expressed term or unit of measurement, and are meant to identify a distinction between results that have been simulated by the Model as opposed to values of the historical reported record.

with approximately 683,400 acre-feet occurring as unregulated inflow. Although not completely appropriate for comparison purposes, the historically computed annual total inflow to Don Pedro Reservoir has also been shown in the figure as confirmation that the Model's simulation of inflow is capturing the magnitude and range of historical hydrology. It is known that simulated inflow and historical inflow will differ for several reasons including historical CCSF water diversions and operations that differ from the Base Case operation represented by the Model.

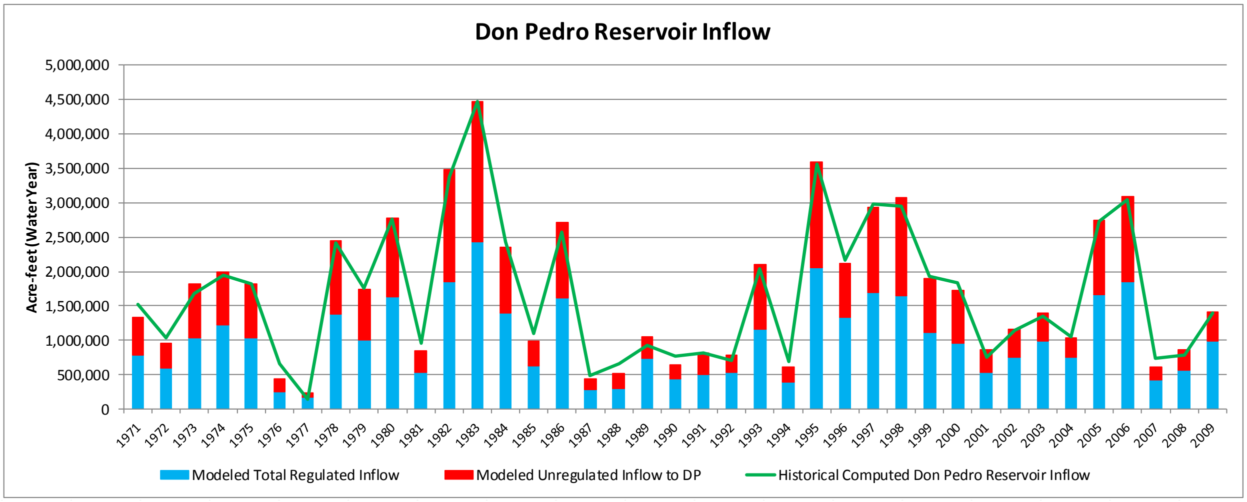


Figure 2.1-1. Projected Don Pedro Reservoir inflow – Base Case.

2.2 Don Pedro Project Minimum Flow Requirement

Table 2.2-1 illustrates the FERC minimum flow requirements for the Base Case. Values for each defined flow period by year type are consistent with the FERC order issued July 31, 1996. Seven water year types are defined based on the San Joaquin Basin 60-20-20 water supply index. The sequence year of the flow schedule begins in April and continues through the following March. The historical actual 60-20-20 index is used for computations. The volume of water interpolated between annual base flow schedules, October attraction flow and the total flow schedule is distributed daily among April (16 days) and May (15 days). The October attraction flow volume is provided equally during two days, beginning October 15. Base flow during October for year types 1, 2 and 6 has been modeled as an average value for the entire month for modeling convenience to fit within the daily parsing logic of the Model.

The daily parsing of April-May outmigration flows is illustrated in Figure 2.2-1. The 31-day pulse flow during April and May occurs beginning April 15 and ends May 15.

The simulated annual minimum flow requirement for the Base Case is illustrated in Figure 2.2-2, and ranges from a minimum of 94,000 acre-feet up to a maximum of 300,900 acre-feet. The 39-year average of the flow requirement is 212,700 acre-feet.

Table 2.2-1. FERC license flow requirements from Don Pedro Project to the lower Tuolumne River.

Year Type	1	2	3	4	5	6	7
Oct 1-15 (CFS)	100	100	150	150	180	200	300
Oct 16-31 (CFS)	150	150	150	150	180	175	300
Total Base (AF)	7,736	7,736	9,223	9,223	11,068	11,504	18,447
Attraction (AF)	0	0	0	0	1,676	1,736	5,950
Total Oct (AF)	7,736	7,736	9,223	9,223	12,744	13,240	24,397
Nov (CFS)	150	150	150	150	180	175	300
AF	8,926	8,926	8,926	8,926	10,711	10,413	17,852
Dec (CFS)	150	150	150	150	180	175	300
AF	9,223	9,223	9,223	9,223	11,068	10,760	18,447
Jan (CFS)	150	150	150	150	180	175	300
AF	9,223	9,223	9,223	9,223	11,068	10,760	18,447
Feb (CFS)	150	150	150	150	180	175	300
AF	8,331	8,331	8,331	8,331	9,997	9,719	16,661
Mar (CFS)	150	150	150	150	180	175	300
AF	9,223	9,223	9,223	9,223	11,068	10,760	18,447
Apr (CFS)	150	150	150	150	180	175	300
AF	8,926	8,926	8,926	8,926	10,711	10,413	17,852
May (CFS)	150	150	150	150	180	175	300
AF	9,223	9,223	9,223	9,223	11,068	10,760	18,447
Migration Flow							
AF	11,091	20,091	32,619	37,060	35,920	60,027	89,882
Jun (CFS)	50	50	50	75	75	75	250
AF	2,975	2,975	2,975	4,463	4,463	4,463	14,876
Jul (CFS)	50	50	50	75	75	75	250
AF	3,074	3,074	3,074	4,612	4,612	4,612	15,372
Aug (CFS)	50	50	50	75	75	75	250
AF	3,074	3,074	3,074	4,612	4,612	4,612	15,372
Sep (CFS)	50	50	50	75	75	75	250
AF	2,975	2,975	2,975	4,463	4,463	4,463	14,876
Total Annual	94,001	103,001	117,017	127,508	142,503	165,004	300,926

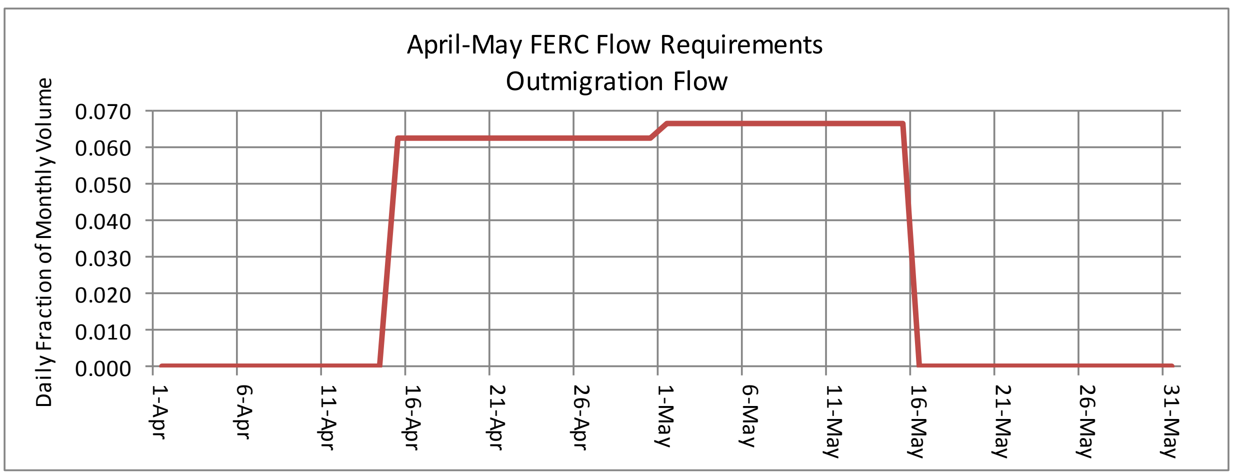


Figure 2.2-1. Daily parsing of April-May outmigration flow – Base Case.

The volumes of outmigration and attraction flows can be shaped within the current FERC requirements. The actual daily distribution of outmigration and attraction flows can in practice be different than patterned in the Base Case. At the time of simulation of any alternative operation and subsequent comparison to the Base Case, it must be recognized that the Base Case daily distribution of these flows is not absolute. For comparison purposes it may be necessary to rerun the Base Case releases with a distribution for the outmigration and attraction flows in the same pattern as provided for the alternative. If required, the Districts would perform and provide such additional versions of the Base Case.

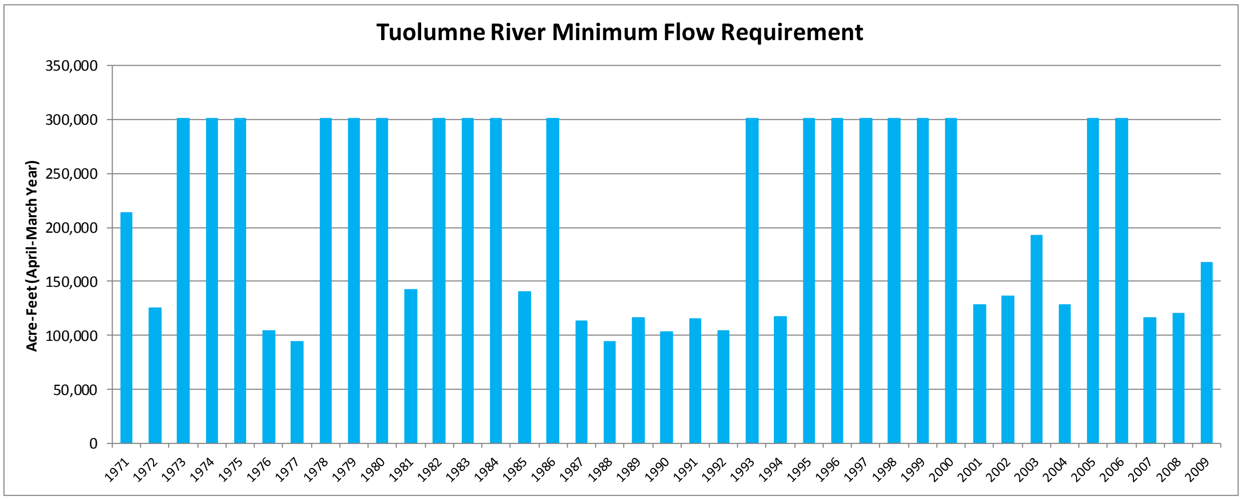


Figure 2.2-2. Minimum annual FERC flow requirement – Base Case.

The annual and monthly volume of the minimum flow requirement used in the Base Case is listed in Table 2.2-2.

Table 2.2-2. Minimum FERC flow requirement in the Base Case Model.

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total	Apr-Mar
1971	24,397	17,852	18,447	18,447	16,661	18,447	66,685	63,515	4,463	4,612	4,612	4,463	262,598	214,003
1972	13,240	10,413	10,760	10,760	9,719	10,760	30,288	29,251	2,975	3,074	3,074	2,975	137,292	125,788
1973	9,223	8,926	9,223	9,223	8,331	9,223	64,241	61,936	14,876	15,372	15,372	14,876	240,823	300,923
1974	24,397	17,852	18,447	18,447	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	300,923	300,923
1975	24,397	17,852	18,447	18,447	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	300,923	300,923
1976	24,397	17,852	18,447	18,447	16,661	18,447	20,153	19,749	2,975	3,074	3,074	2,975	166,250	104,663
1977	7,736	8,926	9,223	9,223	8,331	9,223	14,649	14,589	2,975	3,074	3,074	2,975	94,000	94,000
1978	7,736	8,926	9,223	9,223	8,331	9,223	64,241	61,936	14,876	15,372	15,372	14,876	239,336	300,923
1979	24,397	17,852	18,447	18,447	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	300,923	300,923
1980	24,397	17,852	18,447	18,447	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	300,923	300,923
1981	24,397	17,852	18,447	18,447	16,661	18,447	29,339	28,532	4,463	4,612	4,612	4,463	190,269	142,675
1982	12,744	10,711	11,068	11,068	9,997	11,068	64,241	61,936	14,876	15,372	15,372	14,876	253,329	300,923
1983	24,397	17,852	18,447	18,447	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	300,923	300,923
1984	24,397	17,852	18,447	18,447	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	300,923	300,923
1985	24,397	17,852	18,447	18,447	16,661	18,447	34,656	33,346	4,463	4,612	4,612	4,463	200,400	140,301
1986	9,223	8,926	9,223	9,223	8,331	9,223	64,241	61,936	14,876	15,372	15,372	14,876	240,823	300,923
1987	24,397	17,852	18,447	18,447	16,661	18,447	24,481	23,806	2,975	3,074	3,074	2,975	174,636	113,049
1988	7,736	8,926	9,223	9,223	8,331	9,223	14,649	14,589	2,975	3,074	3,074	2,975	94,000	94,000
1989	7,736	8,926	9,223	9,223	8,331	9,223	25,991	25,222	2,975	3,074	3,074	2,975	115,975	115,975
1990	7,736	8,926	9,223	9,223	8,331	9,223	19,362	19,008	2,975	3,074	3,074	2,975	103,131	103,131
1991	7,736	8,926	9,223	9,223	8,331	9,223	25,870	25,109	2,975	3,074	3,074	2,975	115,740	115,740
1992	7,736	8,926	9,223	9,223	8,331	9,223	19,995	19,601	2,975	3,074	3,074	2,975	104,357	104,357
1993	7,736	8,926	9,223	9,223	8,331	9,223	64,241	61,936	14,876	15,372	15,372	14,876	239,336	300,923
1994	24,397	17,852	18,447	18,447	16,661	18,447	25,903	25,140	2,975	3,074	3,074	2,975	177,392	117,292
1995	9,223	8,926	9,223	9,223	8,331	9,223	64,241	61,936	14,876	15,372	15,372	14,876	240,823	300,923
1996	24,397	17,852	18,447	18,447	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	300,923	300,923
1997	24,397	17,852	18,447	18,447	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	300,923	300,923
1998	24,397	17,852	18,447	18,447	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	300,923	300,923
1999	24,397	17,852	18,447	18,447	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	300,923	300,923
2000	24,397	17,852	18,447	18,447	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	300,923	300,923
2001	24,397	17,852	18,447	18,447	16,661	18,447	28,572	27,642	4,463	4,612	4,612	4,463	188,613	128,513
2002	9,223	8,926	9,223	9,223	8,331	9,223	32,729	31,539	4,463	4,612	4,612	4,463	136,567	136,567
2003	9,223	8,926	9,223	9,223	8,331	9,223	55,641	53,161	4,463	4,612	4,612	4,463	181,101	192,606
2004	13,240	10,413	10,760	10,760	9,719	10,760	28,696	27,758	4,463	4,612	4,612	4,463	140,258	128,753
2005	9,223	8,926	9,223	9,223	8,331	9,223	64,241	61,936	14,876	15,372	15,372	14,876	240,823	300,923
2006	24,397	17,852	18,447	18,447	16,661	18,447	64,241	61,936	14,876	15,372	15,372	14,876	300,923	300,923
2007	24,397	17,852	18,447	18,447	16,661	18,447	26,085	25,310	2,975	3,074	3,074	2,975	177,743	116,156
2008	7,736	8,926	9,223	9,223	8,331	9,223	27,470	26,609	2,975	3,074	3,074	2,975	118,840	120,328
2009	9,223	8,926	9,223	9,223	8,331	9,223	42,919	41,235	4,463	4,612	4,612	4,463	156,452	167,957
Average	16,957	13,625	14,079	14,079	12,717	14,079	46,531	44,910	9,078	9,381	9,381	9,078	213,897	212,651
Min	7,736	8,926	9,223	9,223	8,331	9,223	14,649	14,589	2,975	3,074	3,074	2,975	94,000	94,000
Max	24,397	17,852	18,447	18,447	16,661	18,447	66,685	63,515	14,876	15,372	15,372	14,876	300,923	300,923

2.3 Districts' Canal Demands

The computation of canal demands incorporates the projected demand of applied water ("PDAW") and the canal operation and maintenance practices of the Districts. Canal operation assumptions include the operation of the Districts' irrigation system reservoirs - Turlock Lake and Modesto Reservoir, seepage and losses, groundwater pumping and canal operational spills. Table 2.3-1 lists the Base Case assumptions for the Districts' canal operations. Also described in the data set are monthly turnout delivery factors, unique to each District that represent a modeling mechanism to adjust the PDAW for irrigation practices that are not included in the estimation of the consumptive use of applied water, such as irrigation that provides for groundwater recharge. Refer to the Model's Users' Guide for additional information regarding the canal demand components.

Table 2.3-1. Districts' canal demand components in the Base Case.

Modesto Irrigation District

Month	Turnout Delivery Factor	Private GW Pumping	Canal Operational Spills Critical	Canal Operational Spills Non-crit	System Losses below Modesto Res	Intercepted Flows	MID GW Pumping	Modesto Res and Upper Canal Losses/Div	Municipal Delivery from Modesto Res	Modesto Res Target Storage	Modesto Res Target Storage Change
	%	TAF	TAF	TAF	TAF	TAF	TAF	TAF	TAF	TAF	TAF
January	35.0	0.0	2.0	2.0	0.1	0.0	0.0	0.0	2.3	17.0	2.0
February	35.0	0.0	2.0	2.0	0.1	0.0	0.0	0.0	2.3	18.0	1.0
March	65.0	1.0	1.0	3.0	0.6	0.9	1.0	2.0	2.7	18.0	0.0
April	70.0	2.0	3.0	6.0	0.6	0.9	2.3	2.9	2.7	19.0	1.0
May	85.0	3.0	4.0	6.5	0.6	1.2	2.3	3.9	3.0	20.0	1.0
June	85.0	4.0	3.5	6.5	0.6	1.0	2.3	4.3	3.2	20.0	0.0
July	77.5	4.0	3.5	6.5	0.6	1.0	2.6	4.9	3.3	21.0	1.0
August	70.0	4.0	4.9	7.0	0.6	1.4	2.4	4.9	3.3	22.0	1.0
September	65.0	2.0	5.0	7.0	0.6	1.2	2.3	4.2	3.3	20.0	-2.0
October	40.0	1.0	2.8	6.9	0.6	0.9	2.1	2.0	3.2	17.0	-3.0
November	30.0	0.0	2.0	2.0	0.1	0.0	0.0	2.0	2.7	15.0	-2.0
December	35.0	0.0	2.0	2.0	0.1	0.0	0.0	0.0	2.5	15.0	0.0
Total		21.0	35.7	57.4	5.4	8.5	17.3	31.1	34.5		

MID March TO Factor

Factor Break Pnt (PDAW-TAF)	Factor %
0.0	65.0
9.9	65.0
13.2	65.0
20.0	65.0
9999.0	65.0

TID March TO Factor

Factor Break Pnt (PDAW-TAF)	Factor %
0.0	65.0
19.8	65.0
27.5	65.0
40.0	65.0
9999.0	65.0

MID April TO Factor

Factor Break Pnt (PDAW-TAF)	Factor %
0.0	70.0
10.0	70.0
17.5	70.0
25.0	80.0
9999.0	80.0

TID April TO Factor

Factor Break Pnt (PDAW-TAF)	Factor %
0.0	57.5
20.0	57.5
35.0	70.0
50.0	80.0
9999.0	80.0

Turlock Irrigation District

Month	Turnout Delivery Factor	Private GW Pumping	Canal Operational Spills Critical	Canal Operational Spills Non-crit	System Losses below Turlock Lk	Intercepted and Other Flows	TID GW Pumping	Turlock Lk and Upper Canal Losses	Other Delivery from Turlock Lk	Turlock Lk Target Storage	Turlock Lk Target Storage Change
	%	TAF	TAF	TAF	TAF	TAF	TAF	TAF	TAF	TAF	TAF
January	30.0	0.0	2.0	2.0	0.8	0.0	0.0	1.0	0.0	18.0	5.0
February	30.0	0.0	2.0	2.0	0.8	0.0	0.0	1.0	0.0	25.0	7.0
March	65.0	1.2	3.0	3.0	4.5	0.5	4.1	1.0	0.0	30.0	5.0
April	57.5	2.4	5.1	6.3	4.5	1.0	8.0	6.6	0.0	30.0	0.0
May	85.0	3.6	4.6	6.7	4.5	1.3	10.3	7.7	0.0	32.0	2.0
June	92.5	5.2	4.2	6.7	4.5	1.3	12.4	8.2	0.0	32.0	0.0
July	75.0	6.4	4.2	6.7	4.5	1.5	14.6	8.7	0.0	32.0	0.0
August	65.0	6.2	4.0	7.3	4.5	1.5	13.3	9.0	0.0	30.0	-2.0
September	67.5	3.9	3.2	7.3	4.5	1.0	9.1	5.0	0.0	27.0	-3.0
October	40.0	2.4	2.3	7.3	4.5	0.5	5.3	2.0	0.0	13.0	-14.0
November	30.0	0.0	2.0	2.0	0.8	0.0	0.0	1.0	0.0	13.0	0.0
December	30.0	0.0	2.0	2.0	0.8	0.0	0.0	1.0	0.0	13.0	0.0
Total		31.3	38.6	59.3	39.2	8.5	77.1	52.2	0.0		

2.4 Don Pedro Water Supply Factor

The premise of the Don Pedro water supply factor ("WSF") factor is to simulate the Districts' historical practice of reducing the amount of water diverted to the canals during years when lack of carryover storage at Don Pedro Reservoir becomes a concern. In practice, any such reduction is managed on a real-time basis by the Districts using the best information available at the time. The modeling mechanism used to reduce canal diversions is a factor applied to the PDAW of the canal demand. This mechanism results in a reduction to the amount of water delivered or "turned out" to the customers. Table 2.4-1 illustrates the Base Case WSF components in the Model. As an illustration of the use of the WSF in the model, if the forecast of the ending-March Don Pedro Reservoir storage plus projected inflow for April through July is greater than 1,090 TAF and less than 1,700 TAF, the PDAW for the year would be reduced by a factor of 0.875. If the forecast was greater than 1,700 TAF, there would be no reduction to the projected PDAW for the year.

Table 2.4-1. Don Pedro water supply forecast factors – Base Case.

Don Pedro Water Supply Factor		
NDP Stor + Infl Index	WS Factor	*(W)ater (S)upply (F)actor is established by forecasting upcoming water supply, based on antecedent storage and anticipated inflow to Don Pedro Reservoir.*
TAF	%	*Forecast begins for February:*
		EO-January storage + Feb-July UF - Feb-July US adj - Feb-Mar minimum river
0	0.750	*March Forecast:*
1090	0.750	*EO-February storage + Mar-July UF - Mar-July US adj - Mar minimum river*
1090	0.875	*April Forecast: (final)*
1700	0.875	*EO-March storage + Apr-July UF - Apr-July US adj*
1700	1.000	
2300	1.000	*Factor Table is April Forecast based*
9999	1.000	*February and March Forecasts act as adjustments to estimate April 1 state.*

2.5 Don Pedro Reservoir Storage Guidance

The Model allows the user to establish the preferred storage target. The Base Case preferred storage target is the Army Corps of Engineers ("ACOE") rain flood reservation objective, except after July 1, when there is no required reservation space. The preferred storage target reflects a drawdown to evacuate storage during the summer in late and wet runoff years. The preferred target storage is again equal to the ACOE objective on October 7. Figure 2.5-1 illustrates the reservoir storage target used in the Model for the Base Case.

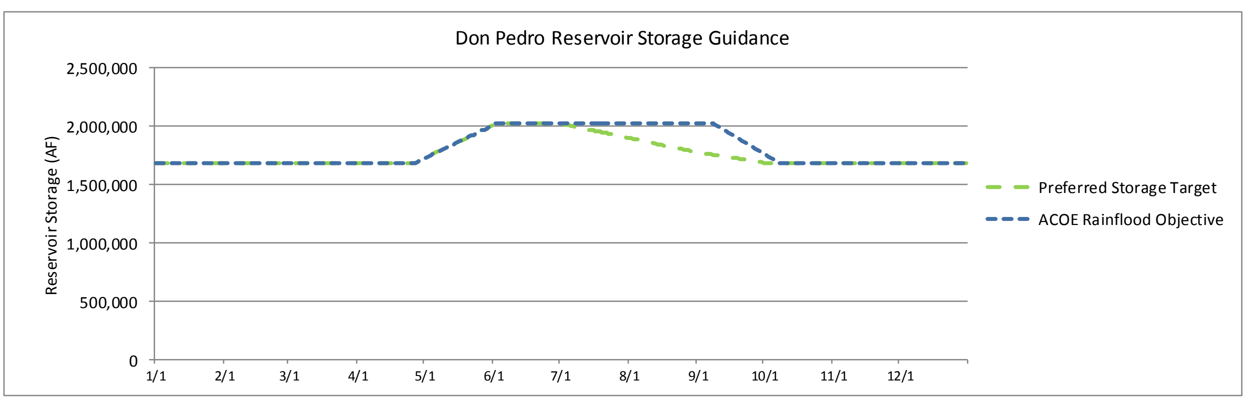


Figure 2.5-1. Don Pedro Reservoir storage guidance targets – Base Case.

2.6 CCSF Water Diversions

The Base Case operation for the CCSF system is based on the existing facilities, operational plans and objectives, and the regulatory requirements in place. The Base Case also includes facilities and operations previously approved under CEQA and authorized for funding by CCSF, but not yet fully implemented. The projected diversions of CCSF to the San Francisco Bay Area from the San Joaquin Pipeline ("SJPL") are imported to the Model from output of CCSF's Hetch Hetchy/Local Simulation Model ("HHLSM") as provided by CCSF to the Districts. Figure 2.6-1 illustrates the annual volume of diversions for the Base Case. Based on an annual average system-wide demand of 238 MGD (266,600 acre-feet), annual average diversions from the Tuolumne River are projected to be 231,200 acre-feet. These diversions integrate with other CCSF water supply resources and fully meet CCSF system-wide demands except during 1977, 1988, 1989, 1990, 1991 and 1992 when a 10 percent reduction in deliveries is needed.

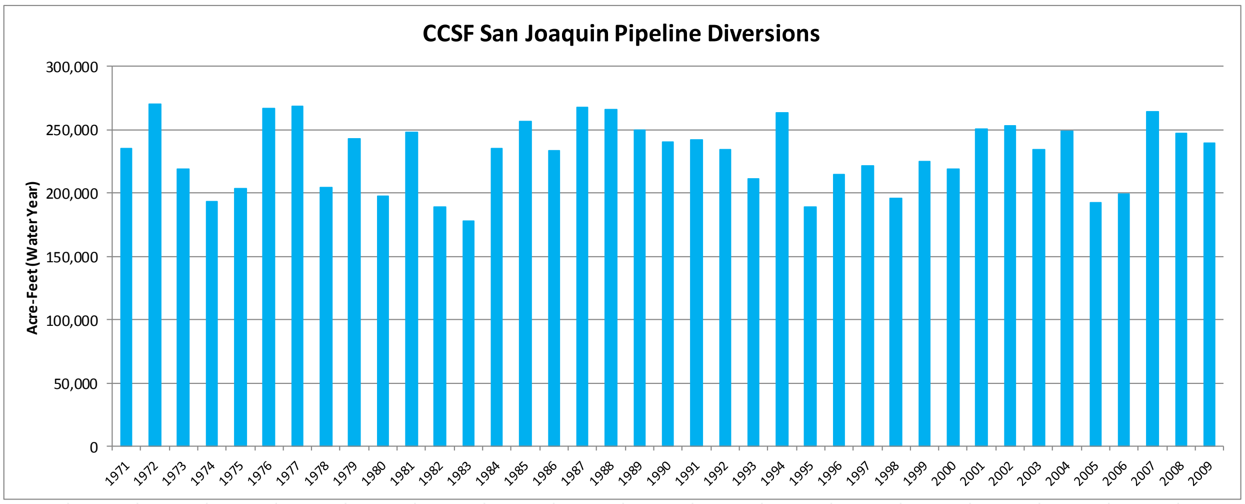


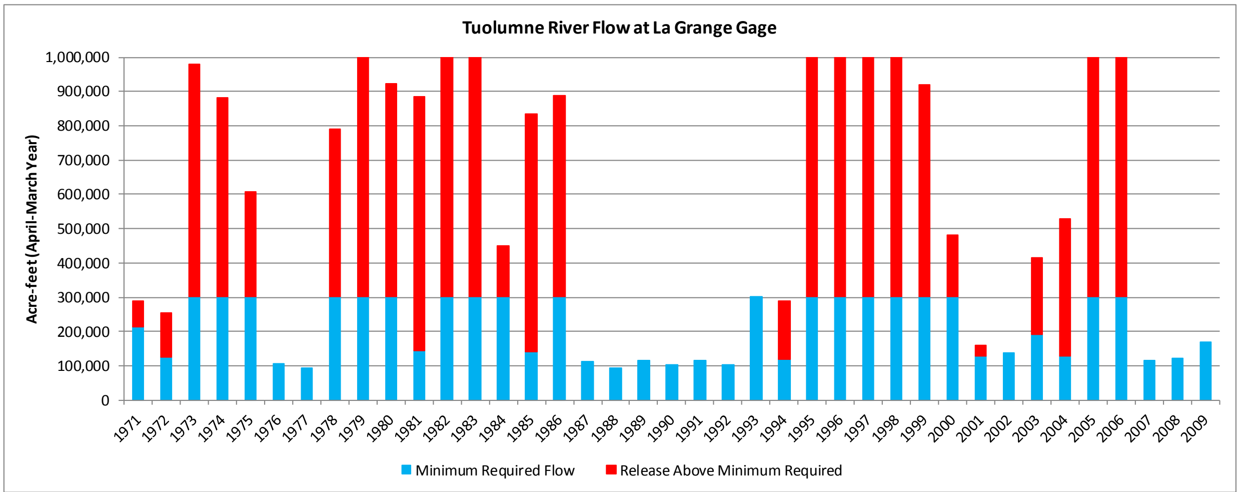
Figure 2.6-1. San Joaquin Pipeline diversions – Base Case.

3.0 REPRESENTATIVE BASE CASE RESULTS

Incorporation of the above described depictions of hydrology and demands, and the performance of operations according to operational parameters established in the Model, result in a 39-year simulation of Don Pedro Project and CCSF Tuolumne River operations under the Base Case.

3.1 Tuolumne River Flow

Flow delivered from Don Pedro to the Tuolumne River at the La Grange gage will result from meeting the FERC license minimum flow requirements and releasing flows for flood control operations and discretionary drawdown of Don Pedro Reservoir. The projected annual flow of the river at the La Grange gage under the Base Case is illustrated in Figure 3.1-1. Seasonal flow volume in the Tuolumne River is illustrated in Table 3.1-1 which provides average flow by month within a ranking of all years according to a preliminary year type classification.[2]



(Flows exceeding scale of graph: 1979 – 1,396,600 acre-feet; 1982 – 3,052,100 acre-feet; 1983 – 3,322,600 acre-feet; 1995 – 4,444,700 acre-feet; 1996 – 4,309,800 acre-feet; 1997 – 1,045,800 acre-feet; 1988 – 2,044,700 acre-feet; 2005 – 1,865,100 acre-feet; 2006 – 1,556,100 acre-feet.)

Figure 3.1-1. Projected flow at La Grange gage – Base Case.

Table 3.1-1. Projected seasonal flow at La Grange gage (acre-feet) – Base Case.

Prelim Year Type		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
W	1	23,912	30,156	51,946	173,266	227,151	304,806	297,533	255,305	300,263	176,799	70,473	38,242	1,949,853
AN	2	27,345	36,232	78,097	98,325	157,042	183,876	155,840	79,345	102,401	27,829	15,372	16,202	977,906
N	3	17,720	12,751	14,214	26,235	69,340	108,279	116,684	55,305	39,080	11,543	9,223	8,926	489,300
BN	4	14,069	11,901	12,298	12,327	26,022	39,636	42,413	28,173	3,613	3,733	3,733	3,613	201,530
D	5	22,274	15,620	16,141	16,141	14,579	24,563	30,035	24,497	3,347	3,459	3,459	3,347	177,461
C	6	15,723	12,586	14,370	12,917	11,663	12,913	18,786	18,467	2,975	3,074	3,074	2,975	129,523
All		20,344	20,947	33,591	69,787	102,511	137,167	134,311	97,533	101,132	53,105	23,509	15,274	809,211

[2] The preliminary relicensing year type is based on a rank-ordering of the water-year runoff for the years 1921-2011. Each water year type W, AN, N, and BN represent 20% of the years of ranking. D and C year types each represent 10% of the years.

Total average daily flow projected for the Tuolumne River at La Grange gage by month is listed in Table 3.1-2.

Table 3.1-2. Projected average daily flow at La Grange gage (cfs) – Base Case.

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1971	397	300	418	960	1,848	1,511	2,253	1,033	75	75	75	75
1972	215	175	175	175	169	291	509	476	50	50	50	50
1973	150	150	150	150	150	2,241	2,659	1,068	2,204	482	250	250
1974	397	300	849	2,210	2,535	3,140	3,720	1,088	2,192	499	250	250
1975	397	300	300	300	2,198	3,247	2,697	1,242	2,748	673	250	384
1976	504	308	419	300	290	300	339	321	50	50	50	50
1977	126	150	150	150	150	150	246	237	50	50	50	50
1978	126	150	150	150	150	150	1,080	1,515	250	250	300	1,146
1979	624	300	300	1,127	2,729	3,584	2,795	1,036	1,248	282	250	250
1980	397	300	300	4,249	6,150	6,001	3,116	2,666	2,136	3,286	996	474
1981	530	300	300	300	300	848	820	464	75	75	75	75
1982	207	180	180	963	5,178	6,633	7,137	6,151	5,979	2,915	1,075	1,155
1983	1,476	3,088	3,832	3,327	6,964	7,772	7,686	8,226	7,597	5,959	3,708	1,572
1984	739	2,303	5,672	5,450	2,962	2,972	2,044	1,007	250	250	250	250
1985	397	300	300	300	825	1,312	1,269	542	75	75	75	75
1986	150	150	150	150	2,819	8,385	5,442	3,177	3,095	661	250	250
1987	397	300	300	300	300	300	411	387	50	50	50	50
1988	126	150	150	150	145	150	246	237	50	50	50	50
1989	126	150	150	150	150	150	437	410	50	50	50	50
1990	126	150	150	150	150	150	325	309	50	50	50	50
1991	126	150	150	150	150	150	435	408	50	50	50	50
1992	126	150	150	150	145	150	336	319	50	50	50	50
1993	126	150	150	150	150	150	1,080	1,007	250	250	250	250
1994	397	300	300	300	300	300	435	409	50	50	50	50
1995	150	150	150	150	150	2,960	5,800	6,622	7,870	5,933	2,927	584
1996	470	300	300	300	4,334	5,068	3,672	2,391	3,239	653	250	250
1997	397	300	2,826	13,576	7,805	3,202	1,997	1,007	677	258	250	250
1998	397	300	300	970	6,323	4,995	5,593	3,996	7,134	5,207	1,455	478
1999	540	300	350	1,184	4,527	3,365	2,501	1,007	1,646	390	250	250
2000	397	300	300	300	3,440	4,540	3,202	1,111	845	250	250	250
2001	397	300	300	300	300	497	984	487	75	75	75	75
2002	150	150	150	150	150	150	550	513	75	75	75	75
2003	150	150	150	150	150	150	1,546	865	75	75	75	75
2004	215	175	175	178	1,477	1,962	894	451	75	75	75	75
2005	150	150	150	150	1,907	4,672	4,340	2,600	7,818	2,100	250	268
2006	440	300	410	4,494	3,235	4,801	7,812	5,563	7,905	2,185	250	250
2007	397	300	300	300	300	300	438	412	50	50	50	50
2008	126	150	150	150	145	150	462	433	50	50	50	50
2009	150	150	150	150	150	150	721	671	75	75	75	75
Average	331	352	546	1,135	1,828	2,231	2,257	1,586	1,700	864	382	257
Min	126	150	150	150	145	150	246	237	50	50	50	50
Max	1,476	3,088	5,672	13,576	7,805	8,385	7,812	8,226	7,905	5,959	3,708	1,572

3.2 Districts' Canal Diversions

Projected Base Case combined diversions of the Districts are illustrated in Figure 3.2-1. The average annual Base Case diversion is 848,600 acre-feet, ranging from a maximum of 966,900 acre-feet to a minimum of 648,300 acre-feet which includes a reduction to deliveries due to a limited water supply from Don Pedro Reservoir. Also shown in Figure 3.2-1 is the full combined diversion demand of the Districts. Reductions from full diversion demand are projected to occur when the projected combined diversions are less than the full diversion demand, during 1977, and 1988 through 1992.

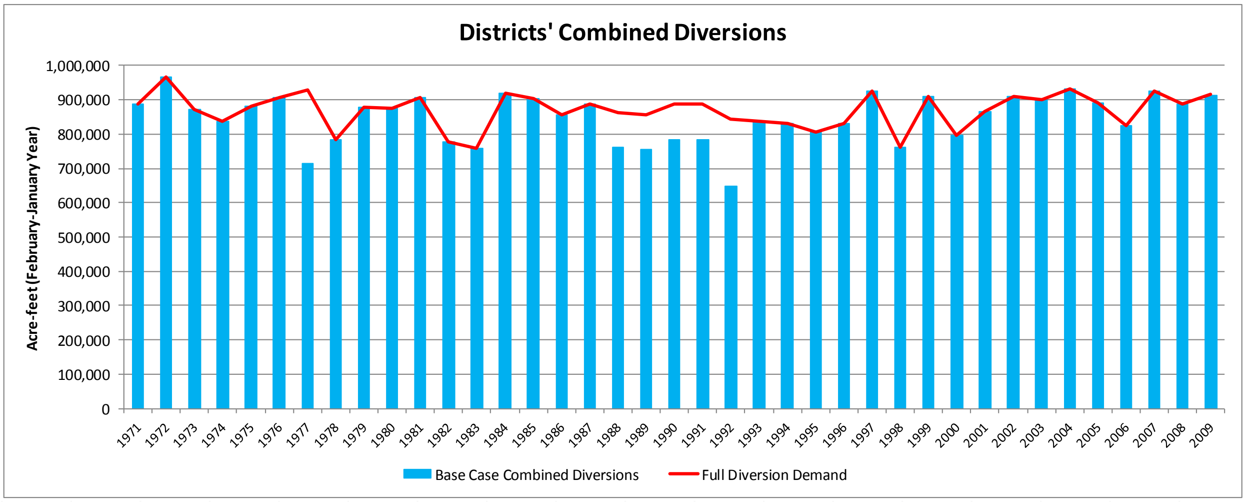


Figure 3.2-1. Districts' combined diversions and demand – Base Case.

3.3 Don Pedro Reservoir

Don Pedro Reservoir storage will fluctuate throughout the year and will result in carryover storage that varies from year to year. Figure 3.3-1 illustrates projected end-of-September storage for the Base Case.

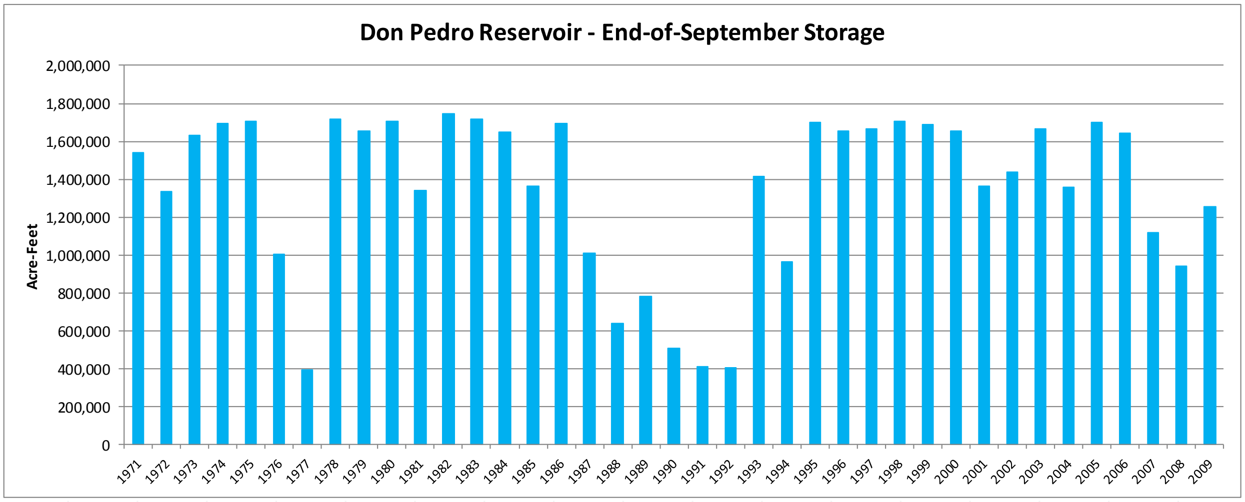
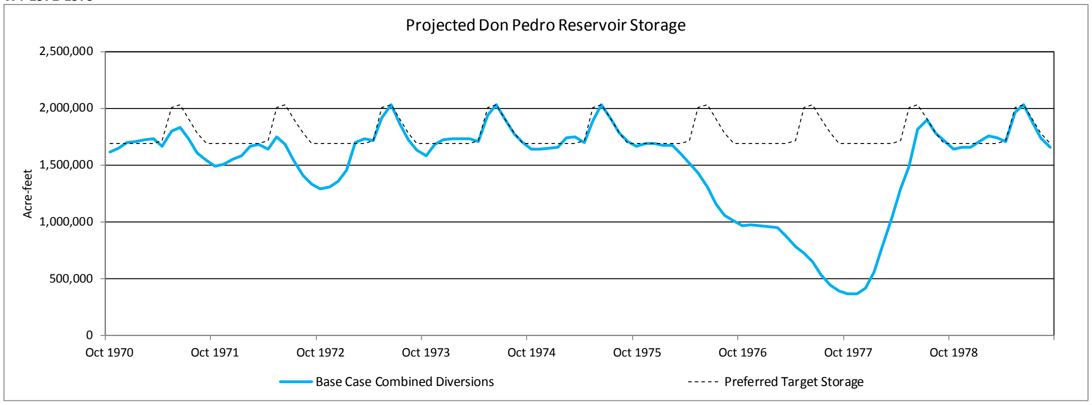


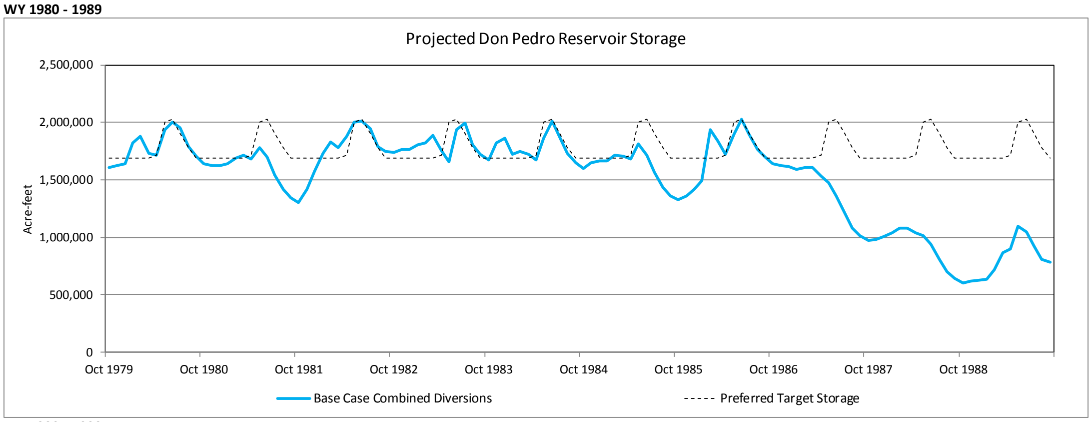
Figure 3.3-1. Don Pedro Reservoir end-of-September storage – Base Case.

The monthly variation of Don Pedro Reservoir storage is cyclic throughout the year in response to inflow, water release demands and preferred storage objectives. Figure 3.3-2 illustrates the projected end-of-month storage of Don Pedro Reservoir of the 39-year simulation period. Severe or prolonged droughts and their effect on storage are noteable during 1976-1977 and 1987-1992.

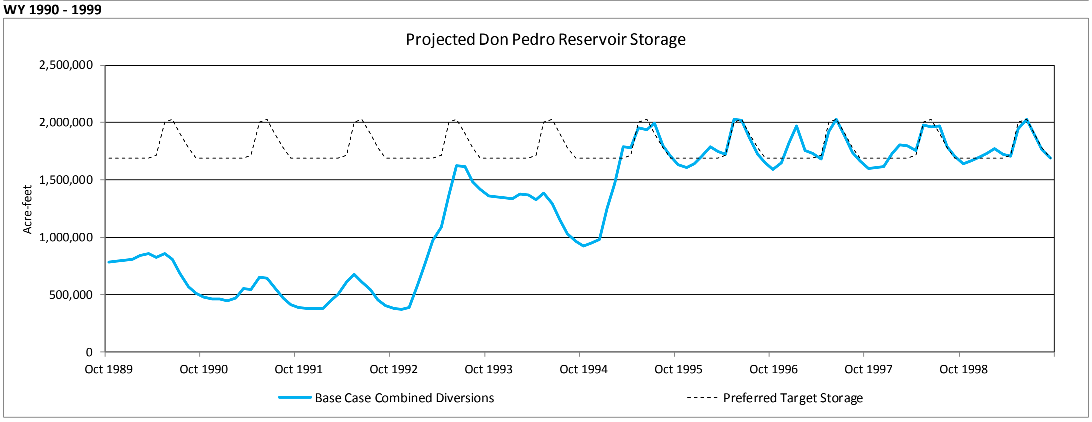
WY 1971-1979



WY 1980 - 1989



WY 1990 - 1999



WY 2000 - 2009

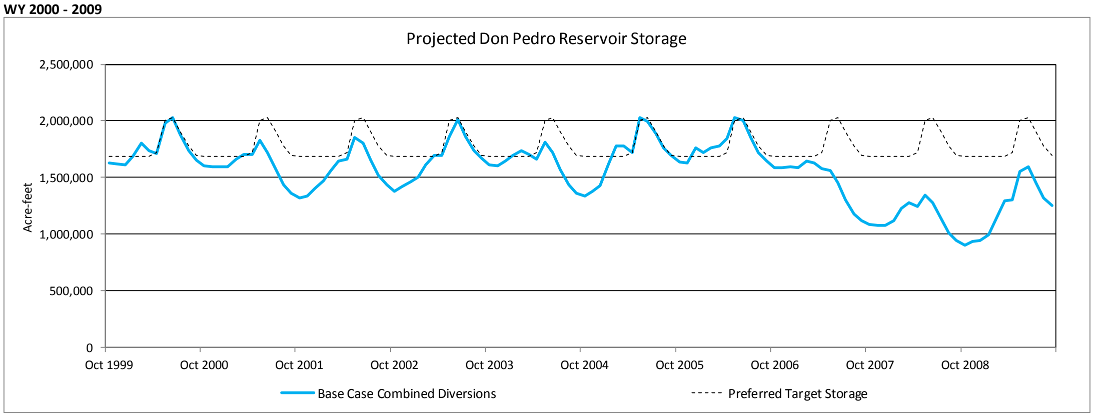


Figure 3.3-2. Don Pedro Reservoir storage – Base Case.

3.4 Don Pedro Project Generation

Hydroelectric generation is incidental to water operations, and will vary from day to day, month to month and year to year as Don Pedro Project reservoir and release operations react to hydrology and water demands. Figure 3.4-1 illustrates the projected annual power generation of the Don Pedro Project for the Base Case. Annual generation is projected to vary from 1,393,900 MWh to 197,500 MWh, with an average of 607,000 MWh.

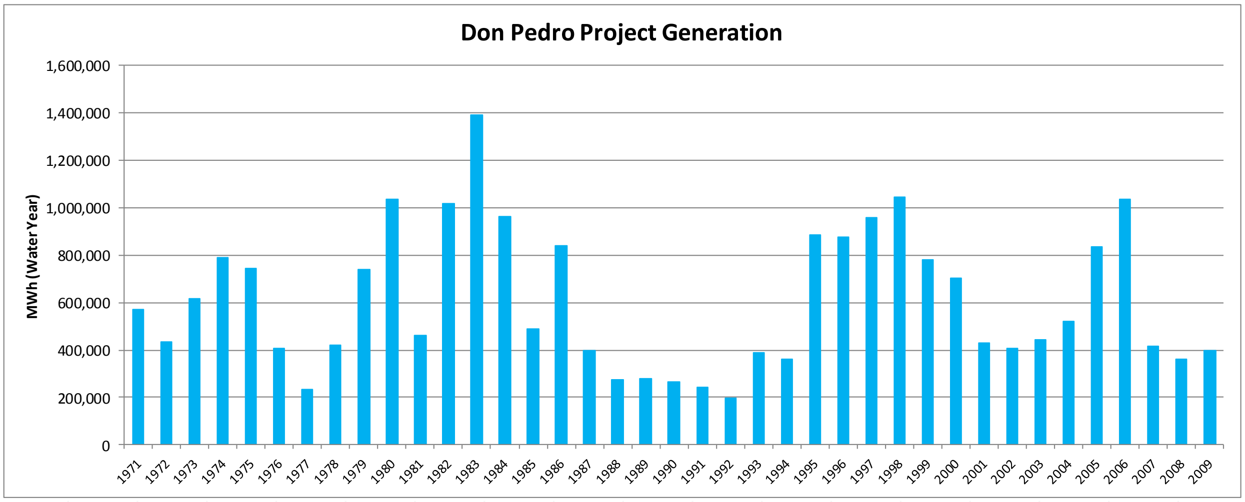


Figure 3.4-2. Don Pedro Project generation – Base Case.

Seasonal Don Pedro Project generation is illustrated in Table 3.4-1 which provides average generation by month within a ranking of all years according to the preliminary year type classification.

Table 3.4-1. Don Pedro Project generation (MWh) – Base Case.

Prelim Year Type		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
W	1	23,510	13,142	22,421	50,518	80,511	122,925	123,739	129,550	128,771	121,263	88,723	42,293	947,367
AN	2	25,294	15,271	29,800	38,956	69,357	101,667	101,180	85,371	103,097	84,287	65,379	37,104	756,762
N	3	22,292	5,933	5,711	12,638	31,376	67,364	86,974	74,381	75,932	76,468	62,650	33,241	554,960
BN	4	18,144	6,427	4,812	6,869	13,551	37,260	55,858	60,801	52,053	62,810	51,153	24,200	393,939
D	5	22,587	7,767	6,195	8,298	9,379	33,428	49,786	51,231	52,237	61,674	49,999	23,948	376,530
C	6	17,735	7,136	5,405	6,885	8,129	26,344	37,790	45,604	41,573	49,402	38,154	18,276	302,435
All		21,768	9,649	13,551	24,182	41,382	72,745	82,882	81,716	82,538	81,718	63,254	31,662	607,047

3.5 CCSF Tuolumne River Storage and Water Supply

The Base Case CCSF water supply of the Tuolumne River can be expressed by the amount of diversions from the basin through the San Joaquin Pipeline (illustrated in Section 2 above), water in CCSF Tuolumne River reservoirs and the credit balance of the CCSF Don Pedro Water Bank Account. Annual CCSF water delivery decisions are guided by the projection of total CCSF system storage for July 1 of a year. Included in the metric is CCSF Tuolumne River reservoir storage and Water Bank Account balance. Figure 3.5-1 illustrates the projected July 1 metric of CCSF Tuolumne River reservoir storage and Water Bank Account balance.

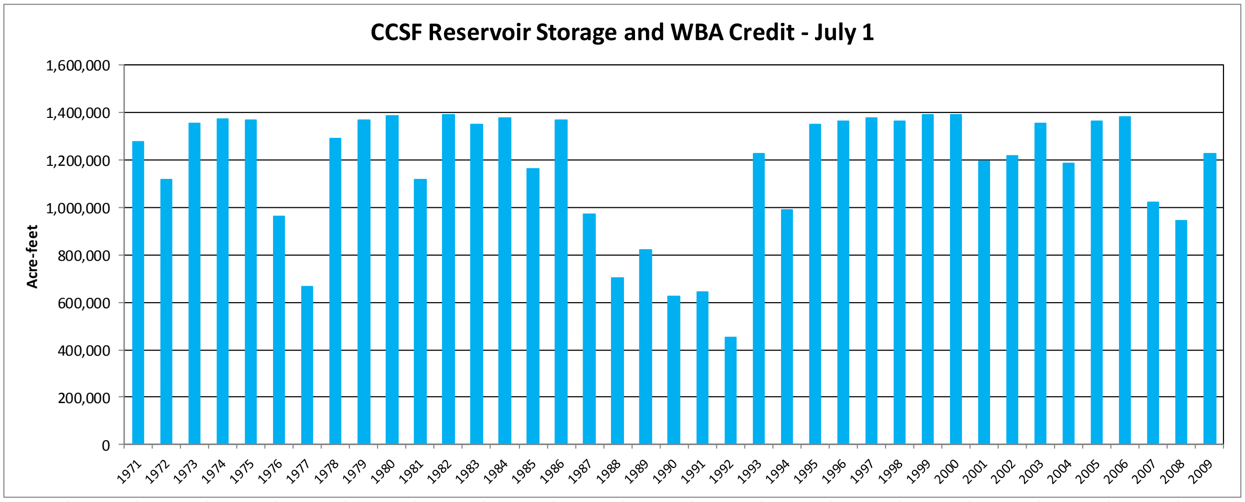


Figure 3.5-1. CCSF Tuolumne River storage and Water Bank Account credit – Base Case.

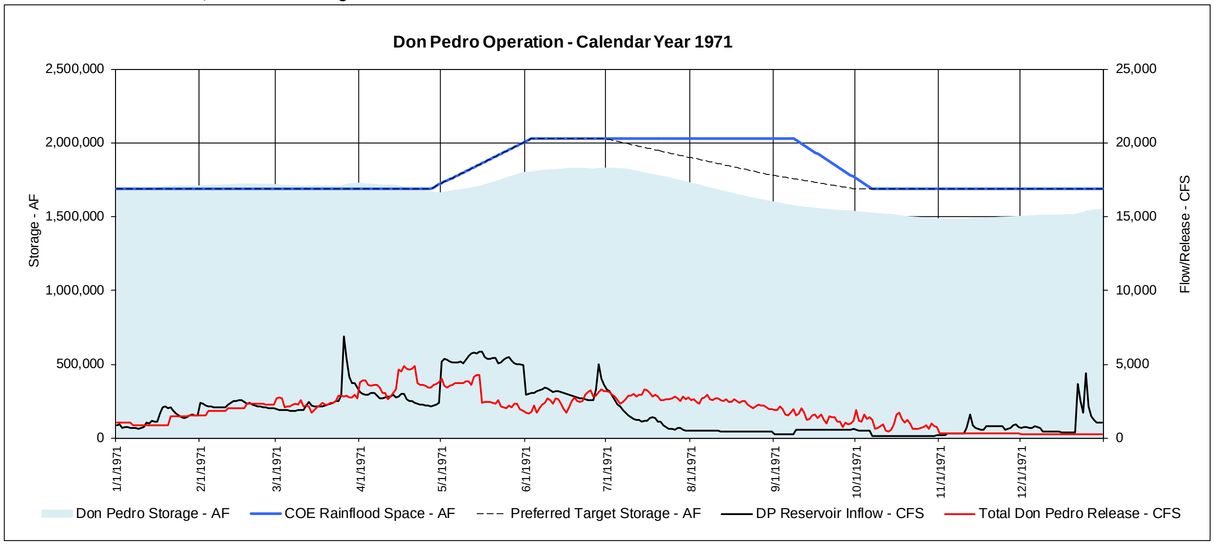
4.0 ANNUAL DON PEDRO PROJECT OPERATIONS

Annual hydrographs for the projected operation of Don Pedro Reservoir and the lower Tuolumne River for the Base Case follow. Three hydrographs are presented for each year of the 39-year simulation. The upper hydrograph illustrates the simulated daily storage of Don Pedro Reservoir (light blue area graph) for an entire calendar year. Plotted for reference is the modeled reservoir target storage during the year (solid blue and black dashed lines). These two components are plotted to the left axis scale (acre-feet), and are also shown in the other two hydrographs. Also illustrated in the upper hydrograph are the inflow to Don Pedro Reservoir (solid black line) and total Don Pedro release (solid red line). Flow values are plotted to the right axis scale (CFS).

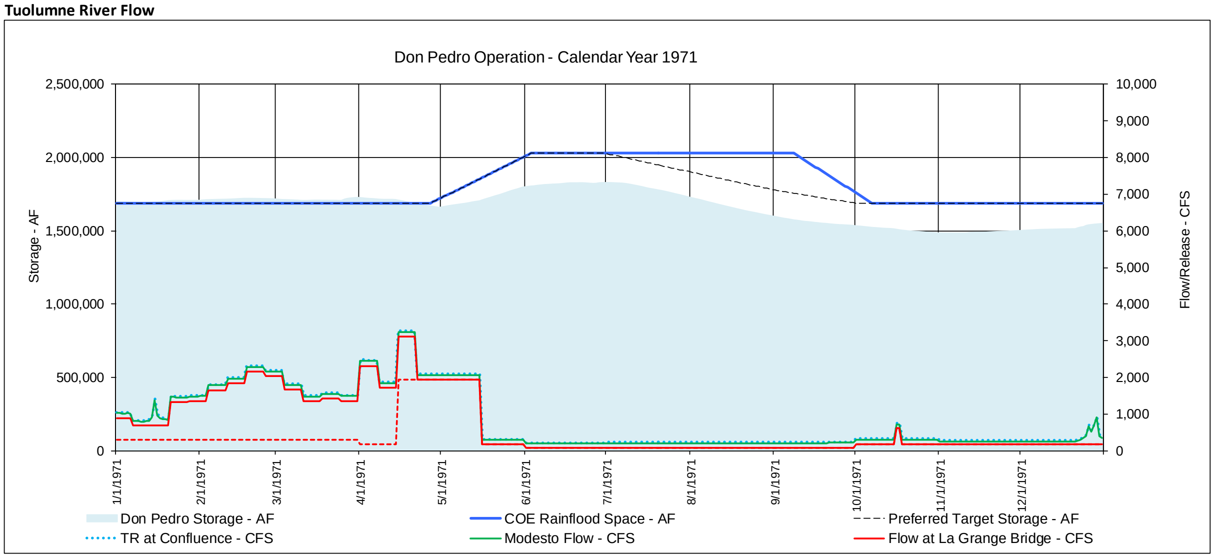
The middle hydrograph illustrates the simulated daily flows at three locations in the lower Tuolumne River: (1) flow at the La Grange Bridge gage (solid red line), (2) flow at the Modesto gage (solid green line), and (3) flow at the Tuolumne River confluence with the San Joaquin River (dotted light blue line). Flow projected to occur at the La Grange Bridge gage is the result of flow being released from Don Pedro Reservoir and depletion by diversions to the Districts' canals. Flow projected to occur at the Modesto gage is the result of adding those flows to lower Tuolumne River accretions occurring above the Modesto gage location and flows from Dry Creek. The accretions and Dry Creek flow data sets are synthesized, and are described in the ISR, January 2013. Flows projected for the Tuolumne River confluence are the sum of flows occurring at the Modesto gage plus an estimated accretion between the Modesto gage and the confluence. This accretion is estimated to be a constant 32 cfs. Also shown in the hydrograph is the Base Case Tuolumne River -daily flow requirement, modeled at the La Grange Bridge gage location.

The lower hydrograph illustrates the simulated daily diversions of the Districts to their respective canals. The projected Modesto Irrigation District diversion is shown by the solid red line and the projected Turlock Irrigation District diversion is shown by the solid blue line.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

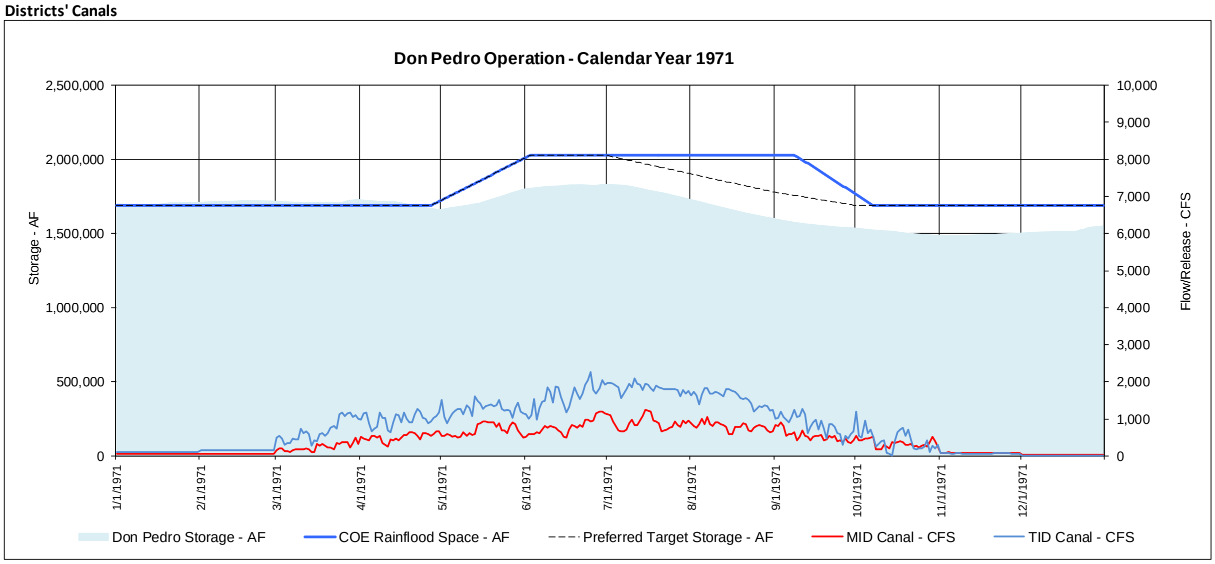
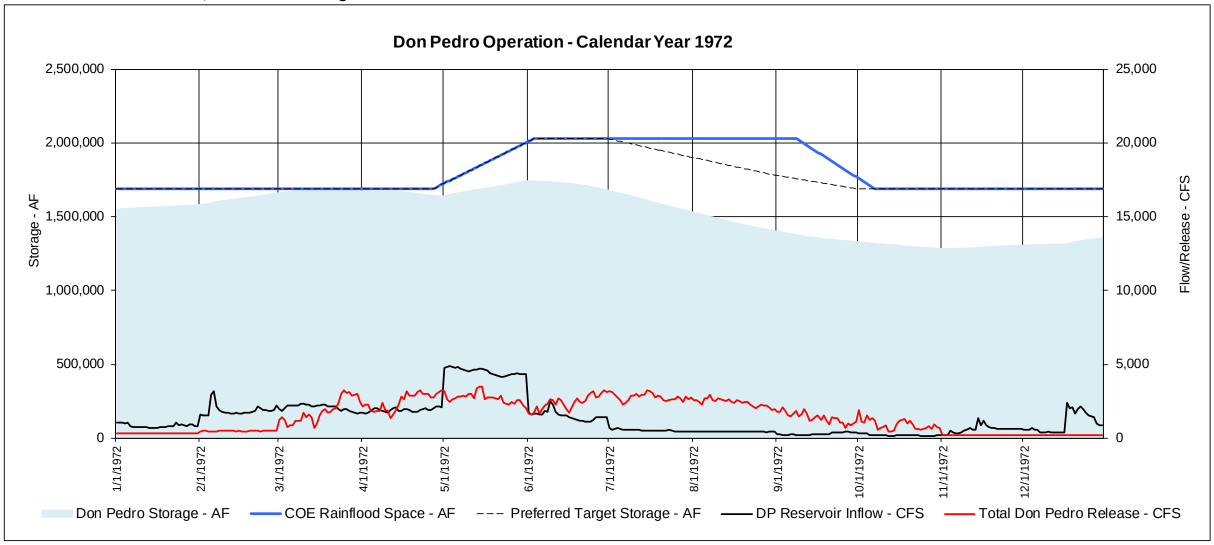
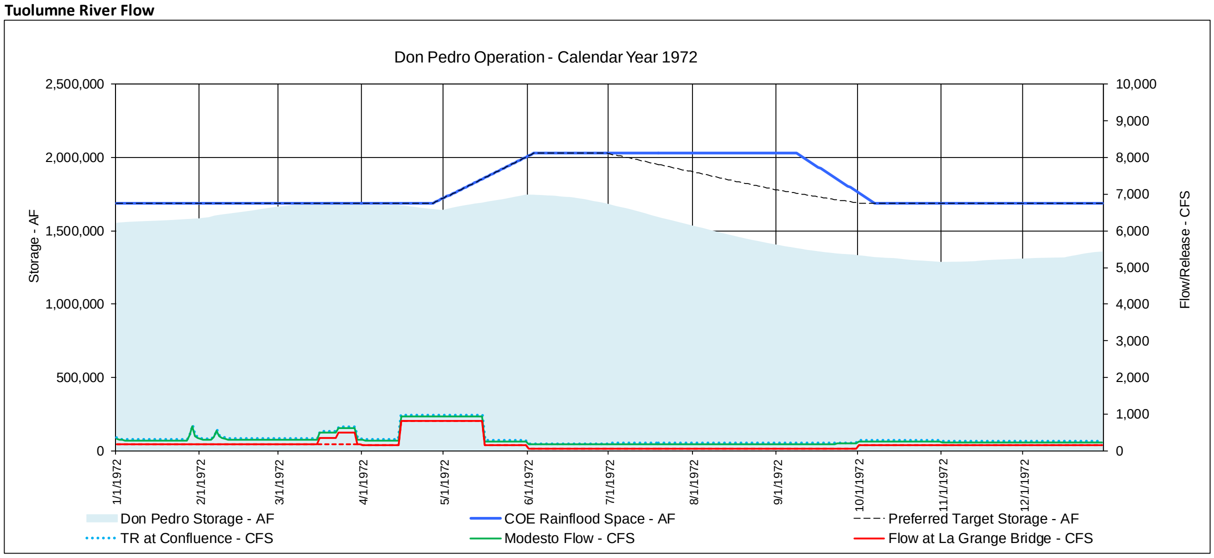


Figure 4-1. Don Pedro operations 1971 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

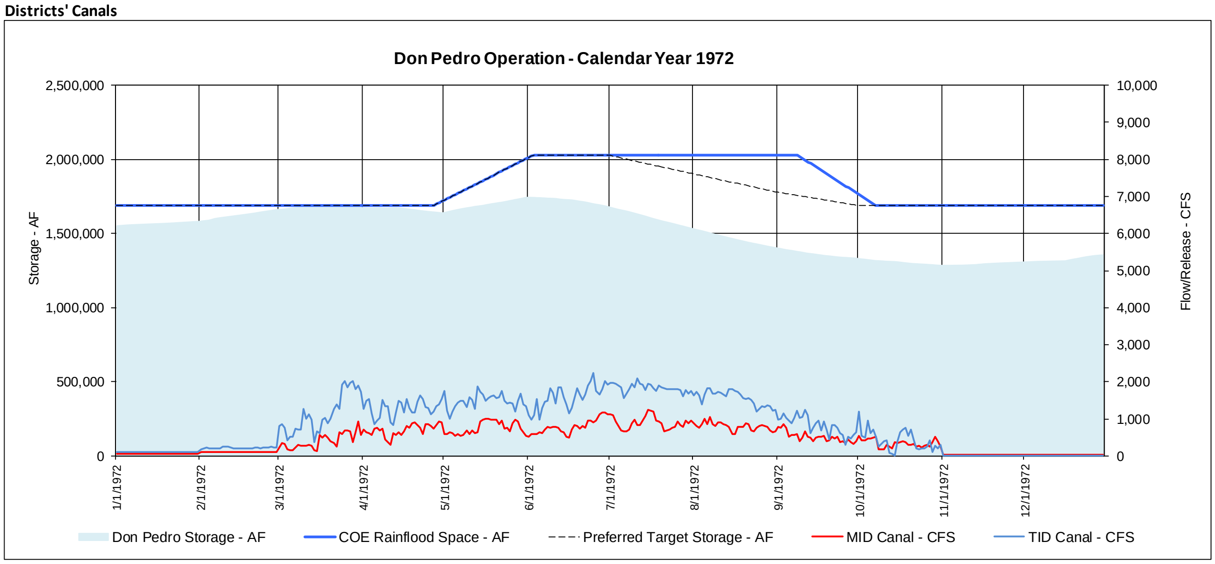
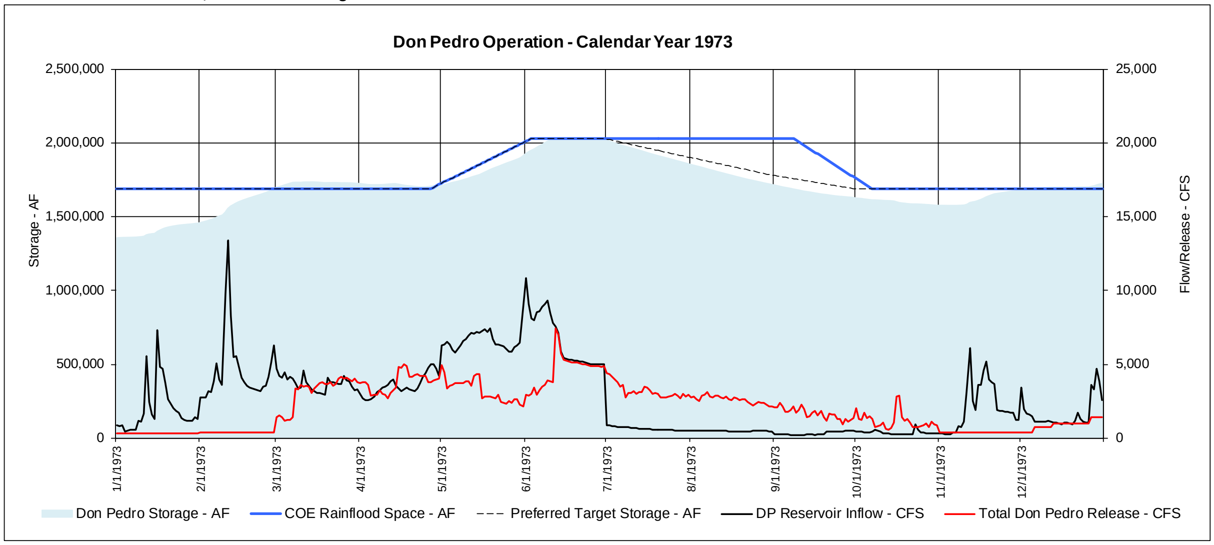
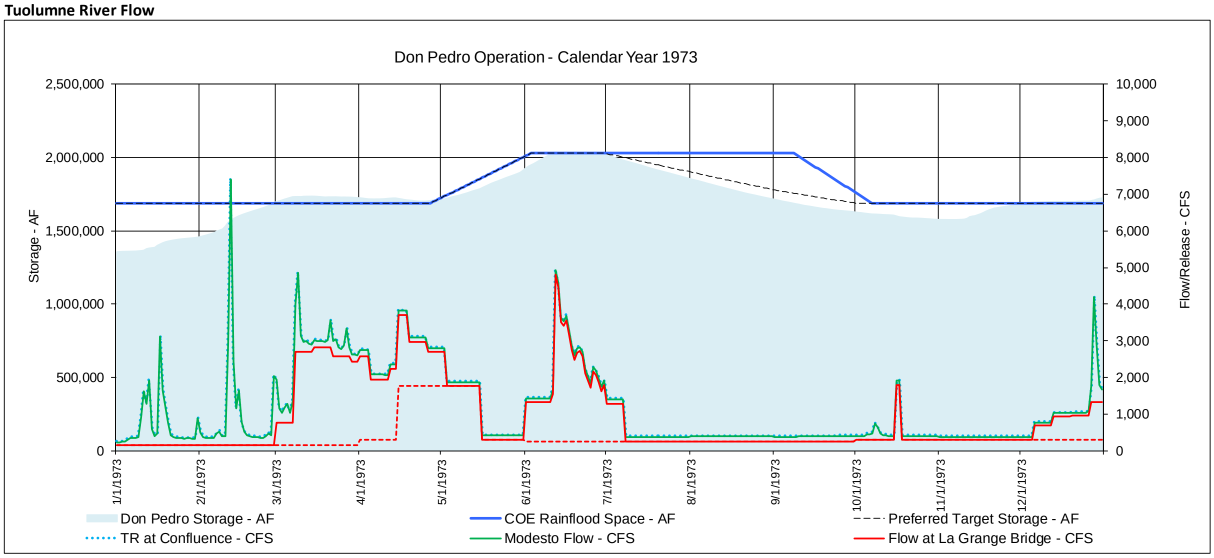


Figure 4-2. Don Pedro operations 1972 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

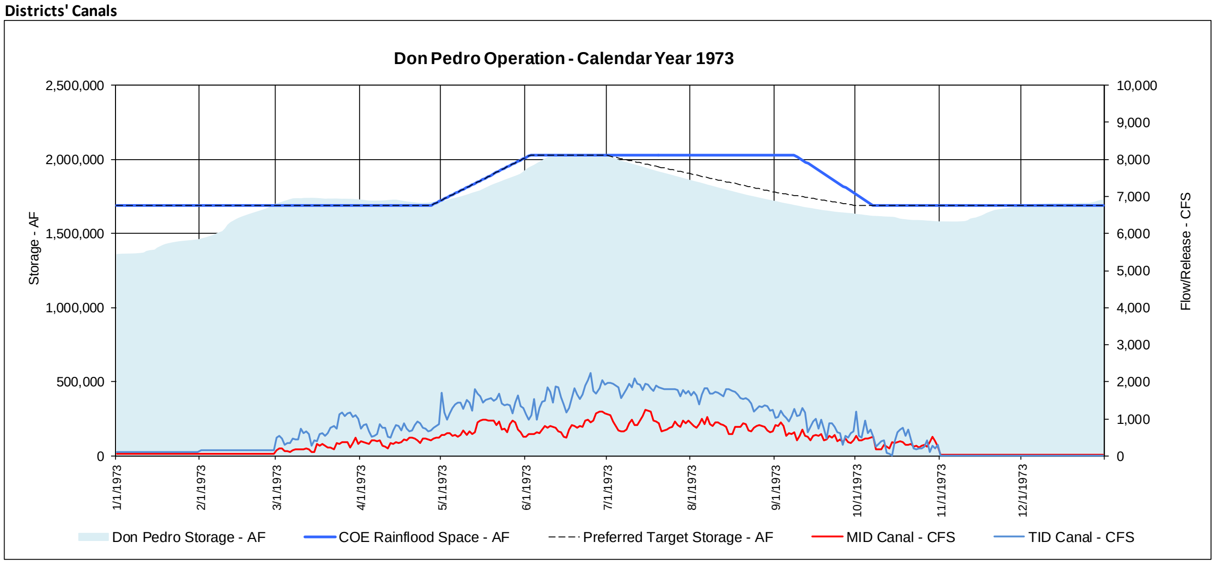
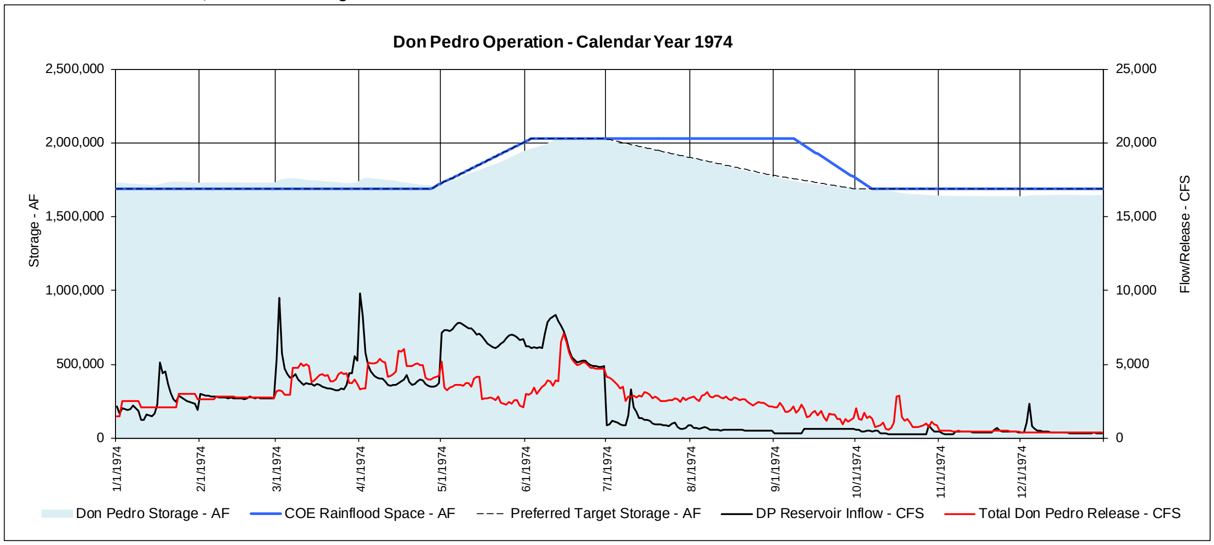
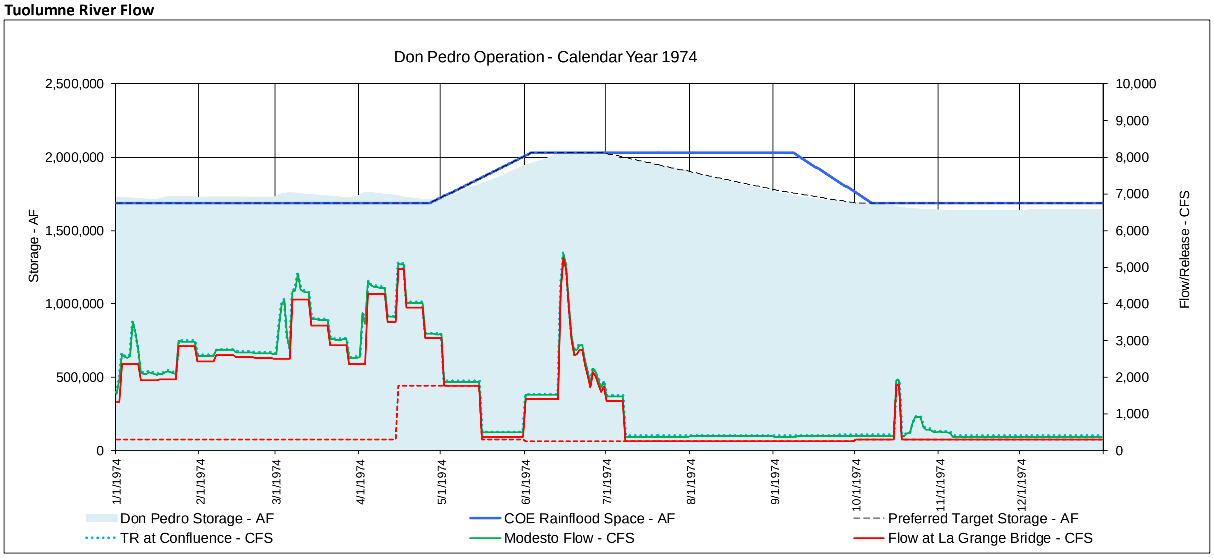


Figure 4-3. Don Pedro operations 1973 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

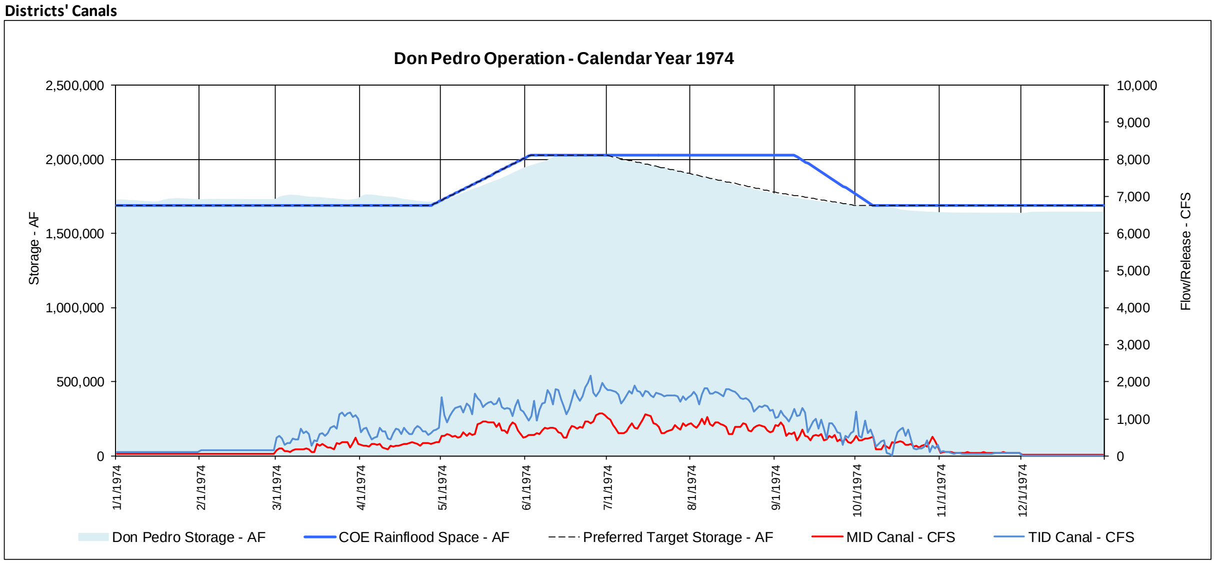
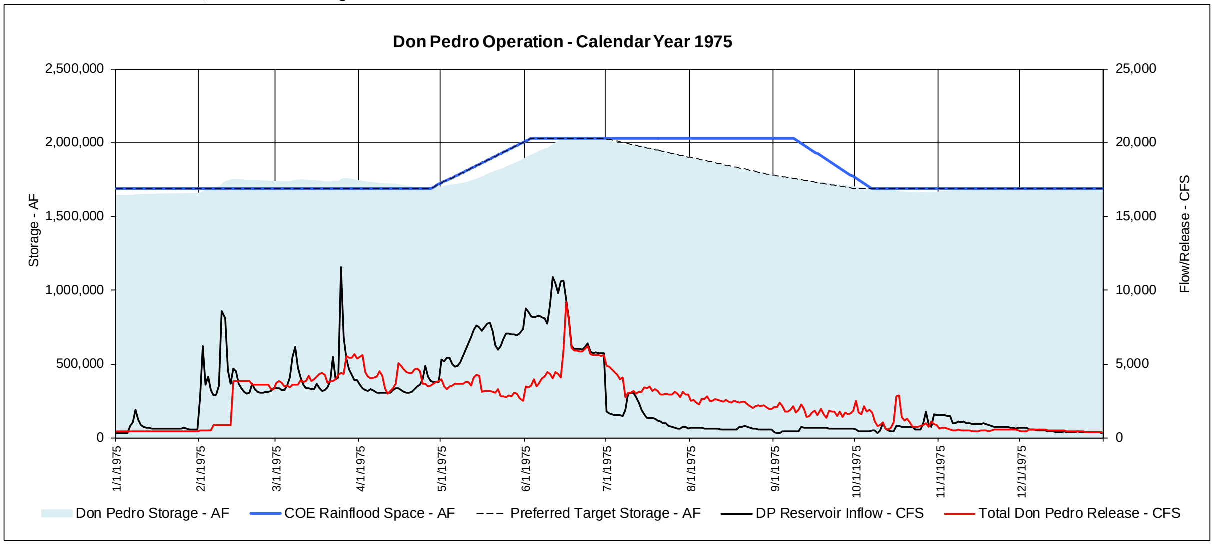
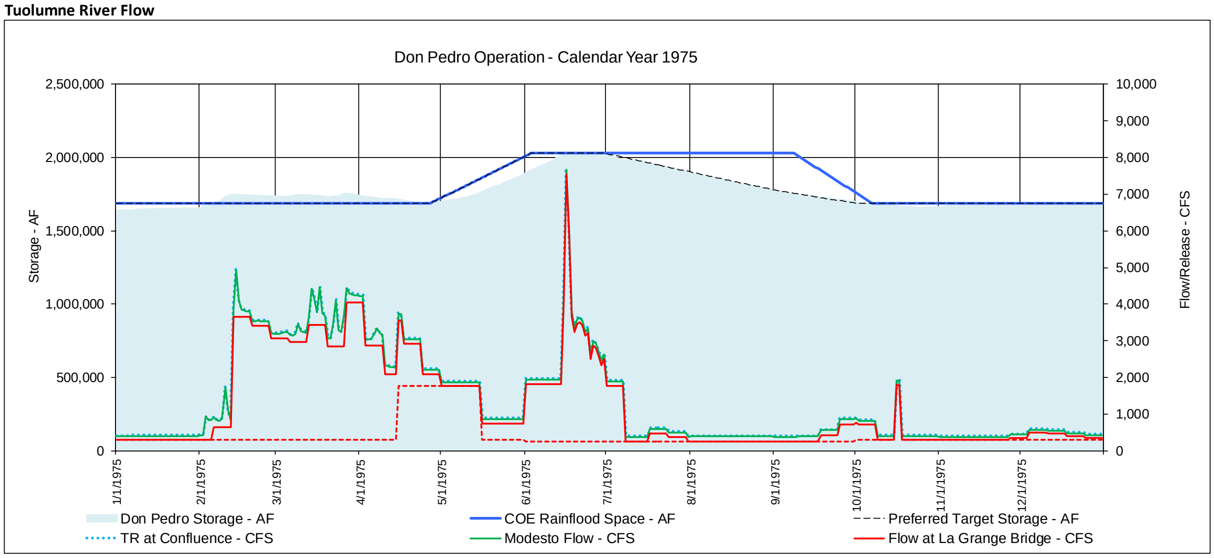


Figure 4-4. Don Pedro operations 1974 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

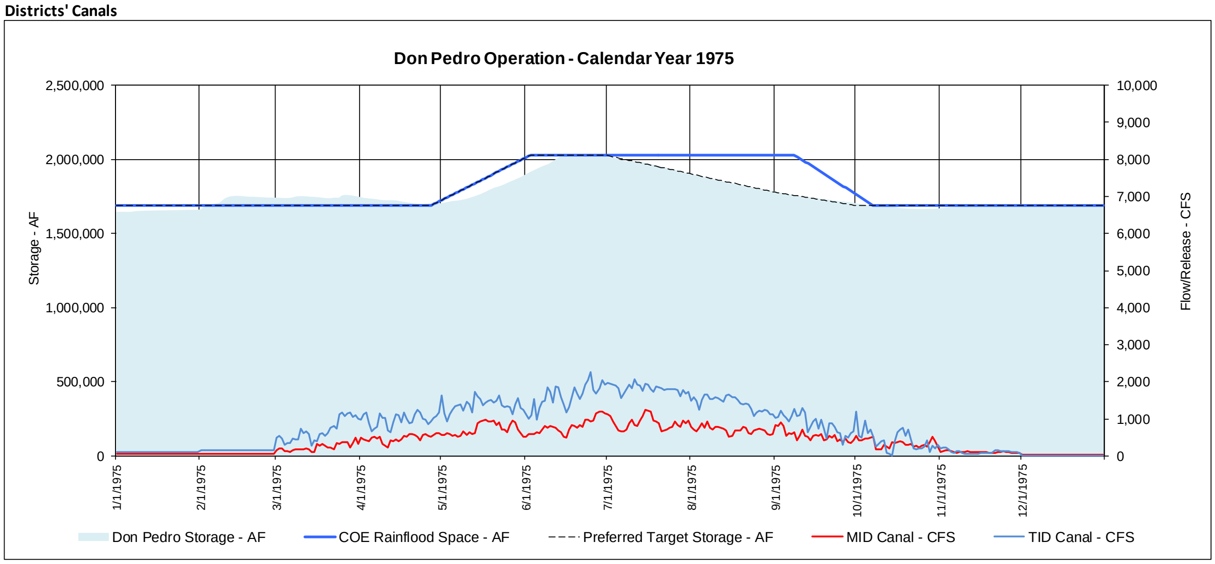
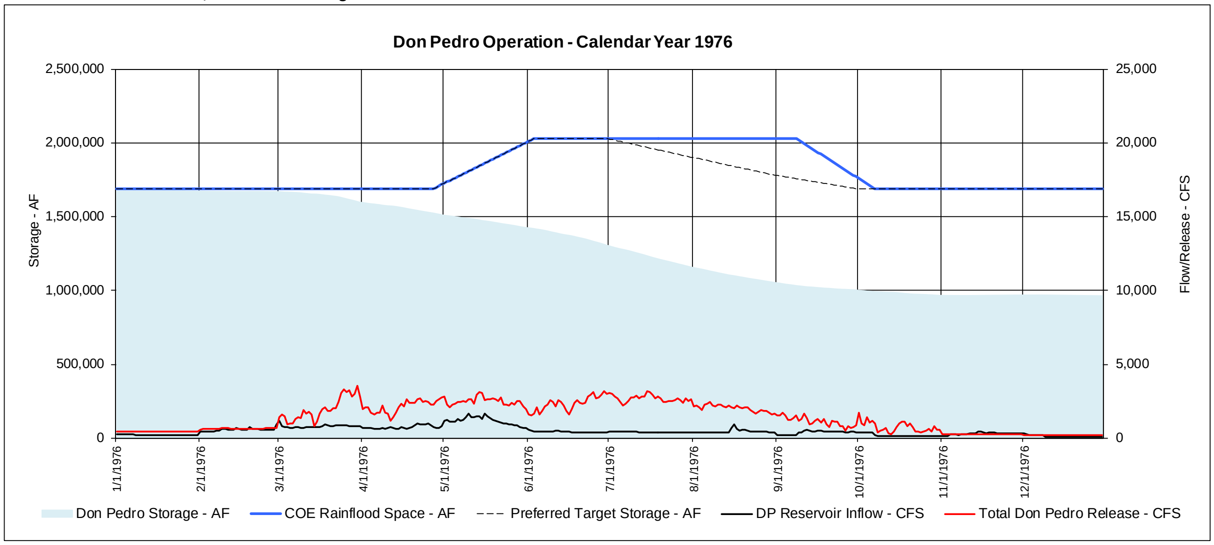
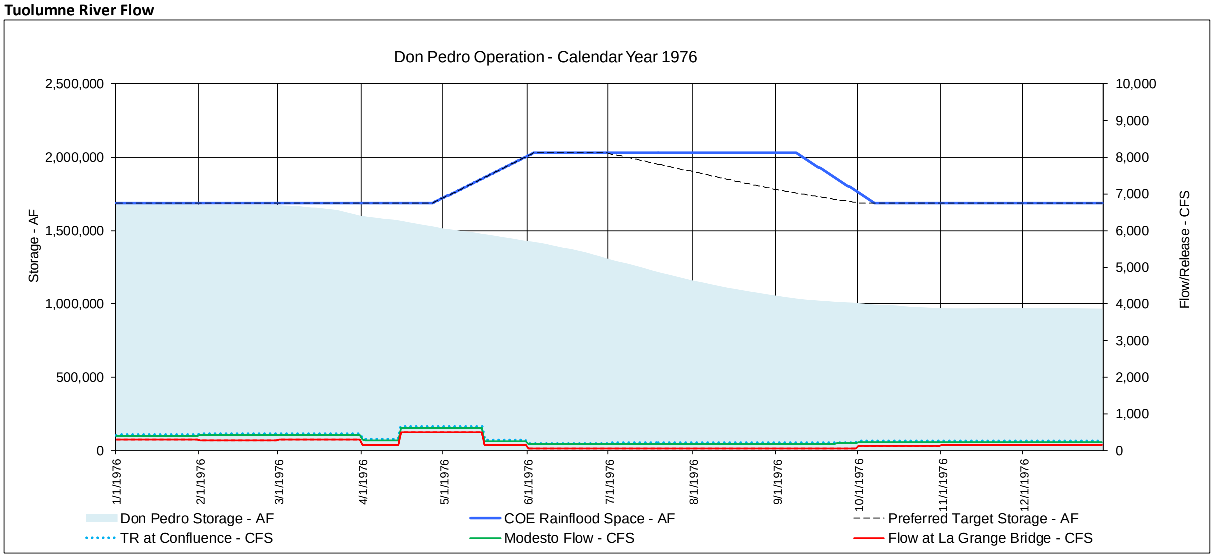


Figure 4-5. Don Pedro operations 1975 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

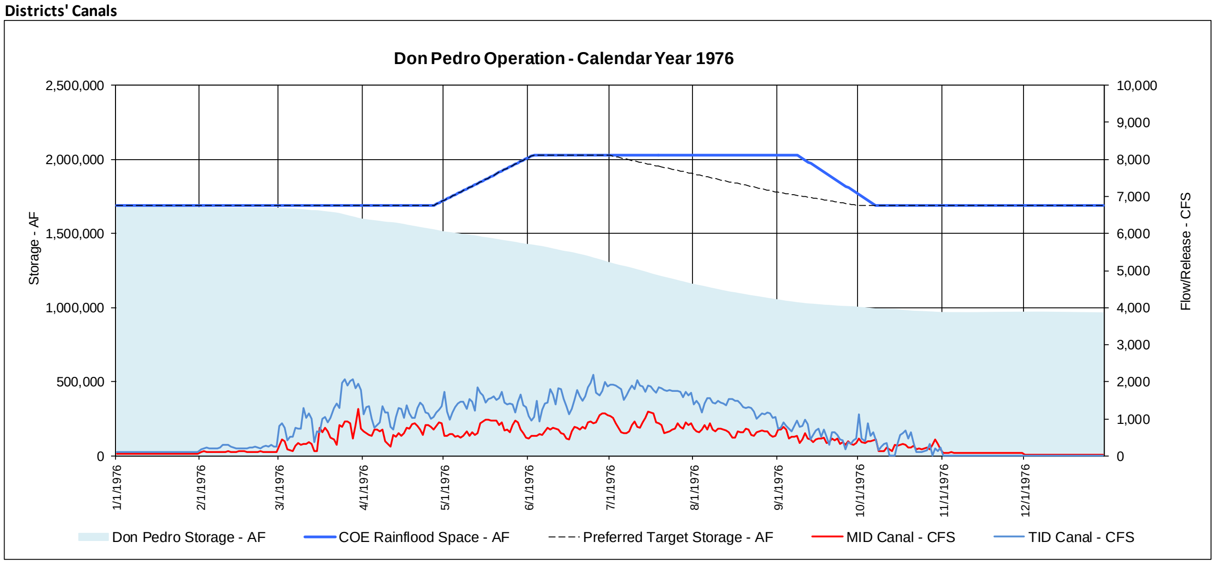
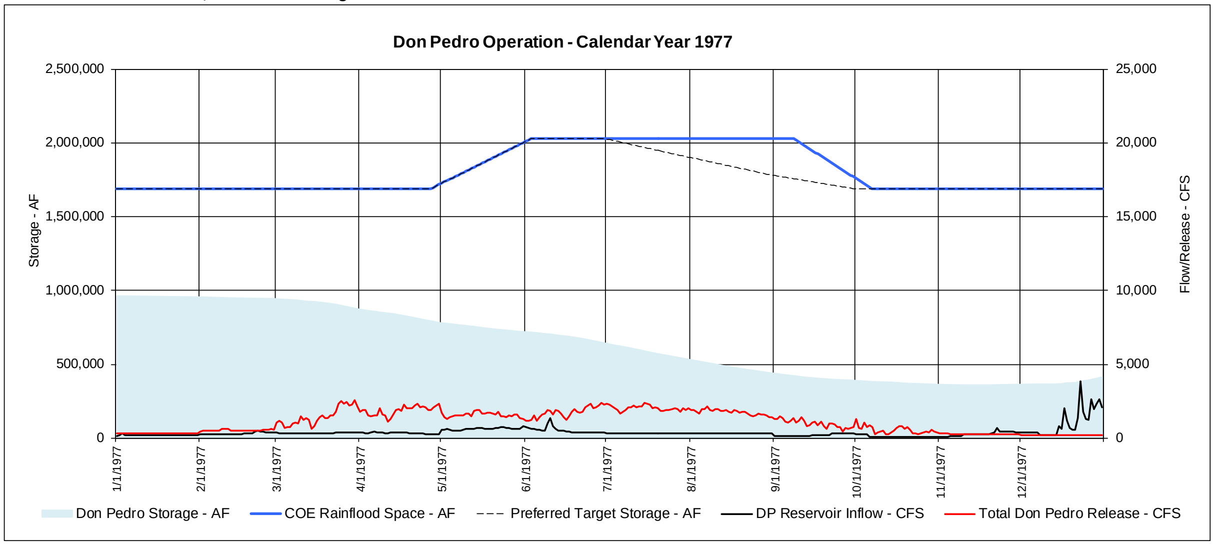
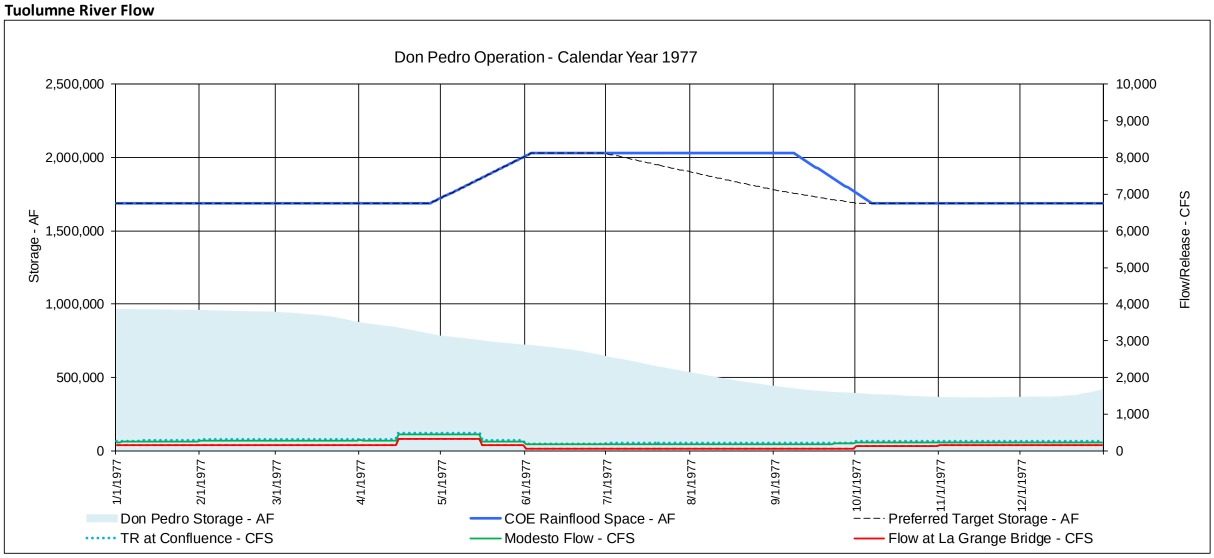


Figure 4-6. Don Pedro operations 1976 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

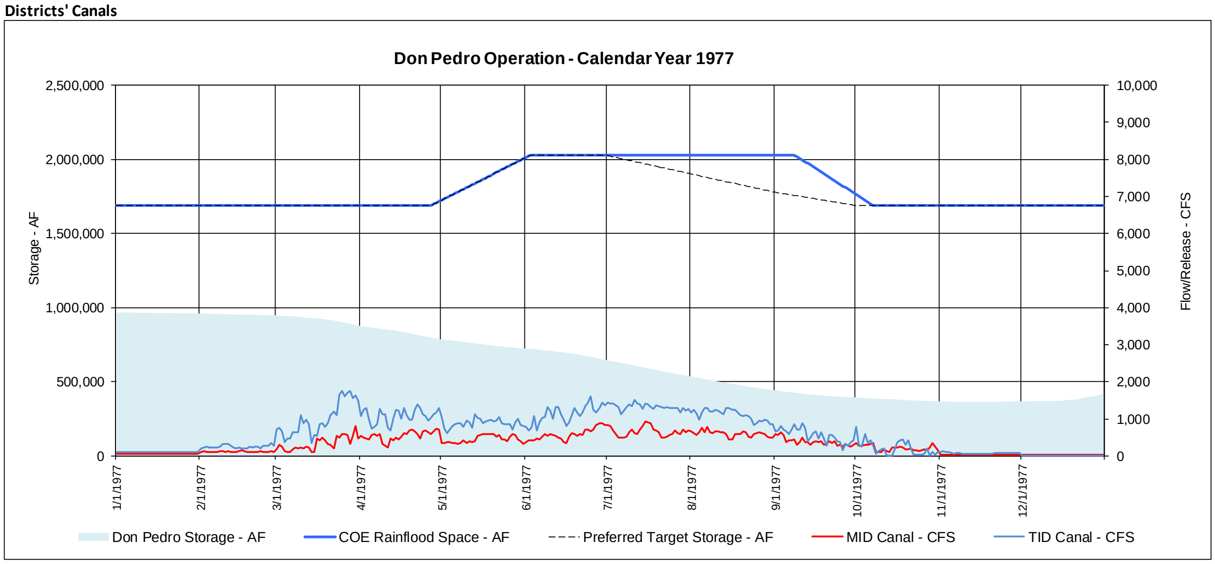
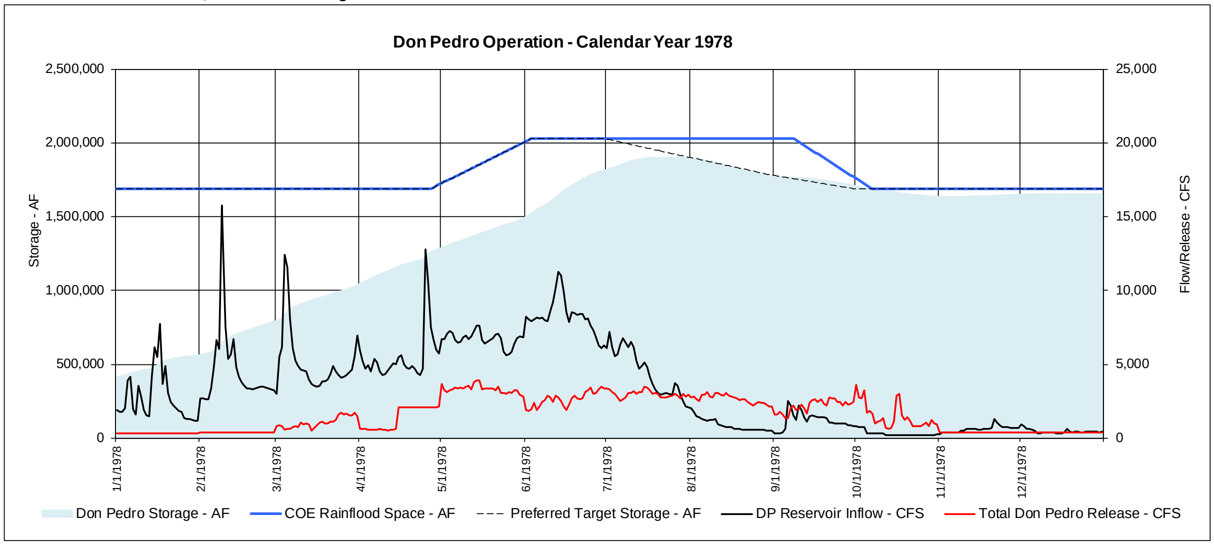
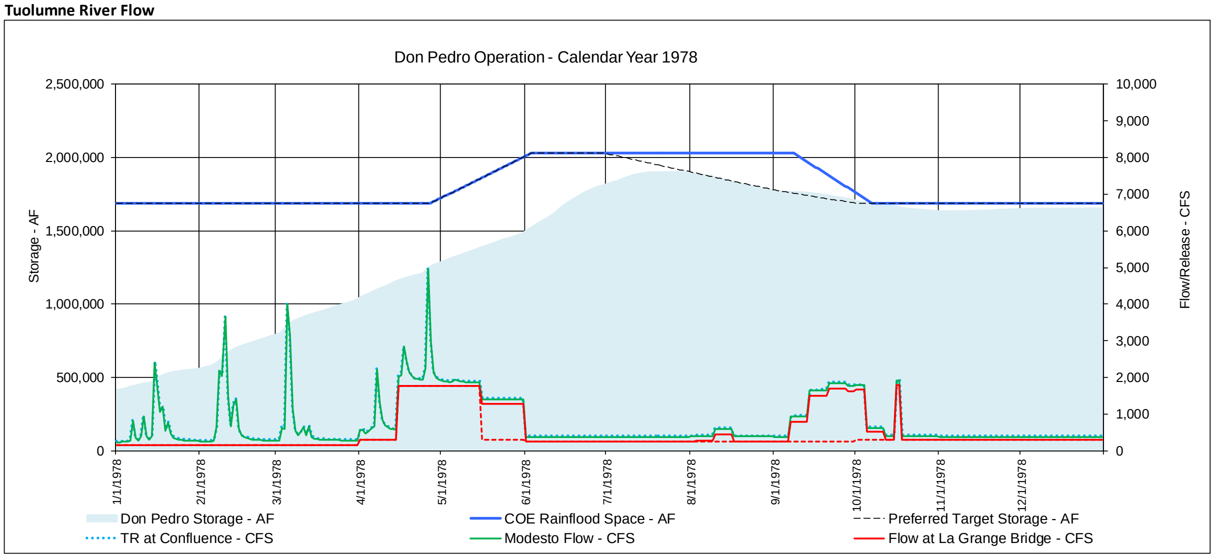


Figure 4-7. Don Pedro operations 1977 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

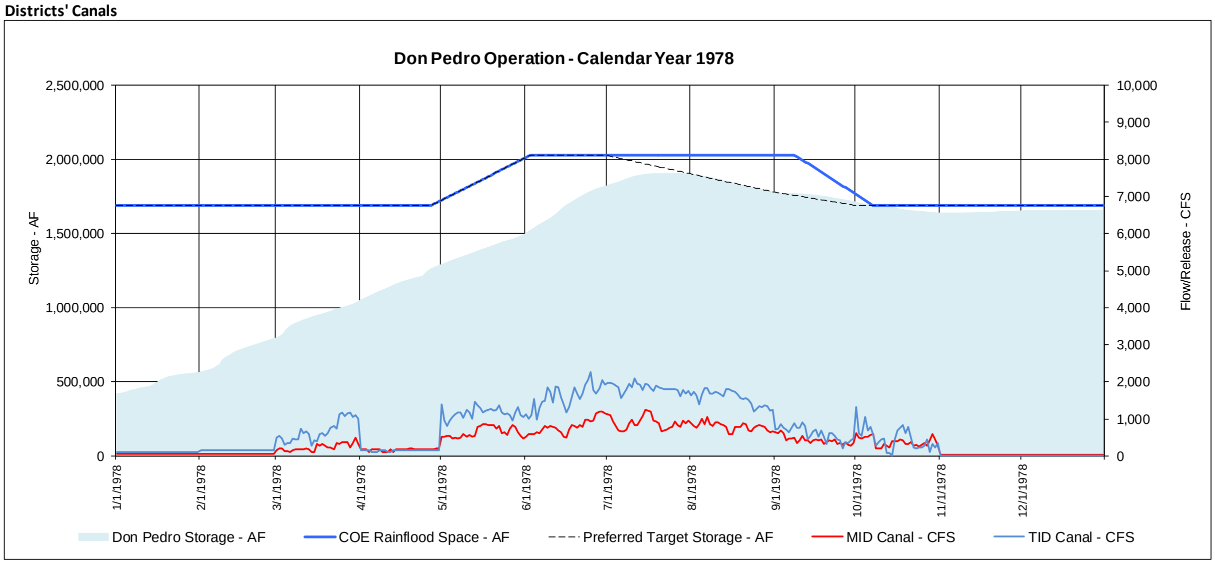
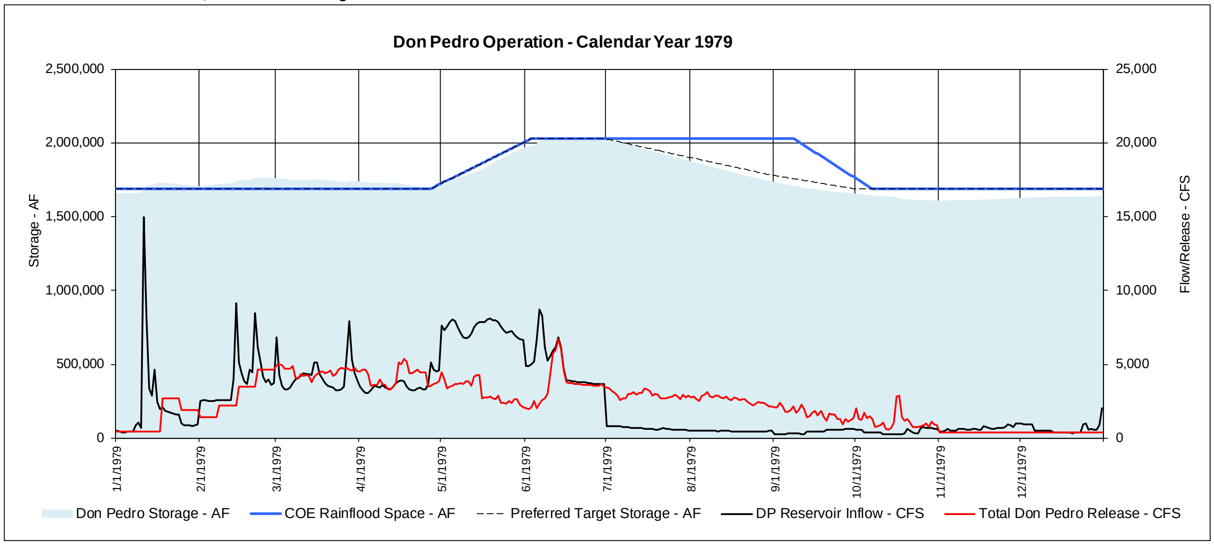
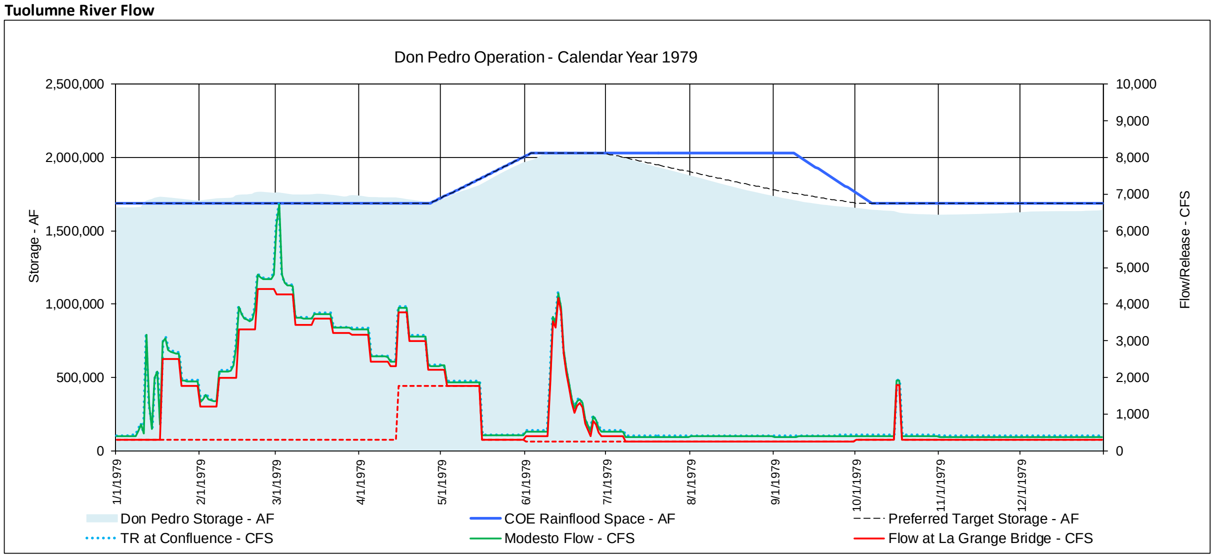


Figure 4-8. Don Pedro operations 1978 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

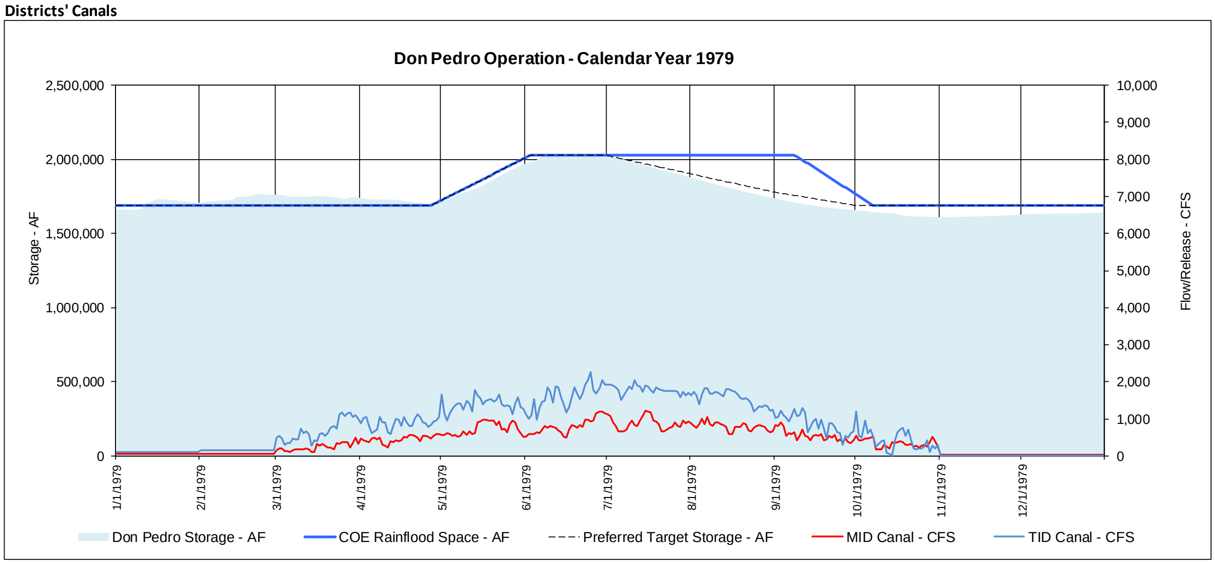
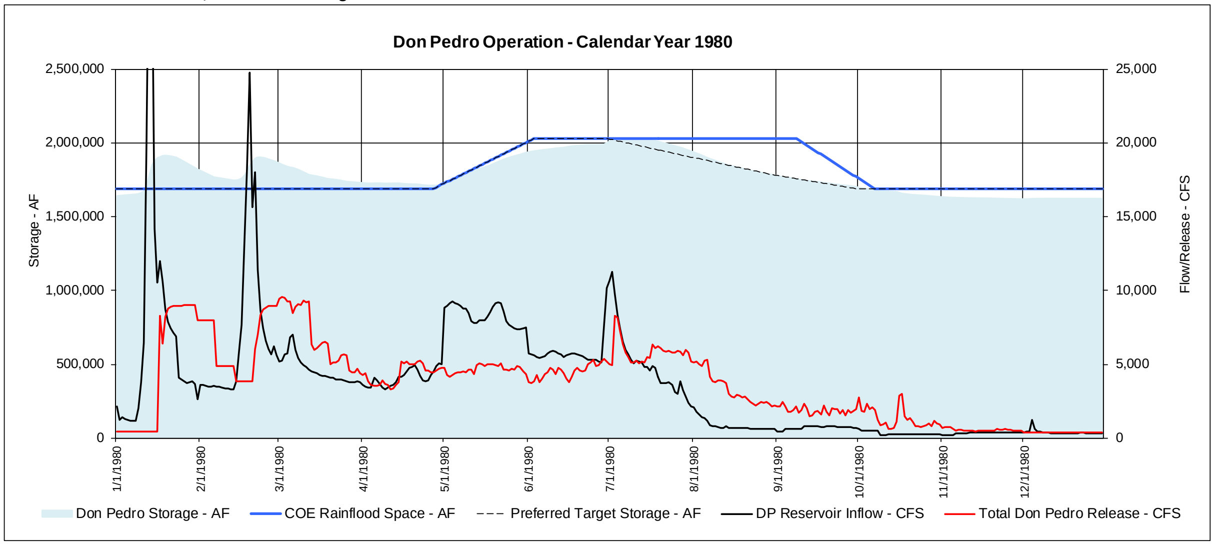
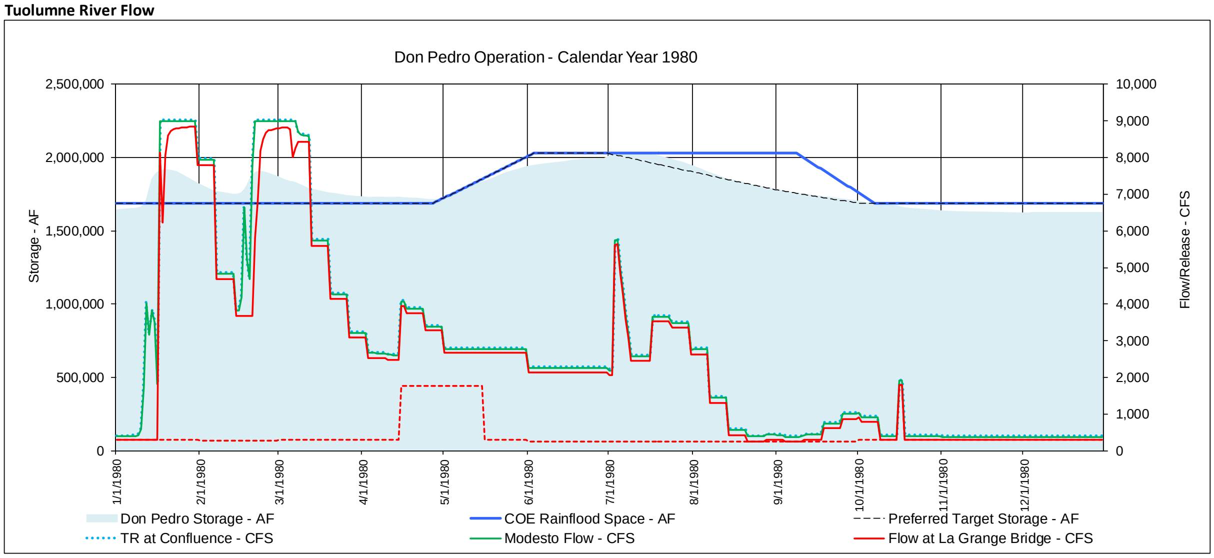


Figure 4-9. Don Pedro operations 1979 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

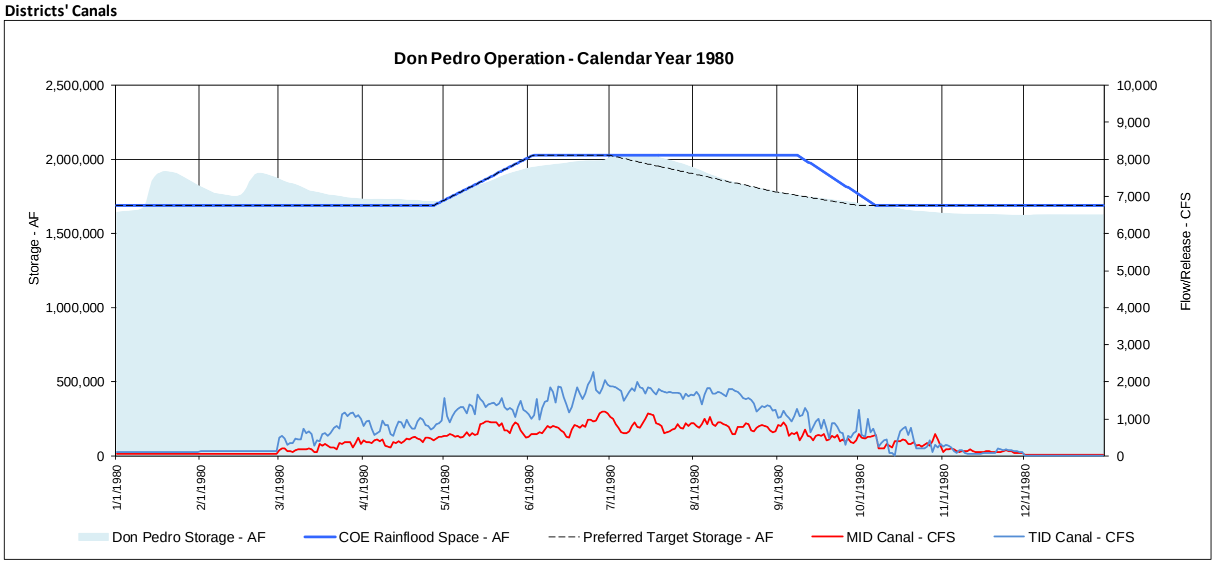
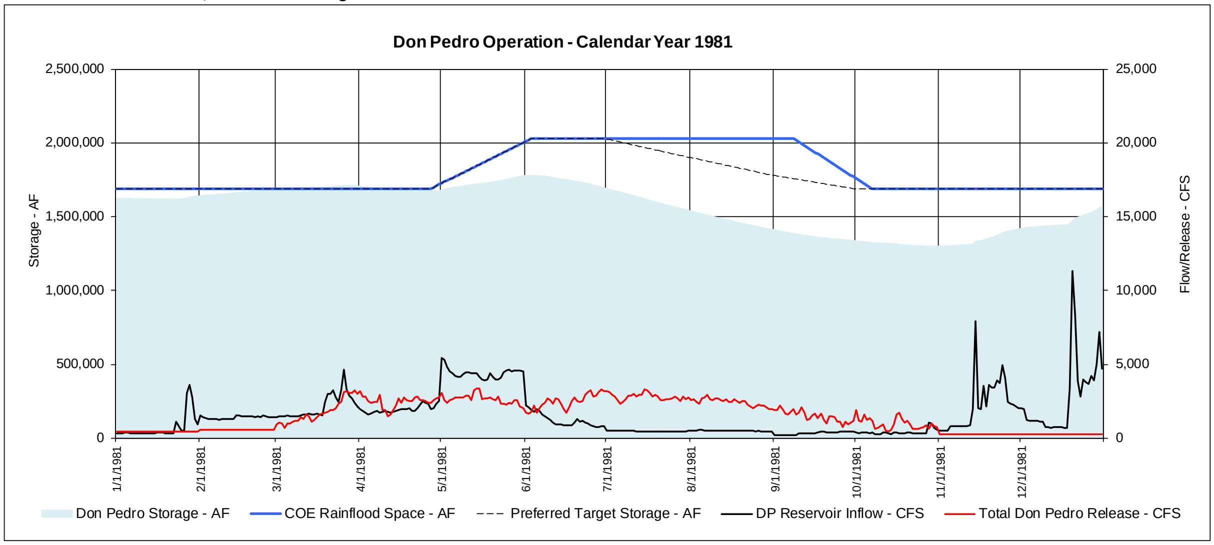
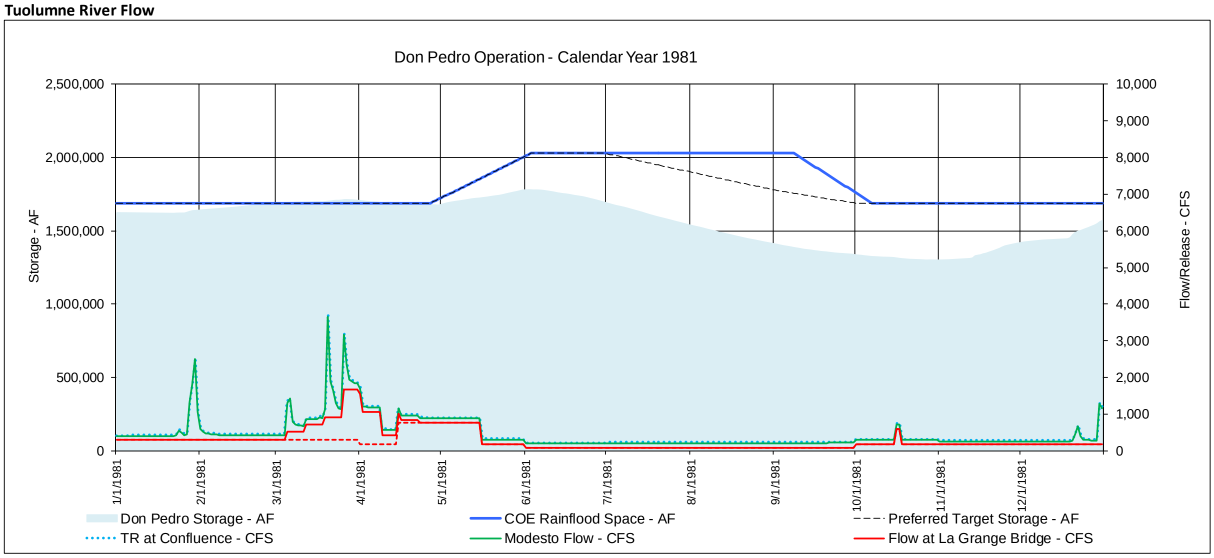


Figure 4-10. Don Pedro operations 1980 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

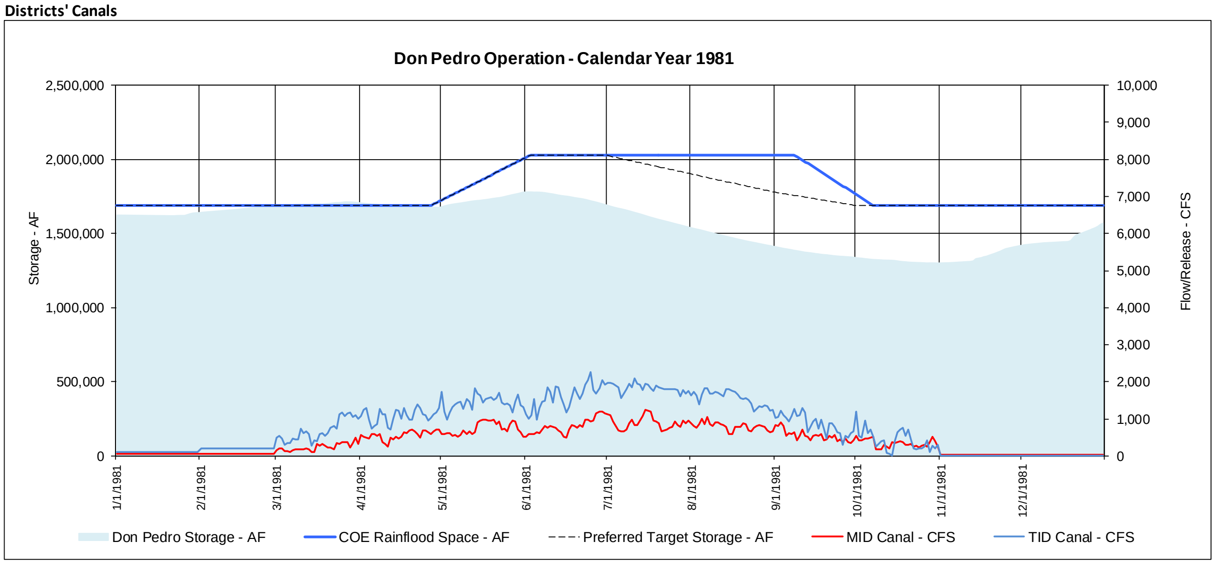
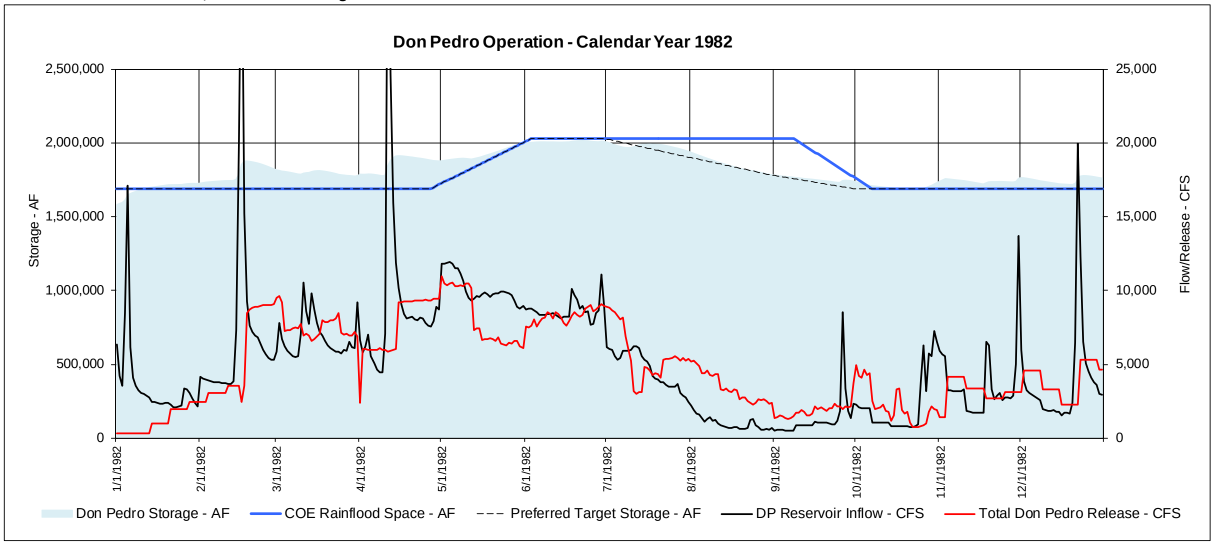
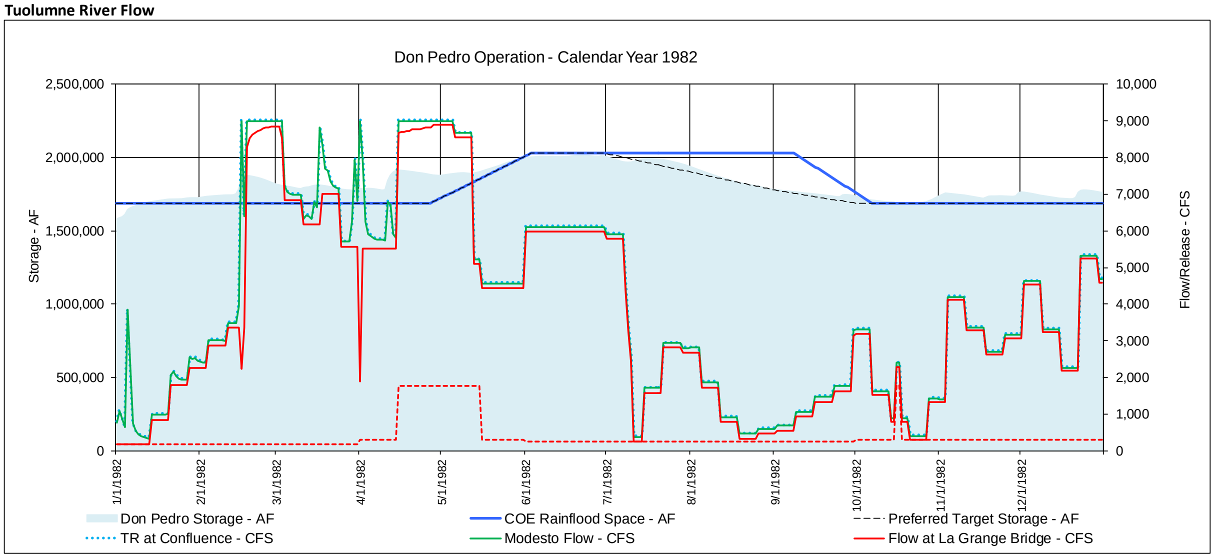


Figure 4-11. Don Pedro operations 1981 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

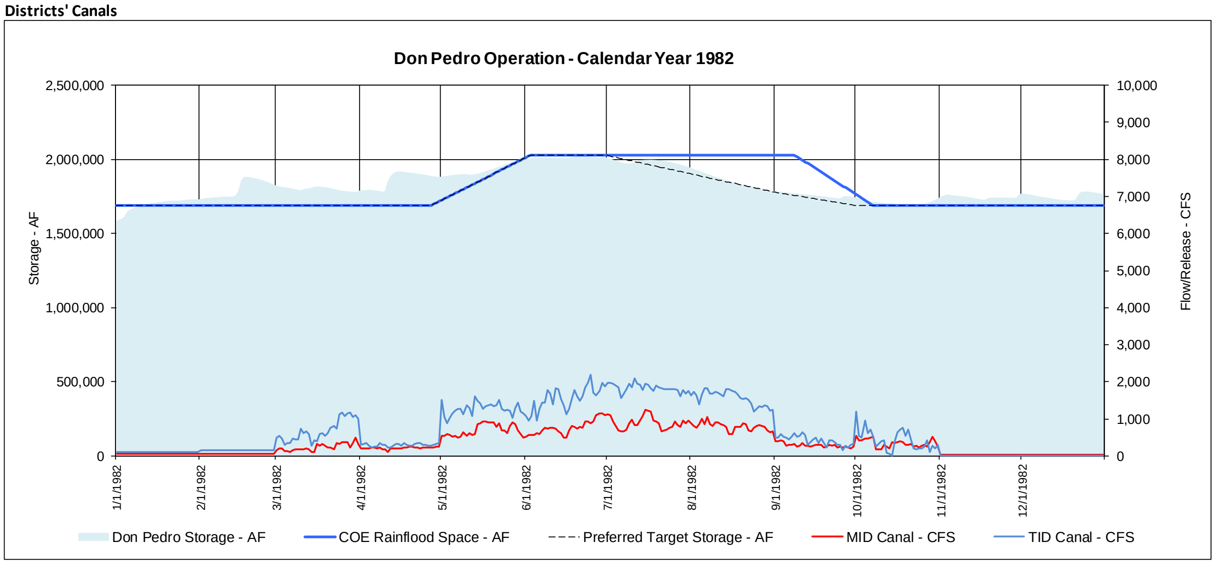
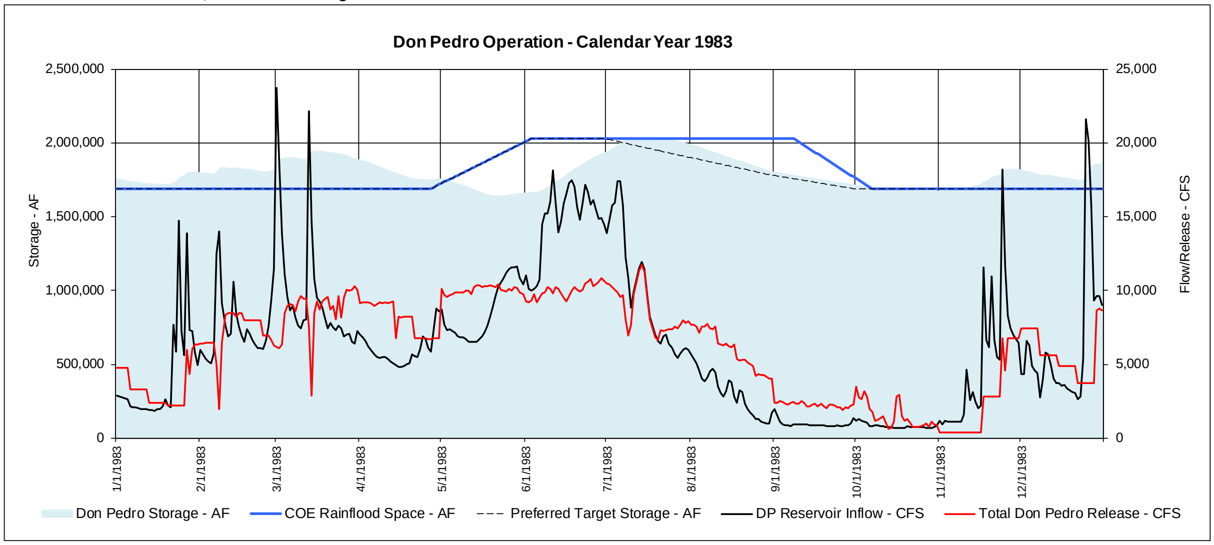
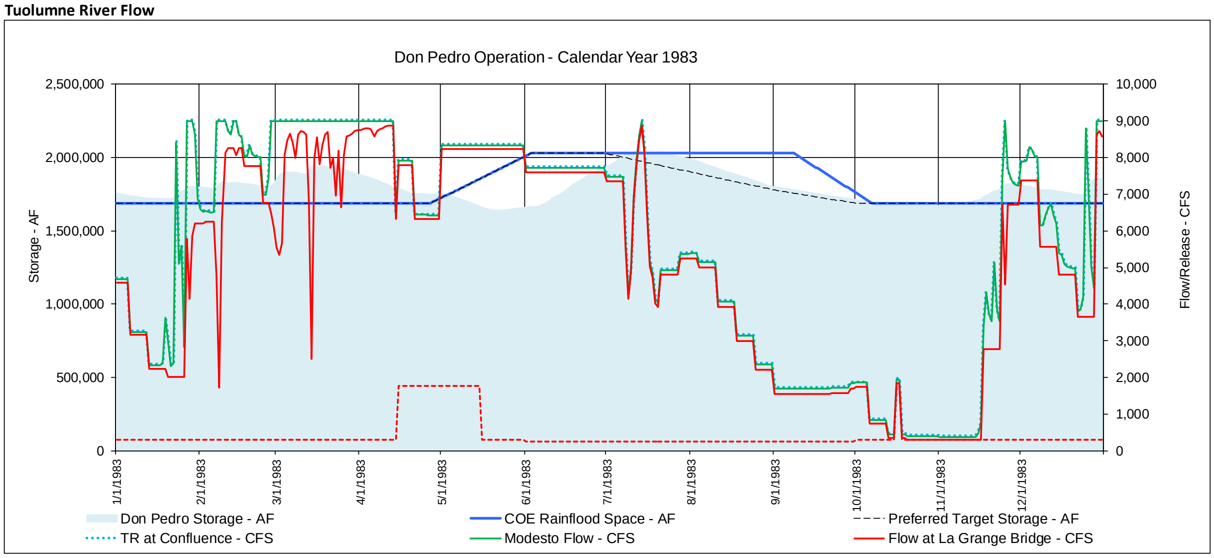


Figure 4-12. Don Pedro operations 1982 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

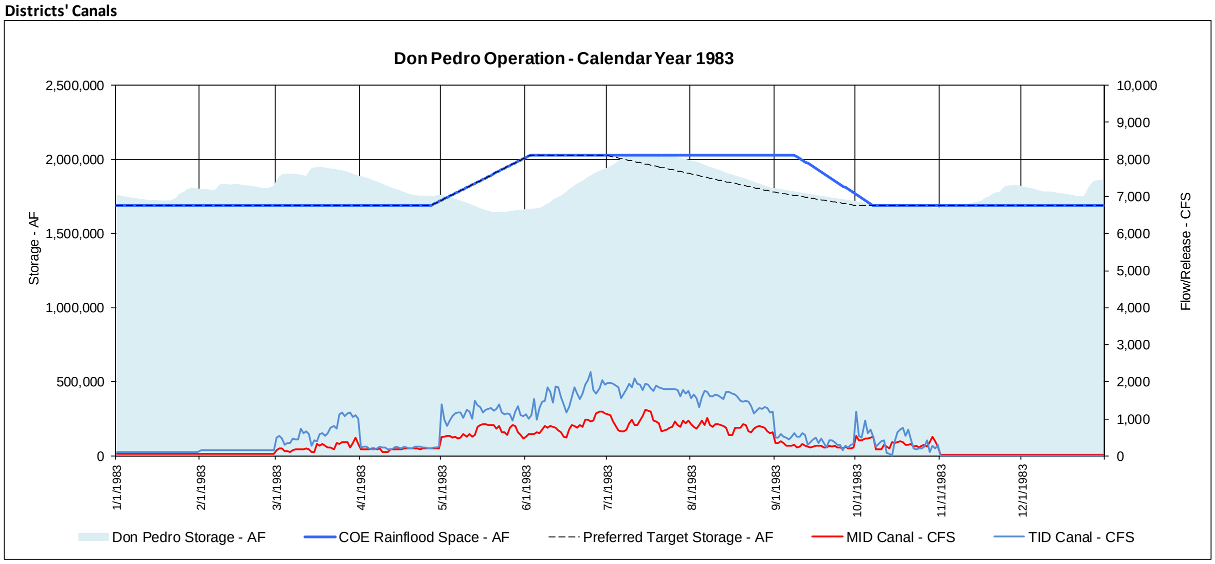
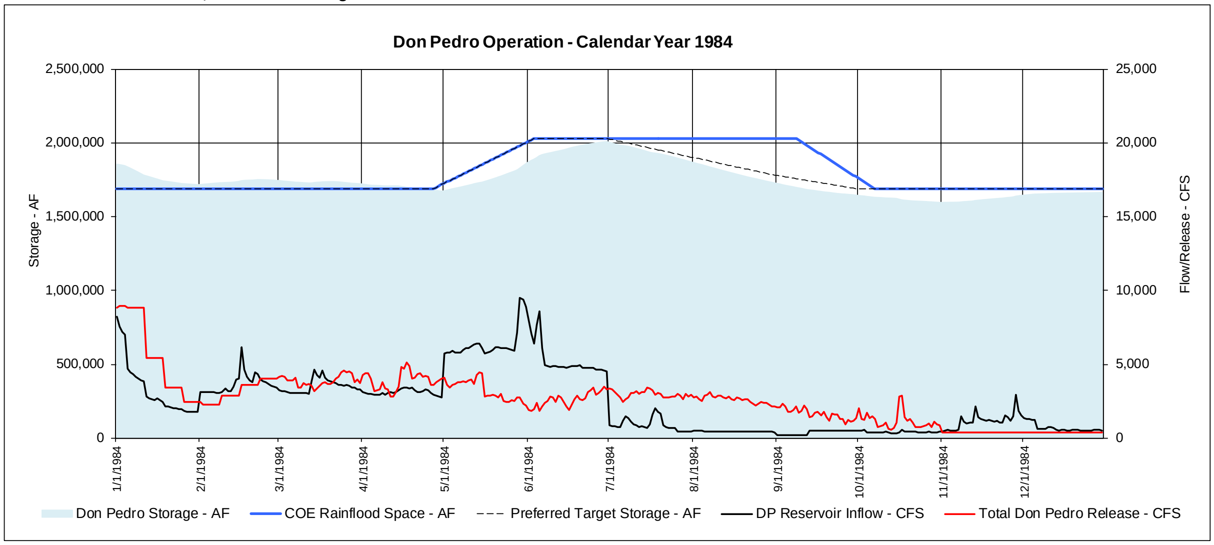
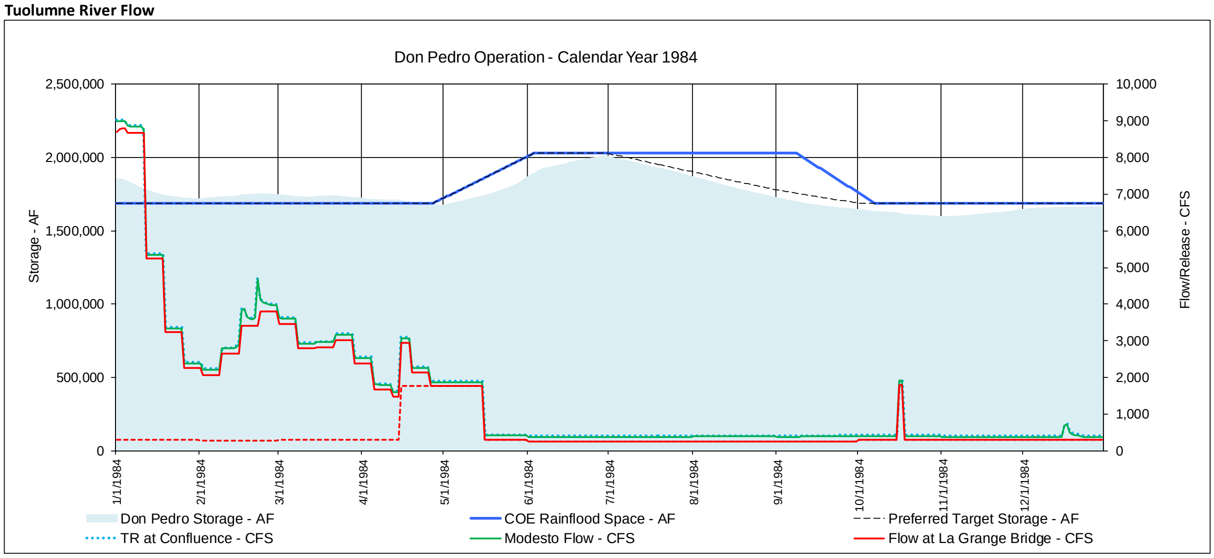


Figure 4-13. Don Pedro operations 1983 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

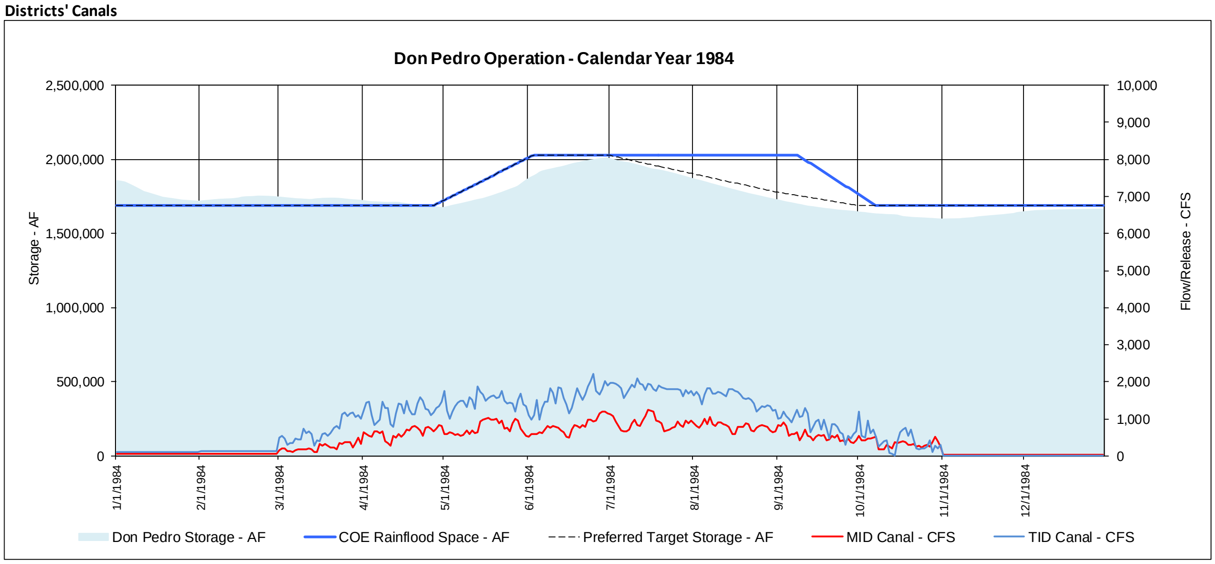
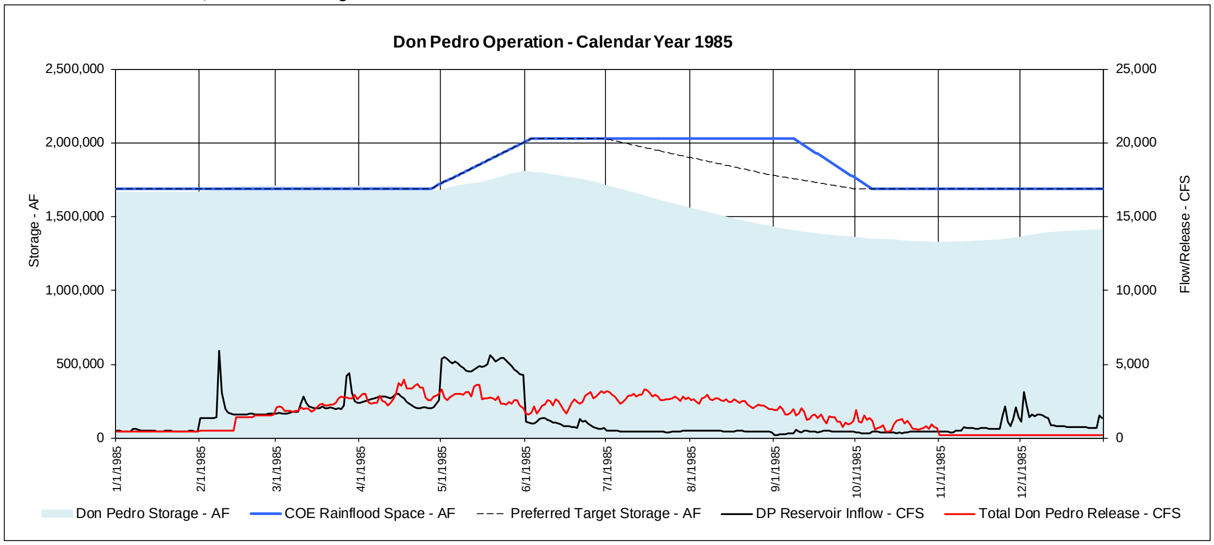
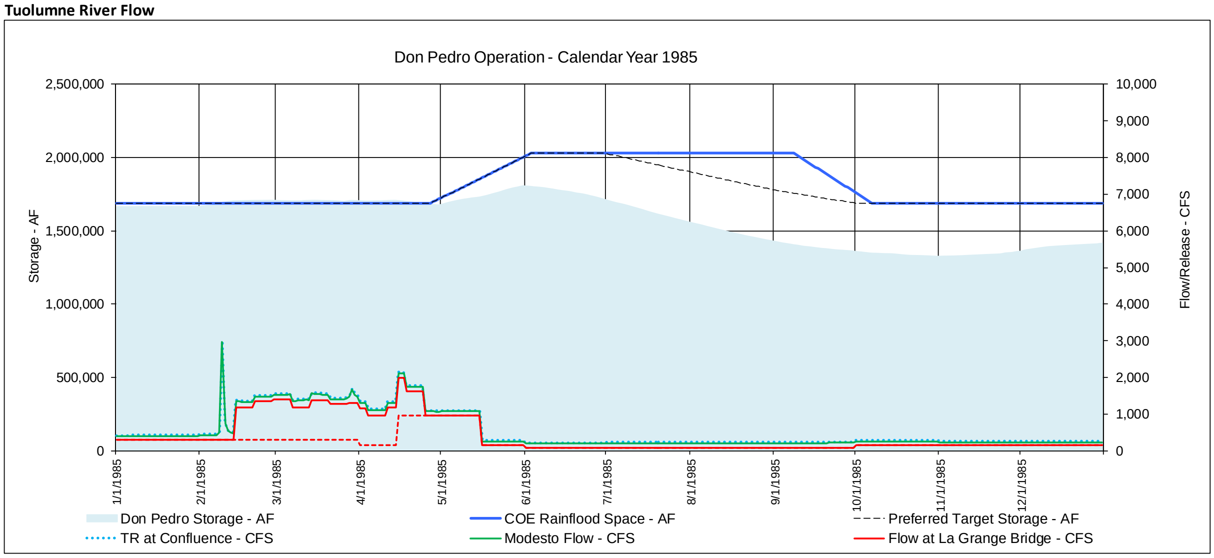


Figure 4-14. Don Pedro operations 1984 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

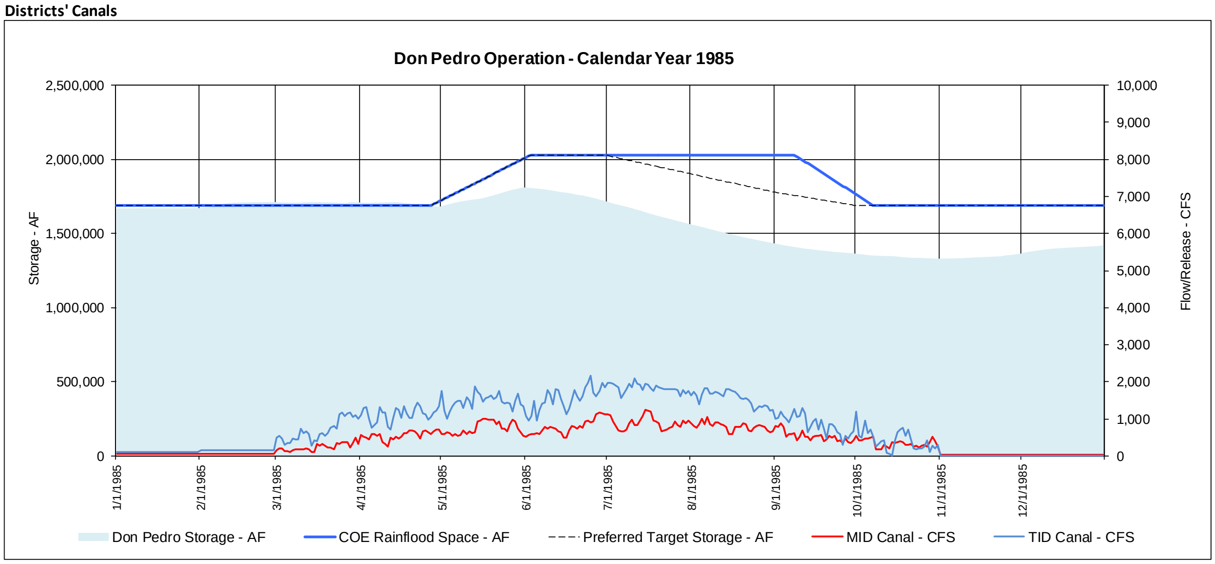
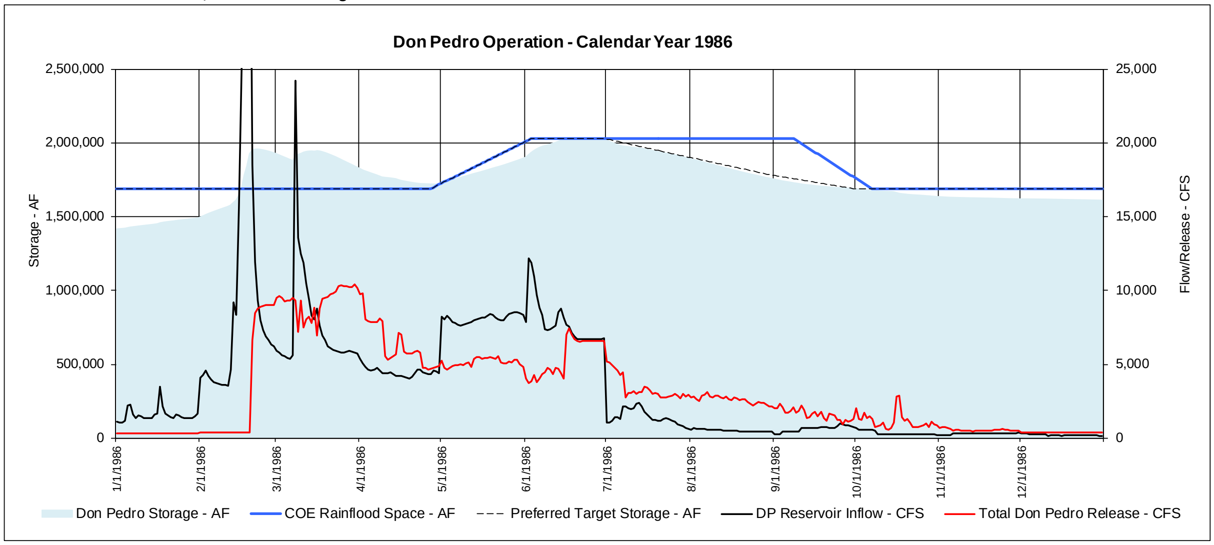
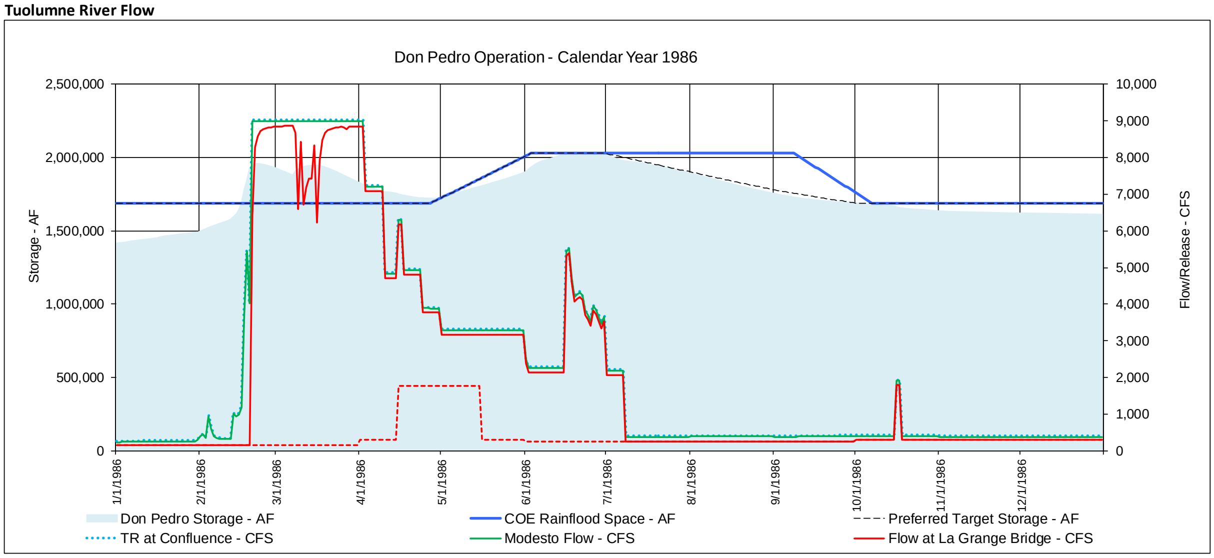


Figure 4-15. Don Pedro operations 1985 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

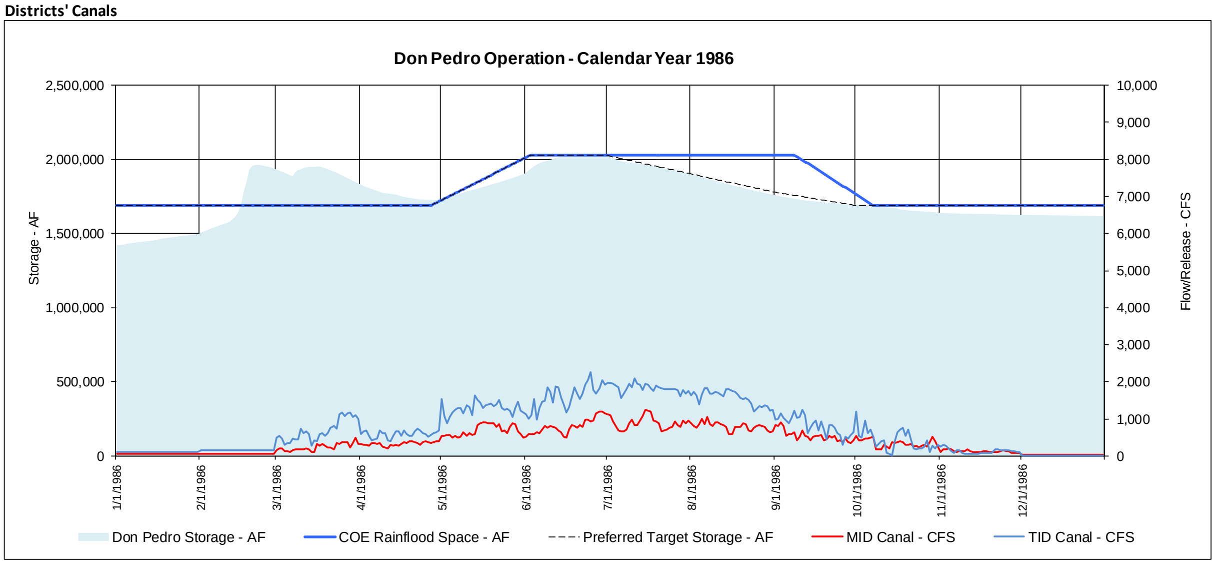
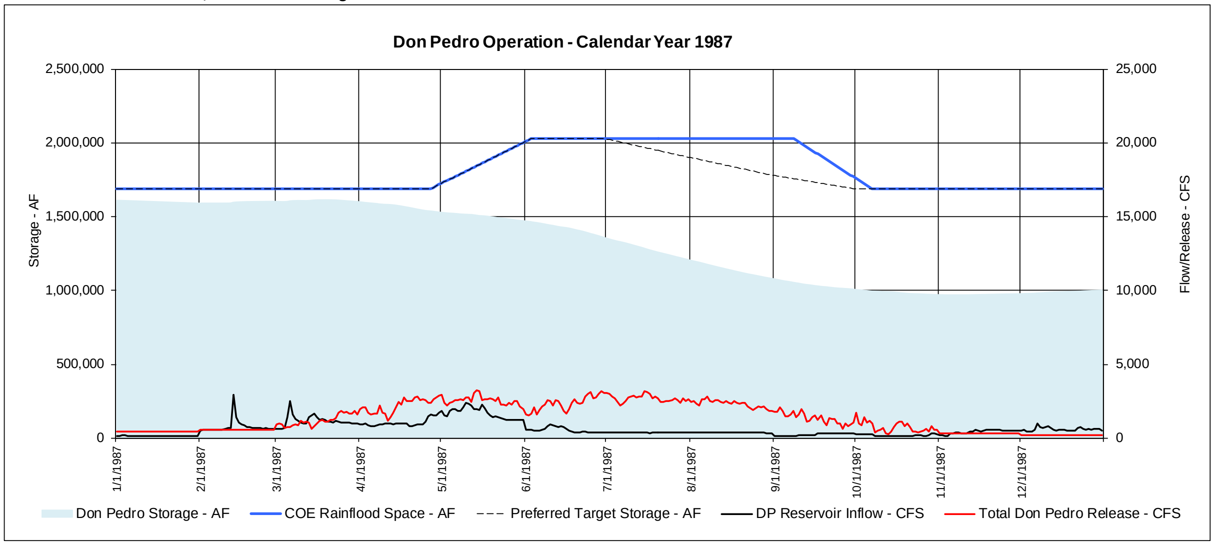
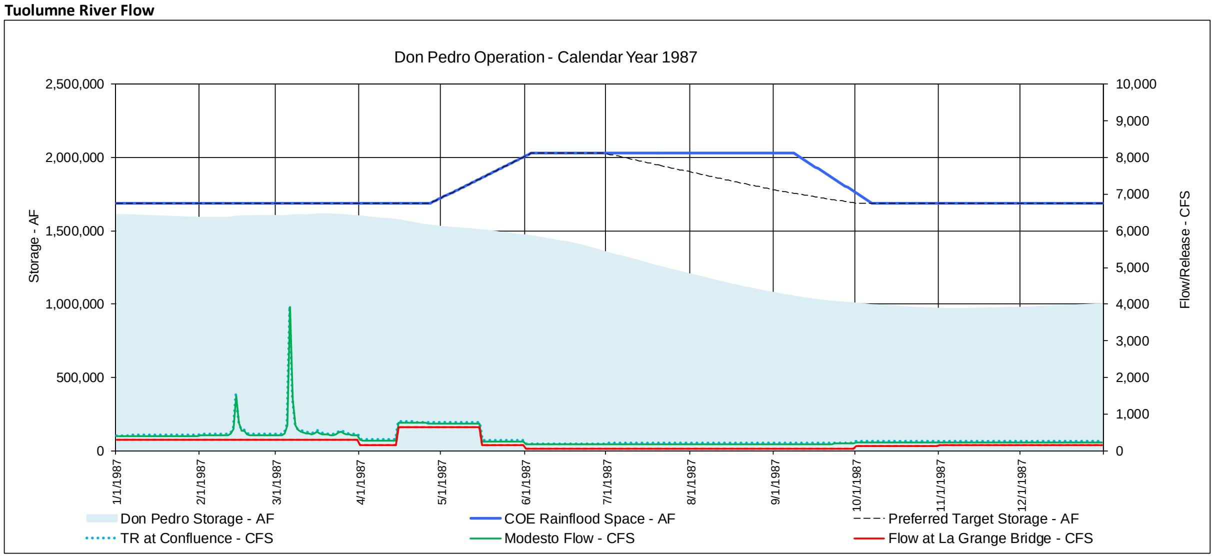


Figure 4-16. Don Pedro operations 1986 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

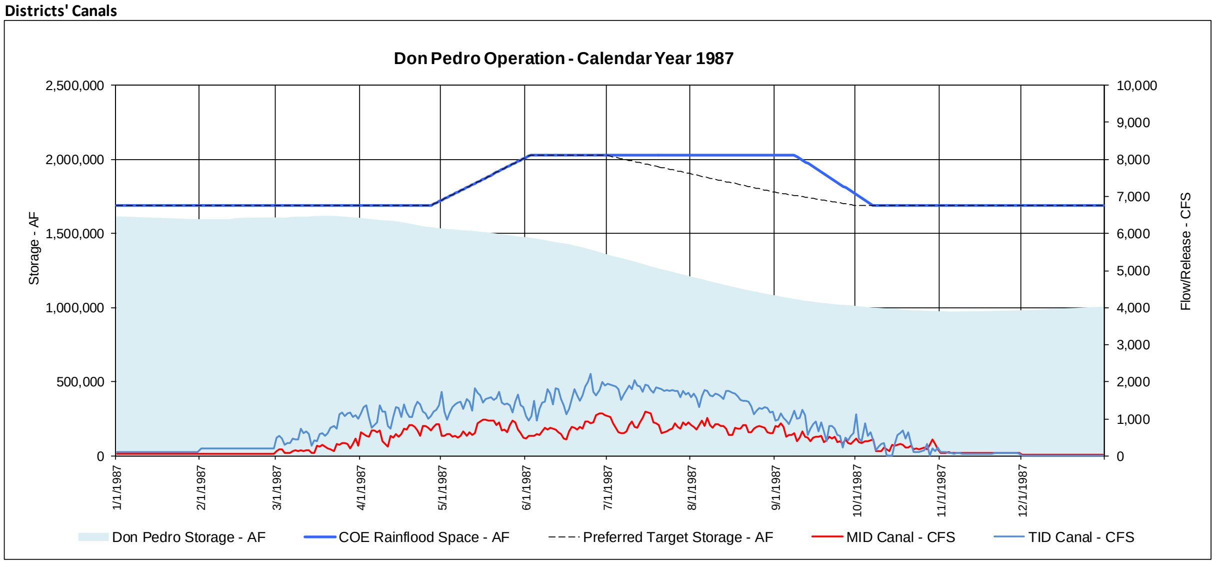
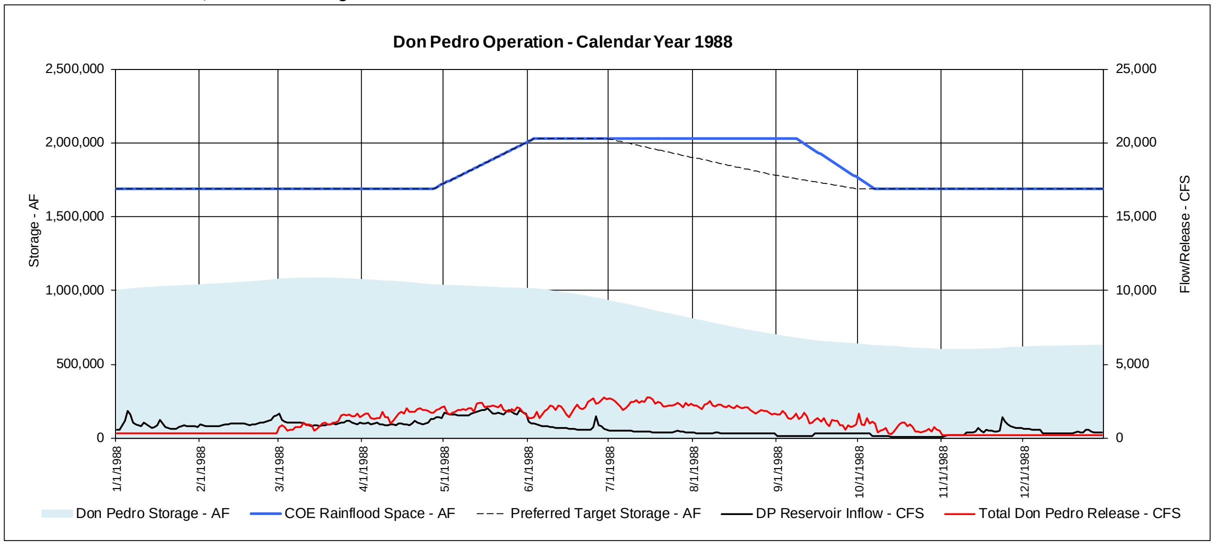
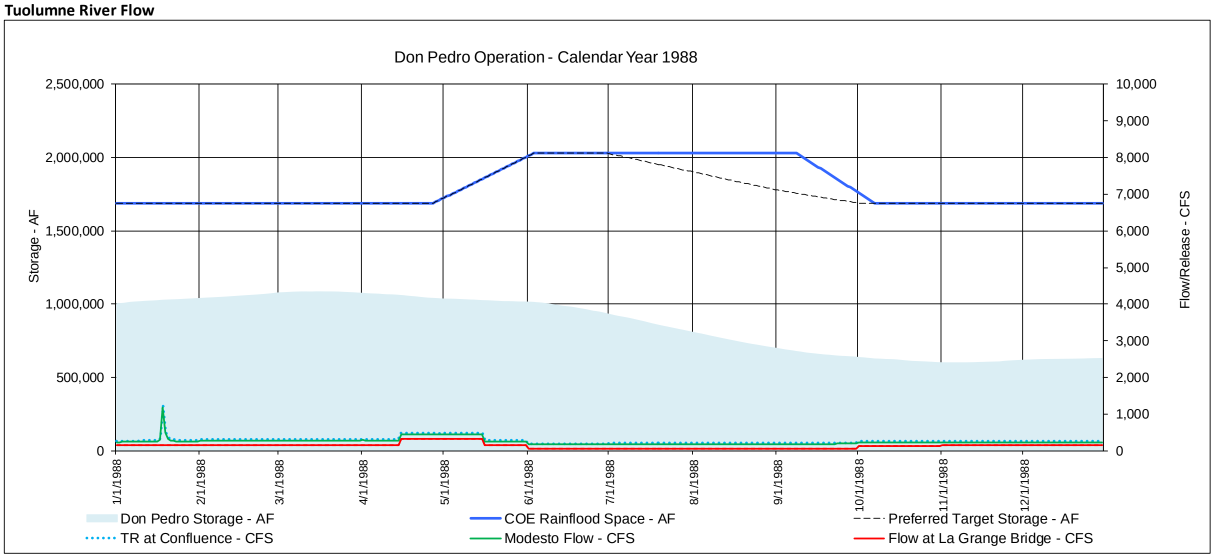


Figure 4-17. Don Pedro operations 1987 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

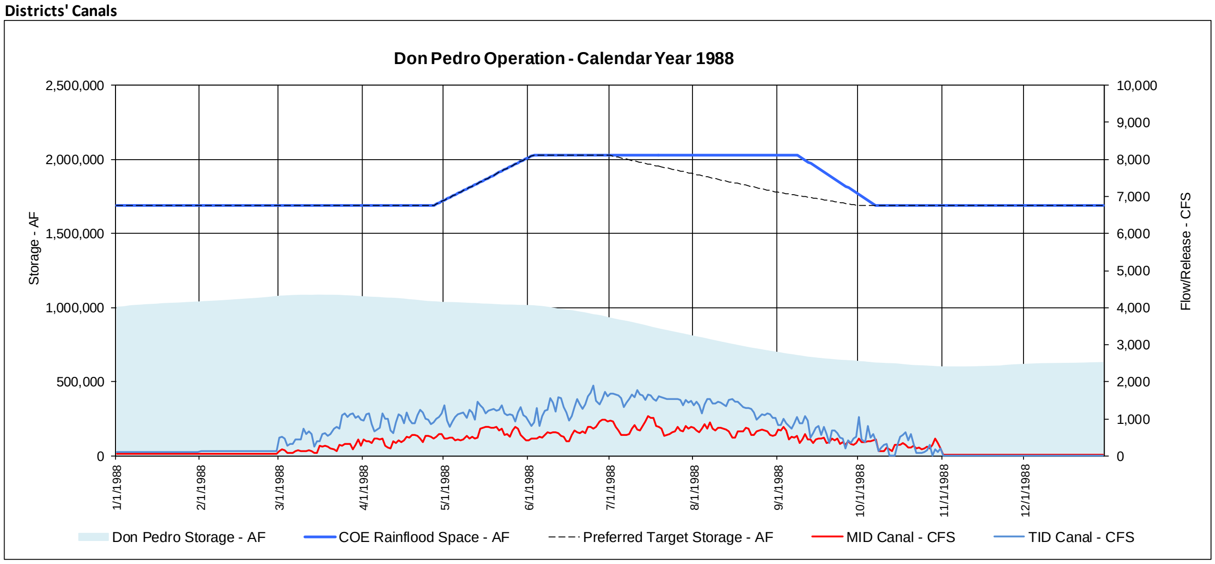
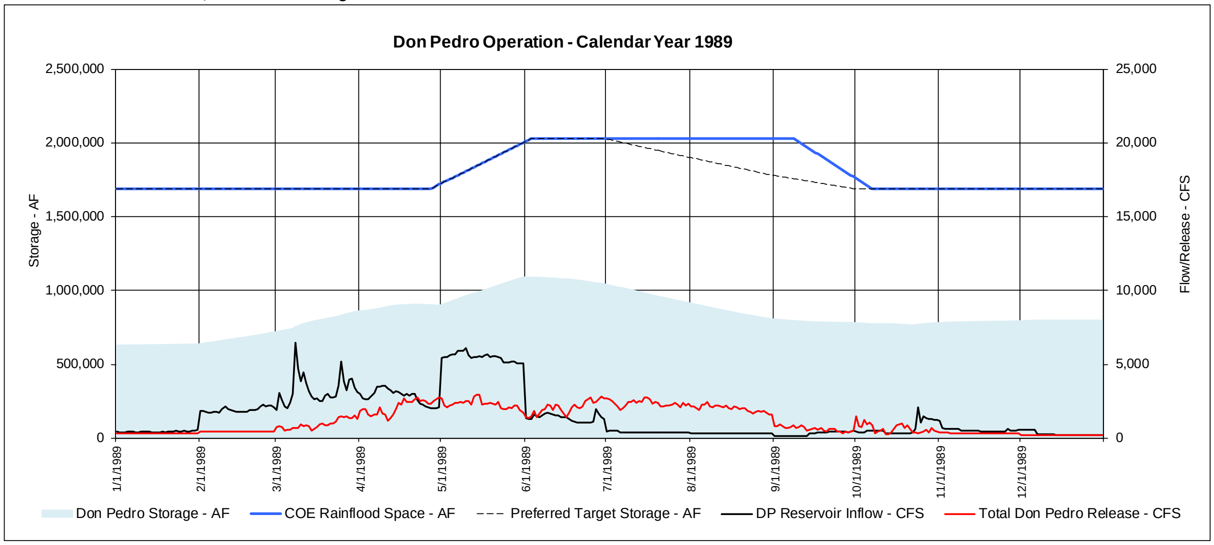
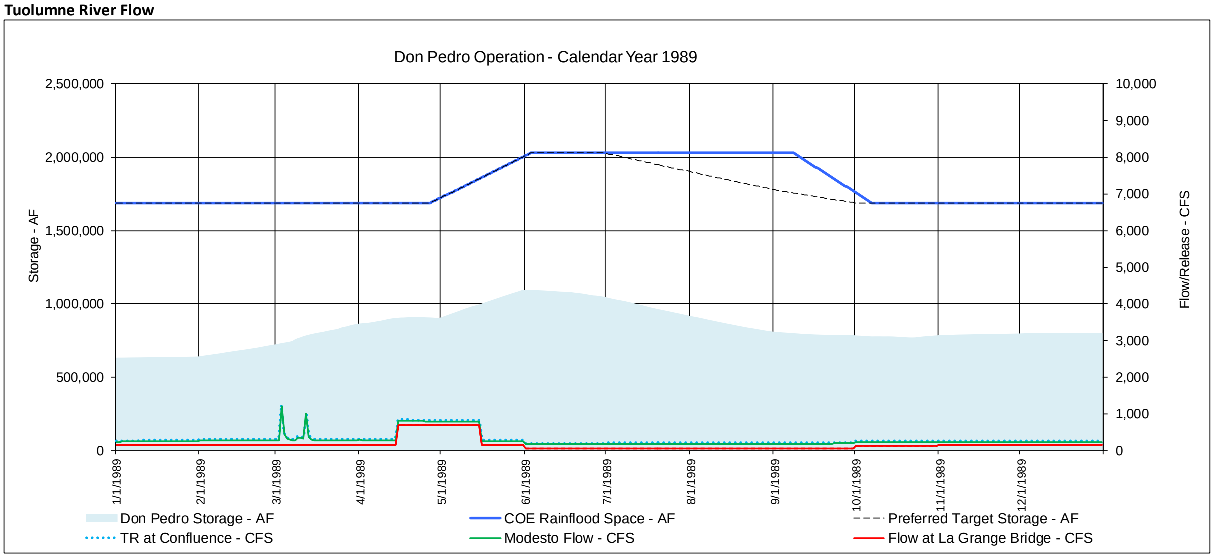


Figure 4-18. Don Pedro operations 1988 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

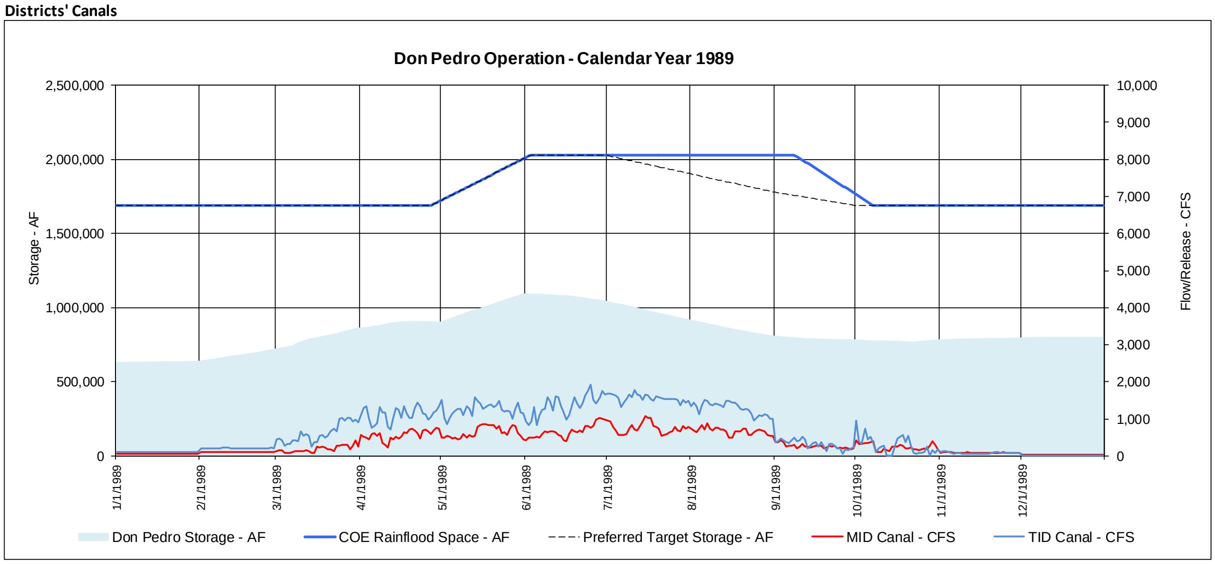
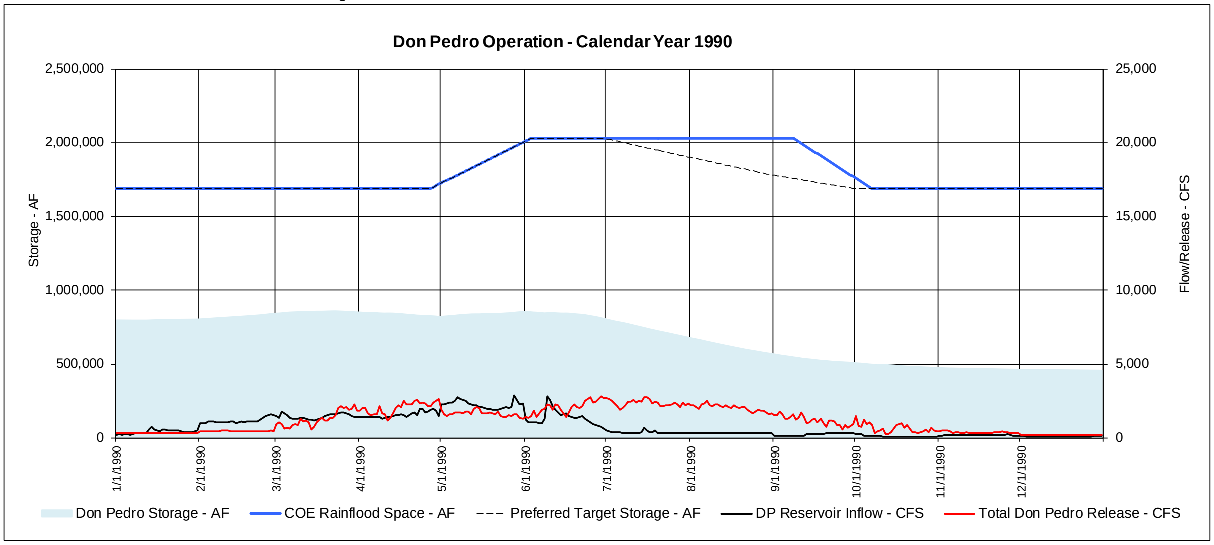
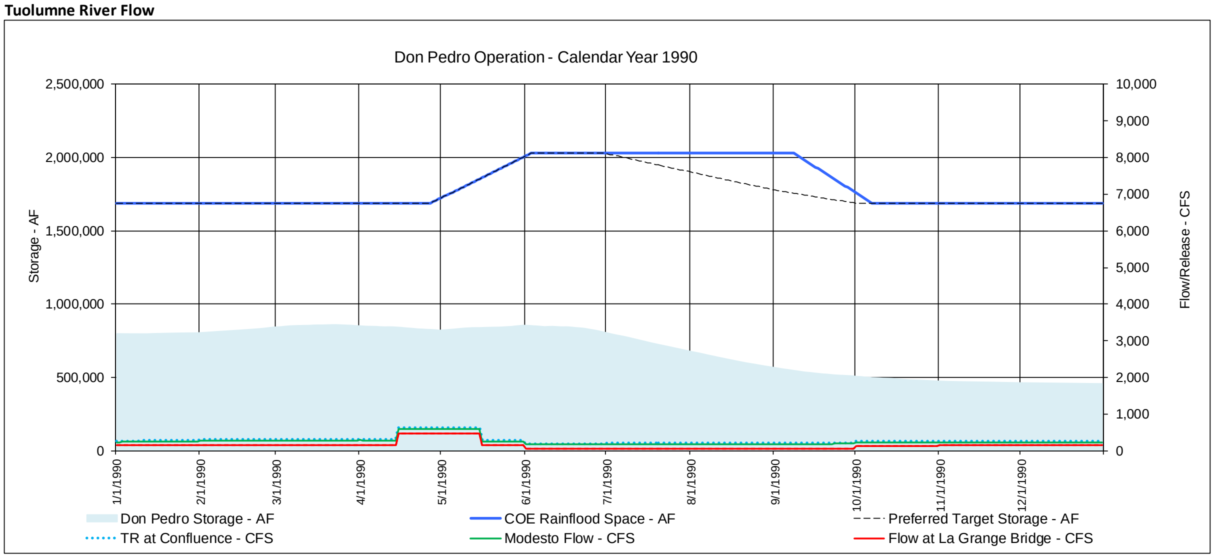


Figure 4-19. Don Pedro operations 1989 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

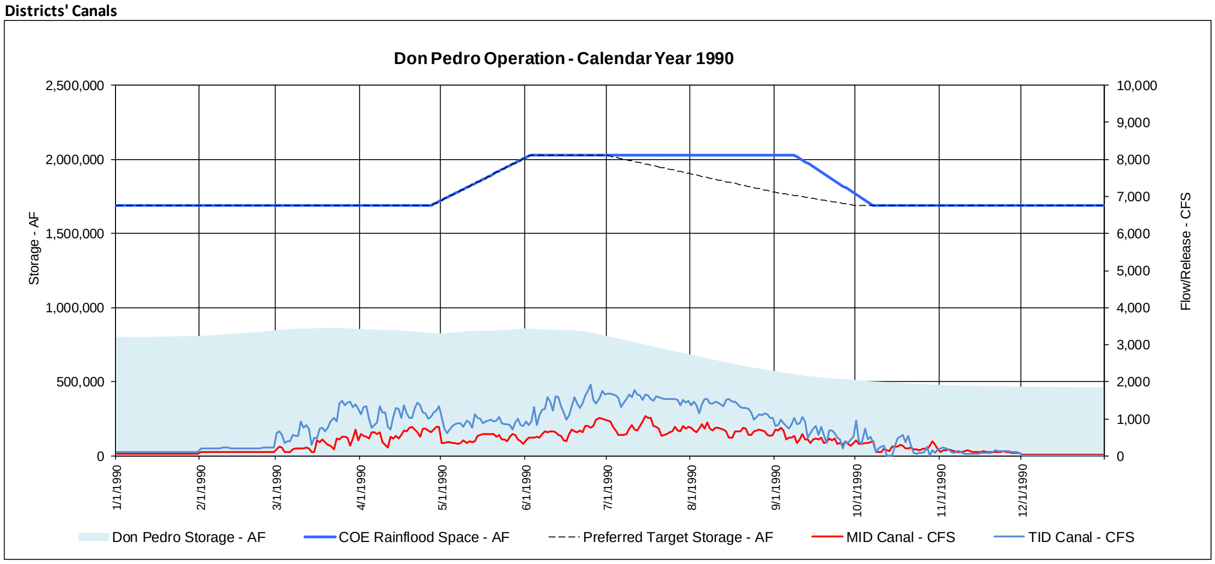
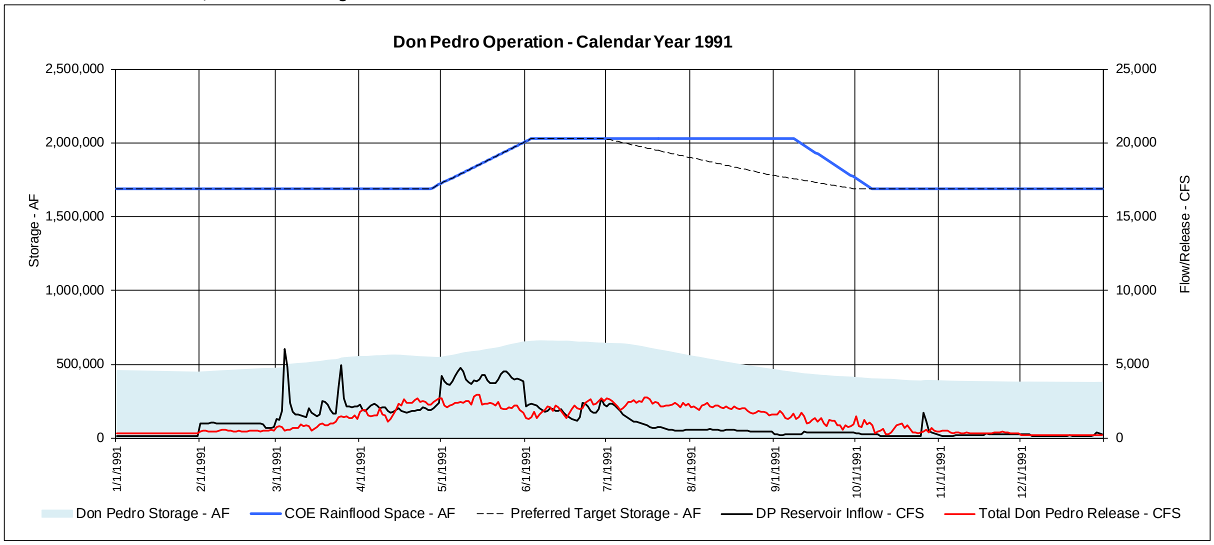
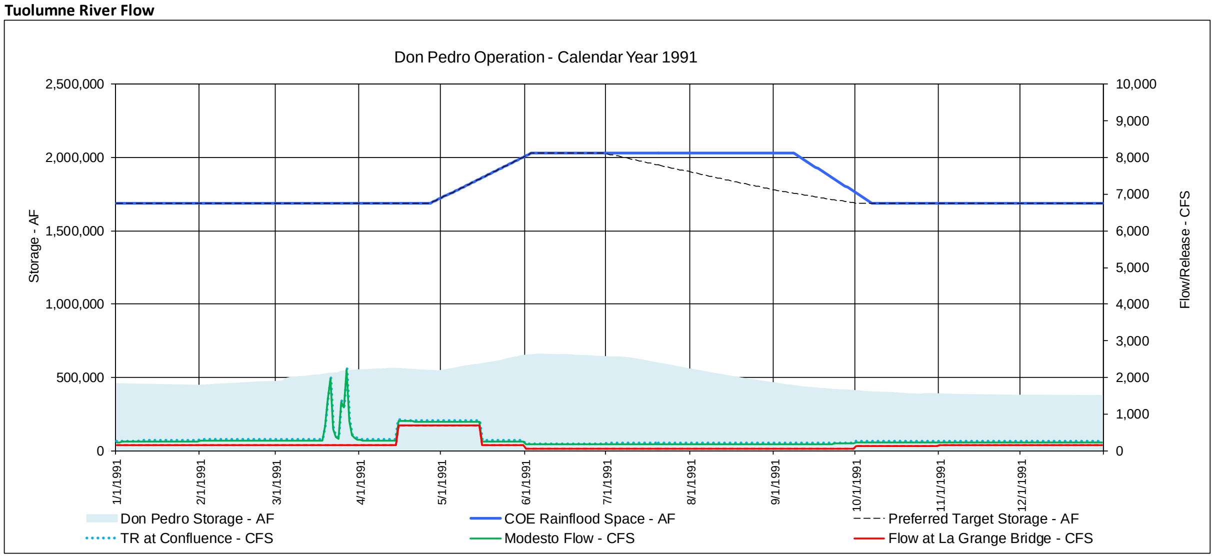


Figure 4-20. Don Pedro operations 1990 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

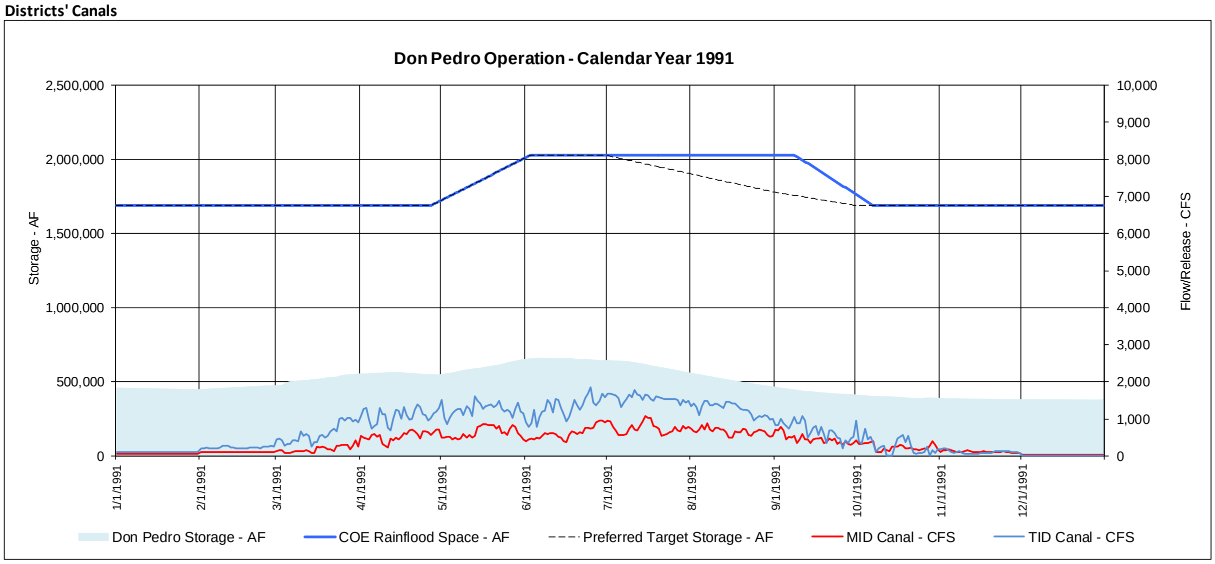
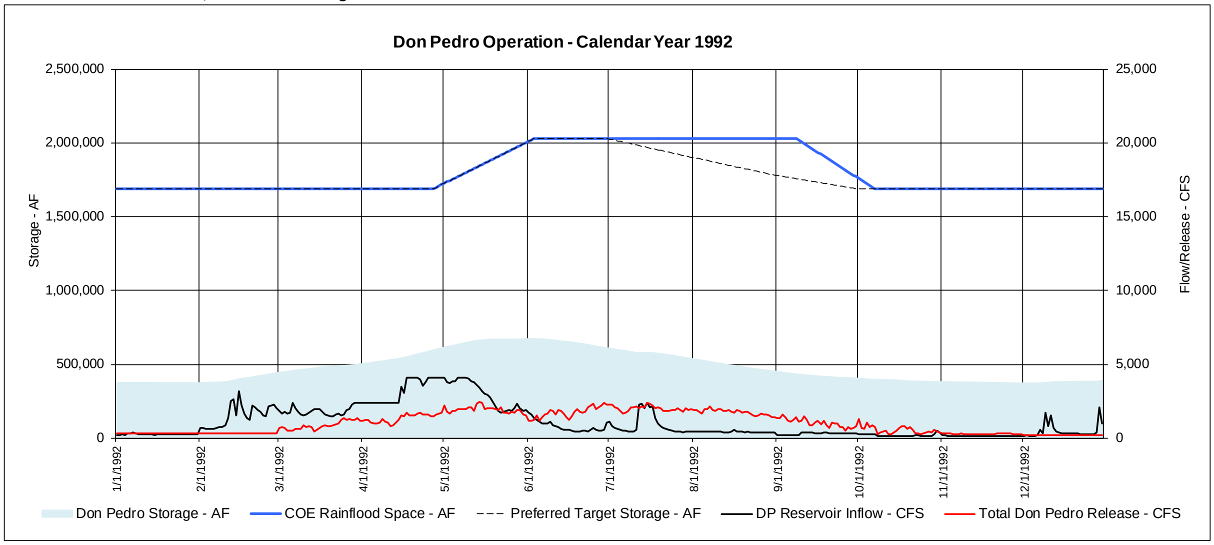
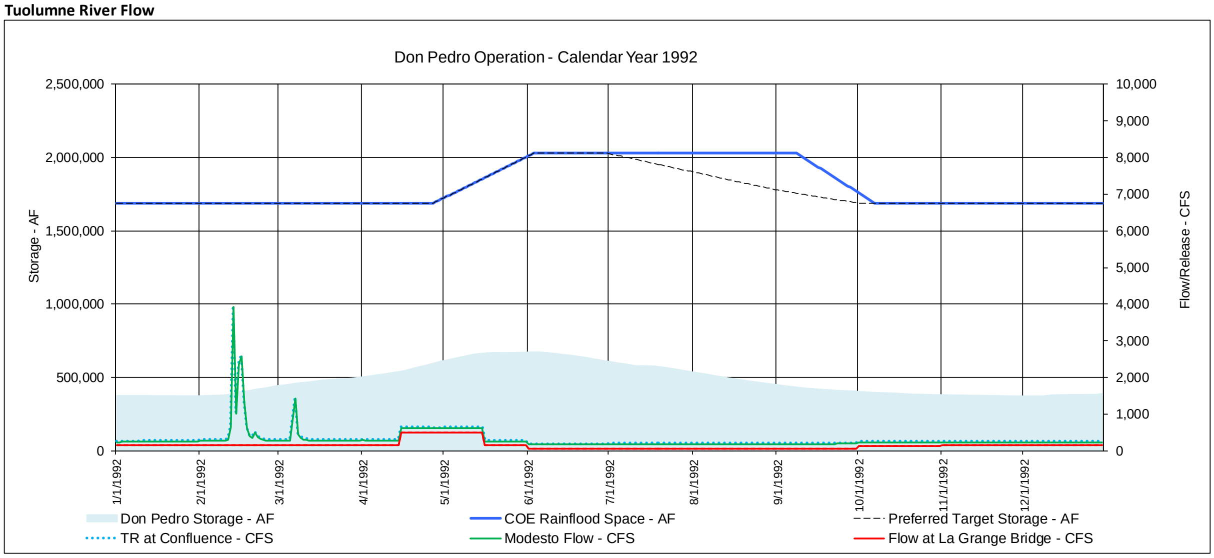


Figure 4-21. Don Pedro operations 1991 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

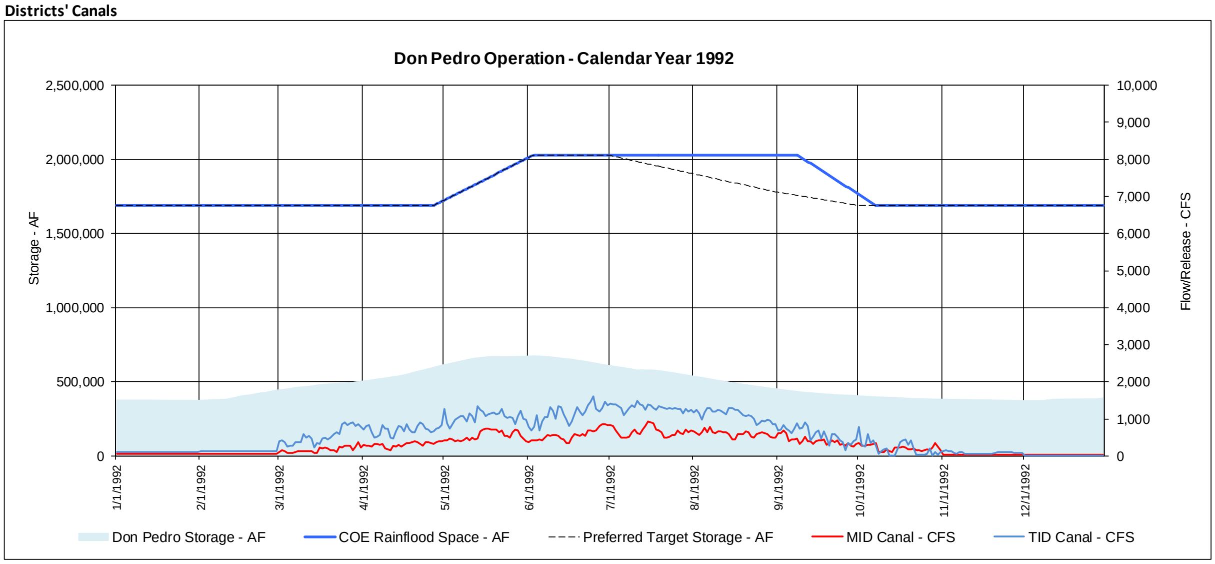


Figure 4-22 Don Pedro operations 1992 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage

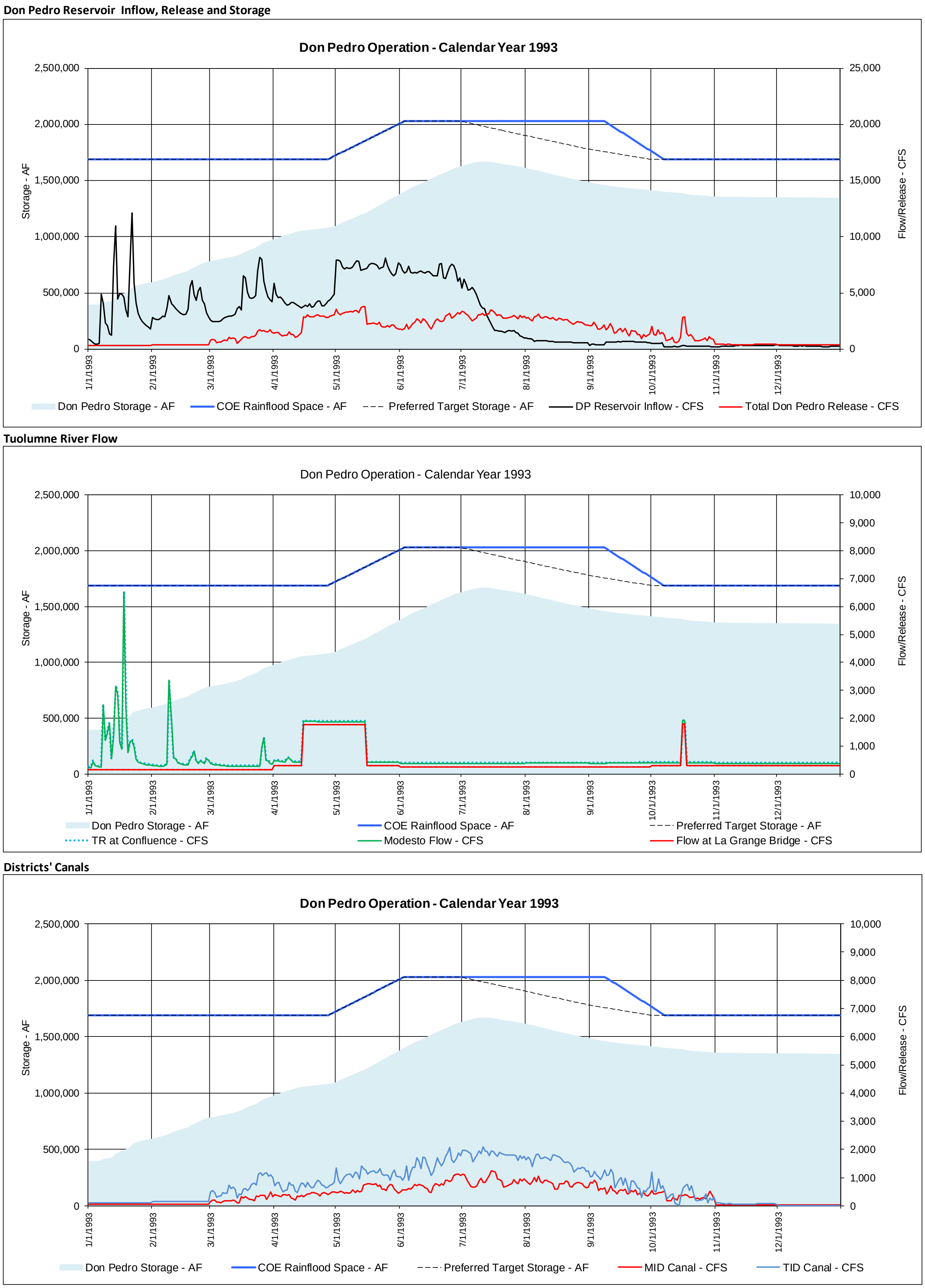
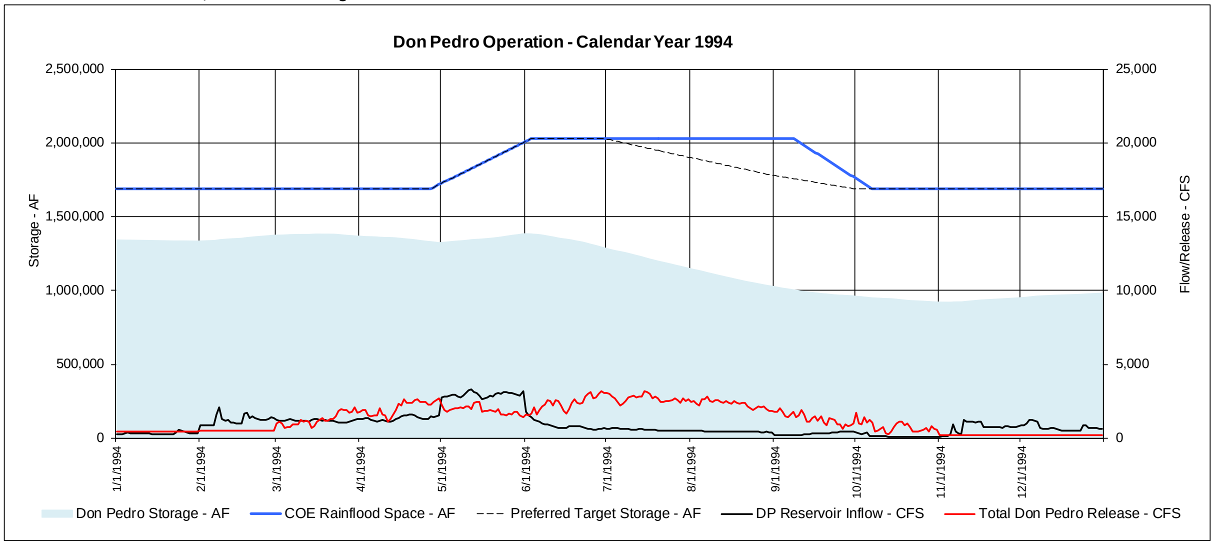
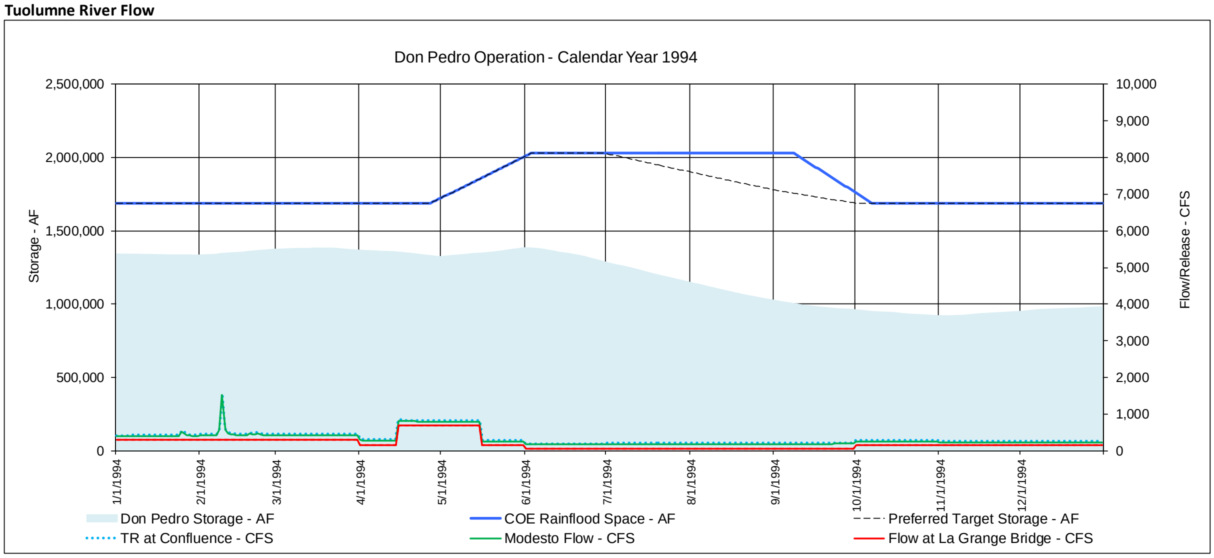


Figure 4-23. Don Pedro operations 1993 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

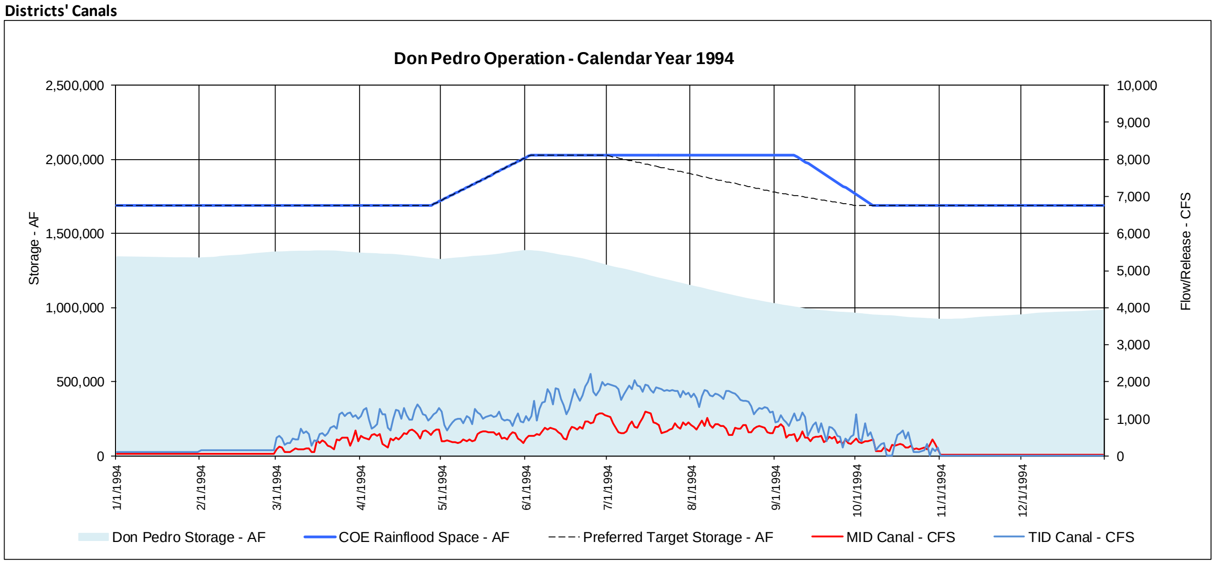
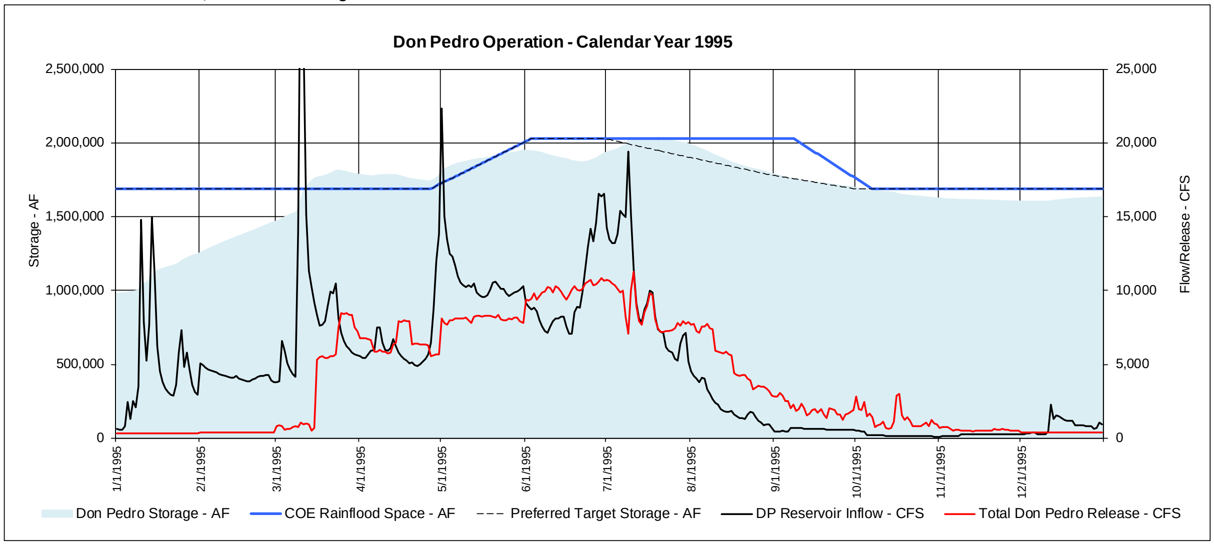
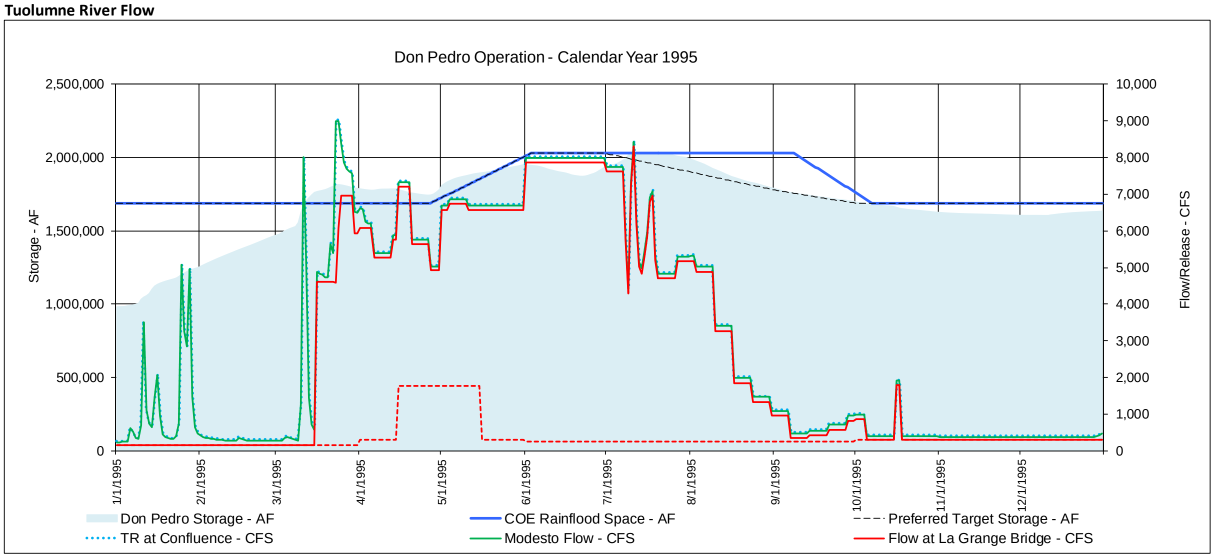


Figure 4-24. Don Pedro operations 1994 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

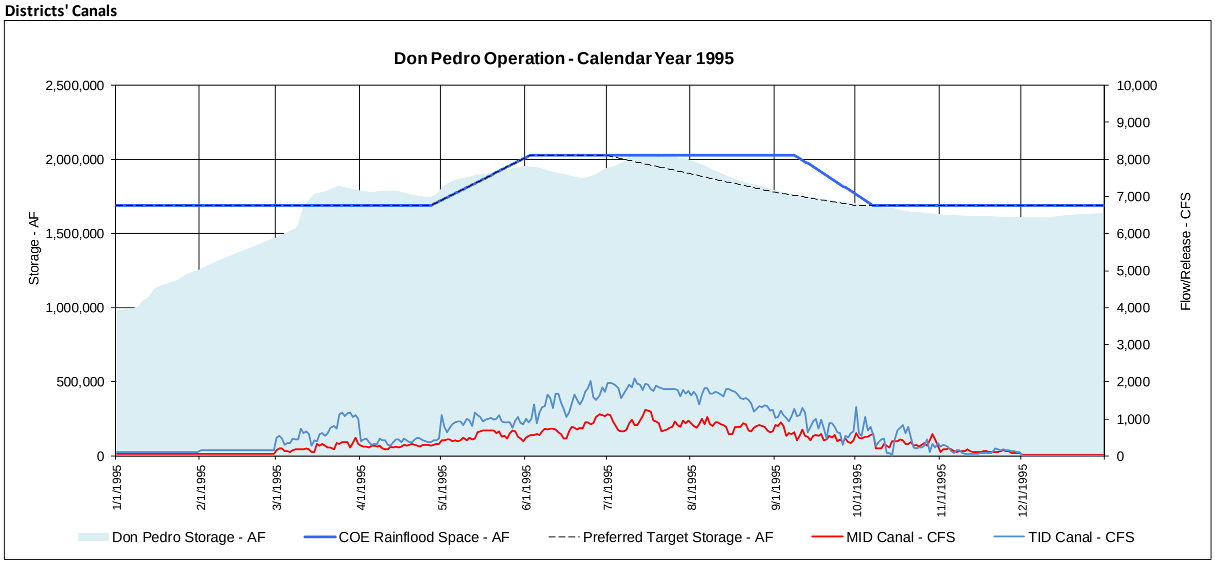
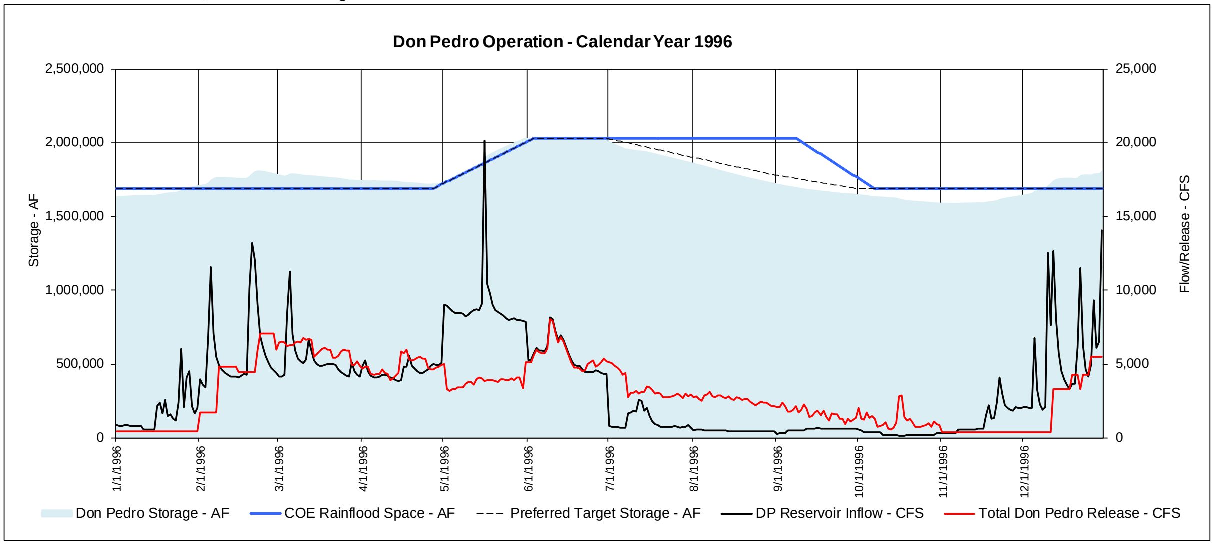
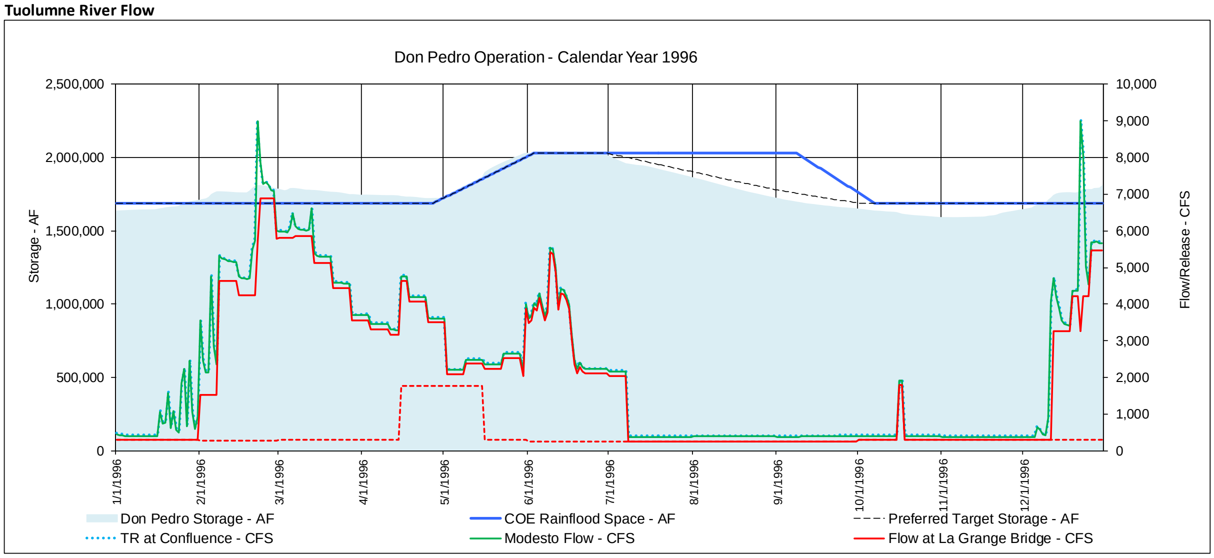


Figure 4-25. Don Pedro operations 1995 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

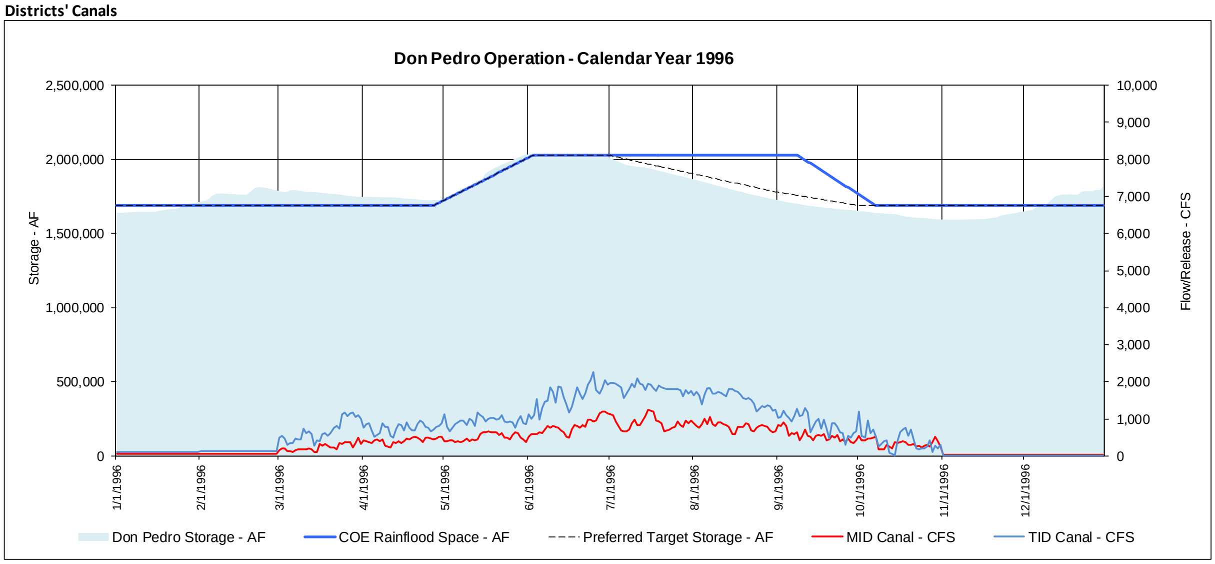
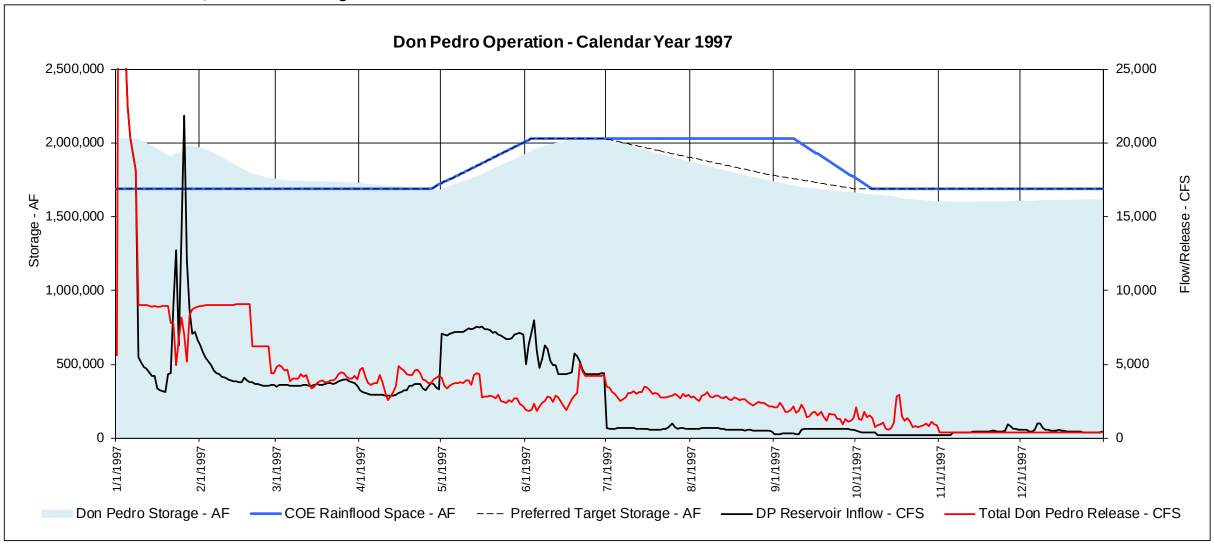
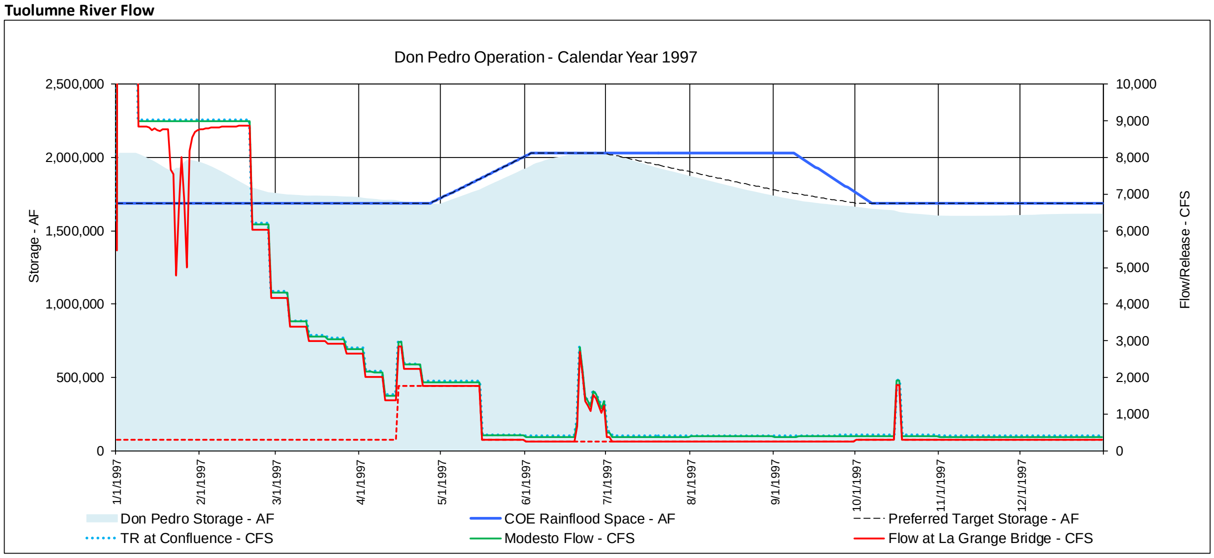


Figure 4-26. Don Pedro operations 1996 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

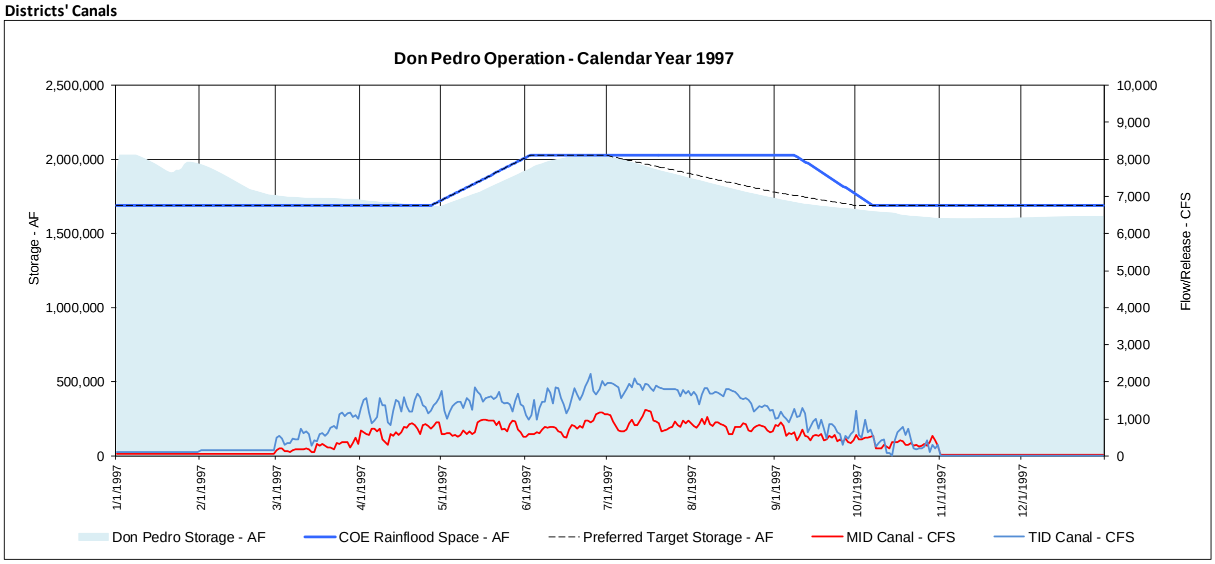
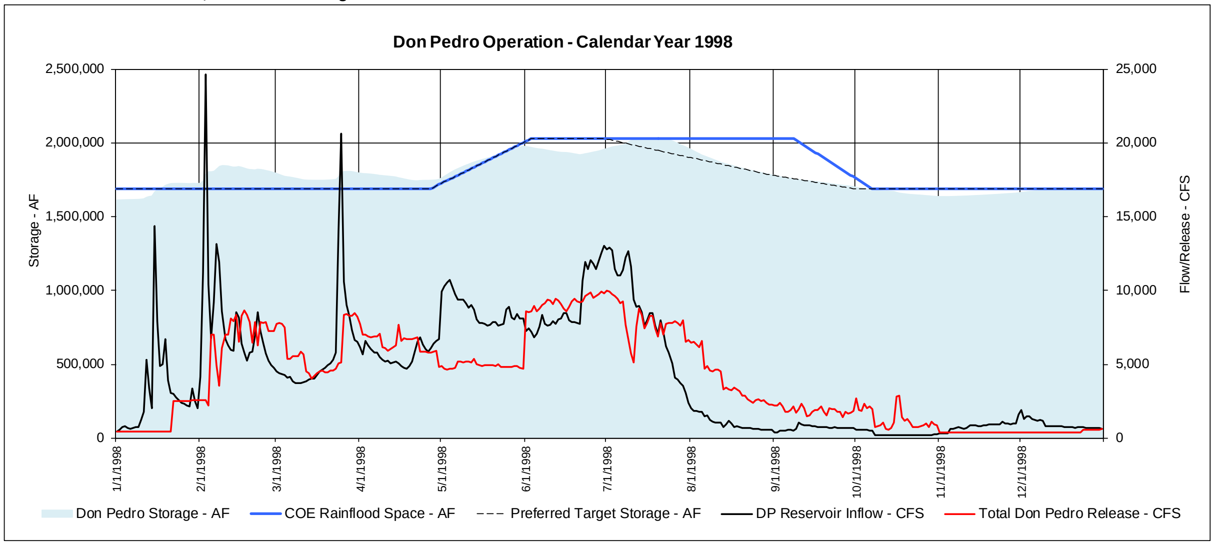
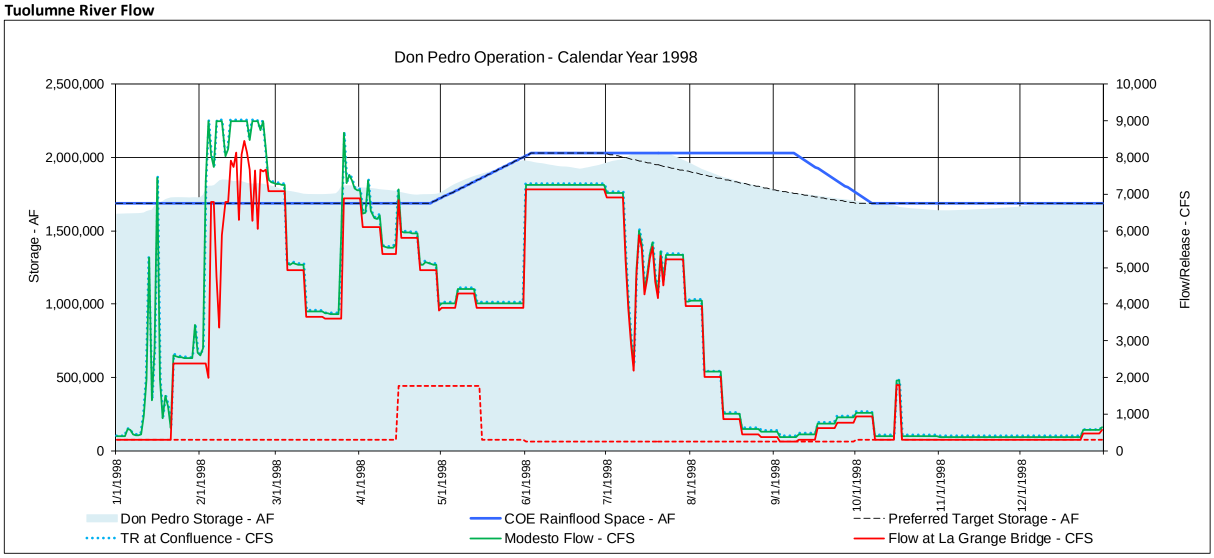


Figure 4-27. Don Pedro operations 1997 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

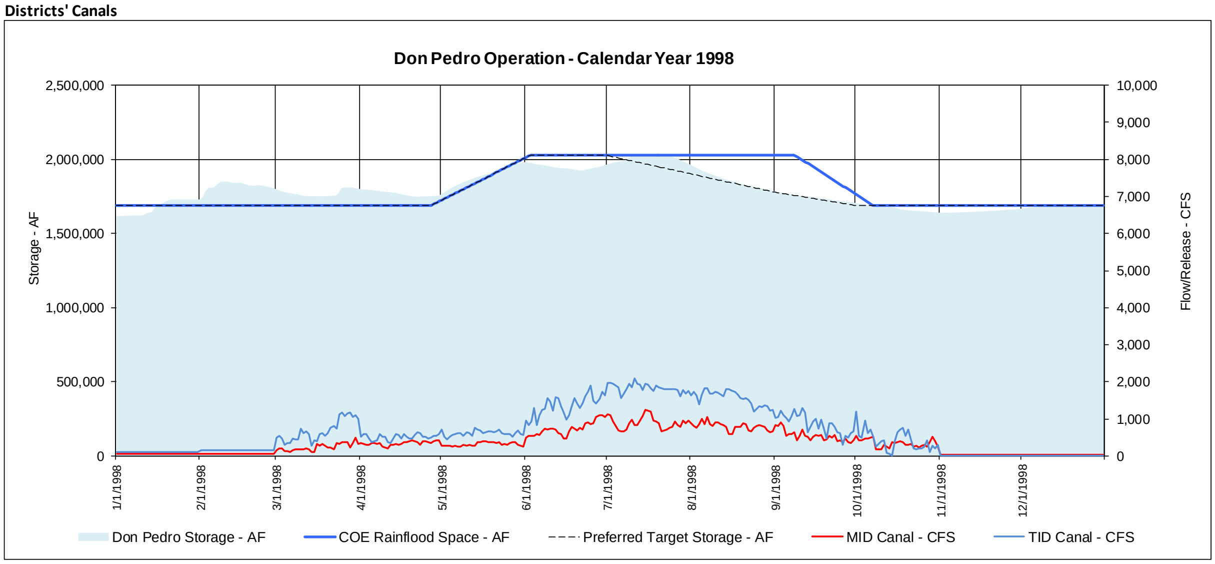
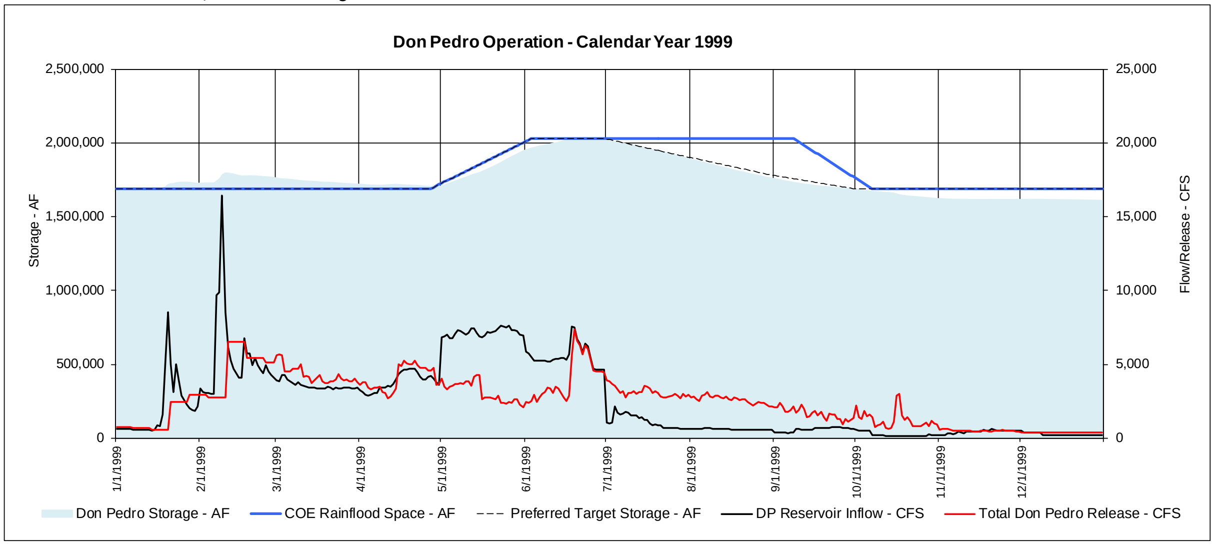
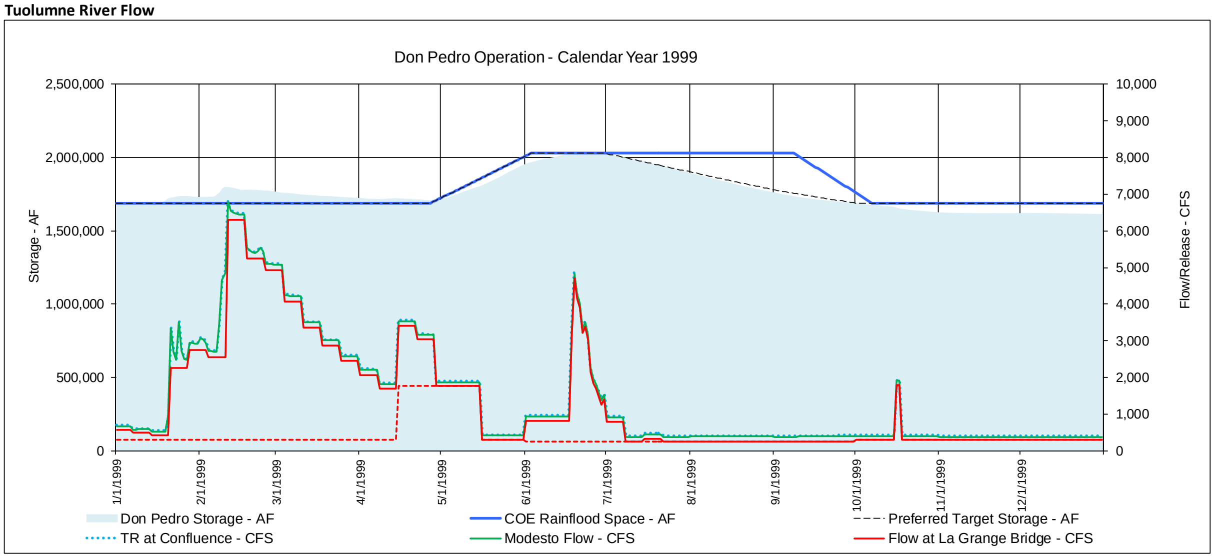


Figure 4-28. Don Pedro operations 1998 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

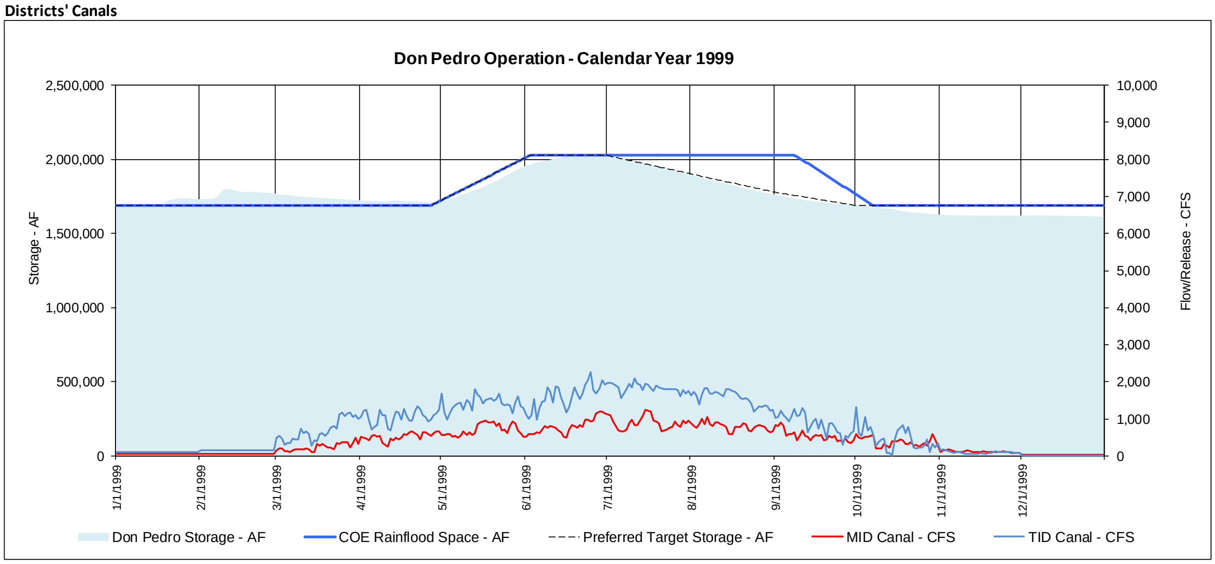
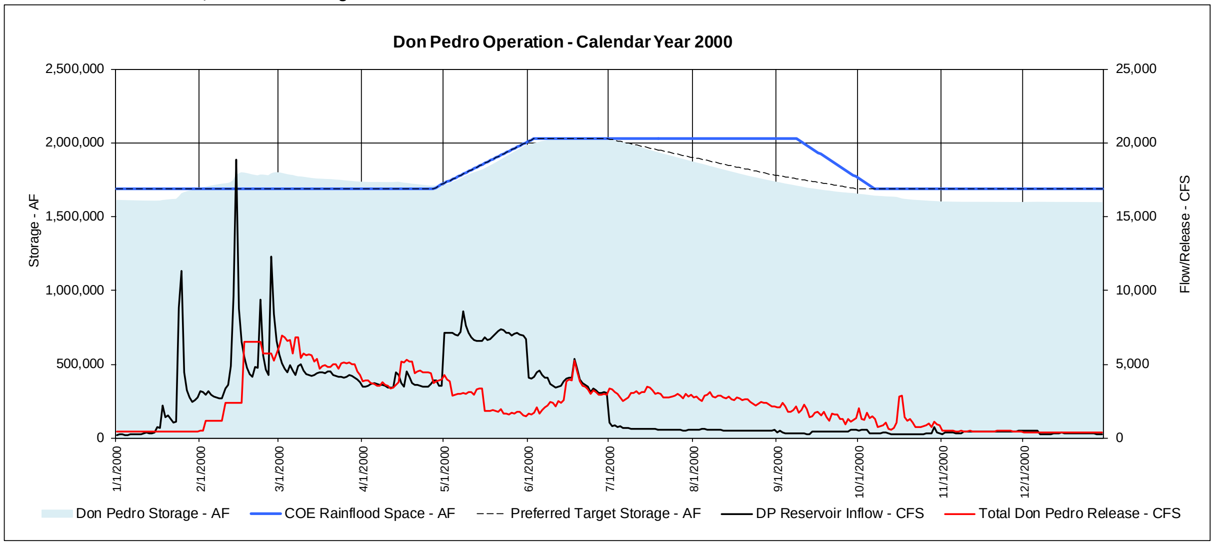
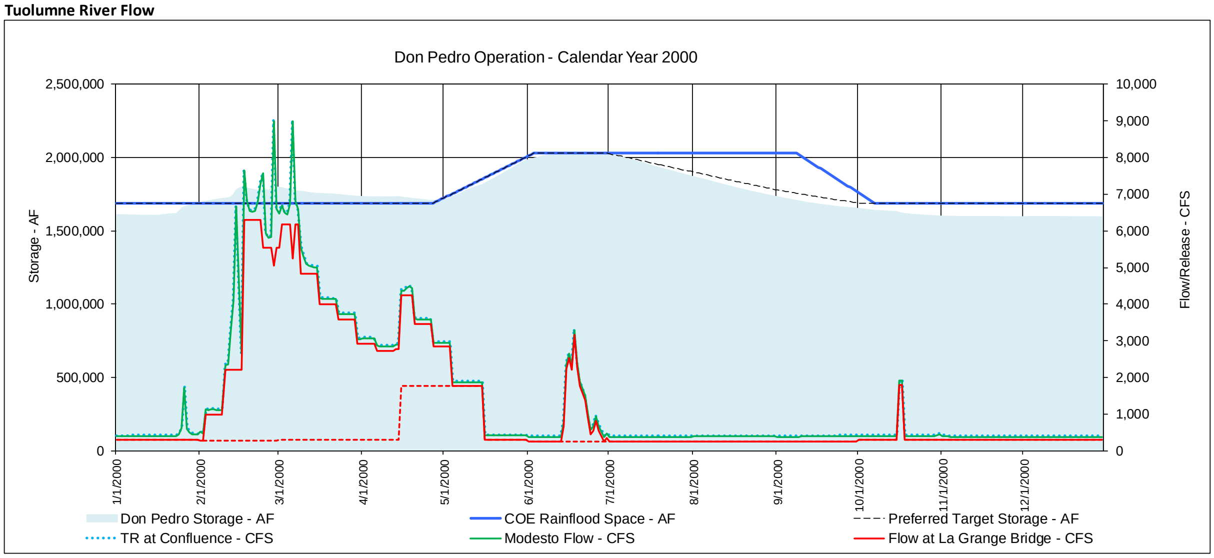


Figure 4-29. Don Pedro operations 1999 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

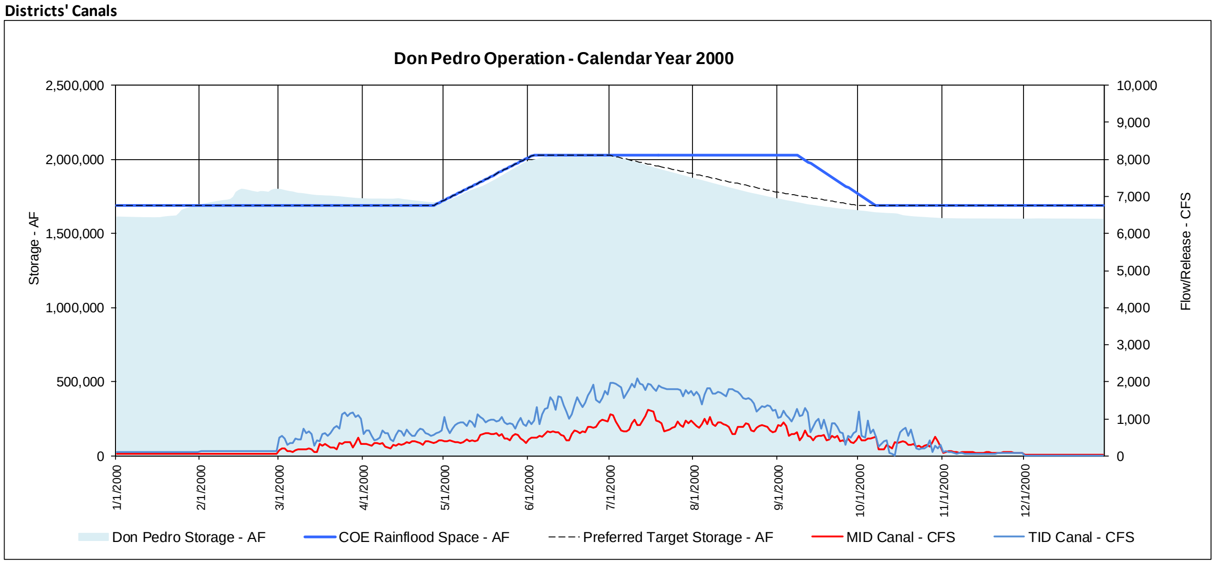
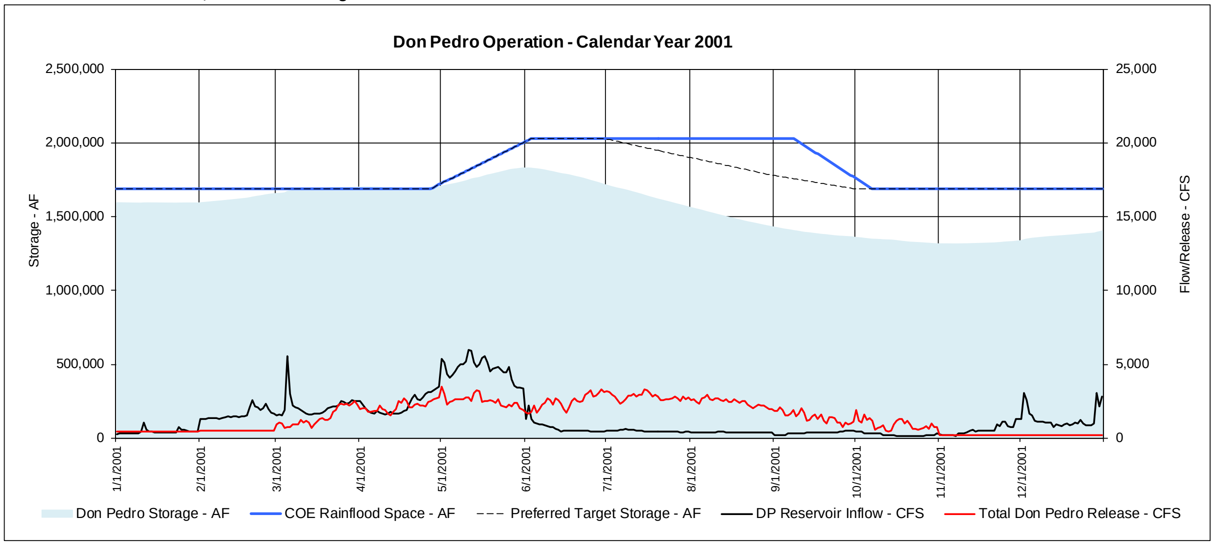
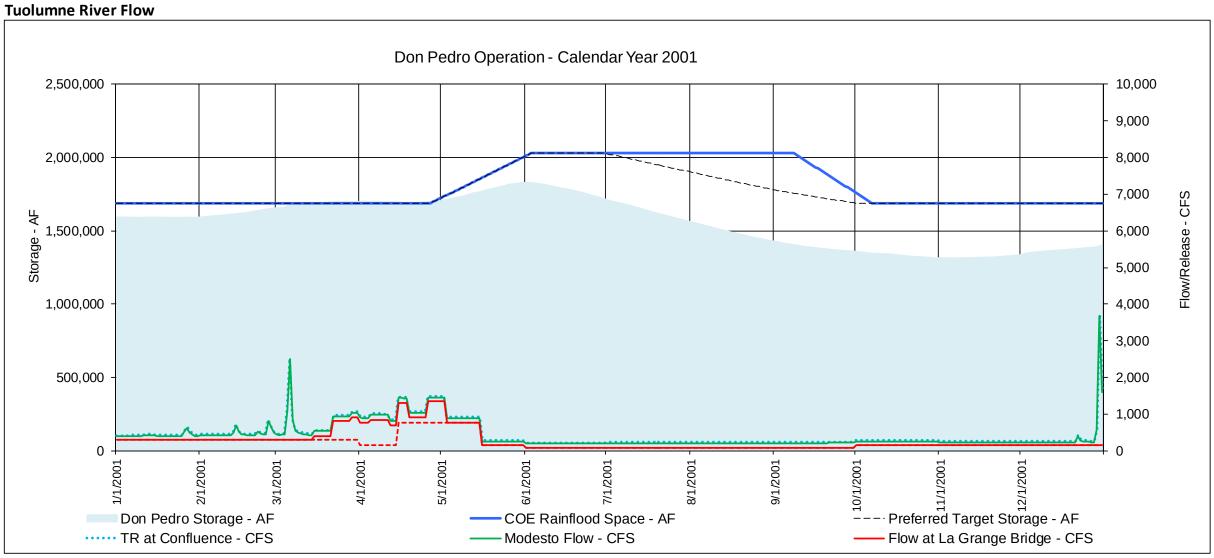


Figure 4-30. Don Pedro operations 2000 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

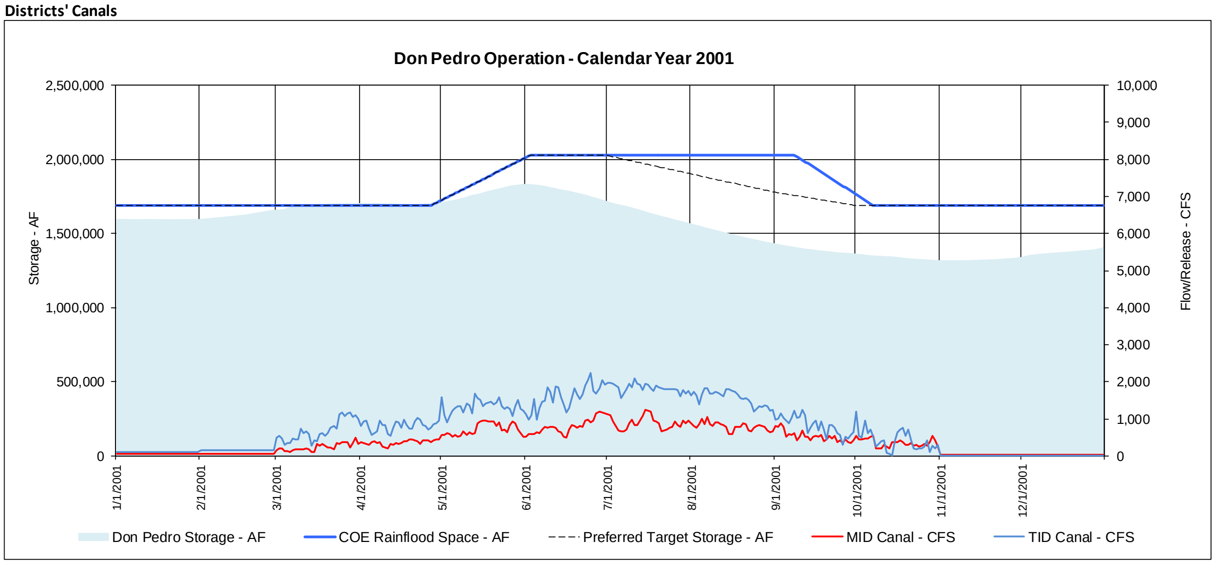
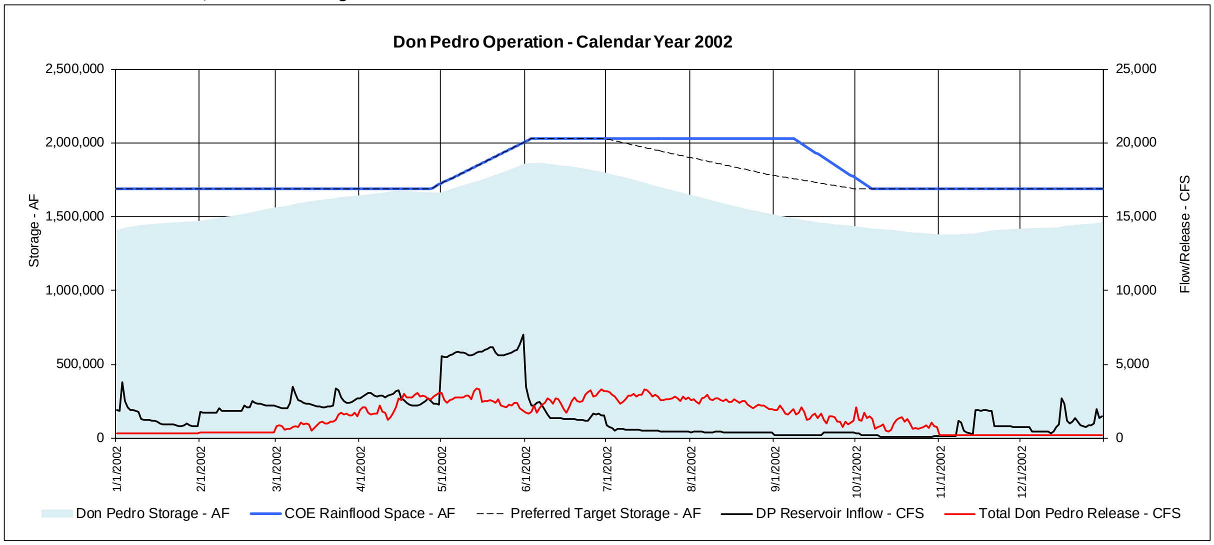
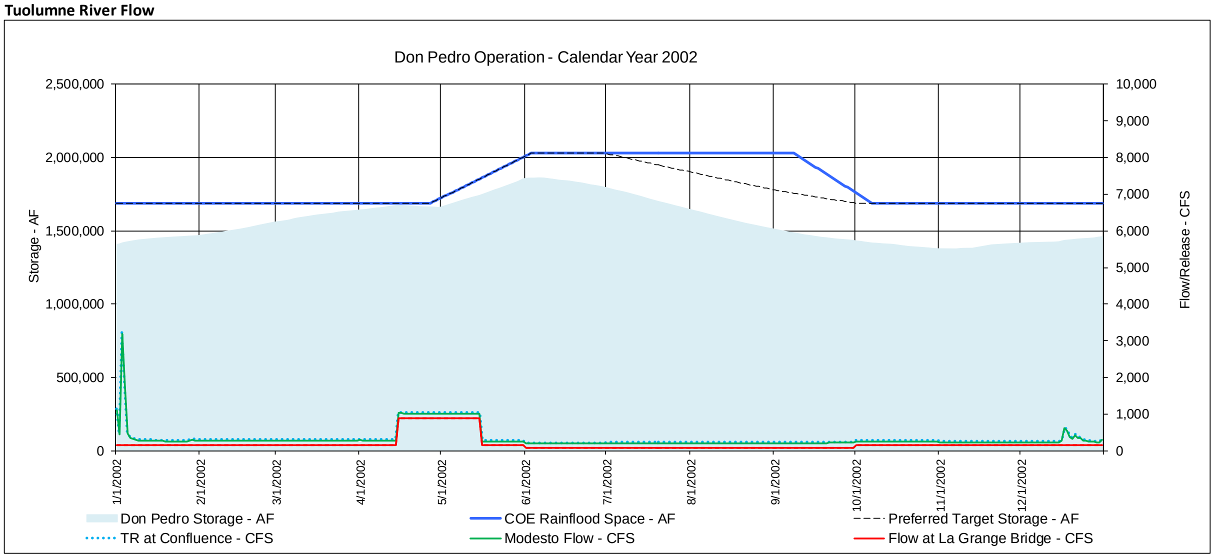


Figure 4-31. Don Pedro operations 2001 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

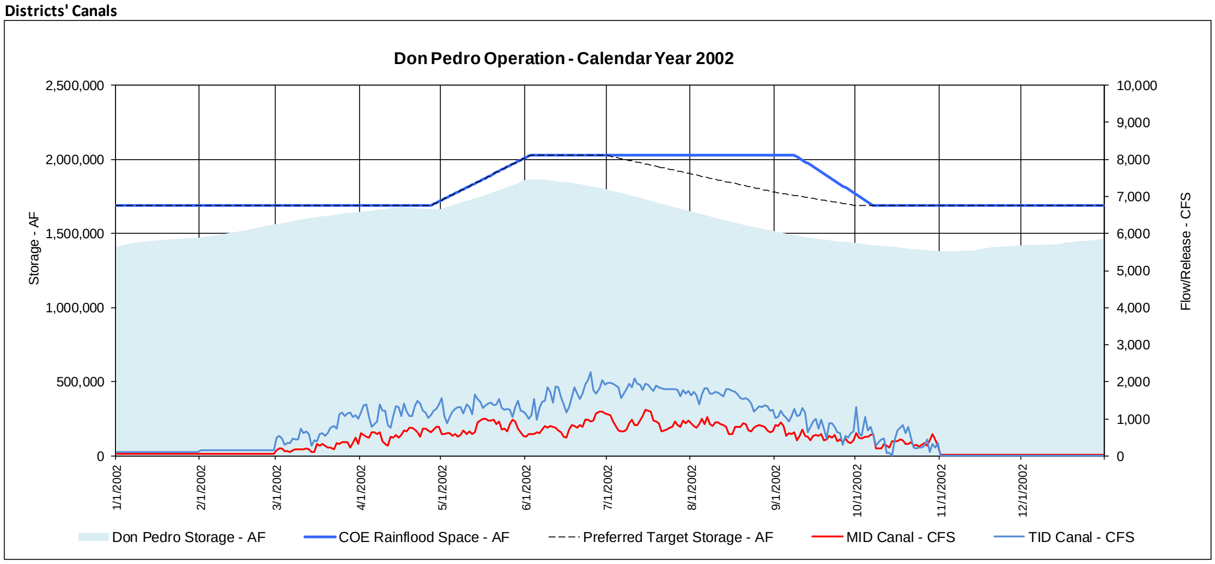
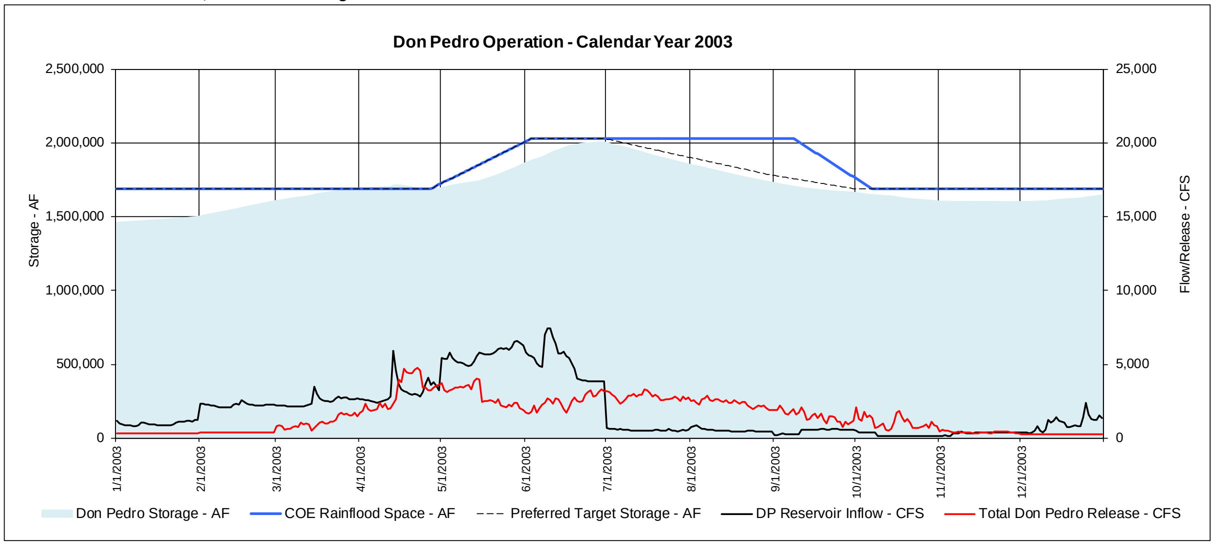
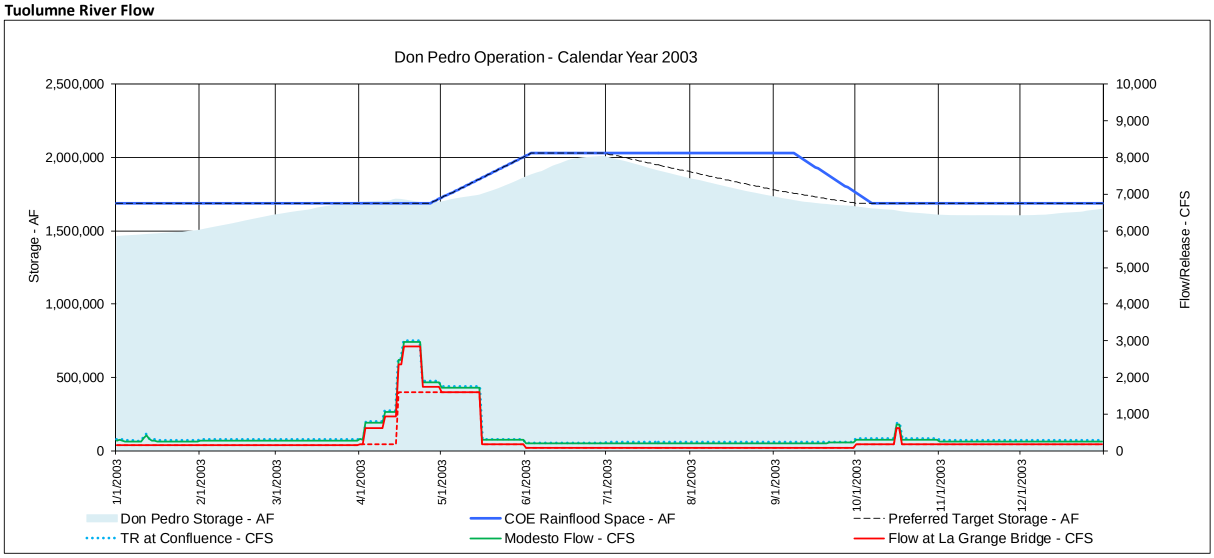


Figure 4-32. Don Pedro operations 2002 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

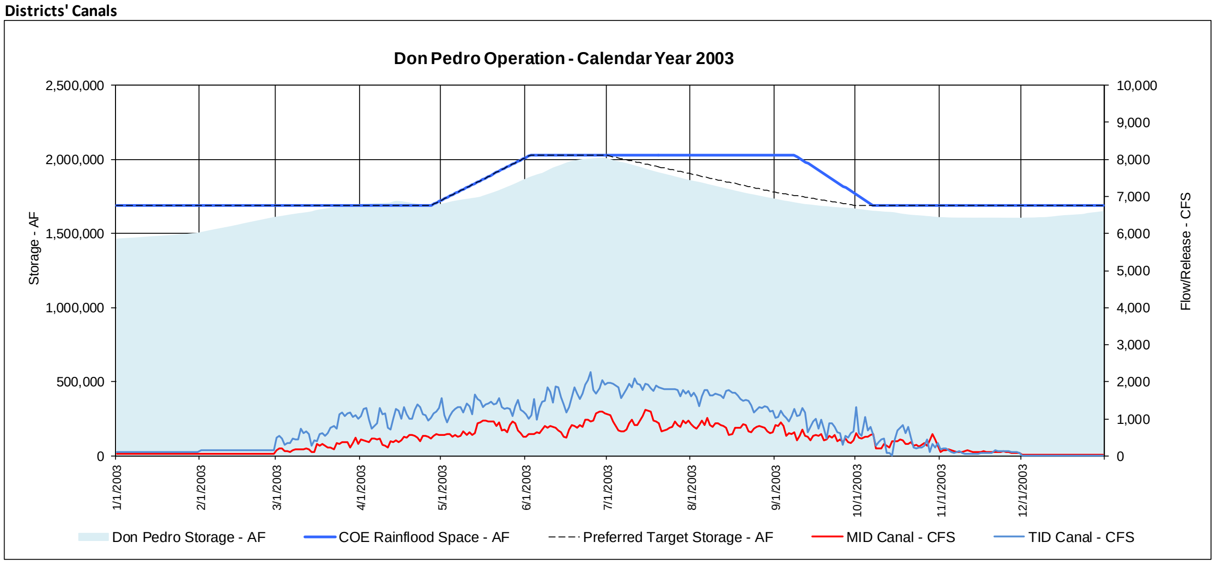


Figure 4-33. Don Pedro operations 2003 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage

Tuolumne River Flow

Districts' Canals

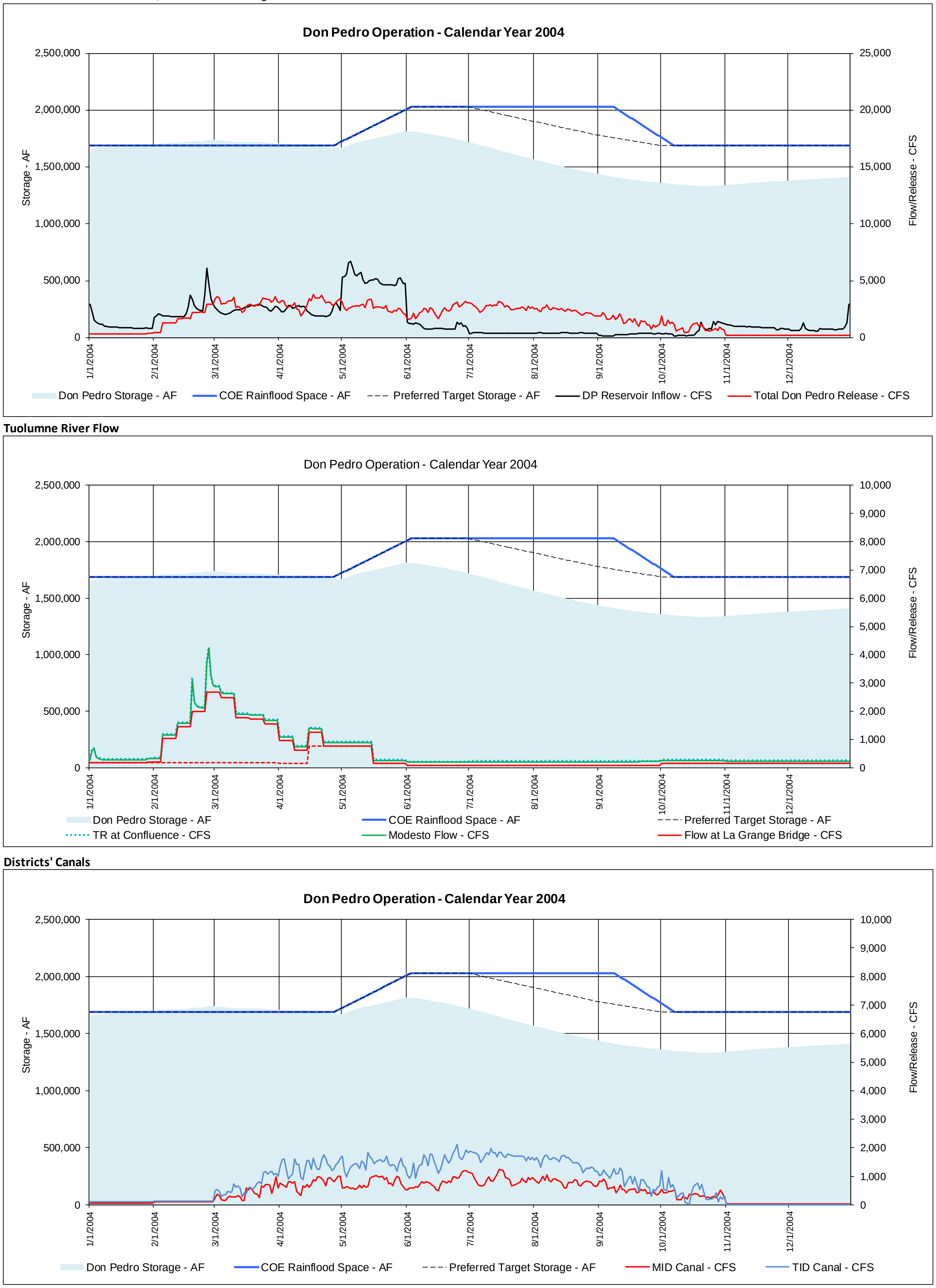
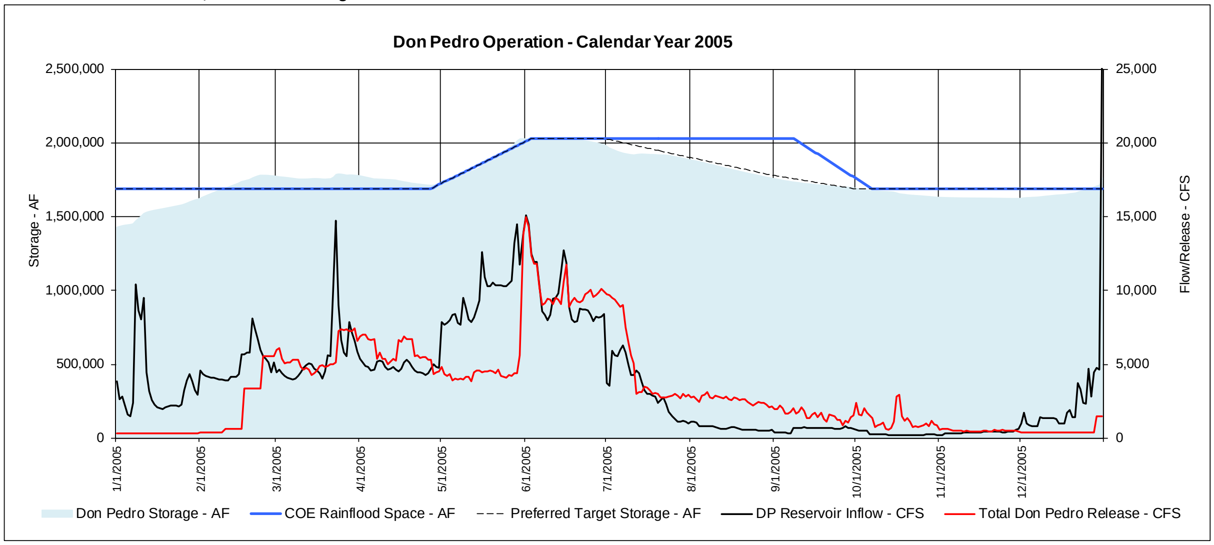
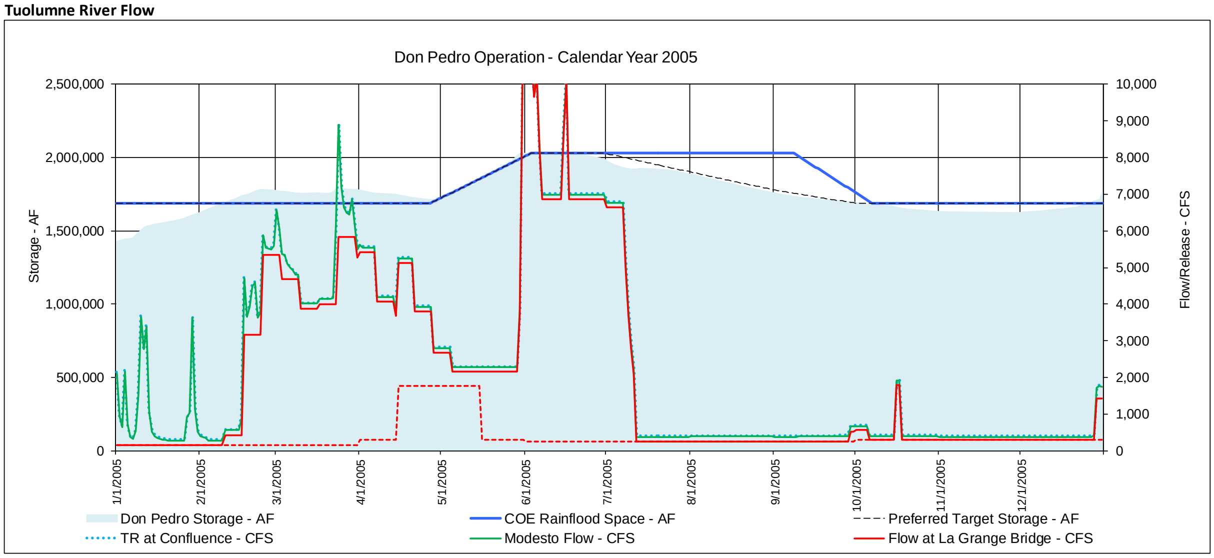


Figure 4-34. Don Pedro operations 2004 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

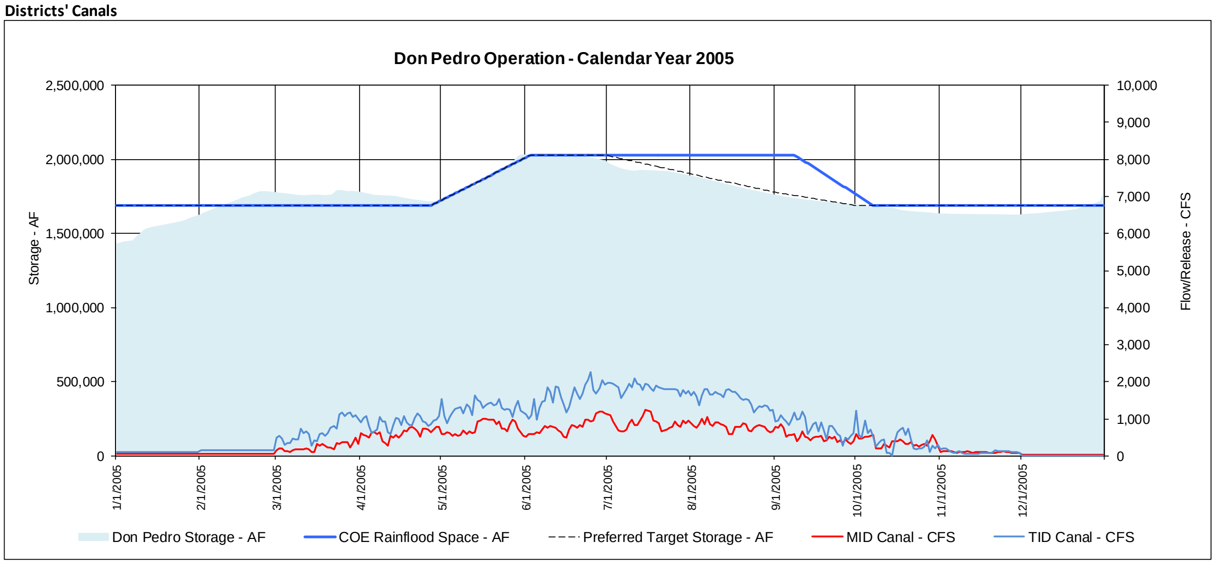
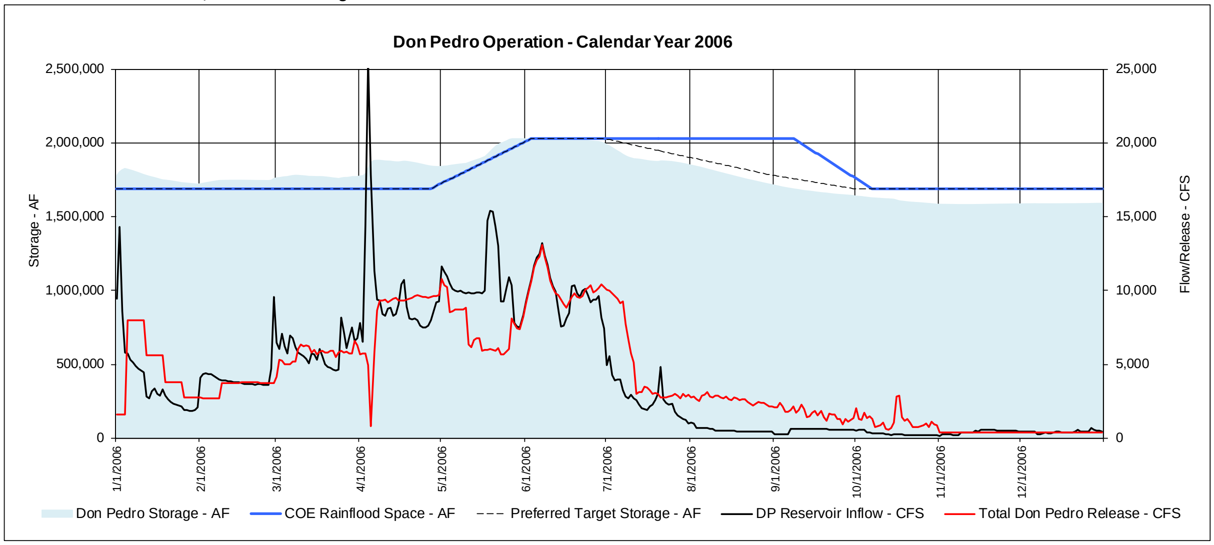
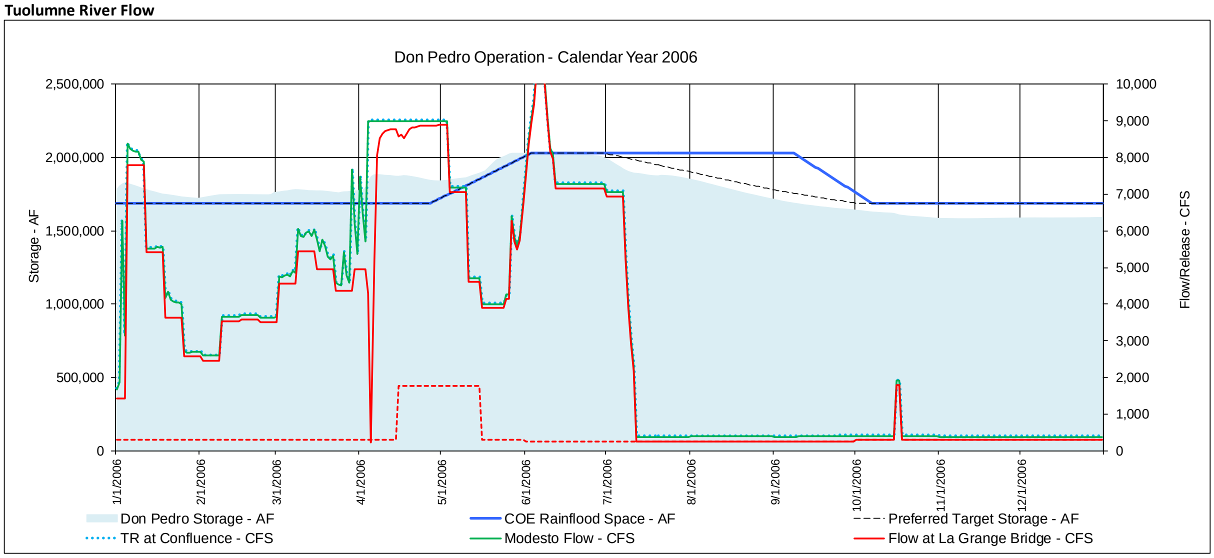


Figure 4-35. Don Pedro operations 2005 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

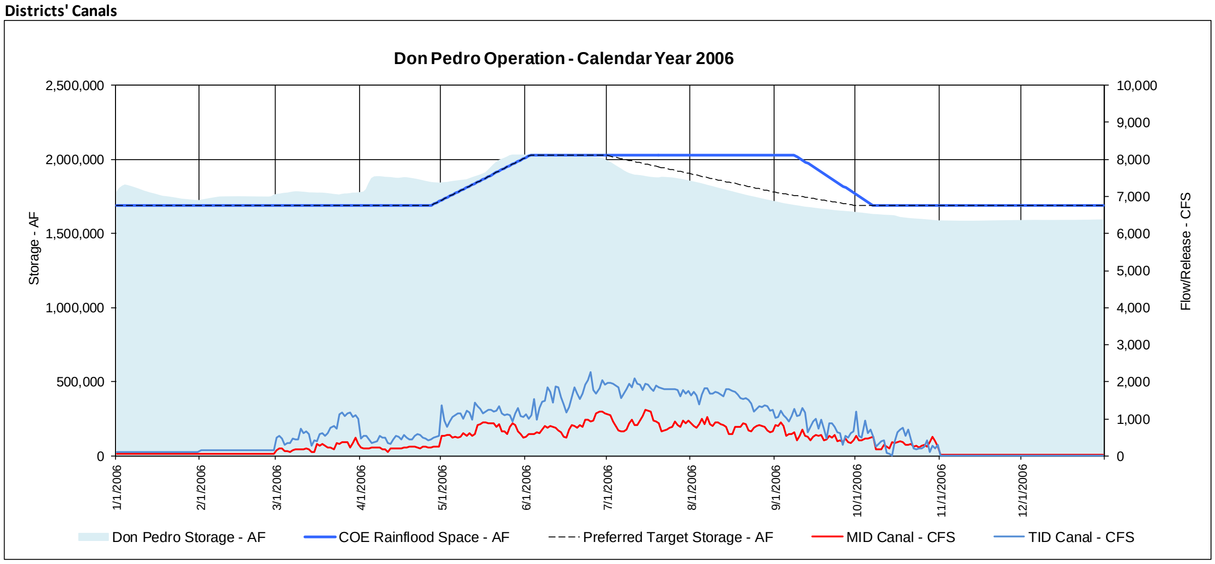
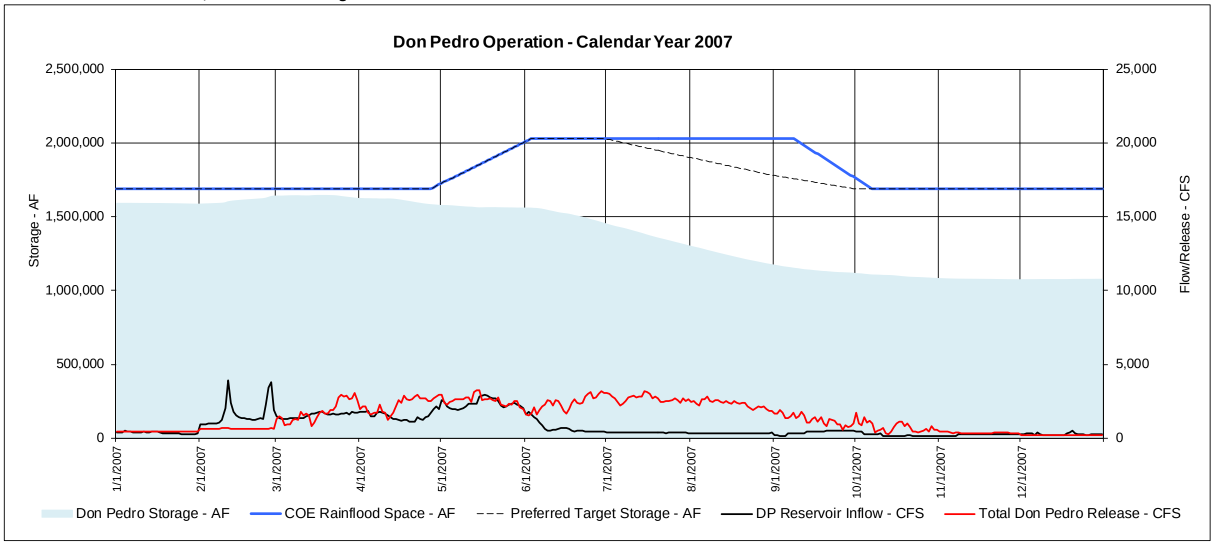
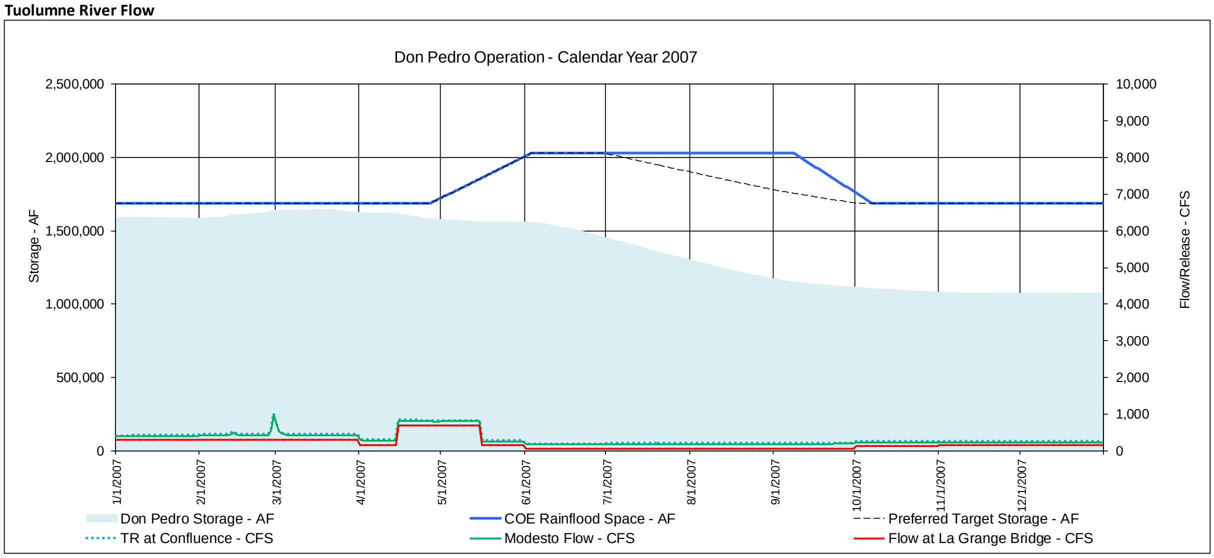


Figure 4-36. Don Pedro operations 2006 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

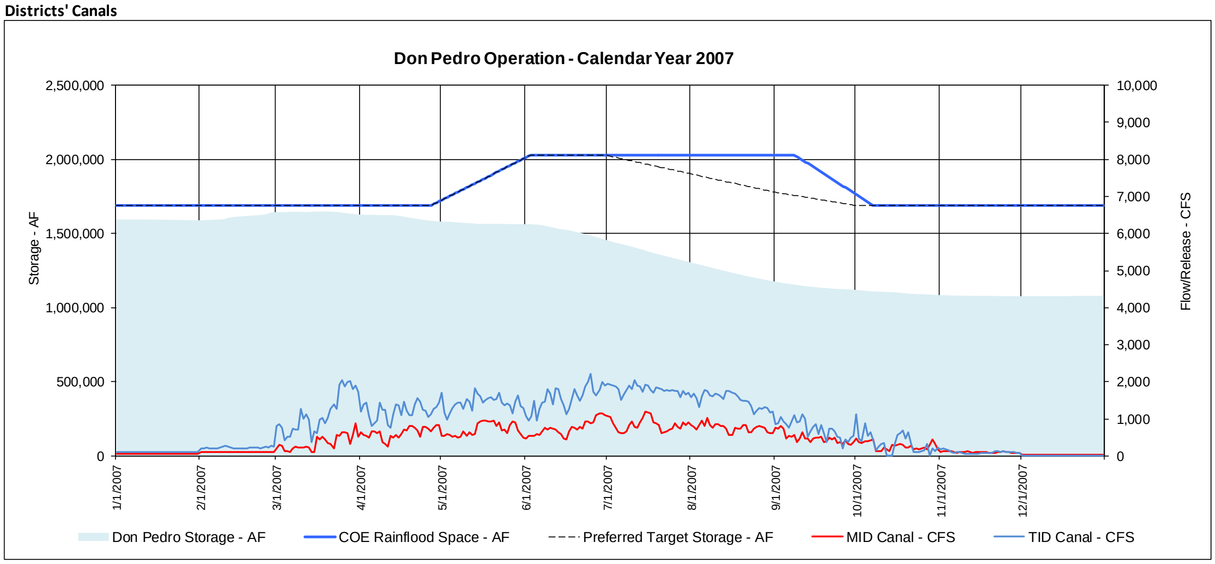
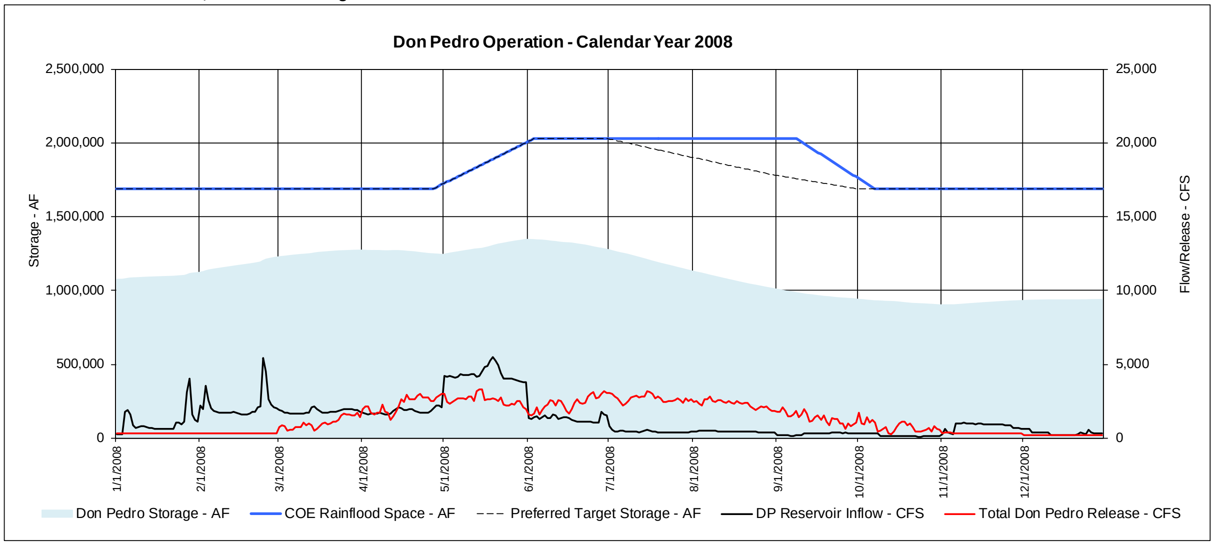
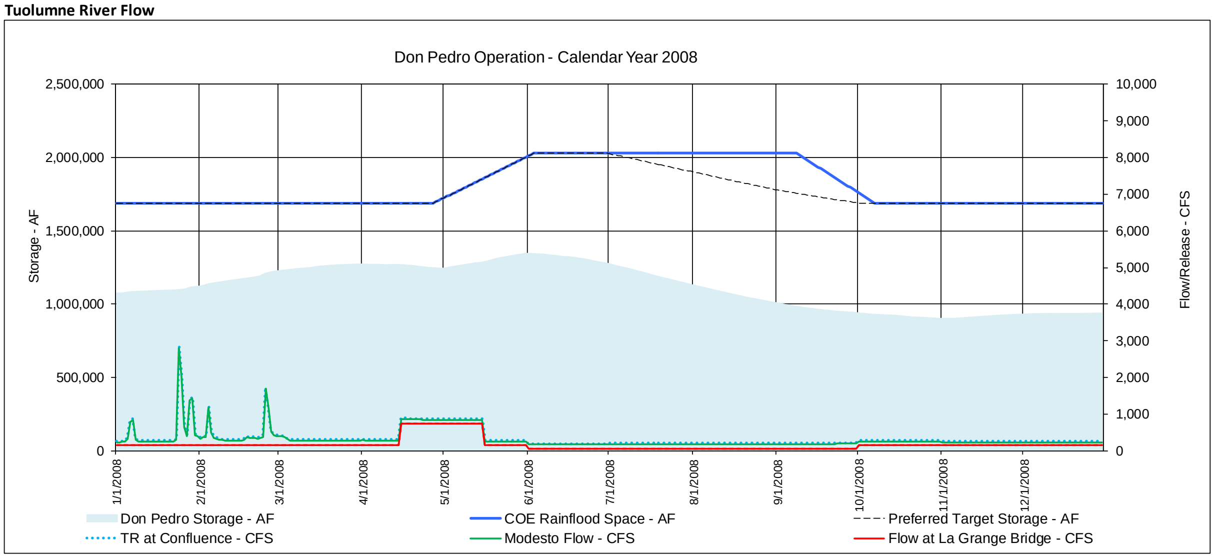


Figure 4-37. Don Pedro operations 2007 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

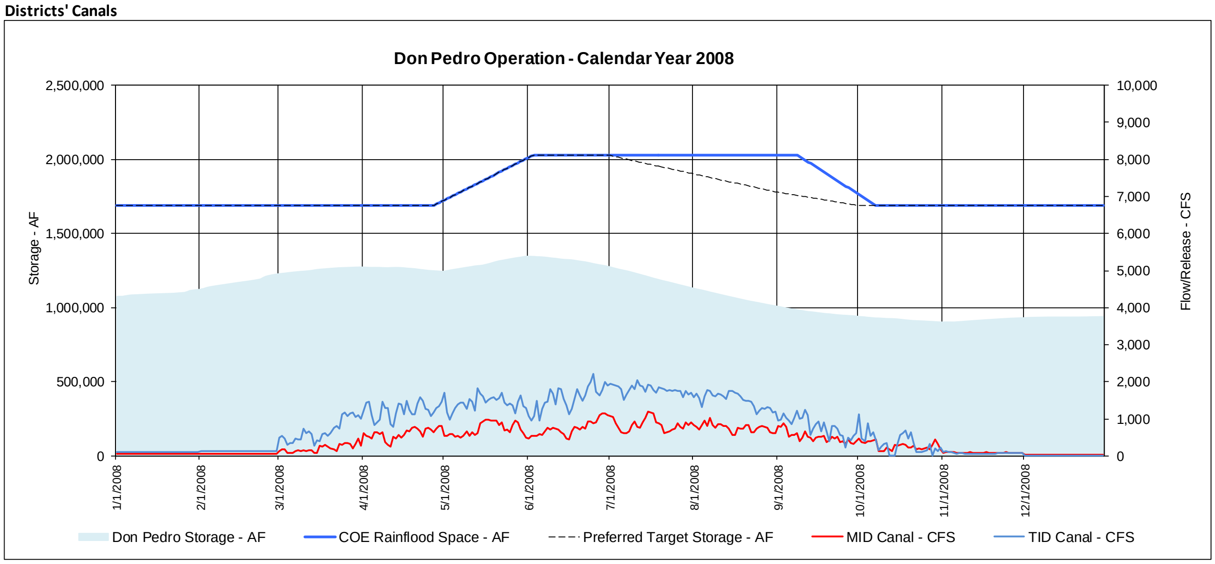
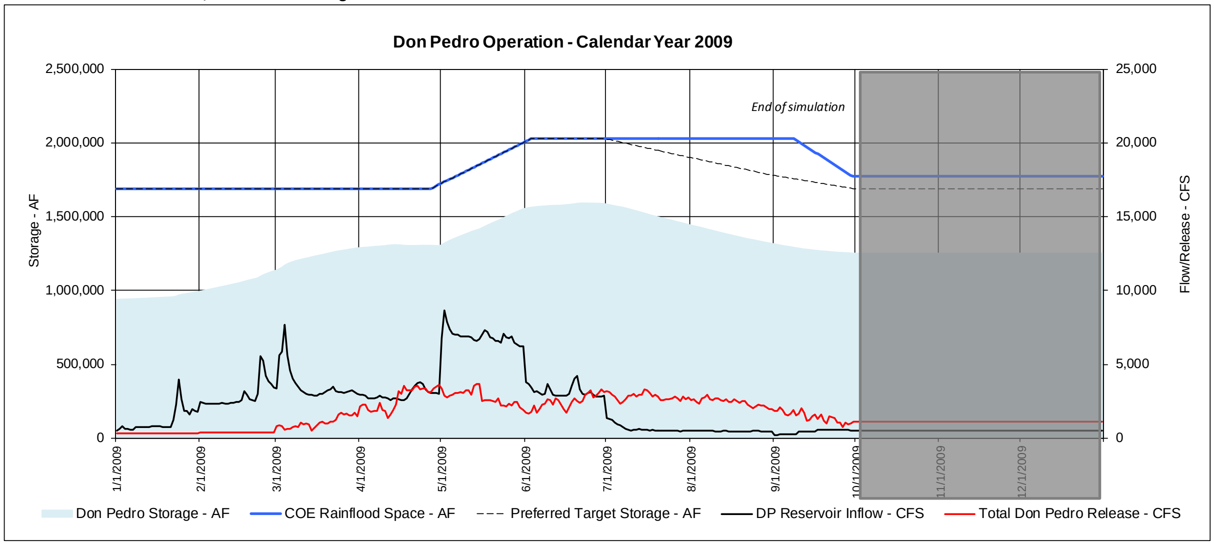
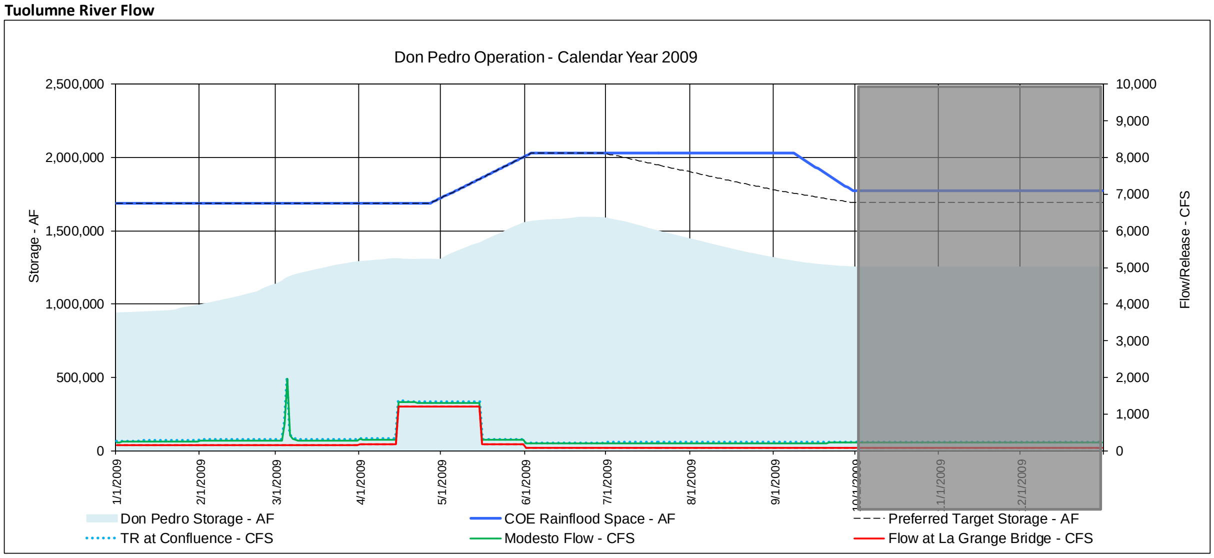


Figure 4-38. Don Pedro operations 2008 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

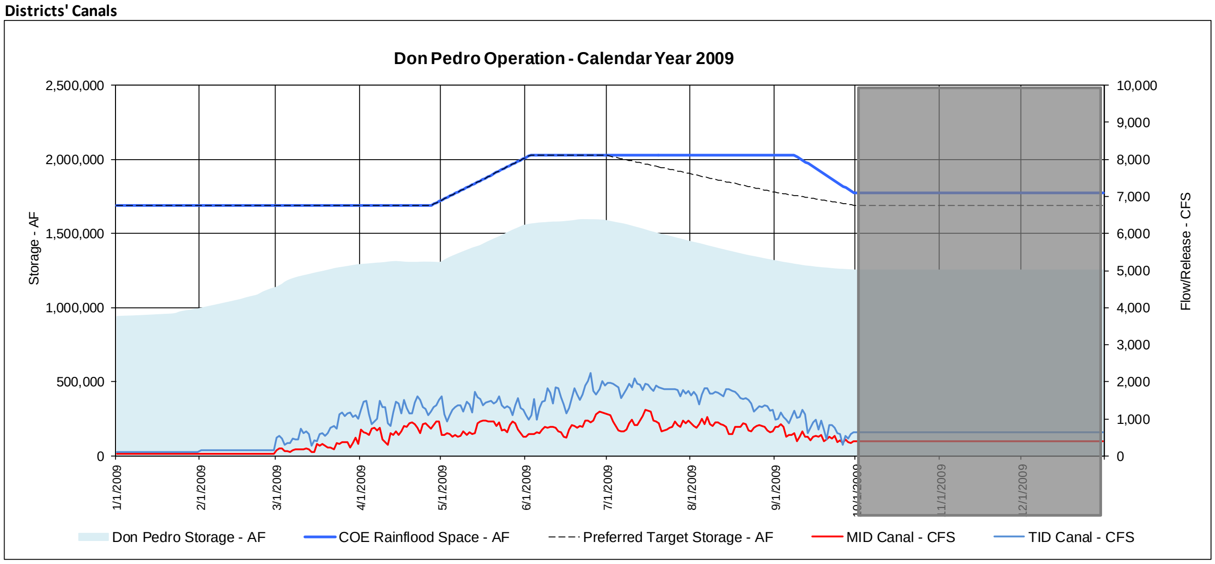


Figure 4-39. Don Pedro operations 2009 – Base Case.

Don Pedro Project
Project Operations/Water Balance Model Study Report
Model Description and User's Guide, Addendum 2
Tuolumne River Daily Operations Model Version 3.00
December 2013

1.0 INTRODUCTION

The Turlock Irrigation District (TID) and Modesto Irrigation District (MID) (collectively, the Districts) have developed a computerized Tuolumne River Daily Operations Model (Model) to assist in the relicensing of the Don Pedro Project (Project) (FERC Project 2299). The Model is fully described in the User's Guide submitted to FERC as part of the Initial Study Report (ISR), January 2013 (Model version 1.01) and supplemented by Addendum 1, May 2013 regarding the version of the Model (Version 2.0) used to develop the "Base Case" which depicts the operation of the Don Pedro Project in accordance with the current FERC license, ACOE flood management guidelines, the Districts' irrigation and M&I water management practices, and CCSF's water management practices at its Hetch Hetchy Water System. The Base Case and the Model (Version 2.0) were presented at a Workshop held with relicensing participants on May 30, 2013.

Subsequent to the May Workshop, the Districts proceeded to integrate the results from the Model into other studies and models that additionally describe the Base Case for the Project and used the Model to begin the evaluation of Project operation alternatives. During those investigations it was found to be advantageous to extend the Model's period of record for analysis by 3 years to be inclusive of hydrology and operations through water year 2012. The "extension" of the Model allows integration of recently acquired or developed data within the modeling processes. The purpose of this Addendum 2 is to document the extension of the Model, describe any refinements and modifications that have been made to the Model (Model Version 2.0) since May 2013, provide an updated comparison of sample Model operations against historical operations, and reissue the Base Case resulting from the extension of the period of analysis and Model modifications.

The Tuolumne River Daily Operations Model provides a depiction of the Don Pedro Project and City and County of San Francisco water operations consistent with the FERC-approved W&AR-02 study plan. The Model portrays operations that can be described systematically by various equations and algorithms. Actual project operations may vary from those depicted by the Model due to circumstantial and real-time conditions of hydrology and weather, facility operation, and human intervention. The FERC-approved study plan has identified a number of user-controlled variables. The fact that the Model provides these user-controlled inputs is not an indication that either the Districts or CCSF endorse or support any specific operational alternative developed by manipulating these inputs.

2.0 MODEL EXTENSION

The Model has been modified to provide a simulation of Tuolumne River operations for the WY 1971-2012 hydrologic period of record. Several tasks were completed to extend the simulation period by 3 years.

2.1 Tuolumne River Unimpaired Flow

The underlying unimpaired hydrology was extended by acquisition of recent reported records by the Districts, CCSF and USGS. Specifically, daily reservoir contents were acquired from USGS in addition to flow records for upstream CCSF stream flow locations and the Districts' flows at the Modesto Main Canal, Turlock Main Canal and Tuolumne River at La Grange gage. The flow for the San Joaquin Pipeline (SJPL) was acquired from CCSF. These records have been incorporated into the hydrology workbook entitled <<Don Pedro Unimpaired and Other Flow Data Version 3.xlsb>>, available upon request to the Districts.

Except for the SJPL record for WY 2012, the above described data only serves as a data set for comparison to simulation results. The data would be used typically to derive unimpaired flow values for inflows to the CCSF reservoirs and the unregulated inflow to Don Pedro Reservoir. However, current model hydrology utilizes a synthetically derived data set for inflows (smoothing) which was developed in March 2013 in conjunction with CDFW and SWRCB and fully described in Attachment B of the Districts' April 9, 2013 Response to ISR Comments.

2.2 CCSF San Joaquin Pipeline Diversions

CCSF planning model (HHLSM) results were used for extending SJPL diversions through WY 2011. WY 2011 is the end of the simulation period for CCSF's model. The actual record of diversion of the SJPL (described above) was used for the Model's input for WY 2012.

2.3 Modesto Irrigation District and Turlock Irrigation District Water Demand

Each District's projected demand for applied water (agriculture) was extended through WY 2012 using DWR's consumptive use model, and adjusted for observed current water use practices.

2.4 Model Logic

The Model's operation logic was extended within each worksheet to include the 3 years of additional daily simulation period.

2.5 Model Support and Reporting Worksheets

The Model's support sheets (data summaries, graphs and tabling) were adapted to incorporate the additional days and years of simulation.

2.6 Base Case Model Operation

The "Base Case" was regenerated with the additional 3 years of simulation, and the prior Base Case results used for alternatives comparison were reset within the Model. The Base Case results did not change for most of the previously developed 1971-2009 period. However, due to a modification to Model logic applied during drought-induced water shortage periods the previously depicted Base Case operation during and immediately subsequent to drought has slightly changed. This circumstance is described in Section 3.0.

3.0 MODEL MODIFICATION

One single logic modification has occurred between Version 2.00 and this Version 3.00 of the Model. The logic affects the daily computation of the Modesto Irrigation District (MID) municipal diversion from its canal system, which ultimately affects the District's diversion from the Tuolumne River.

3.1 Model Logic

The demand for canal diversions for each District is depicted by the summation of numerous components of water demand and canal operations. The components of demand and the computation process are described in Study Report W&AR-02: Project Operations/Water Balance Model, Attachment B Model Description and User's Guide (User's Guide), at Section 3.2, MID and TID Canal Demand, and at Section 5.18, for the Model's DailyCanalsCompute Worksheet. Once the demand is established, the diversion to meet the demand may be reduced in consideration of drought conditions that limit water supply. As described in Section 5.18 of the User's Guide, the Don Pedro Water Supply Factor (WSF) is used to simulate a reduction to diversions during drought. The WSF is applied to components of the Districts' water demand that are intended to represent deliveries to the Districts' customers.

Subsequent to the issuance of the Addendum 1 to the User's Guide, Base Case Description, May 20, 2013, the Districts discovered that an oversight occurred in coding the application of the WSF to the municipal component of MID customers. The error occurred within the calculation of reduced water diversions to the MID canal system. In the previously submitted Model the WSF was coded to affect agricultural deliveries, but did not affect the delivery of water to MID's municipal water demand. This oversight has been corrected in the Model, with consistent (percentage-based) reductions applied to agricultural and municipal customers.

3.2 Effect of Modification

This modification causes no substantial change to the Base Case as previously submitted by the Districts. The effect of the change manifests only during drought periods when the WSF reduces canal diversions due to water shortage. In effect, with the WSF now reducing diversions for the municipal delivery of MID, the total diversion of the Districts is slightly reduced during drought thus requiring less water released from Don Pedro Reservoir. Because only the required FERC releases are being provided to the lower Tuolumne River from the Project during these periods, the other resulting effect of the modification is slightly more storage remaining in Don Pedro Reservoir (as compared to the previous Model) at the end of these drought periods. This circumstance then results in an earlier-occurring and volumetrically larger flow in the Tuolumne River upon refilling of the reservoir, a short-duration event. The difference in Base Case results due to the logic modification is illustrated by the following tables and graphs.

Table 3.2-1 illustrates the underlying difference in result that occurs to MID operations as the outcome of the logic modification. The table shows the difference in MID canal diversions between the May 2013 Base Case results (noted as the “Base_Case_Extended” study) and the revised Base Case results (noted as the “Output” study). A negative result represents a reduction in canal diversions between the May 2013 Base Case and the revised Base Case. As seen in Table 3.2-1 there are differences in MID canal diversions between the two studies and the differences occur during the drought years of 1977 and 1988 through 1992, during which the WSF logic now affects MID municipal deliveries from its canal system. The “negatives” indicate that with the revised logic the revised Base Case will incorporate a lesser canal diversion during these periods of simulation.

Output MID Canal Minus Base_Case_Extended MID Canal — Acre-feet

Yr-Type	WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total WY
N	1971	0	0	0	0	0	0	0	0	0	0	0	0	0
BN	1972	0	0	0	0	0	0	0	0	0	0	0	0	0
N	1973	0	0	0	0	0	0	0	0	0	0	0	0	0
AN	1974	0	0	0	0	0	0	0	0	0	0	0	0	0
AN	1975	0	0	0	0	0	0	0	0	0	0	0	0	0
C	1976	0	0	0	0	0	0	0	0	0	0	0	0	0
C	1977	0	0	0	0	-575	-675	-675	-750	-800	-825	-825	-825	-5,950
W	1978	-800	-675	-625	-575	0	0	0	0	0	0	0	0	-2,675
N	1979	0	0	0	0	0	0	0	0	0	0	0	0	0
W	1980	0	0	0	0	0	0	0	0	0	0	0	0	0
D	1981	0	0	0	0	0	0	0	0	0	0	0	0	0
W	1982	0	0	0	0	0	0	0	0	0	0	0	0	0
W	1983	0	0	0	0	0	0	0	0	0	0	0	0	0
AN	1984	0	0	0	0	0	0	0	0	0	0	0	0	0
BN	1985	0	0	0	0	0	0	0	0	0	0	0	0	0
W	1986	0	0	0	0	0	0	0	0	0	0	0	0	0
C	1987	0	0	0	0	0	0	0	0	0	0	0	0	0
C	1988	0	0	0	0	-288	-338	-337	-375	-400	-412	-412	-413	-2,975
BN	1989	-400	-338	-313	-287	-288	-338	-338	-375	-400	-412	-413	-412	-4,312
D	1990	-400	-338	-313	-287	-288	-338	-338	-375	-400	-412	-412	-413	-4,313
BN	1991	-400	-338	-313	-287	-288	-338	-338	-375	-400	-412	-413	-413	-4,313
C	1992	-400	-338	-313	-287	-575	-675	-675	-750	-800	-825	-825	-825	-7,288
AN	1993	-800	-675	-625	-575	0	0	0	0	0	0	0	0	-2,675
D	1994	0	0	0	0	0	0	0	0	0	0	0	0	0
W	1995	0	0	0	0	0	0	0	0	0	0	0	0	0
AN	1996	0	0	0	0	0	0	0	0	0	0	0	0	0
W	1997	0	0	0	0	0	0	0	0	0	0	0	0	0
W	1998	0	0	0	0	0	0	0	0	0	0	0	0	0
AN	1999	0	0	0	0	0	0	0	0	0	0	0	0	0
N	2000	0	0	0	0	0	0	0	0	0	0	0	0	0
BN	2001	0	0	0	0	0	0	0	0	0	0	0	0	0
N	2002	0	0	0	0	0	0	0	0	0	0	0	0	0
N	2003	0	0	0	0	0	0	0	0	0	0	0	0	0
BN	2004	0	0	0	0	0	0	0	0	0	0	0	0	0
W	2005	0	0	0	0	0	0	0	0	0	0	0	0	0
W	2006	0	0	0	0	0	0	0	0	0	0	0	0	0
D	2007	0	0	0	0	0	0	0	0	0	0	0	0	0
BN	2008	0	0	0	0	0	0	0	0	0	0	0	0	0
N	2009	0	0	0	0	0	0	0	0	0	0	0	0	0
N	2010	0	0	0	0	0	0	0	0	0	0	0	0	0
W	2011	0	0	0	0	0	0	0	0	0	0	0	0	0
D	2012	0	0	0	0	0	0	0	0	0	0	0	0	0
	Ave	-76	-64	-60	-55	-55	-64	-64	-71	-76	-79	-79	-79	-821

Table 3.2-1. Difference in MID Canal diversions, revised Base Case compared to May 2013 Base Case.

This difference in canal diversion then manifests into other, subsequent changes to Project operation. With a lesser diversion of water for the MID canal, less water will be released from Don Pedro Reservoir and during these drought periods will remain in storage, accumulating until released later. Table 3.2-2 illustrates the difference in Don Pedro Reservoir storage that occurs between the May 2013 Base Case and the revised Base Case.

Output End-of-Month Don Pedro Reservoir Storage Minus Base_Case_Extended End-of-Month Don Pedro Reservoir Storage Acre-feet

Yr-Type	WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
N	1971	0	0	0	0	0	0	0	0	0	0	0	0
BN	1972	0	0	0	0	0	0	0	0	0	0	0	0
N	1973	0	0	0	0	0	0	0	0	0	0	0	0
AN	1974	0	0	0	0	0	0	0	0	0	0	0	0
AN	1975	0	0	0	0	0	0	0	0	0	0	0	0
C	1976	0	0	0	0	0	0	0	0	0	0	0	0
C	1977	0	0	0	0	575	1,250	1,923	2,667	3,456	4,262	5,061	5,862
W	1978	6,645	7,315	7,940	8,518	8,518	8,515	8,507	6,291	6,271	6,244	381	5
N	1979	1	1	1	0	0	0	0	0	0	0	0	0
W	1980	0	0	0	0	0	0	0	0	0	0	0	0
D	1981	0	0	0	0	0	0	0	0	0	0	0	0
W	1982	0	0	0	0	0	0	0	0	0	0	0	0
W	1983	0	0	0	0	0	0	0	0	0	0	0	0
AN	1984	0	0	0	0	0	0	0	0	0	0	0	0
BN	1985	0	0	0	0	0	0	0	0	0	0	0	0
W	1986	0	0	0	0	0	0	0	0	0	0	0	0
C	1987	0	0	0	0	0	0	0	0	0	0	0	0
C	1988	0	0	0	0	288	625	962	1,334	1,728	2,131	2,533	2,936
BN	1989	3,329	3,664	3,976	4,265	4,553	4,889	5,221	5,582	5,962	6,346	6,727	7,115
D	1990	7,499	7,832	8,144	8,434	8,723	9,057	9,385	9,735	10,083	10,447	10,808	11,178
BN	1991	11,547	11,875	12,188	12,480	12,772	13,107	13,434	13,775	14,108	14,452	14,783	15,130
C	1992	15,487	15,812	16,125	16,441	16,991	17,659	18,314	19,016	19,749	20,472	21,179	21,909
AN	1993	22,647	23,303	23,929	24,513	24,515	24,506	24,508	24,446	24,364	24,258	24,150	24,068
D	1994	24,017	24,002	24,002	24,009	24,011	24,003	23,980	23,918	23,836	23,728	23,620	23,538
W	1995	23,485	23,471	23,471	23,478	23,480	2,816	17	-1	0	0	0	0
AN	1996	0	0	0	0	0	0	0	0	0	0	0	0
W	1997	0	0	0	0	0	0	0	0	0	0	0	0
W	1998	0	0	0	0	0	0	0	0	0	0	0	0
AN	1999	0	0	0	0	0	0	0	0	0	0	0	0
N	2000	0	0	0	0	0	0	0	0	0	0	0	0
BN	2001	0	0	0	0	0	0	0	0	0	0	0	0
N	2002	0	0	0	0	0	0	0	0	0	0	0	0
N	2003	0	0	0	0	0	0	0	0	0	0	0	0
BN	2004	0	0	0	0	0	0	0	0	0	0	0	0
W	2005	0	0	0	0	0	0	0	0	0	0	0	0
W	2006	0	0	0	0	0	0	0	0	0	0	0	0
D	2007	0	0	0	0	0	0	0	0	0	0	0	0
BN	2008	0	0	0	0	0	0	0	0	0	0	0	0
N	2009	0	0	0	0	0	0	0	0	0	0	0	0
N	2010	0	0	0	0	0	0	0	0	0	0	0	0
W	2011	0	0	0	0	0	0	0	0	0	0	0	0
D	2012	0	0	0	0	0	0	0	0	0	0	0	0
	Ave	2,730	2,792	2,852	2,908	2,962	2,534	2,530	2,542	2,609	2,675	2,601	2,660

Table 3.2-2. Difference in Don Pedro Reservoir storage, revised Base Case compared to May 2013 Base Case.

The difference in reservoir storage accumulates during the periods of canal diversion reduction, and eventually returns to the same storage occurring in the May 2013 Base Case after the droughts end. The time when the revised Base Case storage becomes the same as the May 2013 Base Case is dependent on how quickly the hydrologic conditions following drought "refill" the reservoir and lead to releases in excess of minimum flow requirements. Table 3.2-3 illustrates the difference in Tuolumne River flow resulting from the change in canal diversion and storage operation.

Output Lower Tuolumne River Flow Minus Base_Case_Extended Tuolumne River Flow — Acre-feet

Yr-Type	WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total WY
N	1971	0	0	0	0	0	0	0	0	0	0	0	0	0
BN	1972	0	0	0	0	0	0	0	0	0	0	0	0	0
N	1973	0	0	0	0	0	0	0	0	0	0	0	0	0
AN	1974	0	0	0	0	0	0	0	0	0	0	0	0	0
AN	1975	0	0	0	0	0	0	0	0	0	0	0	0	0
C	1976	0	0	0	0	0	0	0	0	0	0	0	0	0
C	1977	0	0	0	0	0	0	0	0	0	0	0	0	0
W	1978	0	0	0	0	0	0	0	2,195	0	0	5,856	375	8,426
N	1979	4	0	0	1	0	0	0	0	0	0	0	0	5
W	1980	0	0	0	0	0	0	0	0	0	0	0	0	0
D	1981	0	0	0	0	0	0	0	0	0	0	0	0	0
W	1982	0	0	0	0	0	0	0	0	0	0	0	0	0
W	1983	0	0	0	0	0	0	0	0	0	0	0	0	0
AN	1984	0	0	0	0	0	0	0	0	0	0	0	0	0
BN	1985	0	0	0	0	0	0	0	0	0	0	0	0	0
W	1986	0	0	0	0	0	0	0	0	0	0	0	0	0
C	1987	0	0	0	0	0	0	0	0	0	0	0	0	0
C	1988	0	0	0	0	0	0	0	0	0	0	0	0	0
BN	1989	0	0	0	0	0	0	0	0	0	0	0	0	0
D	1990	0	0	0	0	0	0	0	0	0	0	0	0	0
BN	1991	0	0	0	0	0	0	0	0	0	0	0	0	0
C	1992	0	0	0	0	0	0	0	0	0	0	0	0	0
AN	1993	0	0	0	0	0	0	0	0	0	0	0	0	0
D	1994	0	0	0	0	0	0	0	0	0	0	0	0	0
W	1995	0	0	0	0	0	20,658	2,799	18	-1	0	0	0	23,473
AN	1996	0	0	0	0	0	0	0	0	0	0	0	0	0
W	1997	0	0	0	0	0	0	0	0	0	0	0	0	0
W	1998	0	0	0	0	0	0	0	0	0	0	0	0	0
AN	1999	0	0	0	0	0	0	0	0	0	0	0	0	0
N	2000	0	0	0	0	0	0	0	0	0	0	0	0	0
BN	2001	0	0	0	0	0	0	0	0	0	0	0	0	0
N	2002	0	0	0	0	0	0	0	0	0	0	0	0	0
N	2003	0	0	0	0	0	0	0	0	0	0	0	0	0
BN	2004	0	0	0	0	0	0	0	0	0	0	0	0	0
W	2005	0	0	0	0	0	0	0	0	0	0	0	0	0
W	2006	0	0	0	0	0	0	0	0	0	0	0	0	0
D	2007	0	0	0	0	0	0	0	0	0	0	0	0	0
BN	2008	0	0	0	0	0	0	0	0	0	0	0	0	0
N	2009	0	0	0	0	0	0	0	0	0	0	0	0	0
N	2010	0	0	0	0	0	0	0	0	0	0	0	0	0
W	2011	0	0	0	0	0	0	0	0	0	0	0	0	0
D	2012	0	0	0	0	0	0	0	0	0	0	0	0	0
	Ave	0	0	0	0	0	492	67	53	0	0	139	9	760

Table 3.2-3. Difference in Tuolumne River flow (La Grange), revised Base Case compared to May 2013 Base Case.

As illustrated in the table, the reductions in canal diversion and resultant accumulation of those reductions into reservoir storage do not change simulated river flow until subsequent periods. In the instance of the 1976-1977 drought, a change in river flow would not occur until May 1978 and later. In the instance of the 1987-1992 drought, the change would not occur until spring of 1995. These effects are shown in Figure 3.2-1 for 1978 and Figure 3.2-2 for 1995.

Following the drought year 1977, 1978 is a relatively wet year. The difference in storage between the two studies is almost unnoticeable in the graphic, but amounts to about 8,000 acre-feet, the amount of water accumulated by the reduction in canal diversions. A portion of this additional storage is released during May 1978 as directed by the snow-melt reservoir management forecasting routine of the Model, and is seen as a slightly larger river flow during the latter half of May. The remainder of the water is simulated to be additionally released during late August during summer drawdown of the reservoir.

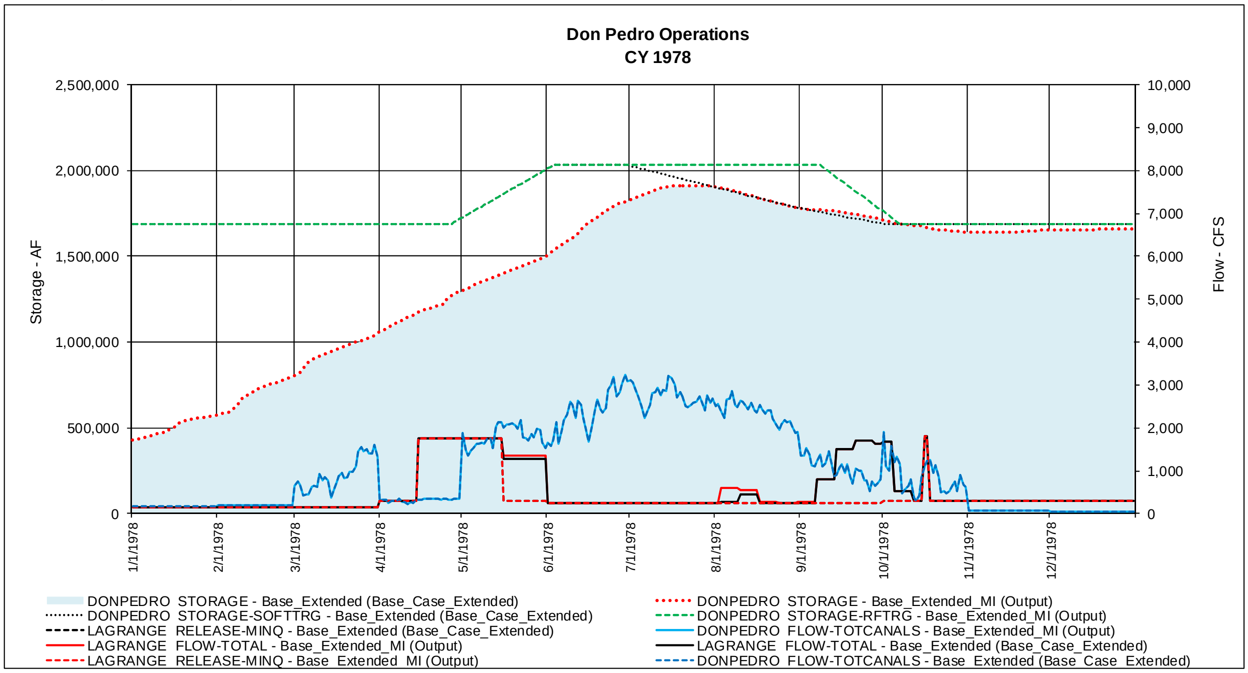


Figure 3.2-1. Simulated 1978 operations illustrating resulting difference due to MID diversion change.

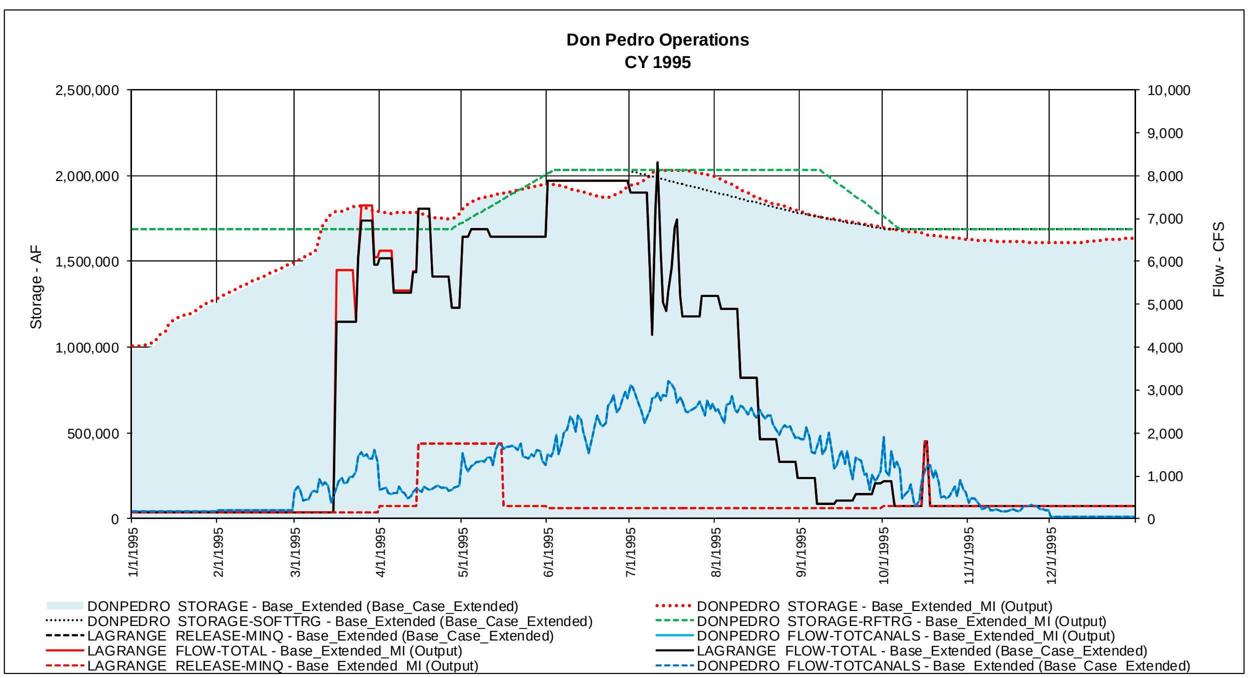


Figure 3.2-2. Simulated 1995 operations illustrating resulting difference due to MID diversion change.

A similar reaction to higher storage following the 1987-1992 drought manifests as a change in operation during the simulation of 1995. Following the drought, 1993 and 1994 hydrology was not sufficiently wet to refill the reservoir and cause releases in excess of minimum required flows in the lower Tuolumne River. Thus, the difference in Don Pedro Reservoir storage carried forward into 1995, approximately 24,000 acre-feet. Again almost unnoticeable in the graphic the additional storage factors into the reservoir management routines and is released during March and April to maintain flood control reservation space.

The modification to MID municipal delivery logic better portrays projected MID operations during periods of water delivery reductions. The change manifests only during drought periods when the WSF reduces canal diversions due to water shortage, and following the circumstance during reservoir refill. The difference in Base Case results due to the logic modification is not expected to change any conclusions previously derived concerning water supply or other environmental factors that were based on the May 2013 Base Case.

4.0 REVISED BASE CASE

Resulting from the extension of period of analysis and the change in Model logic, a revised Model (Version 3.00) and Base Case simulation is being distributed. The workbook titled << TuolumneDailyModel(Version3.00).xlsb>> contains the current working version of the Tuolumne River Daily Operations Model, with its model control parameters and inputs set for the Base Case. As described previously, non-substantive changes occur between the May 2013 Base Case and revised Base Case for the 1971-2009 simulation period, and thus the depiction of Base Case conditions for that period as described in Addendum 1, May 2013 is almost unchanged. However, to provide a context for the extended modeling period the general parameters of the hydrology and operational conditions for the 1971-2012 simulation period are provided below.

4.1 Reservoir Inflows

Projected annual inflow to Don Pedro Reservoir for the Base Case is illustrated in Figure 4.1-1, representing the regulated and unregulated components of total inflow to Don Pedro Reservoir. Average annual inflow to Don Pedro Reservoir is projected to be 1,704,000 acre-feet. Although not completely appropriate for comparison purposes, the historically computed annual total inflow to Don Pedro Reservoir has also been shown in the figure as confirmation that the Model's simulation of inflow is capturing the magnitude and range of historical hydrology. It is known that simulated inflow and historical inflow will differ for several reasons including historical CCSF water diversions and operations that differ from the Base Case operation represented by the Model.

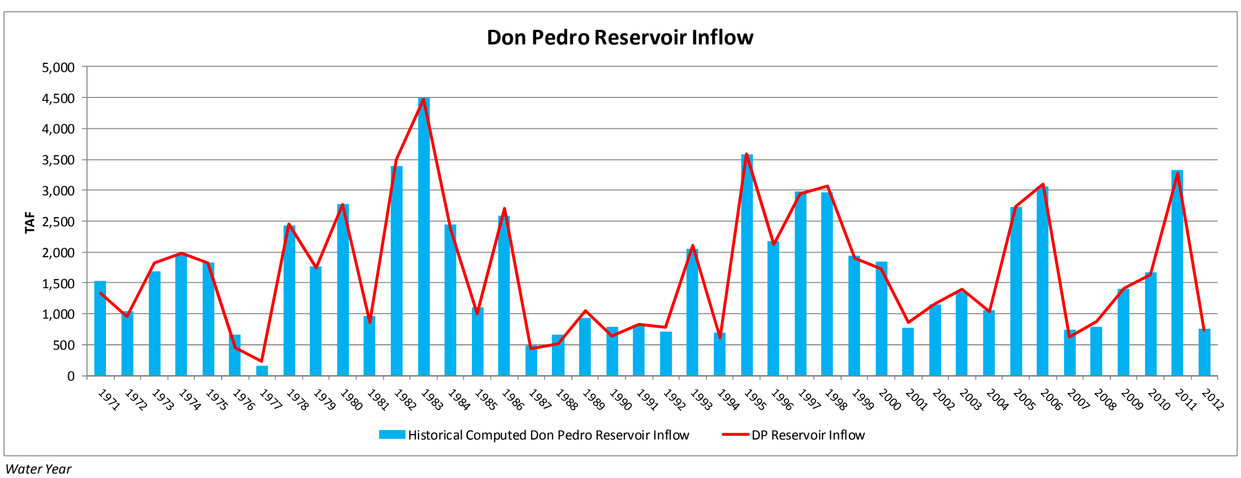


Figure 4.1-1. Projected Don Pedro Reservoir inflow – Base Case.

4.2 Don Pedro Project Minimum Flow Requirement

The simulated annual minimum flow requirement for the Base Case is illustrated in Figure 4.2-1, and ranges from a minimum of 94,000 acre-feet up to a maximum of 300,900 acre-feet. The 42-year average of the flow requirement is 214,800 acre-feet.

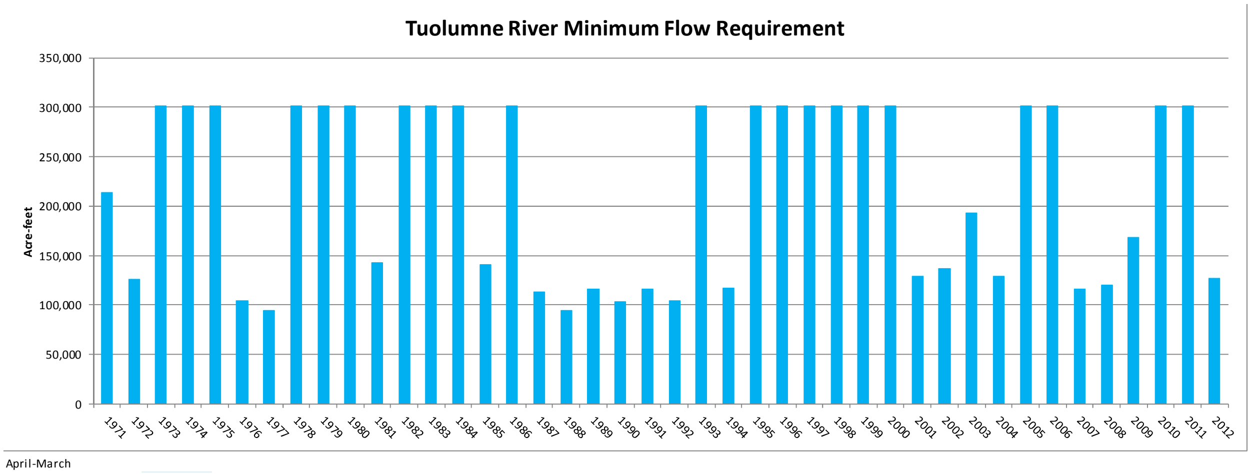


Figure 4.2-1. Minimum annual FERC flow requirement – Base Case.

4.3 CCSF Water Diversions

The Base Case operation for the CCSF system is based on existing facilities, operational plans and objectives, and regulatory requirements in place. The Base Case also includes facilities and operations previously approved under CEQA and authorized for funding by CCSF, but not yet fully implemented. The projected diversions of CCSF to the San Francisco Bay Area from the San Joaquin Pipeline ("SJPL") are imported to the Model from output of CCSF's Hetch Hetchy/Local Simulation Model ("HHLSM") as provided by CCSF to the Districts. CCSF diversions for 2012 represent actual reported diversions. Figure 4.3-1 illustrates the annual volume of diversions for the Base Case. Based on an annual average system-wide demand of 238 MGD (266,600 acre-feet), annual average diversions from the Tuolumne River are projected to be 230,400 acre-feet. These diversions integrate with other CCSF water supply resources and fully meet CCSF system-wide demands except during 1977, 1988, 1989, 1990, 1991 and 1992 when a 10 percent reduction in deliveries is needed.

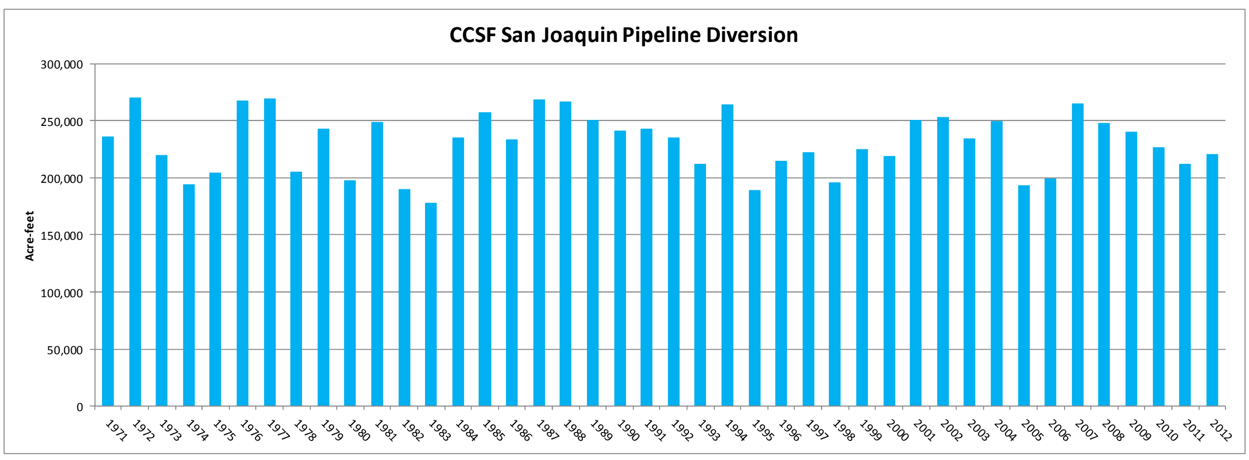
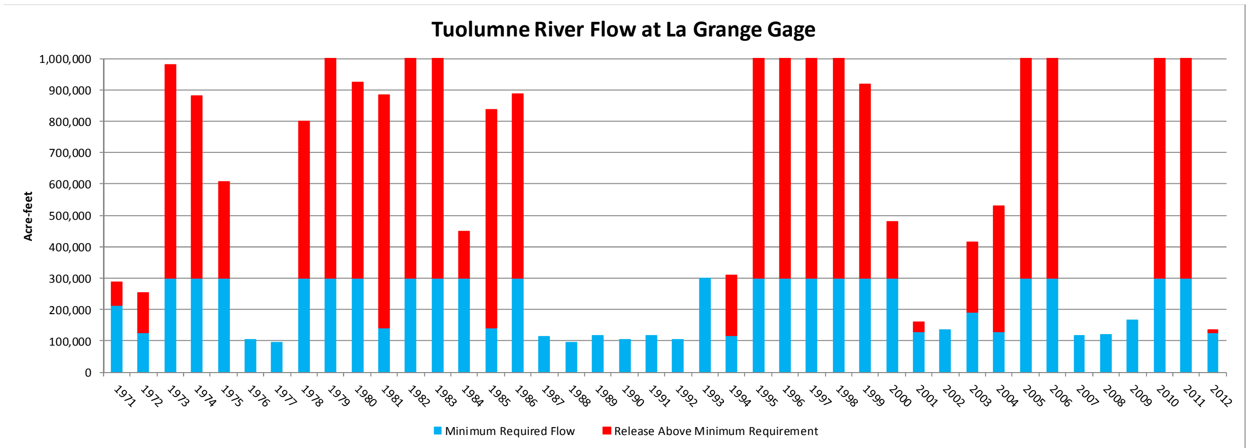


Figure 4.3-1. San Joaquin Pipeline diversions – Base Case.

4.4 Tuolumne River Flow

Flow delivered from Don Pedro to the Tuolumne River at the La Grange gage will result from meeting the FERC license minimum flow requirements and releasing flows for flood control operations and discretionary drawdown of Don Pedro Reservoir. The projected annual flow of the river at the La Grange gage under the Base Case is illustrated in Figure 4.4-1. Seasonal flow volume in the Tuolumne River is illustrated in Table 4.1-1 which provides average flow by month within a ranking of all years according to a preliminary year type classification.[1]



April-March

(Flows exceeding scale of graph: 1979 – 1,396,600 acre-feet; 1982 – 3,052,100 acre-feet; 1983 – 3,322,600 acre-feet; 1995 – 2,444,700 acre-feet; 1996 – 2,309,800 acre-feet; 1997 – 1,045,800 acre-feet; 1988 – 2,044,700 acre-feet; 2005 – 1,865,100 acre-feet; 2006 – 1,556,100 acre-feet; 2010 – 1,285,500; 2011 – 1,476,100.)

Figure 4.4-1. Projected flow at La Grange gage – Base Case.

Table 4.4-1. Projected seasonal flow at La Grange gage (acre-feet) – Base Case.

Prelim Year Type		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
W	1	23,956	29,706	65,854	179,858	223,264	309,812	304,322	260,463	298,307	184,990	72,699	37,574	1,990,806
AN	2	27,345	36,232	78,097	98,325	157,042	183,876	155,840	79,345	102,401	27,829	15,372	16,202	977,906
N	3	17,160	12,459	13,783	24,300	61,888	96,089	110,129	56,134	40,407	17,026	9,992	9,670	469,036
BN	4	14,069	11,901	12,298	12,327	26,022	39,636	42,413	28,173	3,613	3,733	3,733	3,613	201,529
D	5	24,052	15,620	16,141	16,141	14,579	27,129	32,749	26,028	3,347	3,459	3,459	3,347	186,051
C	6	17,168	13,463	15,049	13,839	12,496	13,835	19,972	19,579	2,975	3,074	3,074	2,975	137,501
All		20,537	20,724	36,766	71,350	100,207	136,878	135,984	100,215	101,799	57,059	24,530	15,343	821,393

4.5 Districts' Canal Diversions

Projected Base Case combined diversions of the Districts are illustrated in Figure 4.5-1. The average annual Base Case diversion is 848,100 acre-feet, ranging from a maximum of 966,900 acre-feet to a minimum of 639,700 acre-feet which includes a reduction to deliveries due to a limited water supply from Don Pedro Reservoir. Also shown in Figure 4.5-1 is the full combined diversion demand of the Districts. Reductions from full diversion demand are projected to occur when the projected combined diversions are less than the full diversion demand, during 1977, and 1988 through 1992.

[1] The preliminary relicensing year type is based on a rank-ordering of the water-year runoff for the years 1921-2012. Each water year type W, AN, N, and BN represent 20% of the years of ranking. D and C year types each represent 10% of the years.

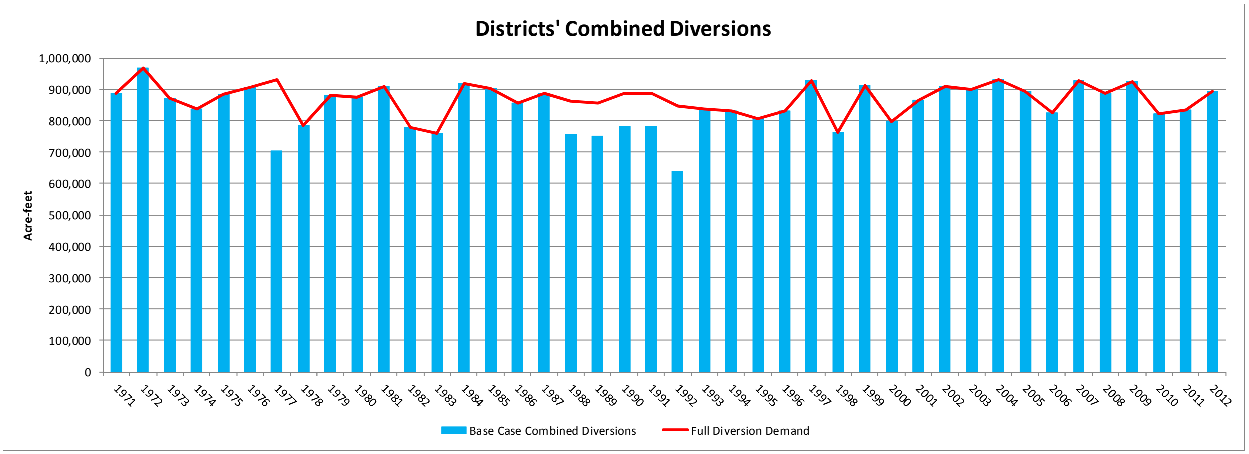


Figure 4.5-1. Districts' combined diversions and full demand – Base Case.

4.6 Don Pedro Reservoir

Don Pedro Reservoir storage will fluctate throughout the year and will result in carryover storage that varies from year to year. Figure 4.6-1 illustrates projected end-of-September storage for the Base Case.

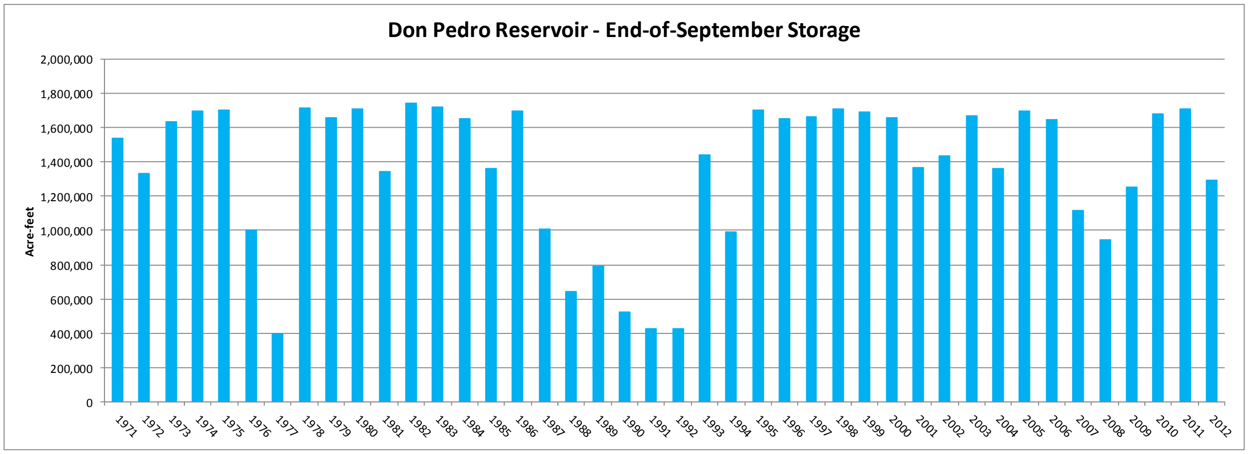


Figure 4.6-1. Don Pedro Reservoir end-of-September storage – Base Case.

The monthly variation of Don Pedro Reservoir storage is cyclic throughout the year in response to inflow, water releases and preferred storage objectives. Figure 4.6-2 illustrates the projected end-of-month storage of Don Pedro Reservoir of the 42-year simulation period. Severe or prolonged droughts and their effect on storage are noteable during 1976-1977 and 1987-1992.

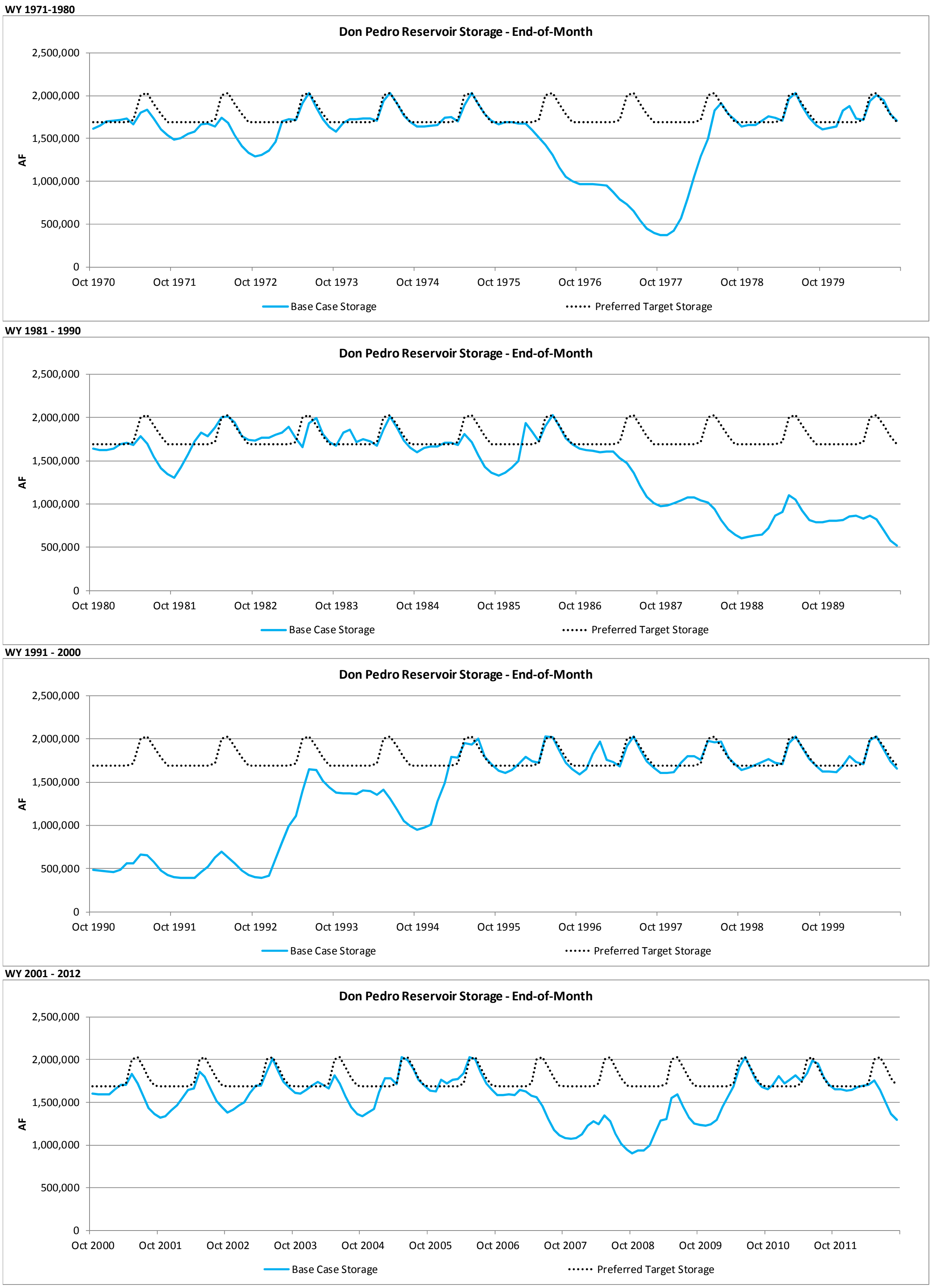


Figure 4.6-2. Don Pedro Reservoir storage – Base Case.

4.7 Don Pedro Project Generation

Hydroelectric generation is incidental to water operations, and will vary from day to day, month to month and year to year as Don Pedro Project reservoir and release operations react to hydrology and water demands. Figure 4.7-1 illustrates the projected annual power generation of the Don Pedro Project for the Base Case. Annual generation is projected to vary from 1,393,900 MWh to 231,400 MWh, with an average of 613,300 MWh.

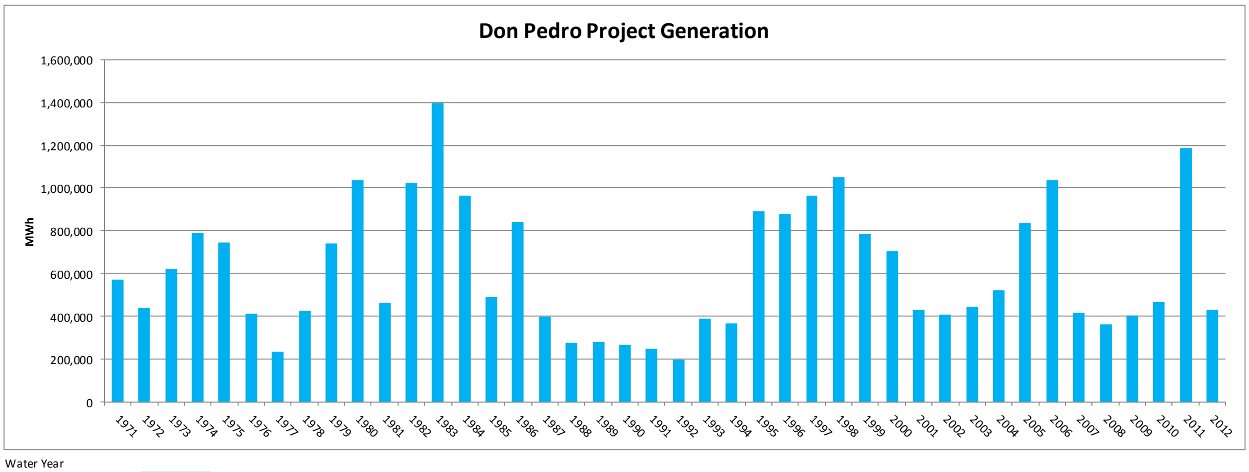


Figure 4.7-1. Don Pedro Project generation – Base Case.

Seasonal Don Pedro Project generation is illustrated in Table 4.7-1 which provides average generation by month within a ranking of all years according to the preliminary year type classification.

Table 4.7-1. Don Pedro Project generation (MWh) – Base Case.

Prelim Year Type		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
W	1	23,668	12,818	27,195	55,223	80,969	124,875	125,550	131,433	130,368	124,277	90,322	42,480	969,177
AN	2	25,285	15,257	29,786	38,945	69,366	101,691	101,235	85,434	103,139	84,345	65,430	37,107	757,019
N	3	21,885	6,137	5,541	11,867	28,280	61,783	80,758	74,665	76,266	79,552	63,196	33,676	543,606
BN	4	18,128	6,410	4,795	6,856	13,540	37,254	55,873	60,812	52,050	62,814	51,175	24,208	393,915
D	5	23,736	7,896	6,284	8,422	9,505	34,677	52,274	57,432	53,249	62,964	51,386	25,150	392,975
C	6	18,817	7,257	5,651	7,241	8,190	26,280	39,098	45,127	43,561	51,707	40,370	19,253	312,551
All		21,950	9,563	14,638	25,266	40,834	72,267	82,603	82,901	83,374	83,603	64,230	32,022	613,251

4.8 CCSF Tuolumne River Storage and Water Supply

The Base Case CCSF water supply of the Tuolumne River can be expressed by the amount of diversions from the basin through the San Joaquin Pipeline (illustrated in Section 4.3 above), water in CCSF Tuolumne River reservoirs and the credit balance of the CCSF Don Pedro Water Bank Account. Annual CCSF water delivery decisions are guided by the projection of total CCSF system storage for July 1 of a year. Included in the metric is CCSF Tuolumne River reservoir storage and Water Bank Account balance. Figure 4.8-1 illustrates the projected July 1 metric of CCSF Tuolumne River reservoir storage and Water Bank Account balance.

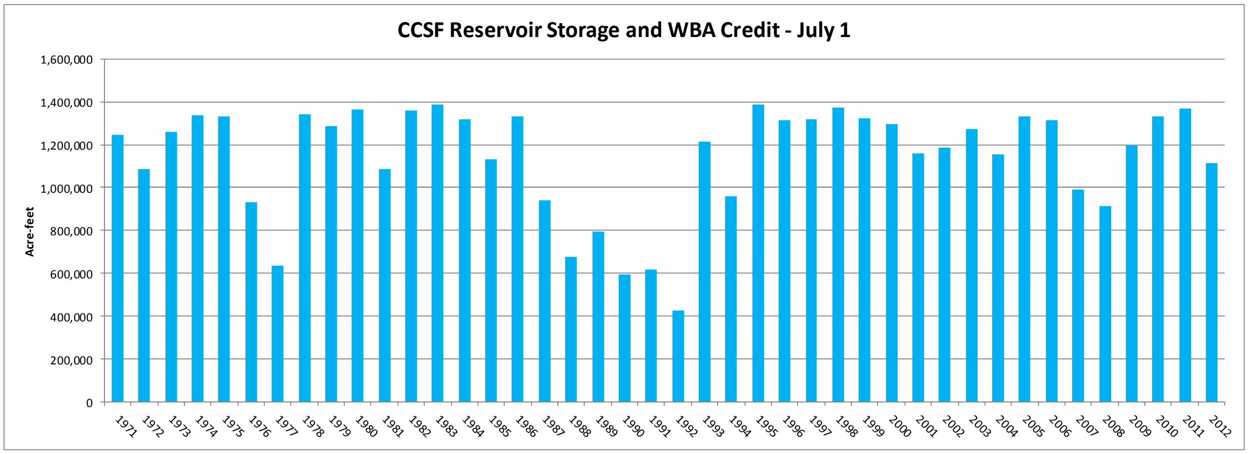


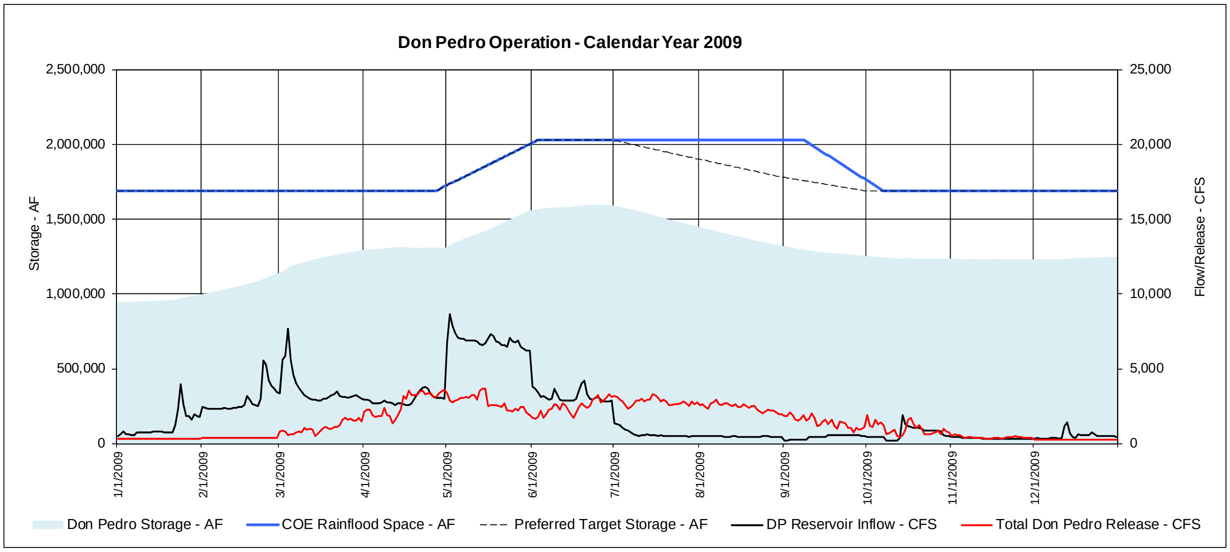
Figure 4.8-1. CCSF Tuolumne River storage and Water Bank Account credit – Base Case.

4.9 Annual Don Pedro Project Operations – 2010 through 2013

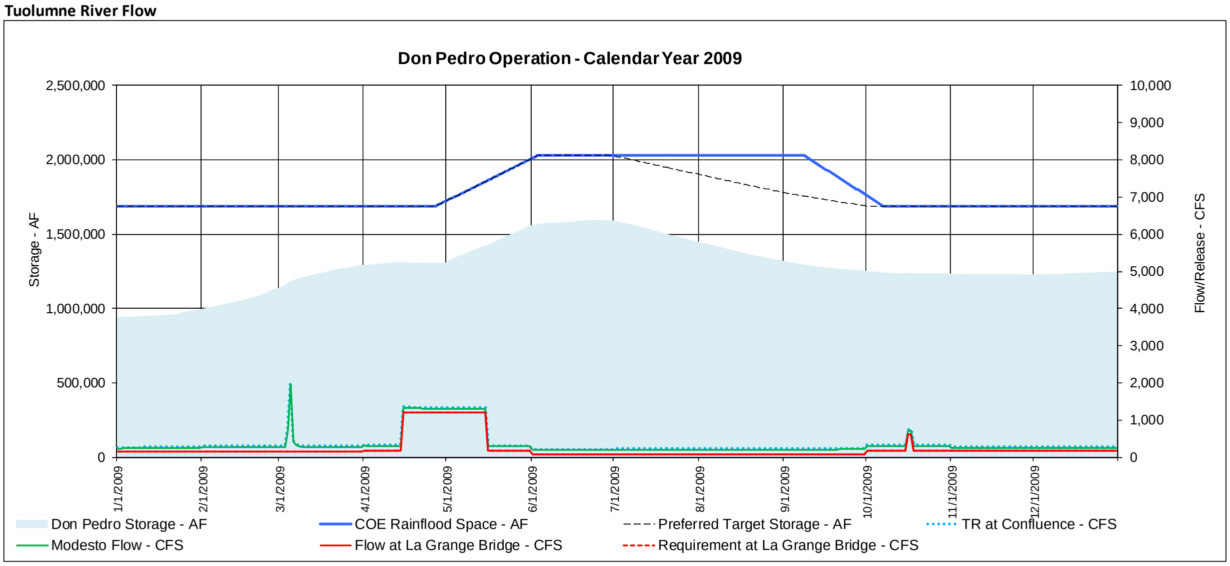
Annual hydrographs for the projected operation of Don Pedro Reservoir and the lower Tuolumne River for the Base Case for the period 2009 through 2013 follow. These hydrographs supplement the series provided in Addendum 1 for the 1971-2009 period of analysis. Three hydrographs are presented for each year. The upper hydrograph illustrates the simulated daily storage of Don Pedro Reservoir (light blue area graph) for an entire calendar year. Plotted for reference is the modeled reservoir target storage during the year (solid blue and black dashed lines). These two components are plotted to the left axis scale (acre-feet), and are also shown in the other two hydrographs. Also illustrated in the upper hydrograph are the inflow to Don Pedro Reservoir (solid black line) and total Don Pedro release (solid red line). Flow values are plotted to the right axis scale (CFS).

The middle hydrograph illustrates the simulated daily flows at three locations in the lower Tuolumne River: (1) flow at the La Grange Bridge gage (solid red line), (2) flow at the Modesto gage (solid green line), and (3) flow at the Tuolumne River confluence with the San Joaquin River (dotted light blue line). Flow projected to occur at the La Grange Bridge gage is the result of flow being released from Don Pedro Reservoir and depletion by diversions to the Districts' canals. Flow projected to occur at the Modesto gage is the result of adding those flows to lower Tuolumne River accretions occurring above the Modesto gage location and flows from Dry Creek. The accretions and Dry Creek flow data sets are synthesized, and are described in the ISR, January 2013. Flows projected for the Tuolumne River confluence are the sum of flows occurring at the Modesto gage plus an estimated accretion between the Modesto gage and the confluence. This accretion is estimated to be a constant 32 cfs. Also shown in the hydrograph is the Base Case Tuolumne River daily flow requirement (dashed red line), modeled at the La Grange Bridge gage location.

The lower hydrograph illustrates the simulated daily diversions of the Districts to their respective canals. The projected Modesto Irrigation District diversion is shown by the solid red line and the projected Turlock Irrigation District diversion is shown by the solid blue line.



Tuolumne River Flow



Districts' Canals

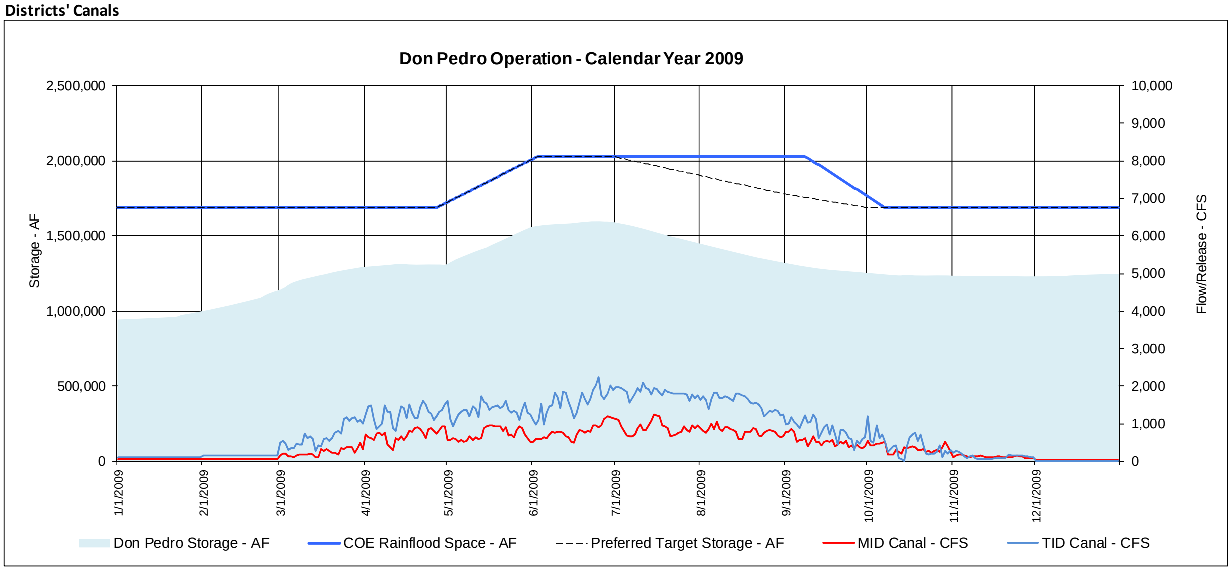
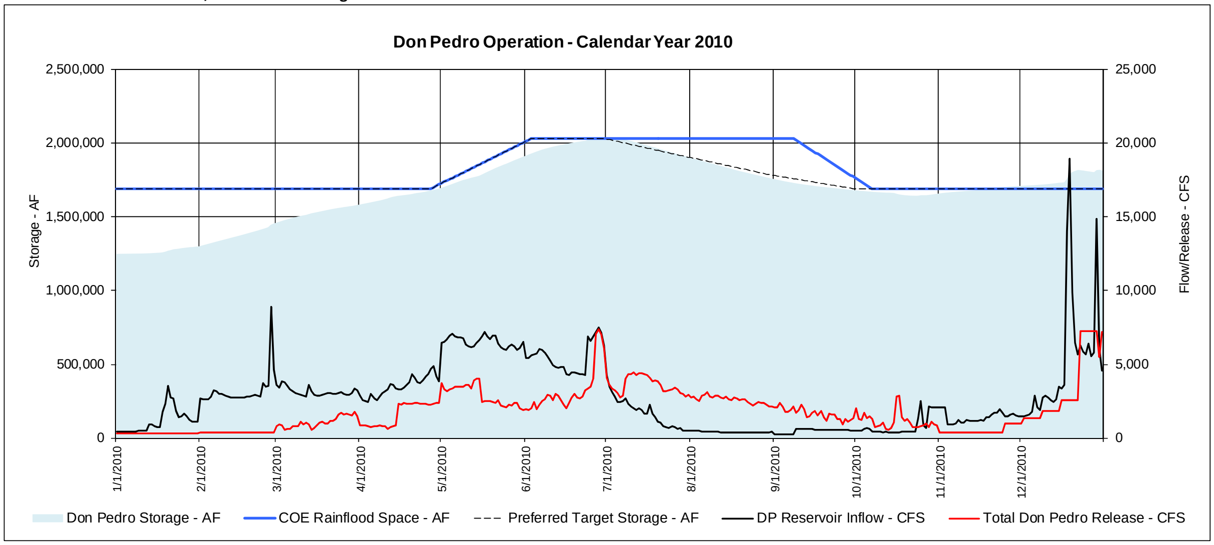
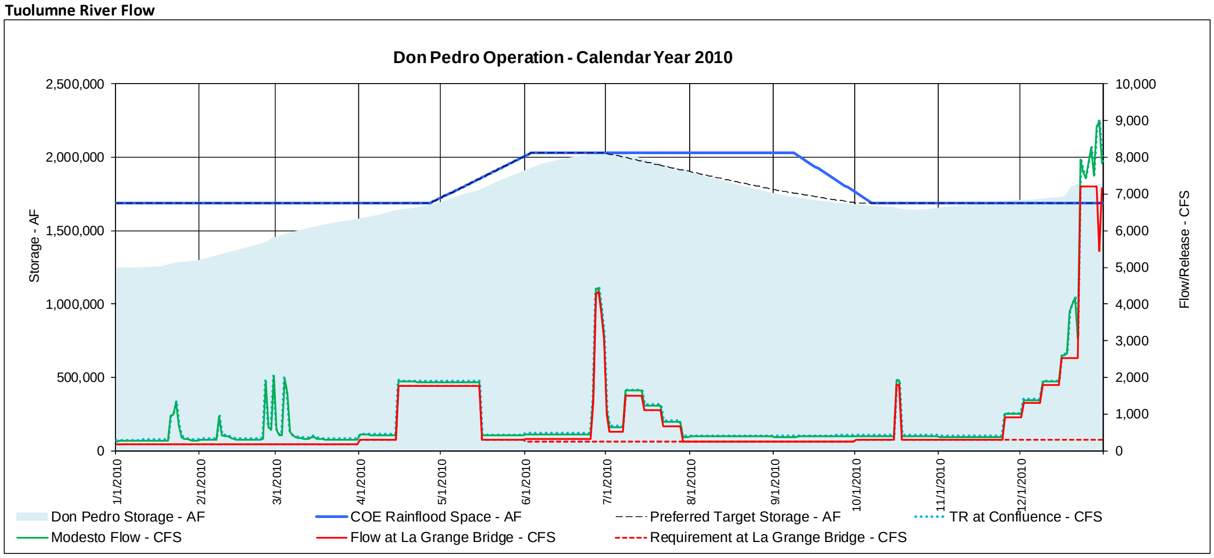


Figure 4.9-1. Don Pedro operations 2009 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

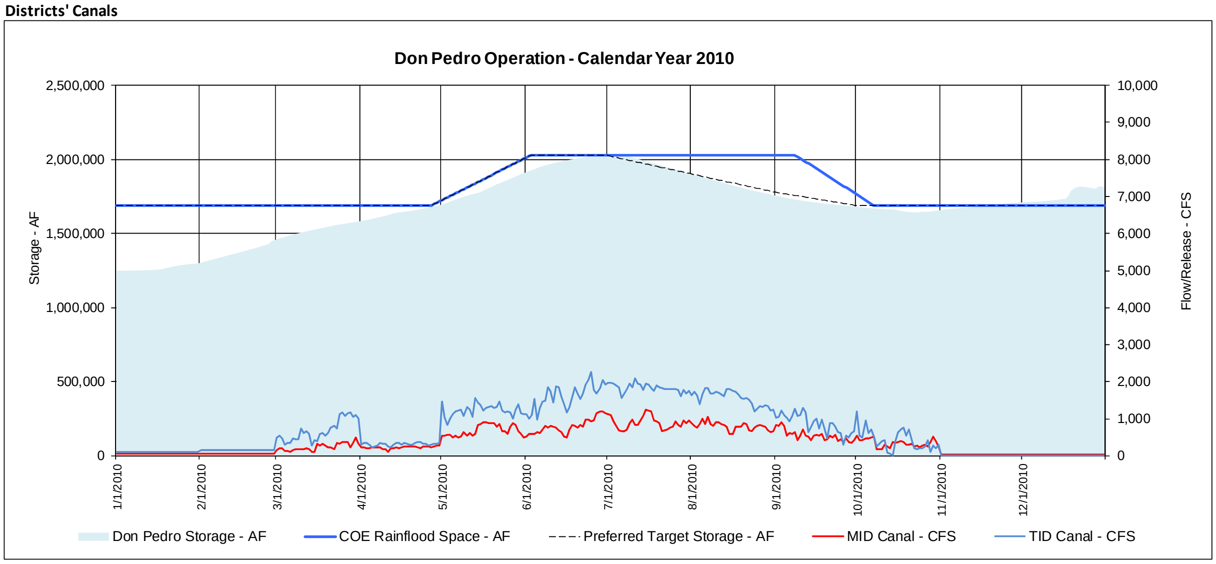
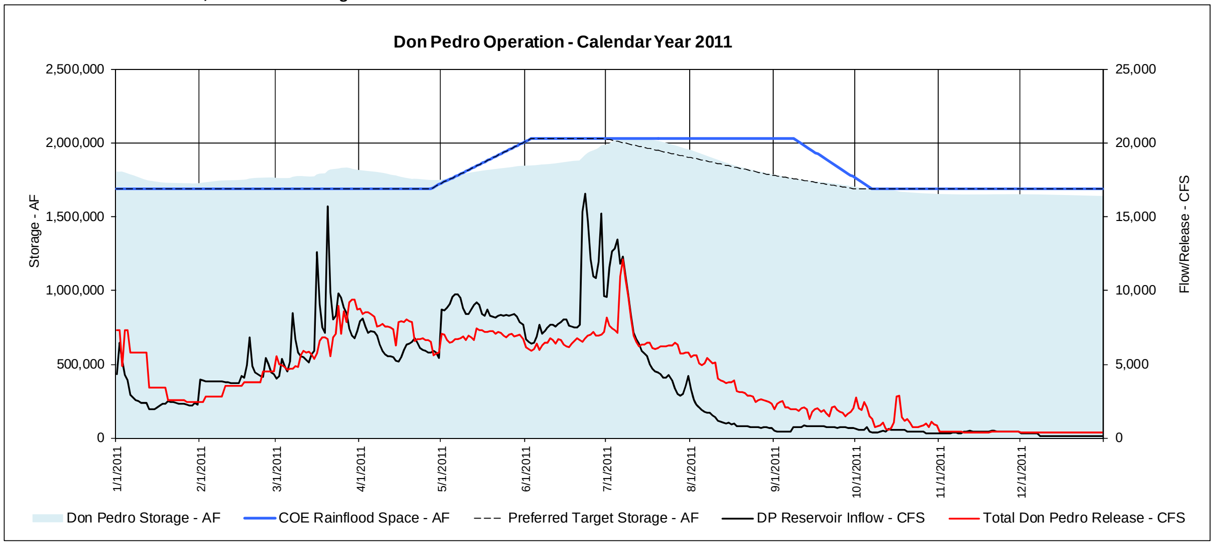
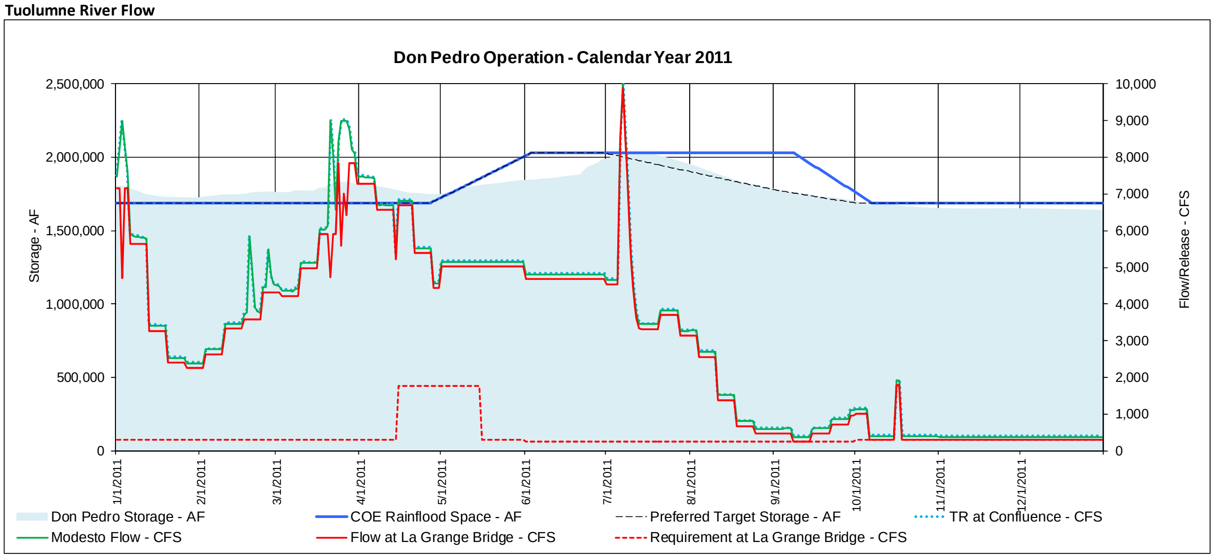


Figure 4.9-2. Don Pedro operations 2010 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

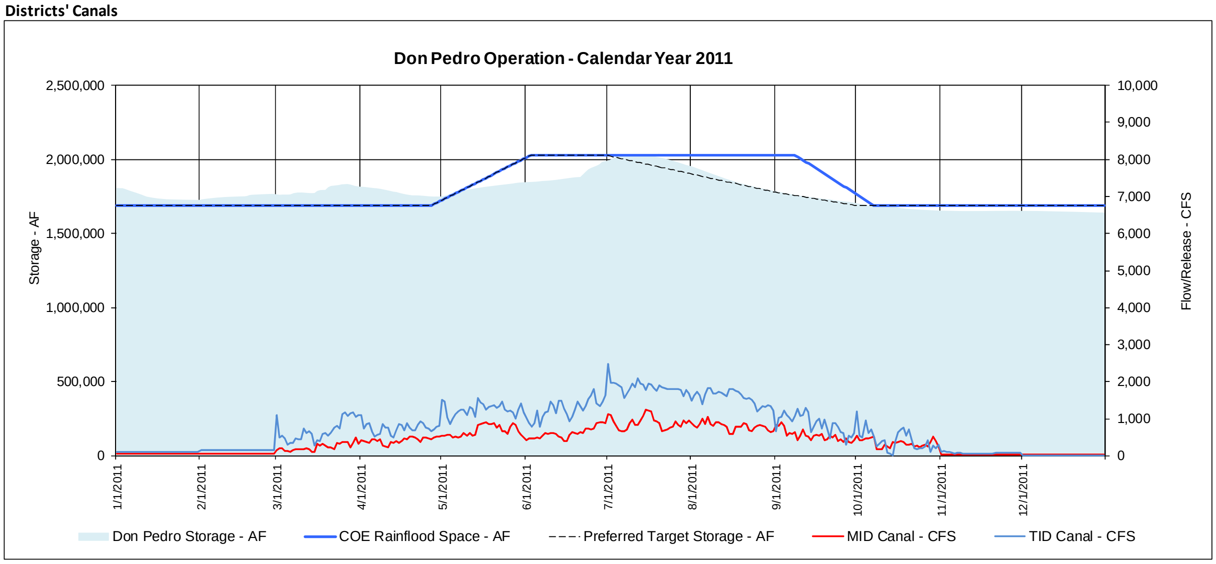
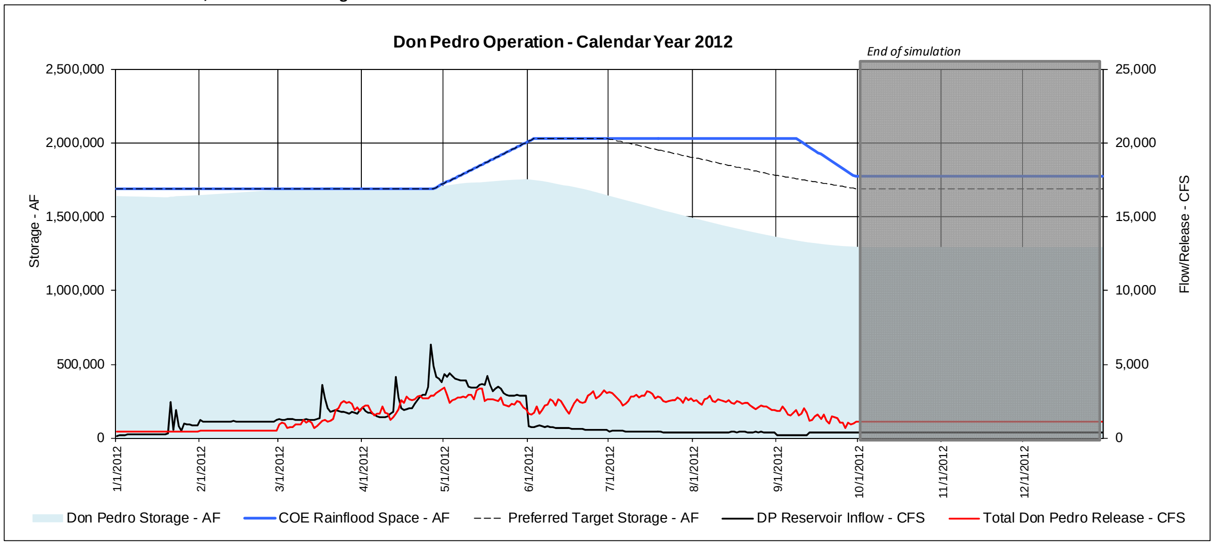
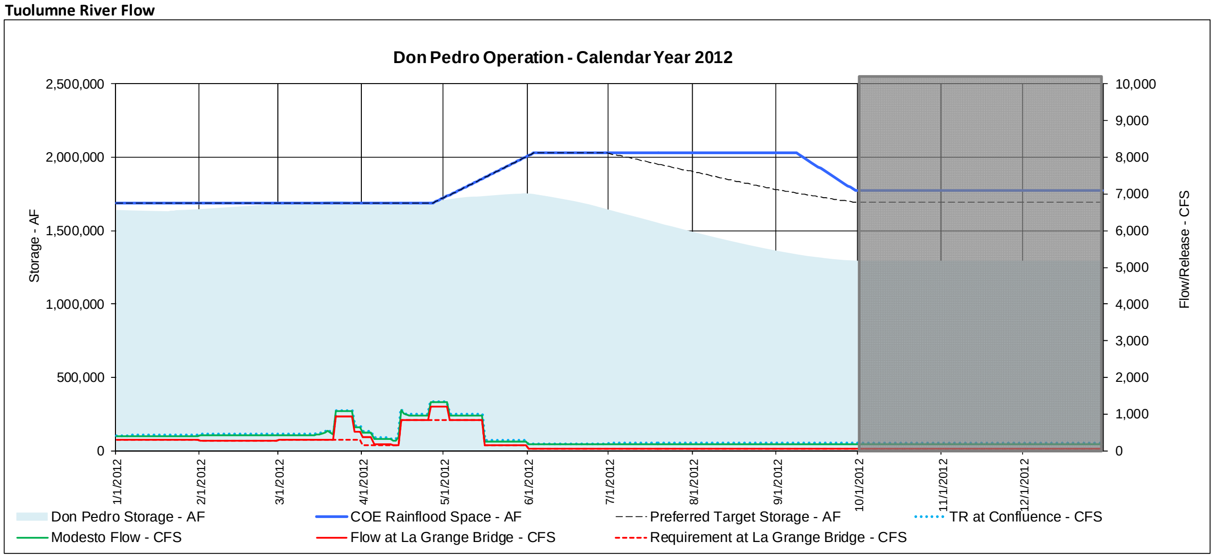


Figure 4.9-3. Don Pedro operations 2011 – Base Case.

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

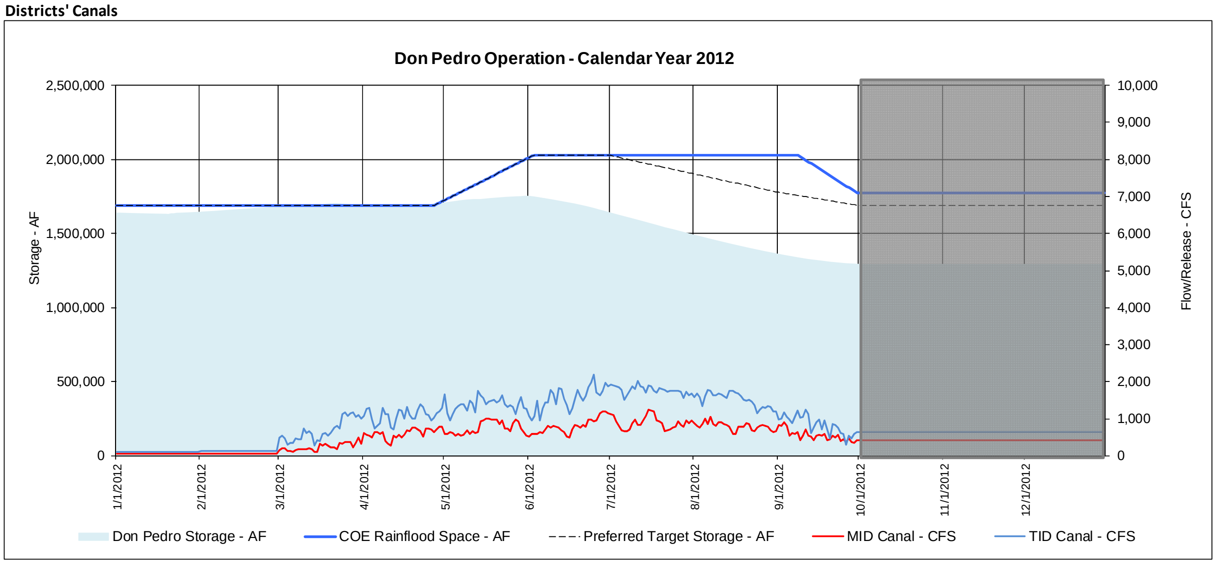


Figure 4.9-4. Don Pedro operations 2012 – Base Case.

5.0 COMPARISON OF MODEL RESULTS TO HISTORICAL OPERATIONS

The Tuolumne River Daily Operations Model provides a depiction of project operations, and represents CCSF and District operations to the extent that their operations can be described numerically and consistently by various equations and algorithms. Actual operations of the two independently operated systems may vary from those depicted by the Model due to circumstantial conditions of hydrology and weather, facility operation, and complex and sometimes inconsistent human decisions. Factors affecting direct comparison to the historical record include:

- The two systems are constantly adjusting to real-time events. Facilities, policies and requirements may change with time.
- Modeling will not always capture issues that arise in actual operation. Decisions based on real-time circumstances may change year to year, and not always consistently.
- Modeled demands assume a constant land use (i.e. crops planted), not recognizing year to year variation.
- Models do not fully capture daily decisions, or the real-time operational discretion and judgment that may be exercised by senior management or the Board of Directors to modify operational goals and constraints, including dealing with potential flood management situational objectives.
- The model will not capture forced outages, unforeseen maintenance or emergency activities that have occurred during historical operations.

Validation of the Model's ability to provide a systematic reaction to changing hydrologic conditions and system demands is the subject of the Initial Study Report (ISR) W&AR-02 Attachment C Model Validation Report, January 2013. Supplementing that effort is the following which compares the Model simulation of basin operations with the recent historical record of operations. The following illustrates the Model's simulation results compared to recent reported operations and flows. As discussed numerous times previously, conclusions concerning these comparisons need to be carefully drawn with appropriate consideration given to the nature of the Model which will simulate operations based on a strict set of systematic algorithms that perform consistently across each year, from year to year. The simulation will at times deviate from the record of historical operations due to many real-time circumstances that cannot be captured with a simulation model.

5.1 CCSF Upstream Operations and Don Pedro Reservoir Inflow

Going directly to a comparison of simulated Don Pedro Reservoir operations to the historical record will not illuminate differences that are due to the simulation of the CCSF system and inflow to Don Pedro Reservoir. Therefore, a first element of comparison is the demonstration of projected CCSF operations and inflow to Don Pedro Reservoir.

The most recent record of operation (2009-2012) of the CCSF system was compared to the simulated operation of the Model. Results of the comparison illustrated that the Model well represents the trends of CCSF reservoir operations and releases including the seasonal release of inflow and storage in excess of minimum release requirements.

The upstream operation of CCSF can be summarized by the depiction of inflow to Don Pedro Reservoir. Inflow will reflect changes in runoff due to CCSF's operations and by implication the ability of the Model to depict the reservoir and diversion operations of CCSF that modify river flow. Figure 5.1-1 illustrates the monthly volume of simulated inflow to Don Pedro Reservoir in comparison to the computed historical inflow. The inflow is the combination of both regulated releases from the CCSF system and unregulated runoff into Don Pedro Reservoir. The comparison is good for the most recent period of comparison (forward from WY2009). The comparison is reasonably good for prior periods also, with the apparent "peaking" difference in the simulation (late spring) prior to 2009 explained by a model-incorporated different operation of Hetch Hetchy Reservoir releases that tends to focus spring-time releases later in the season. This operation which is incorporated in the Model has only occurred in CCSF's more recent actual operations.

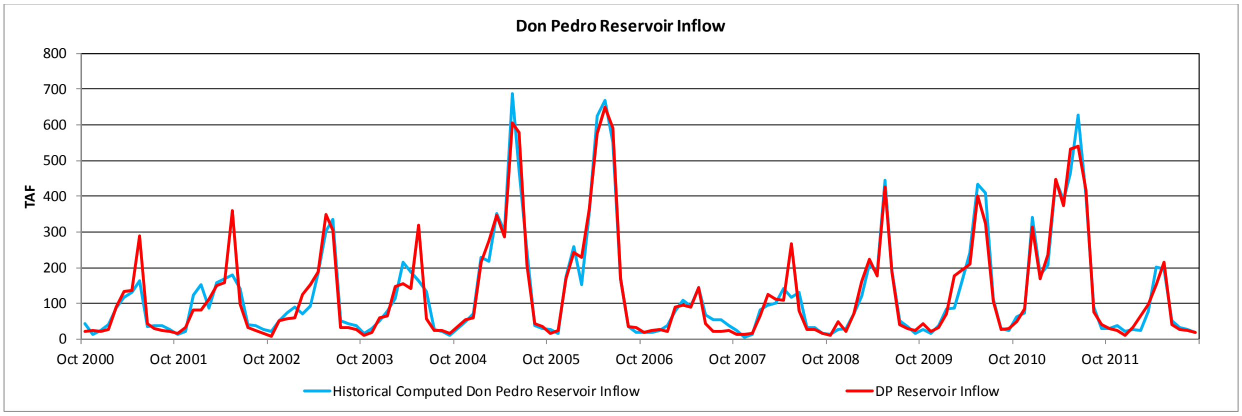
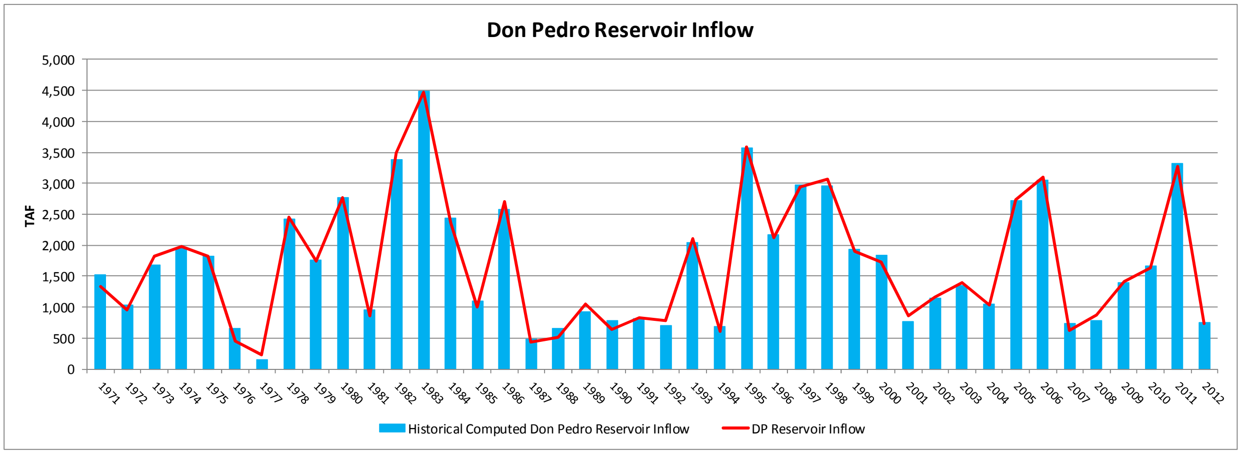


Figure 5.1-1. Don Pedro Reservoir inflow.

Figure 5.1-2 illustrates the comparison of annual (water year) total inflow into Don Pedro Reservoir. This information has been previously illustrated. The blue bars represent the computed historical inflow to the reservoir and the red line represents the total inflow as simulated by the Model.



Water Year

Figure 5.1-2. Don Pedro Reservoir Inflow – Annual Volume 1971-2012.

Table 5.1-1 illustrates the seasonal and annual difference between simulated inflow to Don Pedro Reservoir and computed historical inflow for the entire analysis period. Negative monthly and "Diff Total" values represent instances of the historical computed inflow being less than the simulated values. Also shown in the table is the annual total computed historical volume of inflow to Don Pedro Reservoir for each year.

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Diff Total	Total Inflow
1971	51	51	55	64	-14	-2	-10	-171	25	33	58	43	183	1,517
1972	51	45	41	51	-10	-11	-12	-163	-10	26	35	35	76	1,033
1973	36	35	30	48	-73	-31	-34	-160	-105	36	33	42	-143	1,674
1974	48	-7	40	30	-32	-46	-29	-119	-25	43	27	28	-41	1,945
1975	47	53	53	54	-39	-35	-21	-134	-63	19	36	34	4	1,825
1976	33	35	61	46	19	15	-10	-5	8	4	1	3	211	654
1977	10	3	-3	-2	-9	-11	-8	-18	-20	-13	-11	-5	-86	142
1978	-2	4	-11	23	-28	-7	-28	-24	0	-31	43	26	-36	2,420
1979	56	41	53	38	-39	-31	-21	-124	-68	45	35	34	20	1,763
1980	47	28	54	-72	-58	-36	-5	-87	11	6	63	43	-5	2,766
1981	55	31	32	36	-36	-28	-6	-132	30	43	38	40	104	958
1982	25	-38	-7	33	-63	-61	22	-78	-29	14	36	30	-116	3,376
1983	7	-16	62	28	-81	-37	23	7	-59	6	30	44	13	4,480
1984	61	-20	0	15	-28	-28	-18	-13	-20	43	40	39	72	2,434
1985	43	26	50	66	4	-8	2	-188	7	31	34	34	101	1,096
1986	24	6	4	25	-88	-81	33	-70	-95	42	38	29	-133	2,575
1987	44	46	40	38	0	-13	-20	-68	-15	-8	-2	7	49	482
1988	7	-14	-13	24	-5	-22	19	-30	63	49	27	33	139	659
1989	31	10	12	12	-59	-69	-43	-196	91	26	32	26	-124	920
1990	8	17	39	35	7	16	9	-68	1	17	25	30	137	773
1991	20	41	22	18	-45	-48	-20	-81	21	14	34	16	-7	816
1992	20	18	22	26	-3	-4	-61	-98	-6	-14	11	10	-78	701
1993	10	19	43	44	-28	24	2	-114	-63	5	4	-6	-60	2,042
1994	-6	-3	-3	-1	-23	69	36	-34	21	8	17	1	81	689
1995	11	37	66	58	-34	-41	-14	-40	-65	-17	8	4	-25	3,569
1996	20	-5	0	14	-2	-8	24	-66	-24	51	25	21	50	2,170
1997	20	3	50	-83	15	19	36	-80	-50	57	27	29	42	2,977
1998	33	-11	3	36	-14	-5	-2	-168	73	-64	15	-12	-116	2,958
1999	3	-4	21	7	-2	22	22	-68	-7	30	14	0	39	1,937
2000	12	-9	-2	-9	-40	32	47	-103	30	59	45	45	106	1,836
2001	22	-11	3	15	-3	-16	-3	-126	-7	7	15	5	-100	757
2002	0	-12	42	70	-24	8	11	-179	42	7	14	12	-10	1,149
2003	13	1	16	30	-55	-61	-3	-46	31	17	9	10	-38	1,351
2004	6	9	-7	14	-32	60	46	-155	75	4	-2	-5	14	1,049
2005	-8	-5	12	13	-57	5	17	81	-106	40	-5	-6	-18	2,723
2006	9	-7	7	14	-77	-8	49	19	-41	2	1	-12	-44	3,052
2007	1	-5	-1	17	-12	14	3	0	25	30	34	15	121	740
2008	11	-7	-4	17	-30	-13	31	-150	52	4	4	0	-84	785
2009	3	-22	8	0	-41	-14	8	19	5	10	6	-8	-26	1,391
2010	-15	-4	6	14	-92	-31	35	31	83	6	4	-5	31	1,665
2011	14	-11	29	12	-29	-2	18	-67	86	-16	14	-12	37	3,312
2012	0	11	10	-5	-41	-20	49	-20	10	5	2	0	2	742
Average	21	9	22	22	-31	-13	4	-78	-2	16	22	17	8	1,712

Table 5.1-1. Difference between historical and simulated Don Pedro Reservoir inflow (TAF).

The Model's upstream operation of CCSF facilities provides a reasonable representation of Don Pedro Reservoir inflow compared to recent historical records. The focus of this conclusion is based on the simulation of WY2001-2012, with an emphasis on the comparison of WY2009-2012.

5.2 Don Pedro Reservoir Operations

A critique of simulated Project operations based on a comparison to historical records is complicated by the combined differences that are due to modeled differences in inflow and modeled differences in Project water demands. As a starting point, the potential compounding influence on Project simulated operations due to CCSF upstream operations and projected District canal diversions is removed. Initially, the simulated Don Pedro Reservoir inflow results are replaced with the historical computed inflow to Don Pedro Reservoir. Similarly, the projected District canal demands are replaced with the historical record of canal diversions. By removing the differences between simulated and historical inflows and canal diversions the Model is being tested for decisions concerning the volumes and distribution of releases for the lower river. The comparison of results for river flow between simulated and recent historical operations is shown in Figure 5.2-1 through Figure 5.2-7. The sequential illustration of results is shown beginning in CY2006 in order to capture operations resulting from and following "full reservoir" conditions.

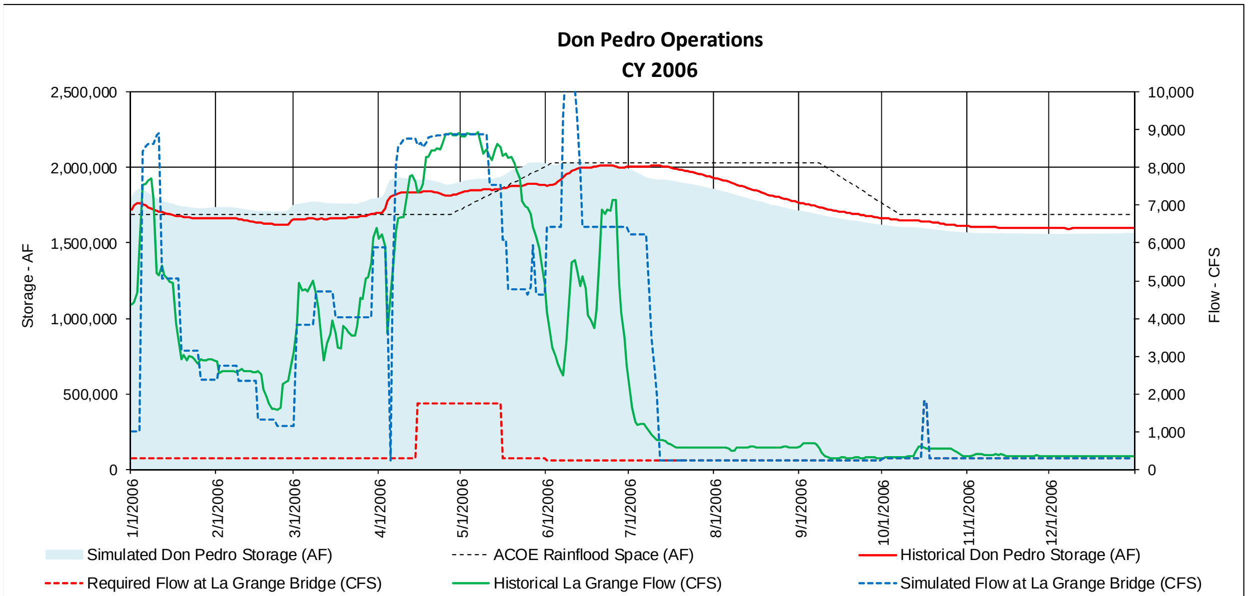


Figure 5.2-1. Don Pedro Reservoir and Tuolumne River operations – 2006.

Of key interest are the storage and release hydrographs: the blue shade is the simulated storage operation, and solid red line is the historical operation; the dashed red line is the simulated required minimum flow at La Grange gage (also referred to in the legend as La Grange Bridge); the solid green line is the historical record of stream flow at La Grange gage, and dashed blue line is simulated flow at La Grange gage.

Entering winter and early spring 2006, actual operations appear to have targeted the rainflood envelope more than simulated operations. Overall, this is a starting-volume difference with the difference being mostly the same throughout the winter and early spring; thus the trend, both magnitude and duration, of simulated releases match well between historical and simulated results. In late spring, actual operations continued to maintain empty reservoir space to absorb impending runoff, while simulated operations allowed the filling of reservoir space. The simulated operation illustrates a peaking of release during early June which would likely not occur. This type of modeling anomaly could likely be remedied with additional logic or refinement of forecasting procedures, or recognition and post-processing modification (smoothing) if used for subsequent modeling. Actual operations held the "full" reservoir longer (July), then started a lengthy drawdown to a similar reservoir condition by fall.

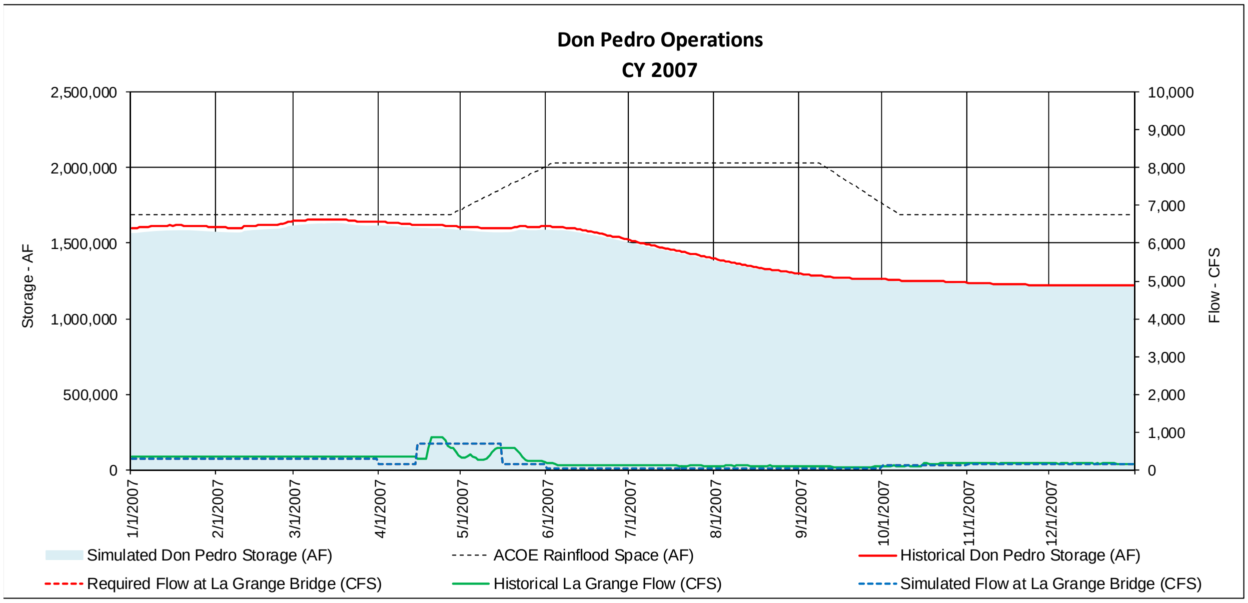


Figure 5.2-2. Don Pedro Reservoir and Tuolumne River operations – 2007.

During 2007 the differences in simulated and actual river flow is the result of an assumed systematic distribution of the current FERC minimum flow requirement and the real-time distribution of releases with consideration given at the time for San Joaquin River flow objectives within the San Joaquin River Agreement.

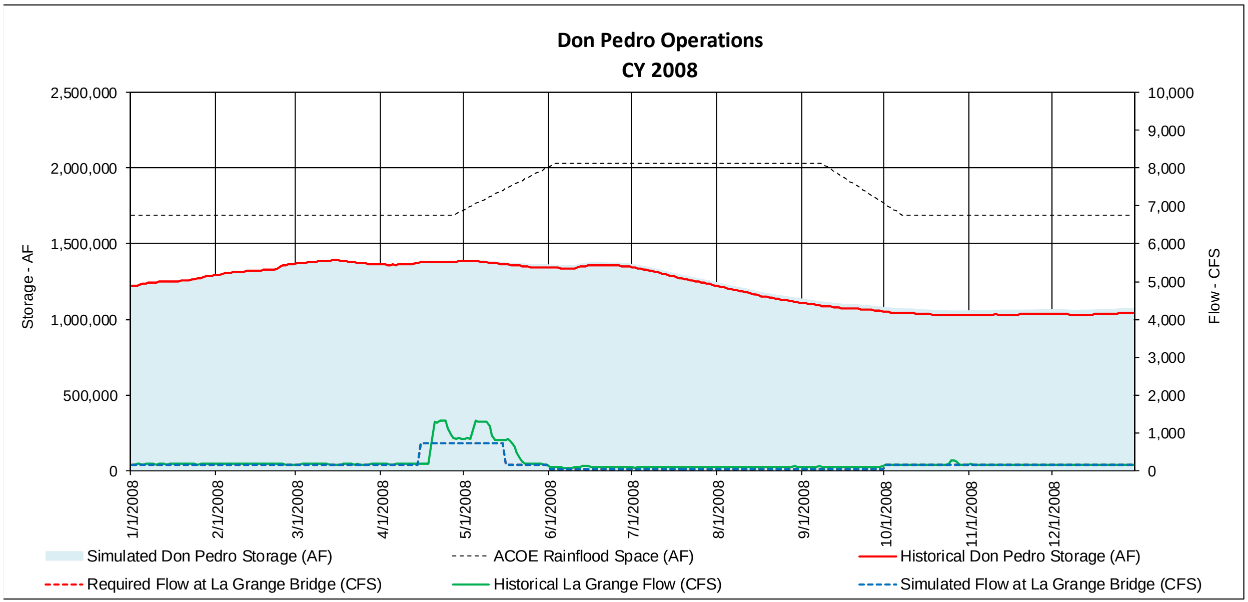


Figure 5.2-3. Don Pedro Reservoir and Tuolumne River operations – 2008.

For 2008, it is the same observation as 2007, with any differences in flow manifesting as a difference between simulated and historical reservoir storage

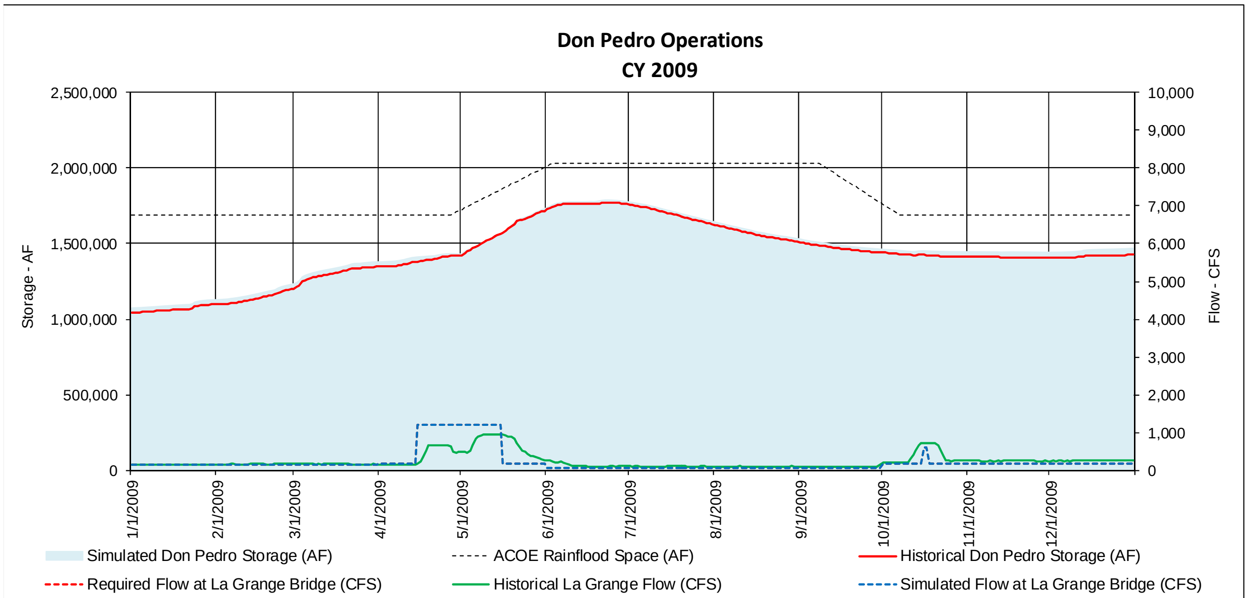


Figure 5.2-4. Don Pedro Reservoir and Tuolumne River operations – 2009.

The same type of differences that occur in simulating 2007 and 2008 occur for 2009. The actual operations and simulated operations of the Don Pedro Project are providing for minimum flow requirements at La Grange.

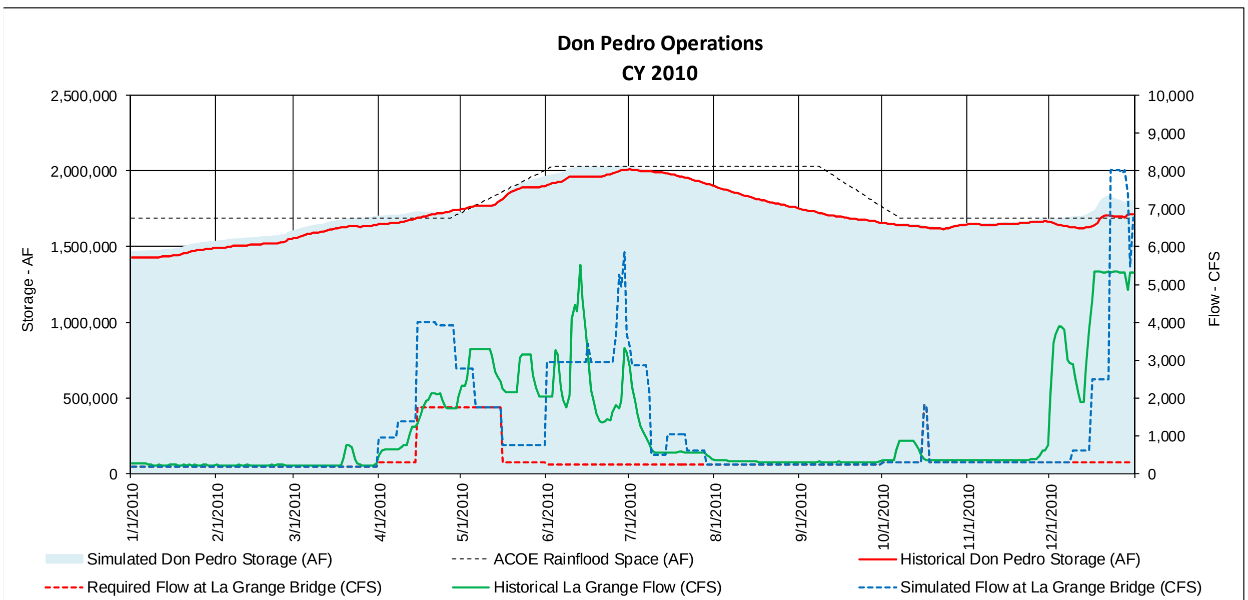


Figure 5.2-5. Don Pedro Reservoir and Tuolumne River operations – 2010.

Year 2010 hydrology following the previous years' of drawdown provides an opportunity to fill the reservoir, with releases occasionally in excess of minimum requirements. A different shaping of releases occurs between actual and simulated operations, but in general the overall approach to managing the reservoir and releases are comparable. During the early winter (late 2010) it appears that actual operation maintained rainflood reservation space a little more cautiously than simulated operations, but the general trend of the early winter river flows are similar.

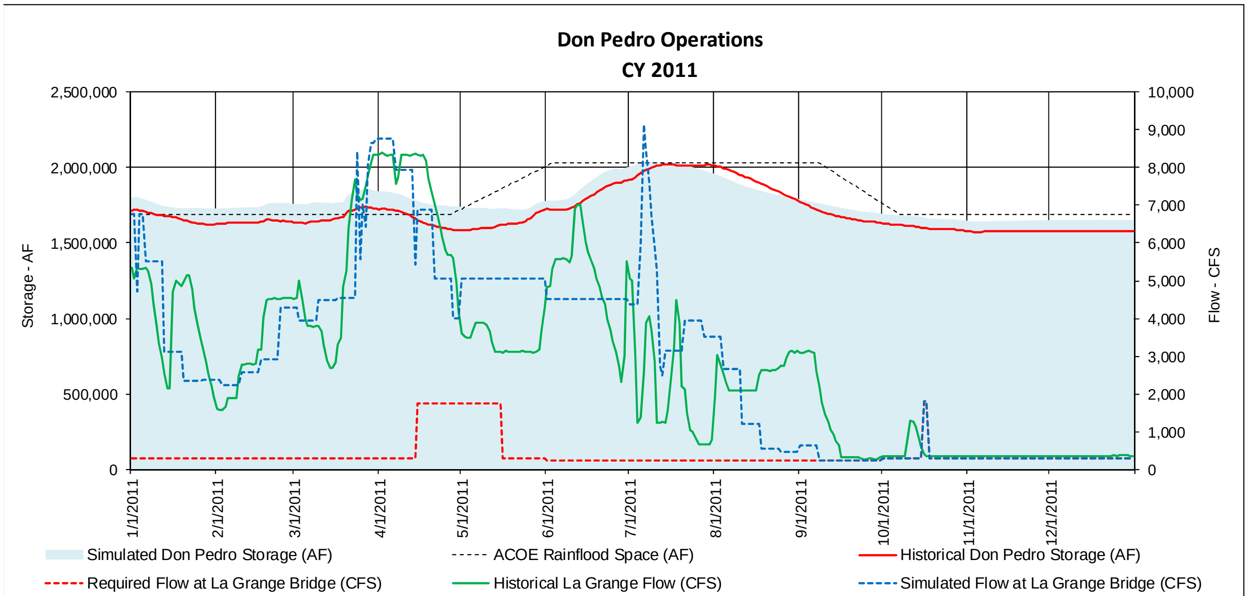


Figure 5.2-6. Don Pedro Reservoir and Tuolumne River operations – 2011.

Year 2011 is a very wet year with significant runoff occurring to the Tuolumne River. Actual operation appears to maintain the reservoir with more available storage than simulated operations, but the trend of releases are similar. Actual operations drew the reservoir lower going into the following fall/winter than simulated operations. The actual operation carryover storage is lower going into 2012 due to actual operations drawing the reservoir down more aggressively during the summer. The short duration "spike" flow shown in the simulation during the early part of July is a Model anomaly that would not likely occur in real operations. This is the same type of Model result circumstance noted for 2006 results, and if significant to the interpretation of modeling results would be adjusted by post-processing to remove the spike.

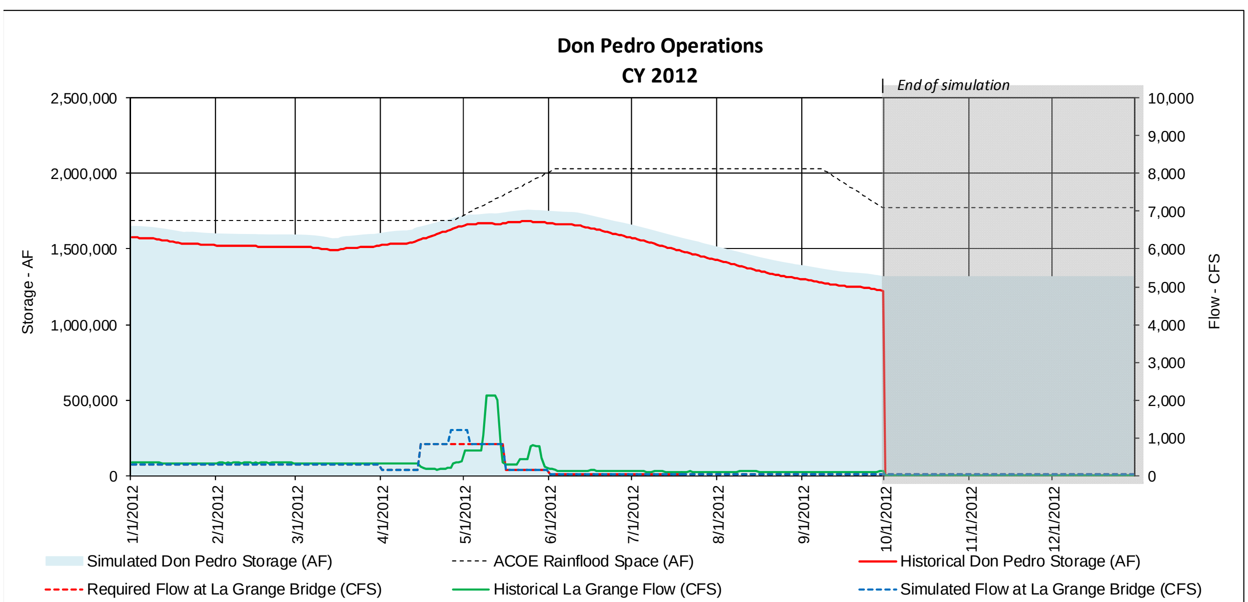


Figure 5.2-7. Don Pedro Reservoir and Tuolumne River operations – 2012.

Year 2012 is a dry runoff year. Minimum flow requirements were controlling operations under actual or simulated conditions except for a short duration additional release made in the simulation during late April. The difference in reservoir storage at the end of the analysis period is mostly the effect of the lower carryover storage of actual operations during 2011 operations.

Comparing the foregoing simulated operations of reservoir management and river releases illustrates the ability of the Model in making systematic decisions, and shows that the Model reasonably well trends with the decisions made by operators during historical conditions.

As a second level of comparing Model results to historical operations, a full simulation of the Base Case is configured by using simulated results for Don Pedro Reservoir inflow and District canal diversions. As previously stated, the simulation will at times deviate from the record of historical operations due to many real-time circumstances that cannot be captured with a simulation model. The full simulation will inherit the compounding effect of differences in simulated inflow as described in Section 5.1 above and differences in simulated District diversions as described by the following.

The historical and simulated combined canal diversions are illustrated in Figure 5.2-8. The annual diversion values are presented for the February-January period, which is best representative of a diversion year total since October (typically the last month of significant irrigation operations) is included in the year. Focus is directed to comparisons of the period WY2001-2012 which the Districts consider the recent past, and for which a reconciliation analysis was performed.

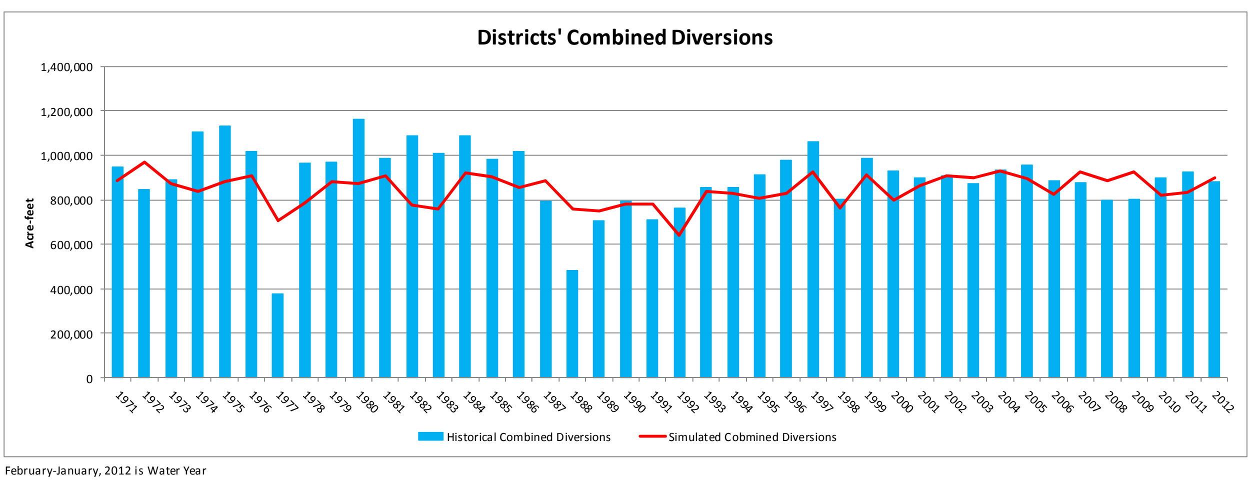


Figure 5.2-8. Historical and simulated combined canal diversions.

Table 5.2-1 provides a listing of the historical and simulated annual diversions of each district and the Districts collectively for the 2001-2012 period of simulation.

Combined Districts - March through October (Acre-feet) — Positives mean Model > Actual

	TID Canal				MID Canal				Combined Canals			
	History	Projected	Differ	Differ %	History	Projected	Differ	Differ %	History	Projected	Differ	Differ %
2001	572,398	551,456	-20,942	-4	304,781	284,911	-19,870	-7	877,179	836,367	-40,813	-5
2002	563,465	576,360	12,895	2	315,971	304,312	-11,659	-4	879,436	880,672	1,236	0
2003	545,552	570,461	24,908	5	284,671	292,088	7,417	3	830,223	862,548	32,325	4
2004	591,951	577,288	-14,663	-2	287,410	322,886	35,477	12	879,361	900,175	20,814	2
2005	588,470	552,330	-36,140	-6	294,180	302,342	8,162	3	882,651	854,672	-27,978	-3
2006	554,920	522,279	-32,640	-6	271,973	274,389	2,415	1	826,893	796,668	-30,225	-4
2007	559,413	590,109	30,695	5	279,003	292,061	13,058	5	838,416	882,169	43,753	5
2008	488,144	568,268	80,124	16	277,604	283,776	6,171	2	765,748	852,044	86,296	11
2009	516,892	579,435	62,543	12	257,008	304,100	47,092	18	773,900	883,534	109,634	14
2010	551,772	517,866	-33,906	-6	249,192	275,089	25,897	10	800,965	792,956	-8,009	-1
2011	568,488	526,959	-41,530	-7	265,355	275,304	9,949	4	833,843	802,262	-31,580	-4
2012	559,695	575,478	15,784	3	298,940	309,178	10,239	3	858,634	884,657	26,022	3

2012 total include January and February due to early season irrigation.

Table 5.2-1. Summary of historical and simulated Districts' diversions.

The data have been provided for the March through October period of each year, which is the period of review for the irrigation season and concerns a significant portion of an entire year's diversion volume (about 94% of the annual total of diversion). While in any year the simulation over- or under-projects diversions the magnitude of difference is reasonable and well within expectations given the many circumstances and decisions that affect actual diversions.

The difference of the Model diverting more than the historical volume illustrated during 2008 can be explained by understanding the water diversion logic of the Model. In actual operations during 2008 the Districts, in particular TID enacted actions that led to reduced diversions to its canal. The actions were in consideration of the current available water supply including consideration of Don Pedro Reservoir storage. Both Districts reduced their "allocations" to their customers, and in the case of TID the district increased its groundwater pumping for deliveries. Thus, historical canal diversions were less than would otherwise occur. The Model similarly adjusts the delivery demands to reduce diversions; however, it is done with a systematic algorithm that also considers Don Pedro Reservoir storage and impending inflow to the reservoir. In the instance of 2008, the systematic rule did not trigger actions to reduce diversions to the canals. The circumstance of 2008 within the Model's forecast of water supply was within 60,000 acre-feet of implanting diversion shortages, but did not simulate a shortage condition and thus simulated full canal diversions. For 2009, the Model again simulates a diversion greater than the historical record. Review of circumstances for the year leads to a conclusion that the consumptive use model overestimated demands for this particular spring season.

5.3 Base Case Don Pedro Reservoir Operations

Don Pedro Project operation hydrographs for the simulated Base Case akin to those shown above with a comparison to the reported recent historical operation of the Project are shown below. The comparisons are shown for the years 2006 through 2012.

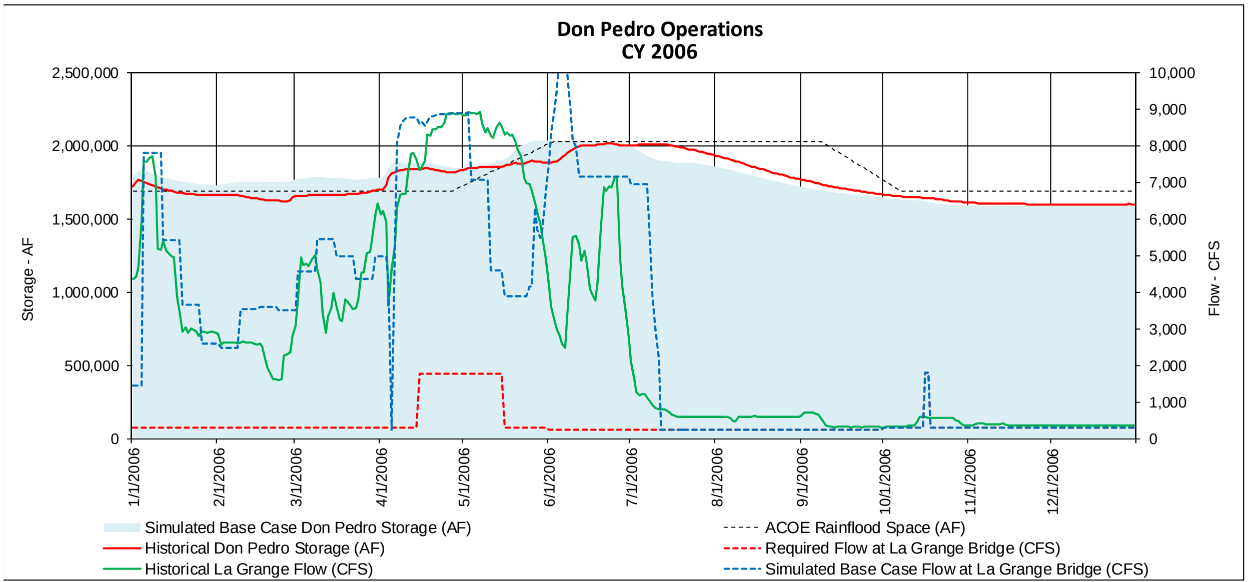


Figure 5.3-1. Base Case Don Pedro Reservoir and Tuolumne River operations – 2006.

Year 2006 was wet in classification, with significant releases in excess of minimum requirements. The general trends of excess releases compares well between historical operations and simulated operations. Differences occur for some of the timing of the releases due to a difference in reservoir management objectives. It appears that historical operations maintained reservoir storage closer to the rainflood storage reservation envelope throughout the winter and early spring, and maintained additional empty reservoir space during the late spring which avoided the short duration large simulated releases during early June.

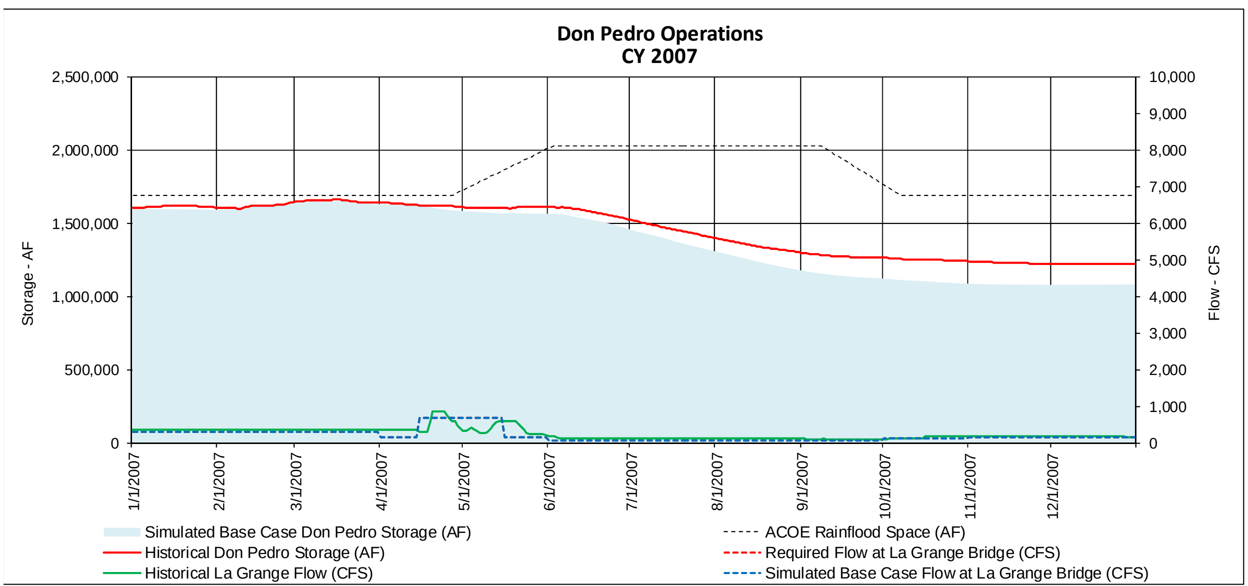


Figure 5.3-2. Base Case Don Pedro Reservoir and Tuolumne River operations – 2007.

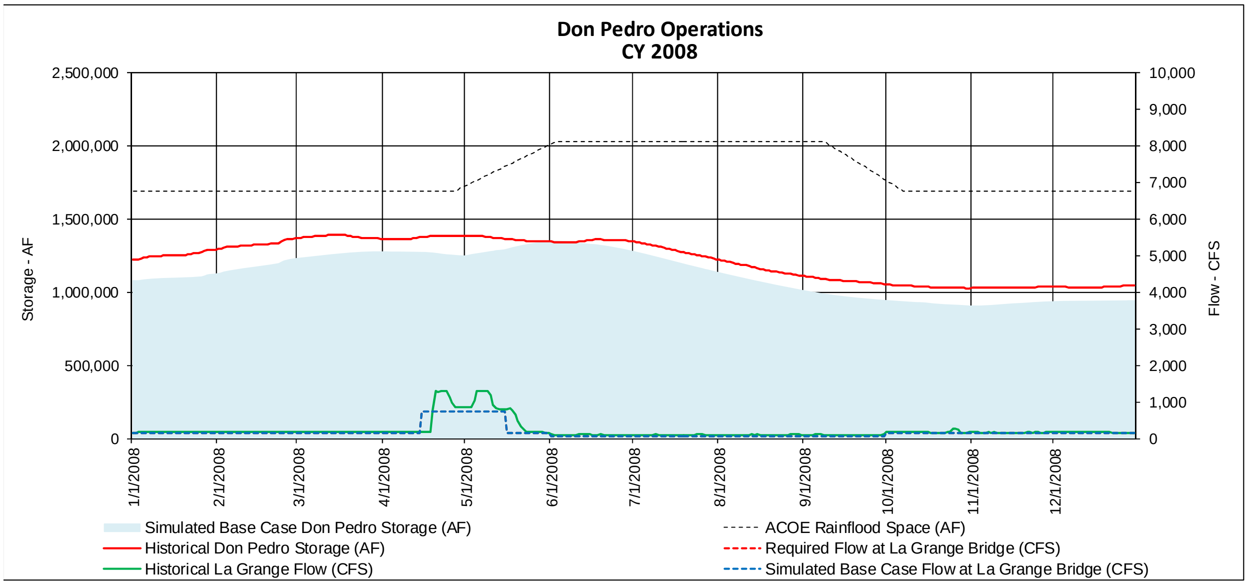


Figure 5.3-3. Base Case Don Pedro Reservoir and Tuolumne River operations – 2008.

Both years were dry in classification leading to no releases in excess of minimum requirements. Simulated river flow tracks well and consistent with historical flow. Simulated inflow and historical inflow were about the same with historical inflow being about a net 40,000 acre-feet larger over the two years. The Base Case diversions are about 130,000 acre-feet larger than the historical record over the two years. That combined effect explains the difference between 2008 year-ending storage of the historical record and the Base Case simulated storage.

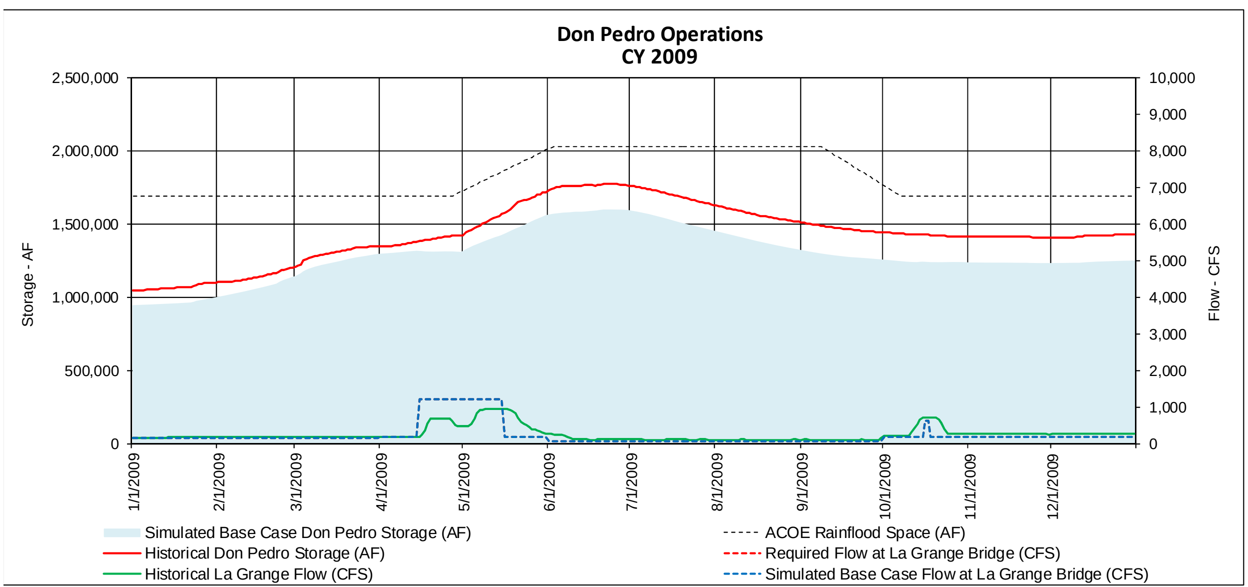


Figure 5.3-4. Base Case Don Pedro Reservoir and Tuolumne River operations – 2009.

The differences brought into 2009 from 2008 remain through the end of the year. The difference between year-ending historical storage and simulated storage slightly increases because simulated diversions are greater than historical diversions for the year.

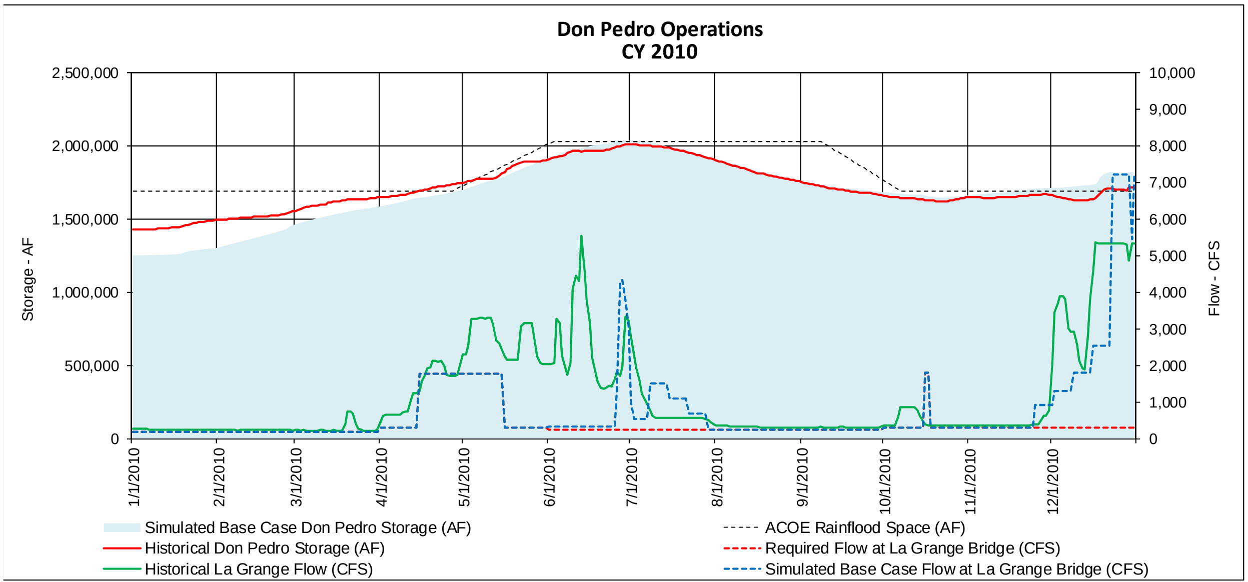


Figure 5.3-5. Base Case Don Pedro Reservoir and Tuolumne River operations – 2010.

For 2010, the difference in beginning year storage caused by the effects of previous years' simulated operations transcend into 2010 until simulated reservoir storage "catches up" (refills) to the level of historical storage. The antecedent difference in storage results in a delay in the first simulated release in excess of minimum FERC flow requirements. Thereafter, simulated storage and releases trend well with historical operations.

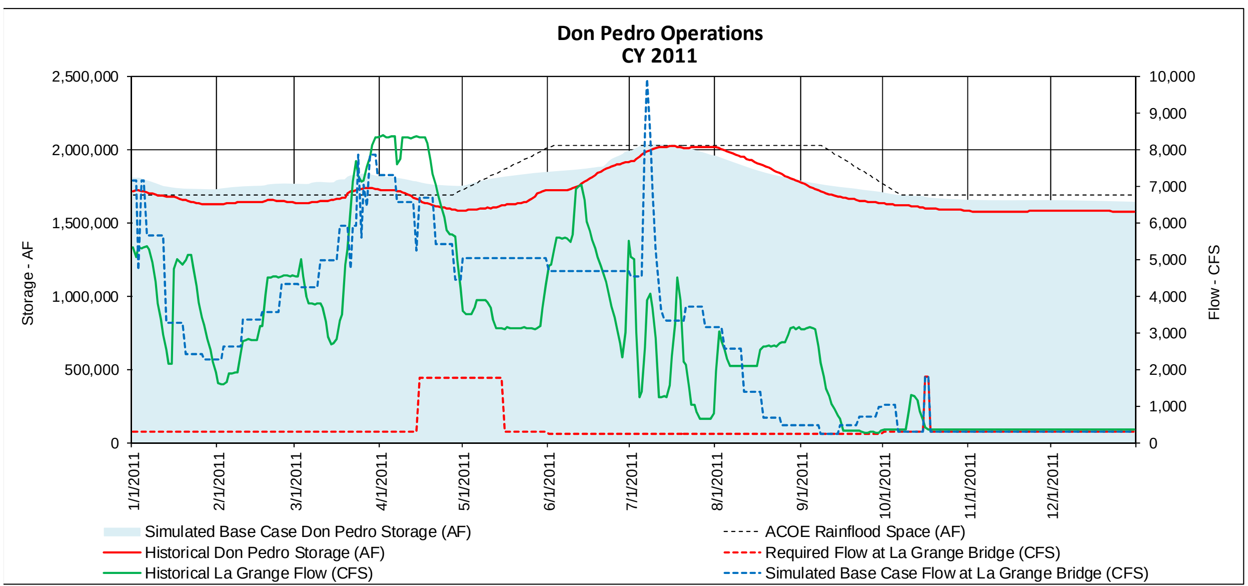


Figure 5.3-6. Base Case Don Pedro Reservoir and Tuolumne River operations – 2011.

Year 2011 was a very wet year with only a slight difference in carryover storage occurring due to historical operations targeting a slightly lower fall reservoir level (lower than the flood control envelop).

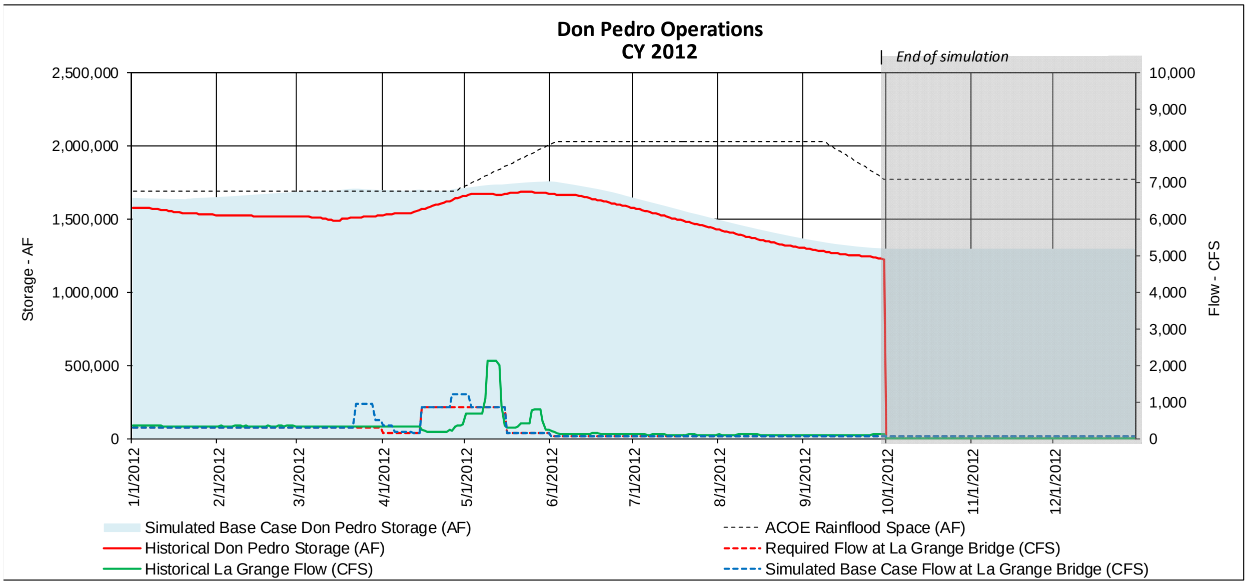


Figure 5.3-7. Base Case Don Pedro Reservoir and Tuolumne River operations – 2012.

This lower carryover storage transcends into 2012 historical operations and with the net effect of inflow and diversion differences that occurred early in the year balancing out with differences later in the year thus resulting in an ending storage of the simulation (September 2012) essential the same between historical and simulated storage.

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PROJECT OPERATIONS/WATER BALANCE MODEL

ATTACHMENT C

MODEL VALIDATION REPORT

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List of Figures

1.0 INTRODUCTION

The Turlock Irrigation District (TID) and Modesto Irrigation District (MID) (collectively, the Districts) have developed a computerized Project Operations Model (Model) to assist in evaluating the relicensing of the Don Pedro Project (Project) (FERC Project 2299). On November 22, 2011, in accordance with the Integrated Licensing Process schedule for the relicensing of the Don Pedro Project, the Districts filed their Revised Study Plan containing 35 proposed studies with the Federal Energy Regulatory Commission (FERC) and relicensing participants. On December 22, 2011, FERC issued its Study Plan Determination approving, with modifications, the proposed studies, including Study Plan W&AR-2: Project Operations /Water Balance Model Study Plan. Consistent with the FERC-approved study plan, the objective of the Model is to provide a tool to compare current and potential future operations of the Project. Due to the fact that the geographic scope of the Model extends from the City and County of San Francisco's (CCSF) Hetch Hetchy system in the upper part of the watershed to the confluence of the Tuolumne and San Joaquin rivers, the Model is now entitled the Tuolumne River Daily Operations Model (Model).

In accordance with the study plan, the Districts have prepared a Model Development Report filed with FERC in January 2013 (W&AR-2 Study Plan, page 7). This Model Validation Report is an attachment to the Model Development Report and provides information concerning the wellness of the Model to assist in evaluating alternative Project operations as part of the relicensing process. Wellness in this instance is being defined by the performance of the Model to reasonably capture the behavior of the physical system being modeled when making "what if" assumptions for different inputs. These inputs include such parameters as inflows to reservoirs and required releases to streams. The validation process establishes the credibility of the Model by demonstrating its ability to reasonably mimic the historical and projected decision process of reservoir operations.

2.0 VALIDATION

Validation in this modeling process has been undertaken to identify the ability of the Model in providing a systematic reaction to changing hydrologic conditions and system demands. As is the case with any model, the Tuolumne River Daily Operations Model is only a depiction of project operations, and is limited to representing CCSF and District operations to the extent that their operations can be described numerically and consistently by various equations and algorithms. Actual operations of the two independently operated systems may vary from those depicted by the Model due to circumstantial conditions of hydrology and weather, facility operation, and complex and sometimes inconsistent human decisions. Although the historical operation of the two systems serve as the Model's validation comparison, caution is advised to not overly rely on the absolute comparison of the Model's results and the historical record for determining the validity of the Model. Validation of the Model is also a matter of reviewing the results of the algorithms that represent the actions of the respective water system operators.

The simulation period of the Model is WY 1971 through WY 2009. While the record of the two project's operations extends back to WY 1971, the period of record used for developing and refining the Model's algorithms was limited to recent historical periods, the period subsequent to the 1987-1992 extended drought period and primarily post 1996. Additional, significant deference was given to discussions with District and CCSF operations staff related to recent operations decision-making. The focus on more recent operations is appropriate for several reasons. For instance, the 1987-1992 drought caused a re-thinking of water operations planning in the two systems, just as the drought of 1976-1977 caused re-thinking at that time. During the 1987-1992 drought, and immediately following, many water management and long-term conservation practices were honed and implemented to react to the extreme shortage of water. As the result of the drought, the two systems are generally not operated today as they were prior to the extensive drought. Limited value occurs from comparing a contemporary operation of the systems with history (prior to the 1987), and it can be problematic. Even the regulatory environment has changed since project development. Instream flow requirements for the Tuolumne River have changed since early Project operation, most significantly with the amendment of the fish flow requirements of the Don Pedro license by FERC in 1996.

The Model is intended to provide a depiction of current operations by CCSF and the Districts on the Tuolumne River. In addition to the overarching moving target dilemma that the historical record creates for a comparison to Model results, there are additional factors that need to be considered when establishing the performance marker for the Model. Factors affecting direct comparison to the historical record include:

- The two systems are constantly adjusting to real-time events. Facilities, policies and requirements may change with time.
- Modeling will not always capture issues that arise in actual operation. Decisions based on real-time circumstances may change year to year, and not always consistently.
- Modeled demands assume a constant land use (i.e. crops planted), not recognizing year to year variation.

- Models do not fully capture daily decisions, or the real-time operational discretion to modify operational goals and constraints, including dealing with potential flood management situational objectives.
- The model will not capture forced outages, unforeseen maintenance or emergency activities that have occurred during historical operations.

However, there is utility in comparing the Model simulation of basin operations with the recent historical record of operations. Most salient to the comparison is how reservoirs are managed during periods when water supplies exceed minimum requirements. It is a simple matter to illustrate against historical operations a model that simply balances inflows and outflows when all supplies can be managed without excess releases. The validation of the Model comes with providing a depiction of how water in excess of minimum requirements is managed, particularly during periods of flood control or reservoir drawdown operation.

3.0 DON PEDRO RESERVOIR AND RELEASES

The Model's simulation of Don Pedro Reservoir management and releases is validated by comparing the Model's depiction of storage and releases to historical operations. Although a record of historical operations since 1970 exists, a comparison using the early records is inappropriate due to the Project's initial filling sequence over several years. In some respects even a comparison of the Model's results with recent operational records is subject to some uncertainty due to inherent differences between the historical values of inputs and simulated values (e.g., inflows).

Several years have been selected to illustrate the performance of the Model in depicting Don Pedro Reservoir operations. Each of these years represents a period of hydrology and circumstances that allow an illustration of certain Model decision processes. As a method to illustrate specific elements of Model decision making, such as reservoir storage objectives vis-a-vi stream releases, certain other elements of hydrology such as inflow and diversions have been set to historically recorded values.

3.1 Don Pedro Reservoir Storage and Stream Release

Several sample years were selected for validating the Model's algorithms related to Don Pedro storage targets. The years 1998, 1999, 2000, 2001, 2004, 2005, and 2006 have been selected as illustrative of circumstances when Don Pedro Reservoir released in excess of minimum demands (canal demand and minimum instream flow requirements). To eliminate the confounding influence of differences in inflow and canal diversions between the historical record and modeling assumptions, both of these parameters have been set to historical values for the sample years.

Figure 3.1-1 illustrates the actual and modeled operation of Don Pedro Reservoir for the year 1998. Of particular importance to this component of validation is the tracking of actual reservoir

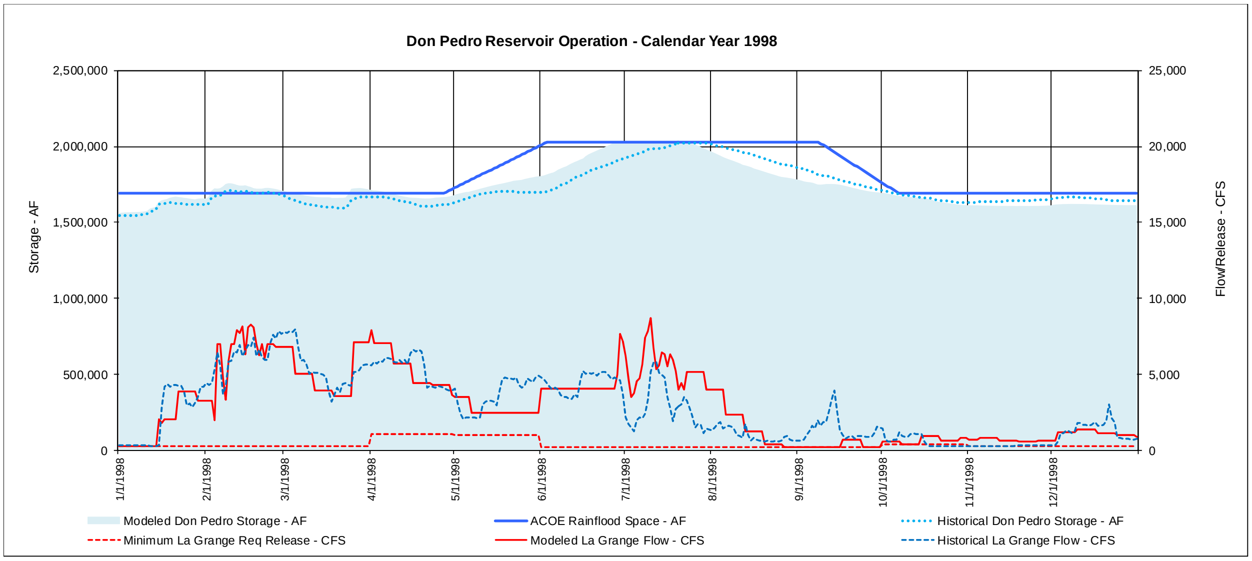

Figure 3.1-1. Historical and modeled Don Pedro Reservoir storage and release - 1998.

storage and stream flow (releases) to the Tuolumne River below La Grange Dam. The results show the modeled storage (light blue fill chart) tracking well with the historical record of storage (light blue dotted line). These storage traces are the result of historical and modeled decisions that were guided by decisions concerning storage targets. Shown coincidentally with the resultant storage are the stream releases, which when combined with releases for the Districts' canal diversions (not shown), resulted in the storage levels. The historical release to the Tuolumne River below La Grange Dam is shown as the dark blue dashed line and the modeled release is shown as the solid red line. Other information shown in the graph are the minimum flows required by the current FERC license depicted by a dashed red line, and the ACOE rain flood storage reservation shown as a solid blue line.

For year 1998, the Model makes total release decisions to provide an additional buffer of storage in addition to the ACOE rain flood space during the fall, winter and early spring.[1] To provide this storage objective the Model's 7-day encroachment logic advised total releases in excess of minimum demands. Although encroachment into storage space above the target occurs, the Model reacts to the encroachment in an effort to remedy the circumstance. Throughout this period the modeled stream release is following the *trend* of historical stream releases and the actual amount of encroachment that occurred.

Beginning in April of the subjet year, both the Model's 7-day encroachment and snow-melt release algorithms guide reservoir total releases. Evident in Figure 3.1-1 is the Modeled reservoir operation during May and June that results in reservoir storage being below the storage target which is an indication that releases are advised in excess of minimum demands so as to distribute occurring and impending snow-melt runoff prior to reservoir filling at the end of June. Some difference occurs between modeled operation and actual historical operation, but in general the modeled and historical storage and coincidental stream releases during this period trend well with each other.

After June 30, the Model uses the 7-day encroachment release algorithm to draw the reservoir down during the summer according to storage targets. Although the historical operation illustrates maintaining the reservoir near full capacity for a longer period that summer, both operations (modeled and historical) drew the reservoir back to the ACOE rain flood reservation space by fall. Both operations illustrated releases to the Tuolumne River below La Grange Dam in excess of minimum requirements during the summer.

Figure 3.1-2 illustrates the historical and modeled operation of Don Pedro Reservoir for the year 1999. The year 1999 illustrates a year that is less abundant in runoff than the previous year. During the winter and early spring of year 1999 the Model again makes release decisions to provide an additional buffer of storage in addition to the ACOE rain flood space. To provide this storage objective the Model's 7-day encroachment logic advised releases in excess of minimum demands. Throughout this period the modeled stream release is following the trend of historical releases and the amount of encroachment that occurred.

[1] An additional buffer of storage is circumstantial and may not occur consistently from year to year, or within a year. For these Model validation examples a buffer was assumed when the historical record of operations appeared to show such a consideration. The current FERC license allows real time operations decision making related to this item.

During April of the year, the Model's 7-day encroachment algorithm continues to guide total reservoir releases, but by May stream releases are reduced to the minimum required. Modeled reservoir operation during April and May differs from historical operations which included consideration of managing stream releases for the Vernalis Adaptive Management Plan (VAMP). Thereafter, both the modeled operation and historical operation released to meet minimum demands (minimum flow requirements and canal diversions).

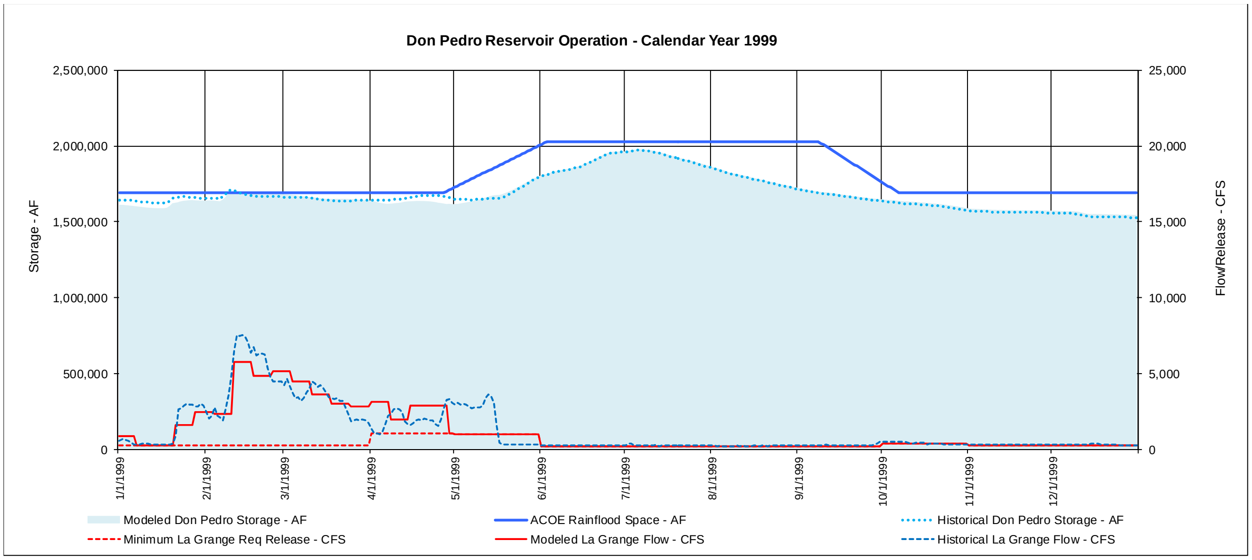

Figure 3.1-2. Historical and modeled Don Pedro Reservoir storage and release - 1999.

Modeled and historical operations for the years 2000, 2001, 2004, 2005, and 2006 are shown in Figure 3.1-3, Figure 3.1-4, Figure 3.1-5, Figure 3.1-6, and Figure 3.1-7, respectively. The results for each of these years demonstrate the Model's consistency of managing releases in excess of minimum demands, and the Model's reasonable depiction of historical operation.

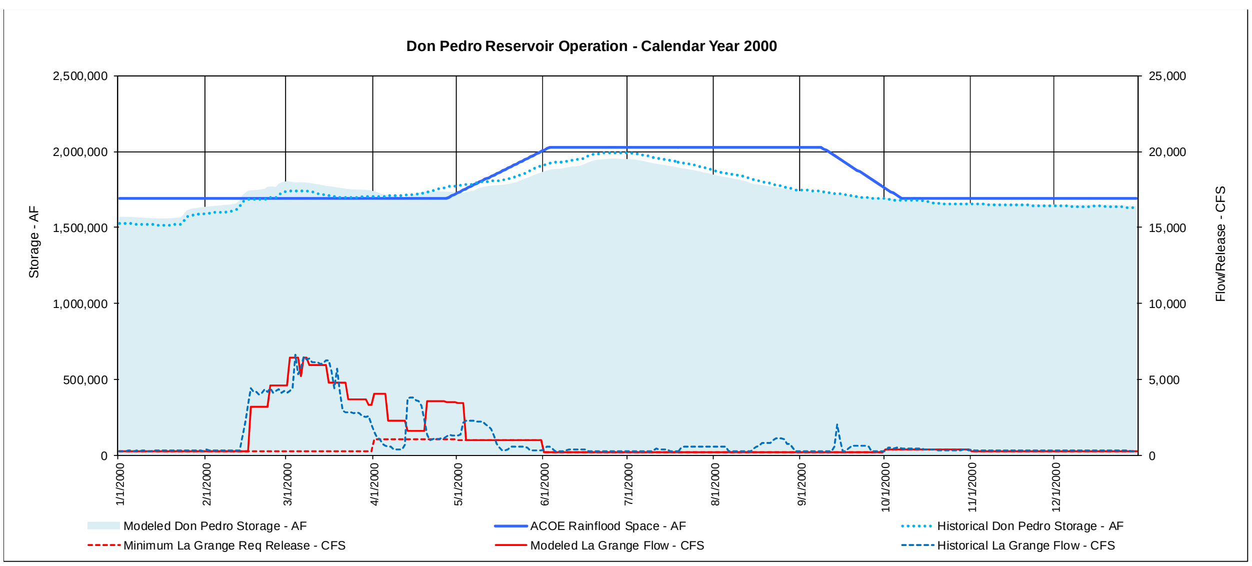

Figure 3.1-3. Historical and modeled Don Pedro Reservoir storage and release - 2000.

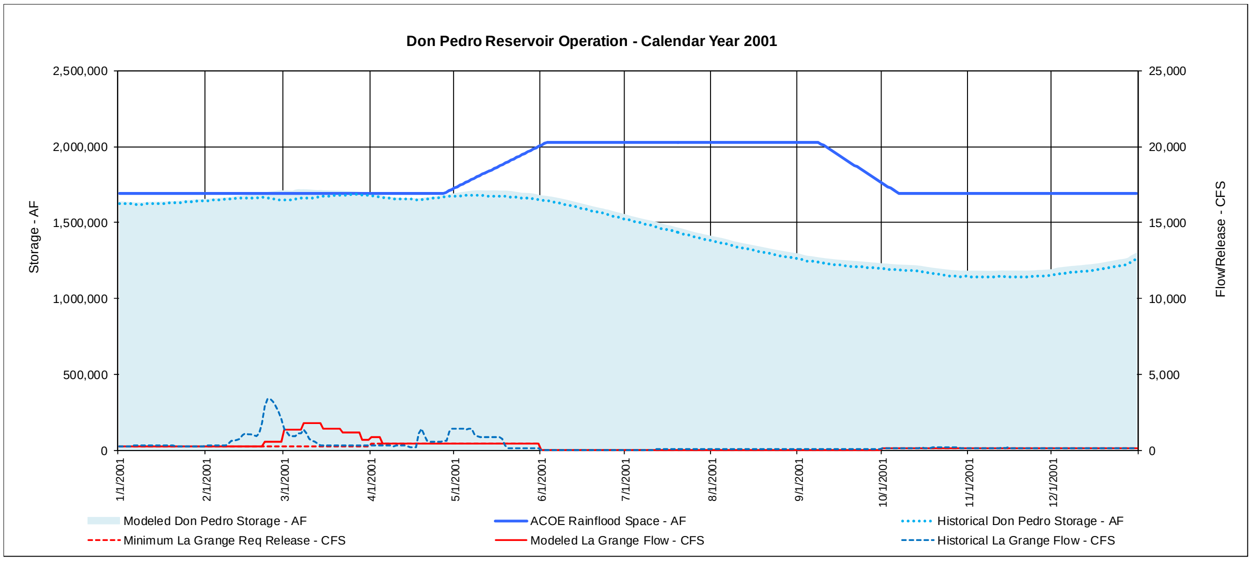

Figure 3.1-4. Historical and modeled Don Pedro Reservoir storage and release - 2001.

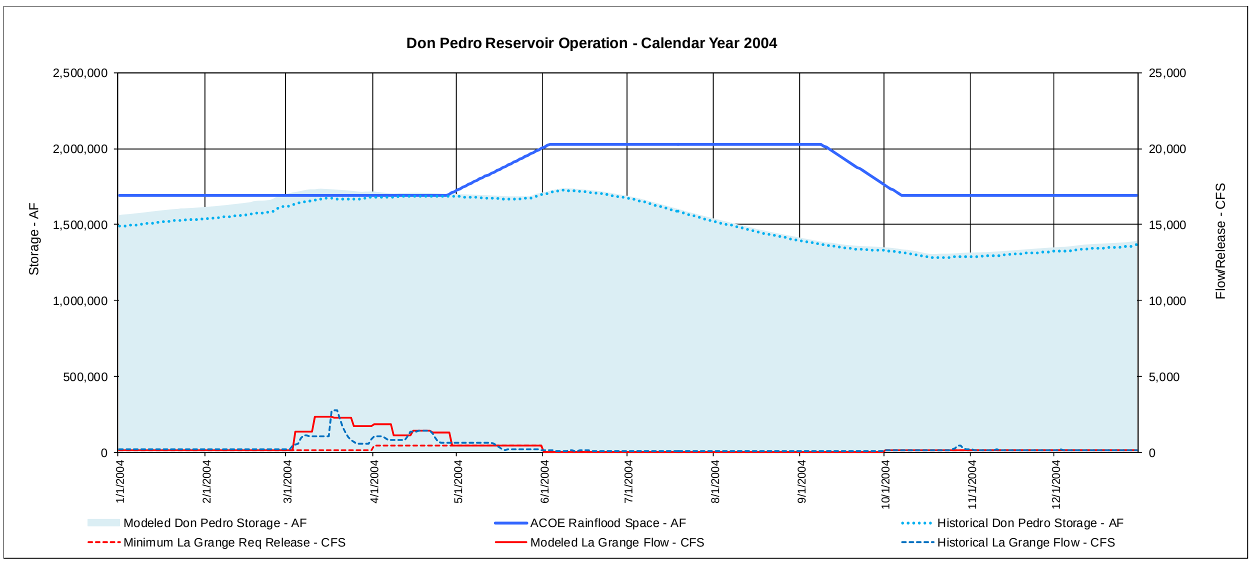

Figure 3.1-5. Historical and modeled Don Pedro Reservoir storage and release - 2004.

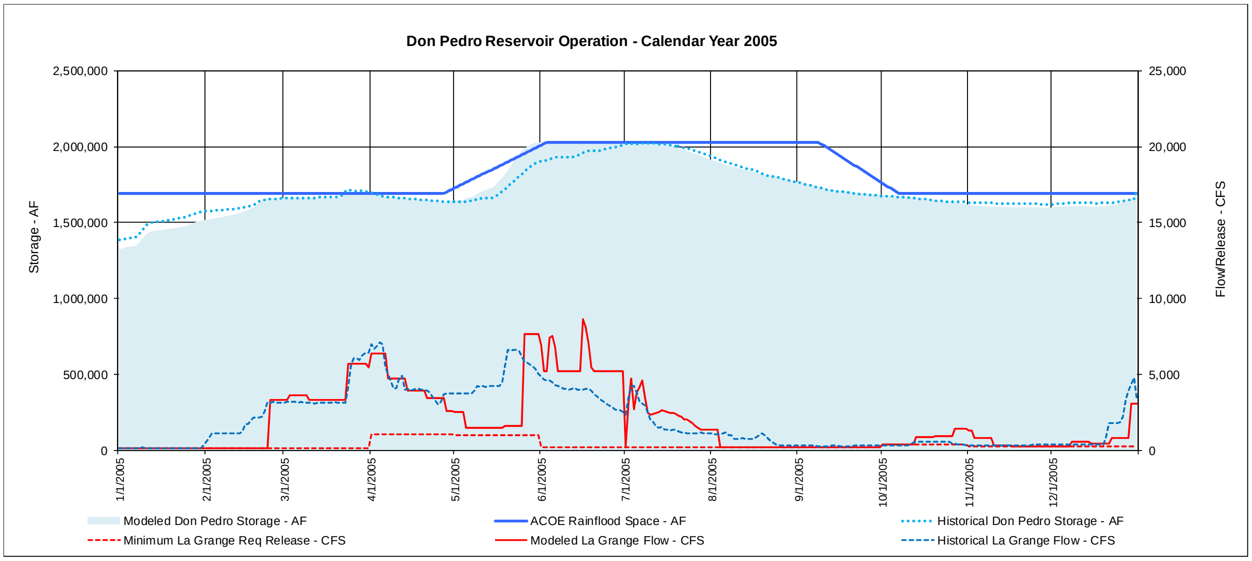

Figure 3.1-6. Historical and modeled Don Pedro Reservoir storage and release - 2005.

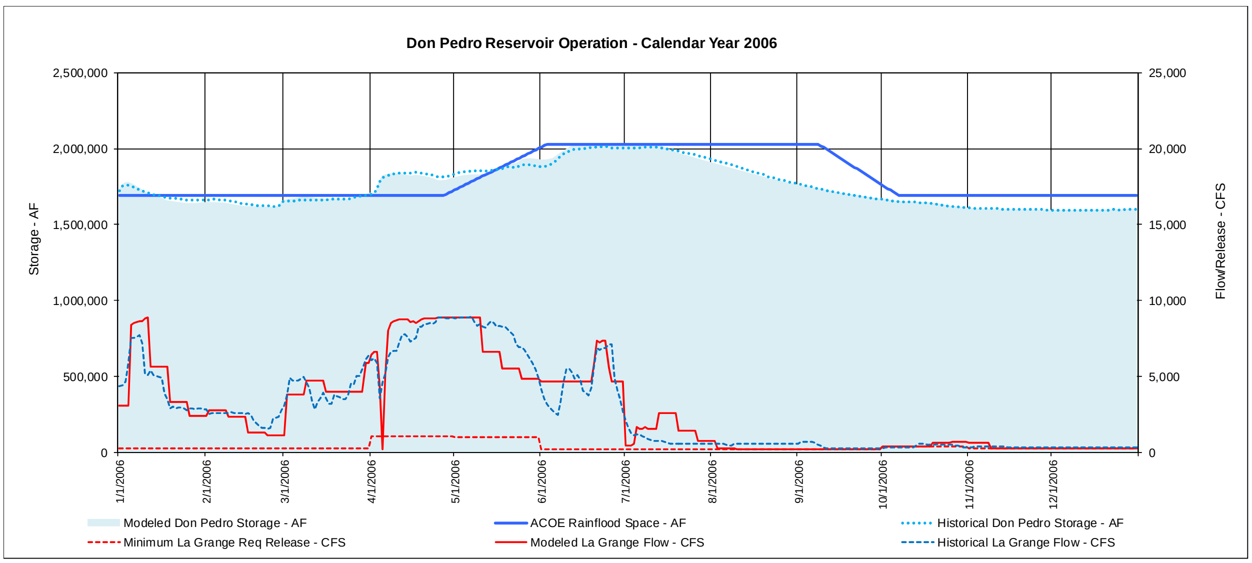

Figure 3.1-7. Historical and modeled Don Pedro Reservoir storage and release - 2006.

3.2 Consideration of Modesto Flood Management Objective

Another element of validation is the Model's performance related to flood management operations that are constrained due to flood flow guidelines at the Modesto 9th Street Bridge location. The ACOE flood flow guideline at the Modesto location is to not exceed 9,000 cfs. The Model includes an algorithm that considers both the accretions that occur between La Grange Dam and Modesto and the flow into the Tuolumne River from Dry Creek when making decisions for releases to the Tuolumne River from Don Pedro Reservoir.

Figure 3.2-1 illustrates year 1983 when releases from the Project were affected by the Modesto flood flow objective. Figure 3.2-1 illustrates results of the modeled operation for 1983. Shown are the modeled and historical depiction of reservoir storage, and a modeled depiction of flows in the Tuolumne River below La Grange Dam and the flow at Modesto. Also shown is the Model's assumption of flow from Dry Creek and the combined flow of Dry Creek and the lower Tuolumne River (LTR) accretions above Modesto. The results show how the Model reacts to accretion flow and the objective. During periods when the combined release and accretion flow would exceed the flow objective, the Model will decrease the release from Don Pedro Reservoir in order to maintain the flow objective. Not shown in this example is an exceedence of the flood flow objective, if needed, to maintain the reservoir below elevation 830 ft. Figure 3.2-2 illustrates the historical record of operations and flows at Modesto during 1983.[2] Reductions to releases to the river can be seen during March in response to the flow objective at Modesto.

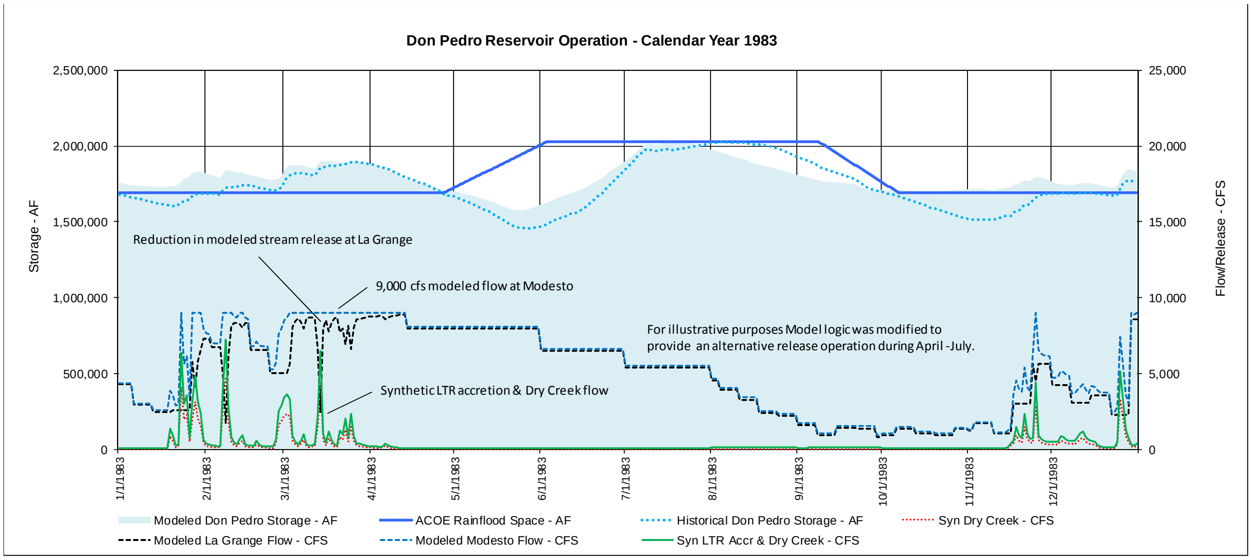

Figure 3.2-1. Historical and modeled operations affected by flow at Modesto – 1983.

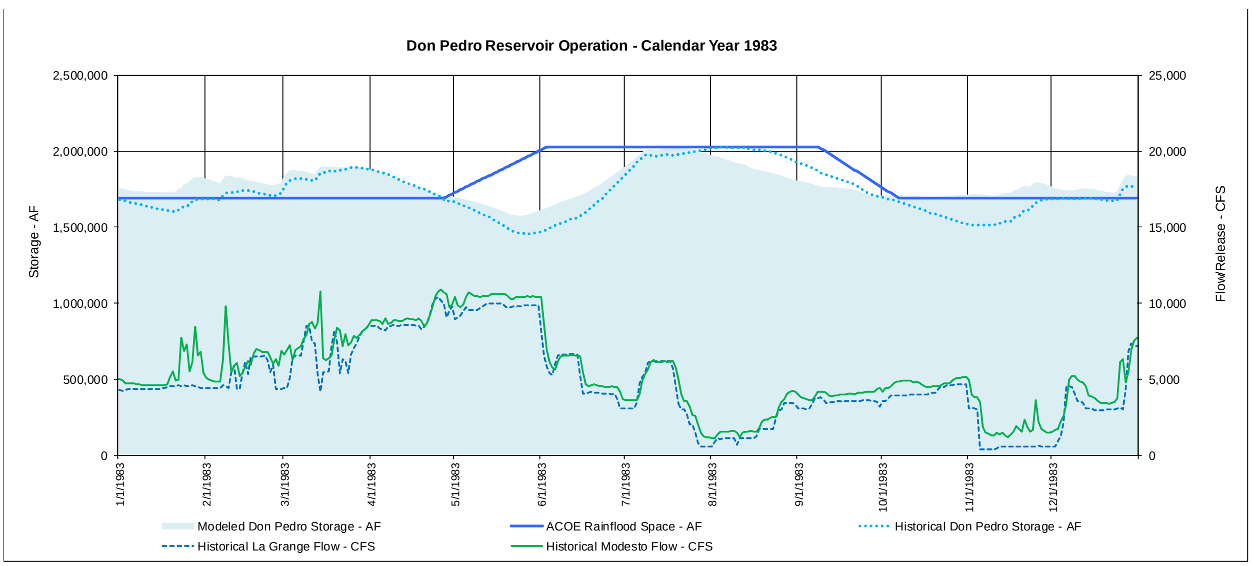

Figure 3.2-2. Historical and modeled operations affected by flows at Modesto – 1983.

2 The historical operation of year 1983 is not within the range of years previously described appropriate for Model validation purposes; however, for the limited purpose of validating the Modesto flow flood control operation algorithm comparison of modeling results to historical operations during the early spring of 1983 is valid.

4.0 DON PEDRO RESERVOIR INFLOW AND CCSF UPSTREAM OPERATION

The elements of Model validation discussed in Chapter 3 above primarily concern the algorithms that systematically advise the Model on Don Pedro reservoir storage and flows to the Tuolumne River below La Grange Dam. Components of hydrology, reservoir inflow and canal demands, were set at the historical record thus allowing a comparison to historical decision processes without the confounding effect of differences between historical and modeled inflow and canal demands. The validation of the upstream CCSF operations, and thus the resultant modeled inflow to Don Pedro Reservoir, requires a different and more general approach.

The operation of CCSF's facilities upstream of Don Pedro Reservoir has changed throughout the modeling period, and continues to evolve. Several factors that have affected the operation include water demand that increased after 1971 but has since decreased twice due to drought and/or regional economic conditions. Current water deliveries are less than were experienced at the beginning of the modeling period, but are projected to increase in the future. Also affecting the evolving operation has been physical changes in CCSF facilities such as the addition of upstream generation capacity and a temporary reduction in local Bay-Area storage as the result of Division of Safety of Dams requirements. Significant changes in the year to year operation of CCSF reservoirs were implemented after the 1987-1992 drought when the potential for extended drought and limited water supply was starkly recognized. These experiences have led to changes in the diversion from the basin and a moving target of regulated releases.

As mentioned previously, the Model does not attempt to mimic the precise historical operations of Don Pedro Reservoir or CCSF facilities, which have experienced changed operating objectives and water demands throughout history. The Model does incorporate a contemporary operation of the Districts' and CCSF's systems layered on top of the underlying hydrology of the basin.

The CCSF water system is modeled by CCSF with a planning model (Hetch Hetchy/Local Simulation Model – HHLSM) which is described in documents supporting CCSF's Water System Improvement Program (WSIP). The relevant operation objectives and constraints of HHLSM for CCSF's Tuolumne River facilities have been incorporated into the Model including current regulatory requirements such as minimum instream flows. The Model does not include an explicit operation of the CCSF Bay-Area system, but instead incorporates the diversion demand of the San Joaquin Pipeline (SJPL). This demand, in addition to CCSF facility operation objectives and requirements, lead to defining the regulated inflow to Don Pedro Reservoir. Other than this single element of diversion demand (SJPL) the Model simulates the operation of the CCSF Tuolumne River system.

Figure 4.0-1 illustrates a Test Case and historical total inflow to Don Pedro Reservoir. The inflow to Don Pedro Reservoir is constructed of two components. One component is the inflow that occurs to the reservoir from sources that are not regulated by CCSF facility operations. This component contributes to an average 40 percent of the total inflow to the reservoir, and is unaffected by the Model's simulated operation of CCSF facilities. The second component of reservoir inflow is affected by CCSF operations. The Test Case incorporates an annual average customer demand from the CCSF system of 238 million gallons per day (MGD) and reflects CCSF's facilities and resultant operations described in the WSIP as currently approved and permitted. The illustration shows a comparison between modeled and historical total inflow for the entire modeling period; however, most germane to the Model validation is a comparison for the period beginning in 1999. While even since 1999 CCSF operations and demands have continued to change, it reflects a relatively consistent, stable period of system operation objectives.

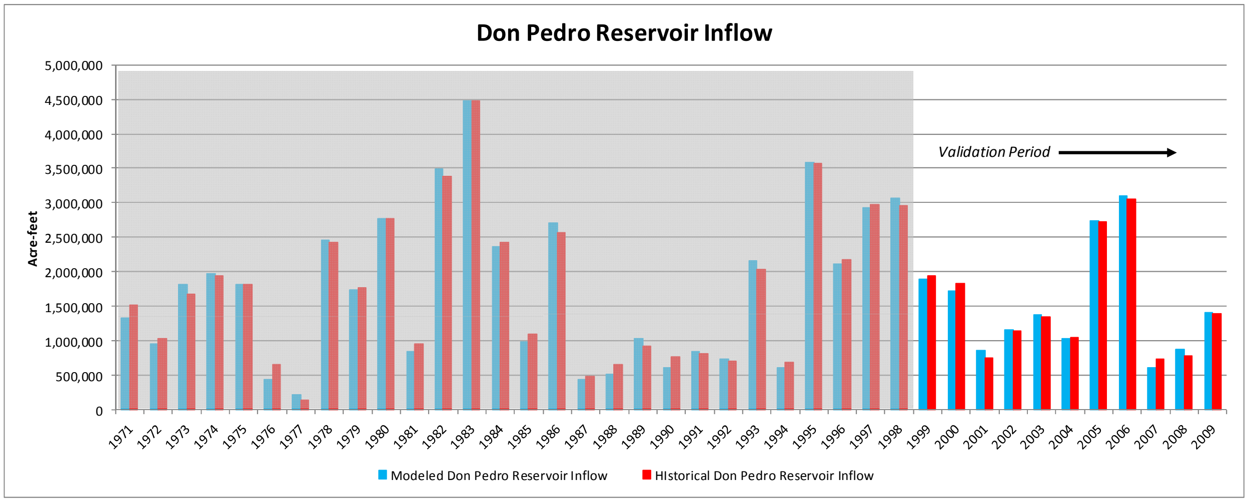

Figure 4.0-1. Modeled and historical Don Pedro Reservoir inflow (water year).

While during the validation period there are annual differences between modeled and historical inflow, ranging approximately ± 100,000 acre-feet (+13% to -16% of historical inflow), the average difference for the 11-year period is less than 4,000 acre-feet, with the differences merely a shifting between water years.

The Model performs operations with a daily time step, capturing the intricacies of sub-monthly and sometimes sub-weekly variations in hydrology and operational decision making. Figure 4.0-2 illustrates a summary of monthly volumes of inflow to Don Pedro Reservoir for the 10-year period Water Year 2000 through 2009. The modeled operation tracks well with seasonal historical inflow. The consistently greater modeled inflow occurring during May is primarily due to a recent change in CCSF operations at Hetch Hetchy Reservoir which was not occurring in the reported historical operation. This recent change in operation provides for scheduling/shifting of forecasted springtime spills from Hetch Hetchy Reservoir into May. The annual differences, if any, due to this change in operations are included in the results presented in Figure 4.0-1.

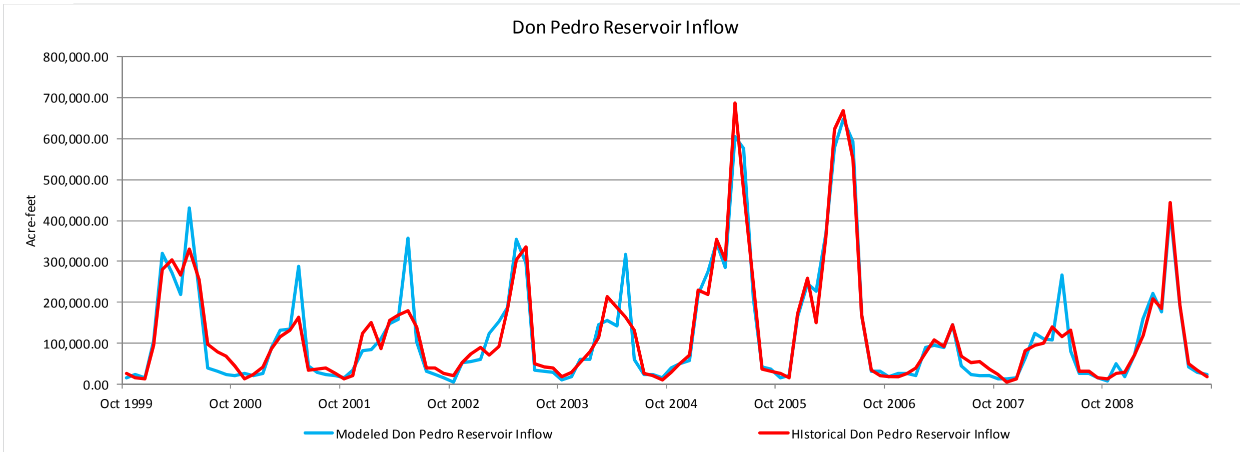

Figure 4.0-2. Modeled and historical Don Pedro Reservoir inflow (monthly volumes).

5.0 DISTRICT CANAL DIVERSIONS

The Model's depiction of the two Districts' canal diversions is another element of hydrology in the Model which reflects contemporary conditions. Due to annual changes in land use (crops planted), groundwater use, rainfall, and changing District and land owner practices the historical record of diversions varies from year-to-year. Therefore, similar to depicting reservoir inflow, the Model uses a projected canal diversion demand based on a planning model approach.

The projected canal diversions are assumed to be driven by three components: (1) a fluctuating customer component, called the projected demand of applied water (PDAW), that varies year to year and month to month, (2) a relatively constant depiction of District and land owner system operation efficiencies, and (3) an overriding water supply availability factor based on Don Pedro Reservoir storage and inflow. The development of projected canal diversions is described in the Tuolumne River Operations Model Report, Appendix B, Model Description and User's Guide, Section 3.

Figure 5.0-1 illustrates a Test Case and the historical diversions of the two Districts for the entire modeling period. The recent period beginning in year 1999 again serves as the period to validate the Model. The annual values represent a February through following January diversion period. Year 2009 contains a partial year of results.

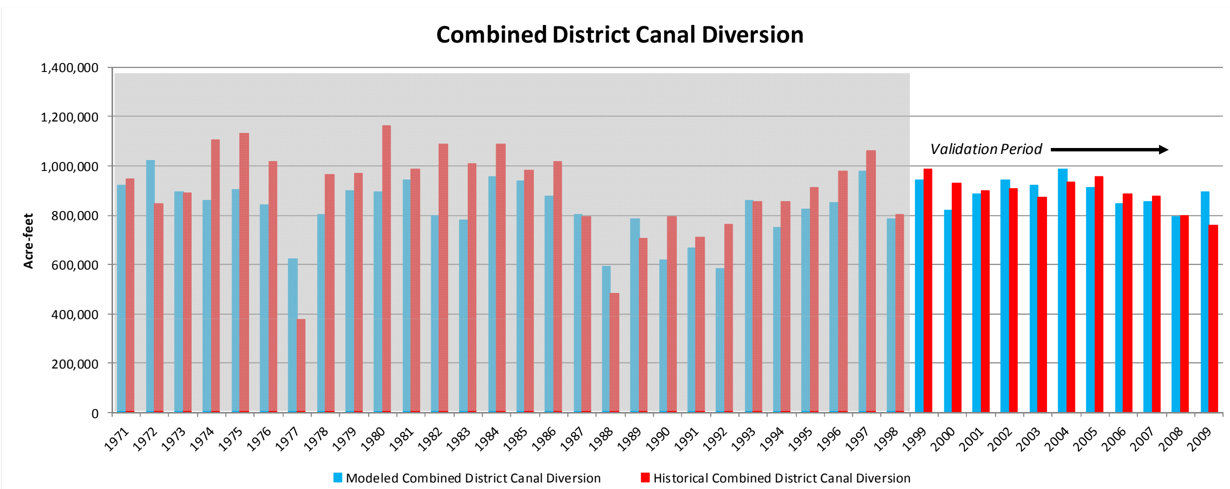

Figure 5.0-1. Historical and modeled combined Districts canal diversion.

While during the validation period there are annual differences between modeled and historical combined diversions, ranging approximately ± 100,000 acre-feet (+18% to -12% of historical annual diversions), the average difference for the 11-year period is less than 1,000 acre-feet, with the differences shifting between water years.

Figure 5.0-2 illustrates a summary of monthly volumes of modeled and historical combined diversions for the 10-year period Water Year 2000 through 2009. The modeled operation tracks well with seasonal historical diversions. The occasional difference in modeled diversion occurring during late spring reflects the challenges of modeling the early portion of the annual irrigation season.

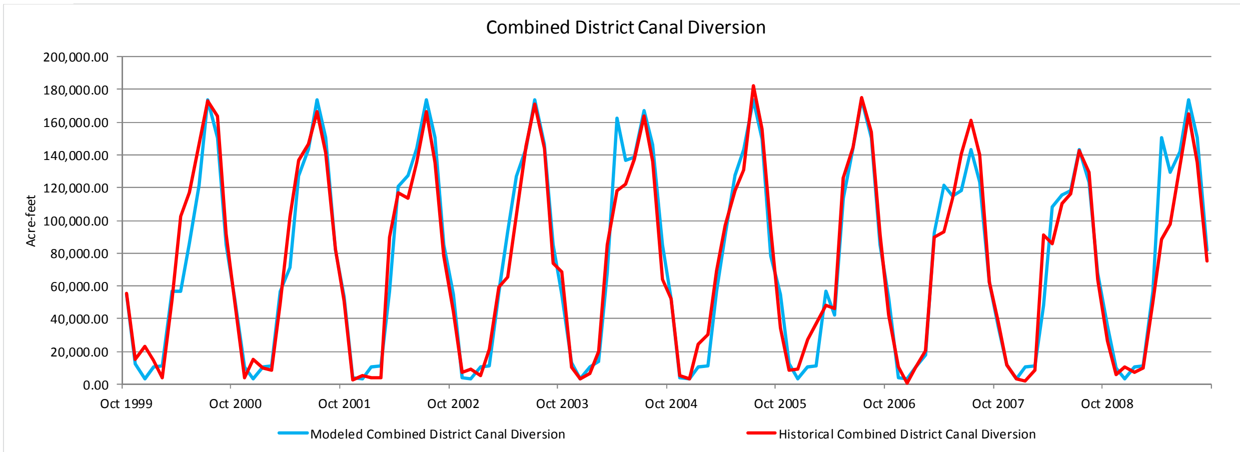

Figure 5.0-2. Historical and modeled combined District canal diversion (seasonal).

6.0 DON PEDRO PROJECT HYDOELECTRIC GENERATION

The hydroelectric generation capability of the Don Pedro powerhouse is currently depicted in the Model by a mathematical equation relating station electrical output to Don Pedro Reservoir storage. The relationship was derived from results relying upon the following equation:

$$Power = (Q \times H \times \eta) \div 11.815$$

Where:

Q = flow through the turbines
H = the effective head in feet (related to reservoir storage)
Ƞ = turbine efficiency as percent

The units of power are kilowatts

The current equation, which results in defining generation efficiency (kwh/acre-foot of turbine flow) based on DonPedro Reservoir storage, was compared to the historical performance of the powerhouse. The historical performance of the powerhouse was evaluated by computing generation efficiency from the historical record of generation, reservoir storage and estimated powerhouse releases. Juxtaposing the illustration of the Model's mathematical relationship between reservoir storage and generation efficiency and the analysis of historical generation yields the results shown in Figure 6.0-1.

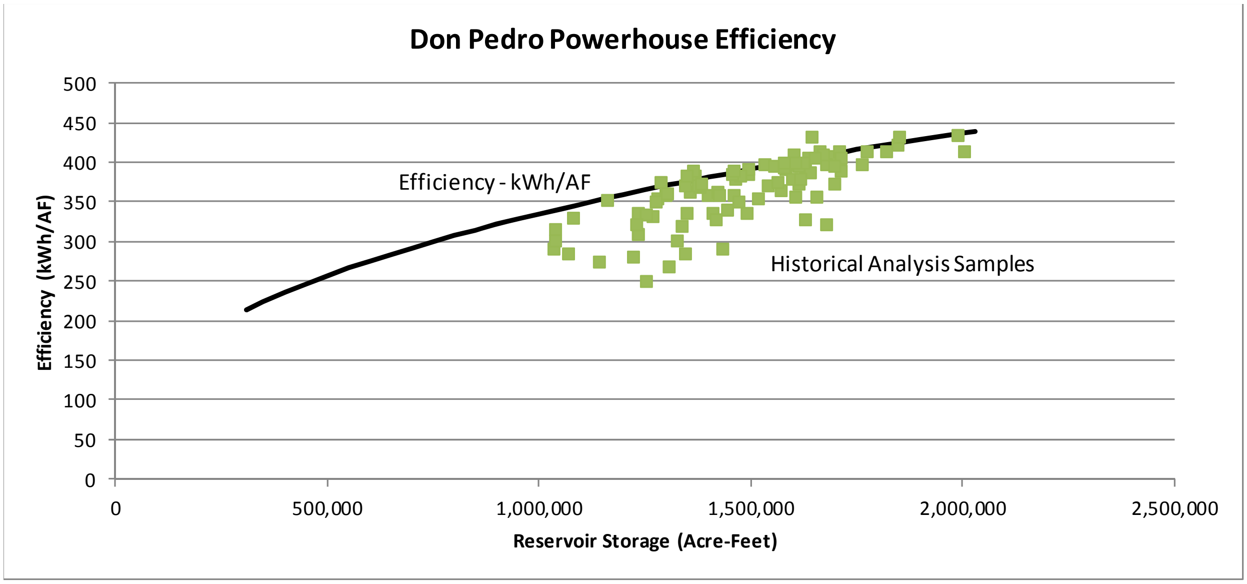

Figure 6.0-1. Comparison between historical generation efficiency and model generation efficiency.

Additional research and development of a refined power output characteristic curve for the Don Pedro powerhouse is being conducted. The refinement will be implemented in the Model coincident with the development of the "base case" scenario to be submitted by the Districts in March, 2013.

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ATTACHMENT D

MODEL DESCRIPTION AND USER'S GUIDE, ADDENDUM 3
TUOLUMNE RIVER DAILY OPERATIONS MODEL VERSION 3.1

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MODEL DESCRIPTION
AND USER'S GUIDE, ADDENDUM 3
TUOLUMNE RIVER DAILY OPERATIONS
MODEL VERSION 3.1
DON PEDRO PROJECT
FERC NO. 2299



WATER & POWER
Serving Central California since 1887

MID
Modesto Irrigation District

Prepared for:
Turlock Irrigation District – Turlock, California
Modesto Irrigation District – Modesto, California

September 2017

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1.0 INTRODUCTION

The Turlock Irrigation District (TID) and Modesto Irrigation District (MID) (collectively, the Districts) have developed a computerized Tuolumne River Daily Operations Model (Model) to assist in the relicensing of the Don Pedro Project (Project) (FERC Project 2299). The Model is described in the User's Guide submitted to FERC as part of the Initial Study Report (ISR), January 2013 (Model version 1.01) and supplemented by Addendum 1, May 2013 regarding the version of the Model (Version 2.0) used to develop the "Base Case" which depicts the operation of the Don Pedro Project in accordance with the current FERC license, ACOE flood management guidelines, the Districts' irrigation and M&I water management practices, and City and County of San Francisco (CCSF's) water management practices at its Hetch Hetchy Water System.

During initial investigations, it was found to be advantageous to extend the Model's period of record for analysis by 3 years to be inclusive of hydrology and operations through water year 2012. The "extension" of the Model allowed integration of more recent and additional developed data within the modeling processes. Addendum 2 (December 2013) documented the extension of the Model and described refinements and modifications that have been made to the Model (Model Version 2.0) since May 2013, and reissued the Base Case resulting from the extension of the period of analysis and Model modifications. The resulting Model as described in Addendum 2 became Model version 3.0.

During the ongoing use of the Model several additional refinements and modifications to the Model have been made. These refinements and modifications have not substantively changed the Model or the results which have been derived from Model studies, but have corrected certain minor errors in the depiction of operations and refined the depiction of daily operations within certain months. The purpose of this Addendum 3 is to describe the modifications associated with the newly issued Model Version 3.1.

The Tuolumne River Daily Operations Model provides a depiction of the Don Pedro Project and CCSF water operations consistent with the FERC-approved W&AR02 study plan. The Model portrays operations that can be described systematically by various equations and algorithms. Actual project operations may vary from those depicted by the Model due to circumstantial and real-time conditions of hydrology and weather, facility operation, and human intervention. The FERC-approved study plan has identified a number of user-controlled variables. The fact that the Model provides these user-controlled inputs is not an indication that either the Districts or CCSF endorse or support any specific operational alternative developed by manipulating these inputs.

2.0 MODEL MODIFICATIONS

Modeled elements of both the CCSF system and the Districts' system have been modified. Within the CCSF system, logic reflecting minimum flow requirements below its reservoirs has been refined to depict mid-month changes in flow requirements, rather than the previous depiction of requirements as an average flow distributed throughout a month. An inaccurate flow requirement depicted in Model Version 3.0 was also remedied. Within the Districts' system, the daily distribution of water user canal demand was corrected to sum to equal the monthly demand. Previously, the mathematical procedure to establish the daily distribution of a monthly demand contained an error, which led to the summation of daily demands being slightly different than the estimated monthly demand. The logic depicting the current flow requirement at La Grange was also refined to better reflect actual operations.

2.1 Hetch Hetchy Reservoir

The release requirement below O'Shaughnessy Dam was incorrectly incorporated into the Model for August (about 50 cfs too little) and September (about 7 cfs too little) for "Year Type B". These errors were remedied in Model Version 3.1. The revision also adds additional disaggregation of the September schedule from an average monthly value into a daily disaggregated schedule that follows the regulatory requirement, a schedule change on the 16th day of September.

The logic defining the year type for releases below O'Shaughnessy Dam was also refined to reflect the regulatory requirement for the precipitation thresholds that establish the required flow schedule. The regulatory requirement requires the threshold be based on a condition of greater or equal ">=" the precipitation value rather than the previous depiction of greater than ">". This refinement increases the flow schedule by 10 cfs in December 1974 and 15 cfs in February 1992.

The modifications to the flow schedules for Hetch Hetchy Reservoir (Tab CCSF), reflecting a revised flow requirement for Schedule B (2) for August and September and a disaggregation of the September schedule, are shown in Figure 2.1-1.

When viewing the simulation through monthly results (Table 2.1-1), changes occur only during those years which Schedule "Year Type B" occurred. This is indicative of the misapplication of the "Year Type B" regulatory requirement during August and September. Although the logic was changed for all year types to also apply a mid-month September flow change, the monthly results do not show a change in the monthly volume of water required. Daily results will show a day-to-day change during September compared to Model Version 3.0. The two changes in flow requirement during January 1975 and February 1992 are due to modifying the triggering logic in Version 3.1 to correctly recognize the regulatory definition for the precipitation thresholds for the flow schedules.

	A	B	C	D	AV	AW	AX	AY	AZ	BA	BB	BC	BD	BE	BF	BG	BH	BI	BJ	BK
1			1			Hetch Hetchy Reservoir Control											15,000	6,500	4,400	
2	Unit Title		2			Schedule Index - Accum Inches or Storage					Below Hetch Hetchy Requirement - CFS					Discretionary Schedule - Acre-feet				
3	Parameter Title		3			Cal Mon	A (1)	B (2)	C (3)		ddmmm	A (1)	B (2)	C (3)		Cal Mon	A (1)	B (2)	C (3)	
4						1	8.80	6.1			01Jan	50	40	35		1	0	0	0	
5	Acre-foot to CFS conversion					2	14	9.5			01Feb	60	50	35		2	0	0	0	
6	divide by :	1.983471				3	18.6	14.2			01Mar	60	50	35		3	0	0	0	
7						4	23	18			01Apr	75	65	35		4	0	0	0	
8						5	26.6	19.5			01May	100	80	50		5	0	0	0	
9						6	28.45	21.25			01Jun	125	110	75		6	0	0	0	
10						7	575,000	390,000			01Jul	125	110	75		7	0	0	0	
11						8	640,000	400,000			01Aug	125	110	75		8	0	0	0	
12											01Sep	100	80	75		9	0	0	0	
13											16Sep	80	65	50		10	0	0	0	
14							Sum of WY	Trigger			01Oct	60	50	35		11	0	0	0	
15						HH Accum	HH Inflow	Due to	Schedule	Schedule	01Nov	60	50	35		12	0	0	0	
16						Precip	To	Inflow	Due to	Due to	01Dec	50	40	35			10	11	12	1
17	Month					beginning	Date	Jul-Dec	Inflow	Inflow	Jan	Feb	Mar	Apr	May	Jun	Oct	Nov	Dec	Jan
18	Index	Date	Day	Days	ddd	Oct 1	AF	AF	Jul	Aug - Dec	Schedule	Schedule	Schedule	Schedule	Schedule	Schedule	Schedule	Schedule	Schedule	Schedule
19					mmm	Inches		709,538		1							CFS	CFS	CFS	CFS
20	1970.10	10/1/1970	T	31	01Oct	0.73	8	709,538	0	1	0	0	0	0	0	0	60	0	0	0
21	1970.10	10/2/1970	F	31	02Oct	0.73	16	709,538	0	1	0	0	0	0	0	0	60	0	0	0
22	1970.10	10/3/1970	S	31	03Oct	0.73	24	709,538	0	1	0	0	0	0	0	0	60	0	0	0
23	1970.10	10/4/1970	S	31	04Oct	0.73	32	709,538	0	1	0	0	0	0	0	0	60	0	0	0
24	1970.10	10/5/1970	M	31	05Oct	0.73	40	709,538	0	1	0	0	0	0	0	0	60	0	0	0
25	1970.10	10/6/1970	T	31	06Oct	0.73	48	709,538	0	1	0	0	0	0	0	0	60	0	0	0

Figure 2.1-1. Modifications to release requirements from Hetch Hetchy Reservoir.

Table 2.1-1. Stream requirement (acre-feet) below O'Shaughnessy Dam – change from Model Version 3.0.

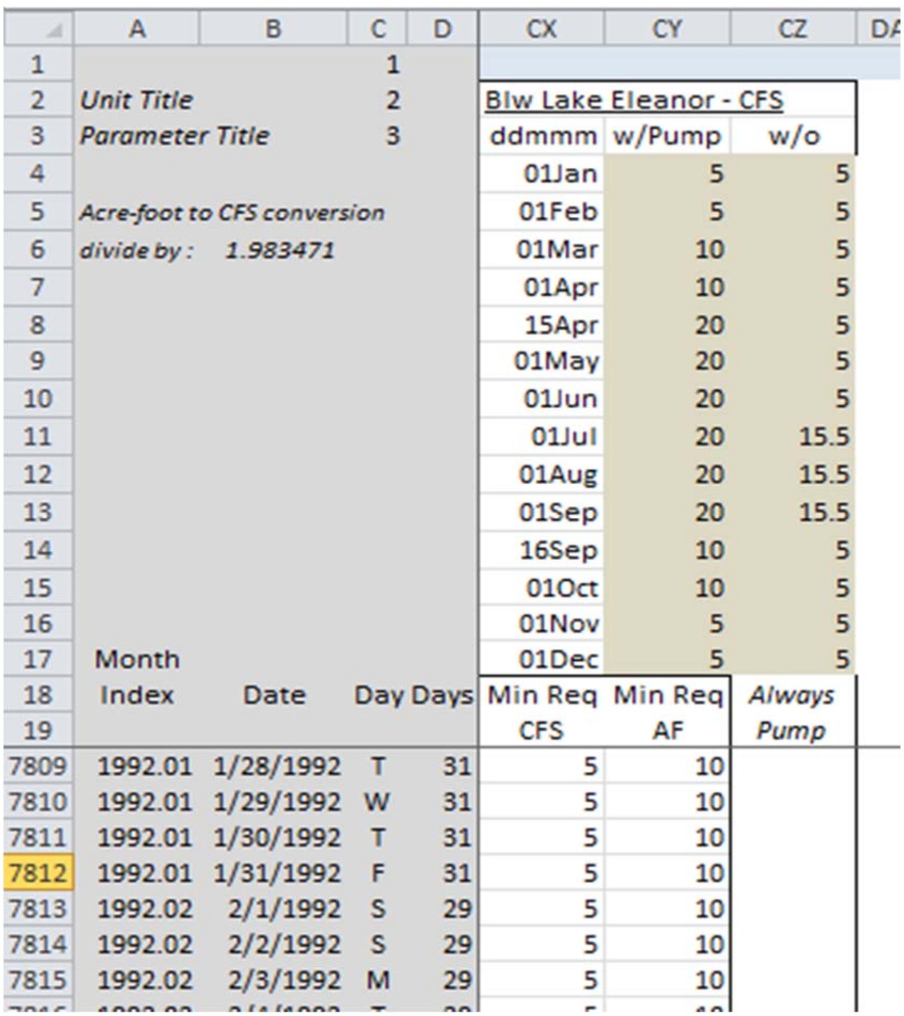
WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1971	0	0	0	0	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0	0	2,306	446	2,752
1973	0	0	0	0	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0	0	0	0	0
1975	0	0	0	615	0	0	0	0	0	0	0	0	615
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	2,306	446	2,752
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	2,306	446	2,752
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	2,306	446	2,752
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	2,306	446	2,752
1992	0	0	0	0	863	0	0	0	0	0	0	0	863
1993	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0	0	0	0	2,306	446	2,752
2002	0	0	0	0	0	0	0	0	0	0	2,306	446	2,752
2003	0	0	0	0	0	0	0	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0	0	0	2,306	446	2,752
2005	0	0	0	0	0	0	0	0	0	0	0	0	0
2006	0	0	0	0	0	0	0	0	0	0	0	0	0

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
2007	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0	2,306	446	2,752
2009	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0	0
Avg	0	0	0	15	21	0	0	0	0	0	494	96	625

2.2 Eleanor Reservoir

Similar to the Hetch Hetchy Reservoir release requirement revisions, a modification was made to Lake Eleanor logic refining the required stream flow during April from an average monthly release to a daily release with a change occurring in mid-month. Logic depicting September requirements was also modified for a mid-month change in daily flow requirement. The modifications to the flow schedules for Eleanor Reservoir (Tab CCSF), reflecting a disaggregation of the April and September schedules, are shown in Figure 2.2-1.

The modification to the Lake Eleanor logic results in essentially no change when viewing through monthly results, but within daily results the daily disaggregation of the flow requirements will be seen. The "20" acre-foot change during April between Version 3.0 and Version 3.1 is due to an incorrect application of the flow requirement during April in Version 3.0. The modification corrects the required monthly volume to include an additional day of 20 cfs flow.



	A	B	C	D	CX	CY	CZ
1			1				
2	*Unit Title*		2		Blw Lake Eleanor - CFS		
3	*Parameter Title*		3		ddmmm	w/Pump	w/o
4					01Jan	5	5
5	*Acre-foot to CFS conversion*				01Feb	5	5
6	*divide by :*	*1.983471*			01Mar	10	5
7					01Apr	10	5
8					15Apr	20	5
9					01May	20	5
10					01Jun	20	5
11					01Jul	20	15.5
12					01Aug	20	15.5
13					01Sep	20	15.5
14					16Sep	10	5
15					01Oct	10	5
16					01Nov	5	5
17	Month				01Dec	5	5
18	Index	Date	Day	Days	Min Req	Min Req	*Always*
19					CFS	AF	*Pump*
7809	1992.01	1/28/1992	T	31	5	10	
7810	1992.01	1/29/1992	W	31	5	10	
7811	1992.01	1/30/1992	T	31	5	10	
7812	1992.01	1/31/1992	F	31	5	10	
7813	1992.02	2/1/1992	S	29	5	10	
7814	1992.02	2/2/1992	S	29	5	10	
7815	1992.02	2/3/1992	M	29	5	10	

Figure 2.2-1. Modifications to release requirements from Lake Eleanor.

Table 2.2-1. Stream requirement (acre-feet) below Lake Eleanor – change from Model Version 3.0.

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1971	0	0	0	0	0	0	20	0	0	0	0	0	20
1972	0	0	0	0	0	0	20	0	0	0	0	0	20
1973	0	0	0	0	0	0	20	0	0	0	0	0	20
1974	0	0	0	0	0	0	20	0	0	0	0	0	20
1975	0	0	0	0	0	0	20	0	0	0	0	0	20
1976	0	0	0	0	0	0	20	0	0	0	0	0	20
1977	0	0	0	0	0	0	20	0	0	0	0	0	20
1978	0	0	0	0	0	0	20	0	0	0	0	0	20
1979	0	0	0	0	0	0	20	0	0	0	0	0	20
1980	0	0	0	0	0	0	20	0	0	0	0	0	20
1981	0	0	0	0	0	0	20	0	0	0	0	0	20
1982	0	0	0	0	0	0	20	0	0	0	0	0	20
1983	0	0	0	0	0	0	20	0	0	0	0	0	20
1984	0	0	0	0	0	0	20	0	0	0	0	0	20
1985	0	0	0	0	0	0	20	0	0	0	0	0	20
1986	0	0	0	0	0	0	20	0	0	0	0	0	20
1987	0	0	0	0	0	0	20	0	0	0	0	0	20
1988	0	0	0	0	0	0	20	0	0	0	0	0	20
1989	0	0	0	0	0	0	20	0	0	0	0	0	20
1990	0	0	0	0	0	0	20	0	0	0	0	0	20
1991	0	0	0	0	0	0	20	0	0	0	0	0	20
1992	0	0	0	0	0	0	20	0	0	0	0	0	20
1993	0	0	0	0	0	0	20	0	0	0	0	0	20
1994	0	0	0	0	0	0	20	0	0	0	0	0	20
1995	0	0	0	0	0	0	20	0	0	0	0	0	20
1996	0	0	0	0	0	0	20	0	0	0	0	0	20
1997	0	0	0	0	0	0	20	0	0	0	0	0	20
1998	0	0	0	0	0	0	20	0	0	0	0	0	20
1999	0	0	0	0	0	0	20	0	0	0	0	0	20
2000	0	0	0	0	0	0	20	0	0	0	0	0	20
2001	0	0	0	0	0	0	20	0	0	0	0	0	20
2002	0	0	0	0	0	0	20	0	0	0	0	0	20
2003	0	0	0	0	0	0	20	0	0	0	0	0	20
2004	0	0	0	0	0	0	20	0	0	0	0	0	20
2005	0	0	0	0	0	0	20	0	0	0	0	0	20
2006	0	0	0	0	0	0	20	0	0	0	0	0	20

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
2007	0	0	0	0	0	0	20	0	0	0	0	0	20
2008	0	0	0	0	0	0	20	0	0	0	0	0	20
2009	0	0	0	0	0	0	20	0	0	0	0	0	20
2010	0	0	0	0	0	0	20	0	0	0	0	0	20
2011	0	0	0	0	0	0	20	0	0	0	0	0	20
2012	0	0	0	0	0	0	20	0	0	0	0	0	20
Avg	0	0	0	0	0	0	20	0	0	0	0	0	20

2.3 Resulting Change to Don Pedro Reservoir Inflow

Modifications to CCSF reservoir operations will lead to changes in inflow to Don Pedro Reservoir. Inflow changes are traceable to 1) the Hetch Hetchy Reservoir minimum flow schedule correction, 2) the revision of the Hetch Hetchy Reservoir minimum flow schedule year type, 3) the revision of the Lake Eleanor stream release, and 4) the CCSF system reaction to relatively minor changes in the water balance and conveyance between its reservoirs. Change in the Don Pedro Reservoir inflow resulting from the several upstream changes is shown in Table 2.3-1.

The most recognizable changes to inflow reflect the changes in August and September from Hetch Hetchy Reservoir; however, with no overall change to the CCSF diversion operation the additional release from the reservoir in one year is normally countered with a lesser release in a following year. The small change in Eleanor Reservoir release is muted within overall system operations. Inconsistencies in rounding and conversions applying to cfs-to-Acre-foot calculations throughout the program were corrected and lead to the many small differences to inflow shown below. Across the entire simulation period the modifications lead to no change in long-term inflow to Don Pedro Reservoir.

2.4 Districts’ Canals

The District’s daily canal demands are prescribed by several components including crop requirements, assumed groundwater supplies, and canal system efficiencies. These components are generally described through monthly volumetric analyses and for many models are expressed in terms of average monthly flow, implying a constant value for each day of a month. For the daily model, the daily canal demand is given a daily fluctuation by applying a daily fraction of a month’s volumetric applied water requirement.

The daily fraction was established through analysis of the historical daily diversions of the Districts. The historical diversion records of the Districts for the years 2009-2011 (three years) were processed to develop an average three-year “centric” seven day average diversion throughout the year (to provide smoothing of the historical daily fluctuation). It was overlooked that the mathematical result of using averaging techniques across the beginning and end of a month would result in the development of daily fractions that would not sum to 1.00 for each month, and the incorporation of the described daily fractions lead to a water demand slightly in excess or deficit of the intended result. This minor discrepancy has been remedied in Model Version 3.1 (Tab DailyCanalsCompute) by modifying each month’s sum of daily fractions to sum to 1.00. Table 2.4-1 illustrates the summation of daily fractions for each month for each District in Model Version 3.0, and verification that Model Version 3.1 incorporates daily fractions that sum to 1.00 for each month.

Viewed through an annual combined District canals diversion perspective, slightly less water is diverted with the modifications to the daily fractions. Slightly more is diverted by MID and slightly less is diverted by TID. For the Base Case, Table 2.4-2 illustrates the average monthly and average annual (water year) combined diversions of the Districts, as developed by Model Version 3.0 and revised by Model Version 3.1.

Table 2.3-1. Don Pedro Reservoir inflow (acre-feet) – change from Model Version 3.0.

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1971	0	0	0	0	-4	-4	-4	8	4	0	0	-59	-59
1972	59	0	0	0	-4	-4	-4	8	5	0	2,306	386	2,752
1973	59	0	0	0	-260	-254	-225	-2,010	1	0	0	-60	-2,749
1974	59	0	0	0	-4	4	-3	2	1	0	0	-59	0
1975	59	0	0	615	-61	-54	-50	-450	0	0	0	-59	0
1976	59	0	0	0	-4	-4	-4	13	-1	0	0	-59	0
1977	59	0	0	0	-4	-4	-4	12	0	0	0	-59	0
1978	59	0	0	0	-3	4	-1	2	0	0	0	-337	-277
1979	59	278	0	0	-4	4	-4	3	2	0	0	-60	278
1980	59	0	0	0	-4	-4	6	1	1	0	0	-59	0
1981	59	0	0	0	-4	-4	8	0	0	0	2,306	387	2,752
1982	59	0	-392	-2,354	-4	-4	5	2	1	0	0	-39	-2,726
1983	40	0	0	0	-4	4	0	0	0	0	0	-167	-127
1984	167	0	0	0	-4	-4	-4	8	4	0	0	-59	108
1985	59	0	0	0	-4	-4	8	0	0	0	2,306	387	2,752
1986	59	0	0	0	-1	-2	-899	-1,851	3	-1	0	-59	-2,749
1987	59	0	0	0	-4	-4	8	0	0	0	0	-59	0
1988	59	0	0	0	-4	-4	8	0	0	0	0	-59	0
1989	59	0	0	0	-4	-4	7	1	0	0	2,306	387	2,752
1990	59	0	0	0	-261	-262	-216	-2,012	2	0	0	-59	-2,748
1991	59	0	0	0	0	-5	-5	6	-7	0	2,306	386	2,740
1992	59	0	0	11	-2,730	-1	0	0	0	0	0	-59	-2,719
1993	59	0	0	0	0	-2	-26	6	2	0	0	-59	-20
1994	59	0	0	0	-4	-4	8	0	0	0	0	-59	0
1995	59	0	0	0	0	-3	3	1	0	0	0	-59	0
1996	59	0	0	0	-1	-5	-5	13	-4	1	0	-59	0
1997	59	0	0	0	-4	-4	-4	14	-3	1	0	-59	0
1998	59	0	0	0	-4	3	-1	2	0	0	0	-59	0
1999	59	0	0	0	-4	-4	6	1	1	0	0	-59	0
2000	59	0	0	0	-4	-4	-4	12	0	0	0	-59	0
2001	59	0	0	0	-4	-4	8	0	0	0	2,306	387	2,752
2002	59	0	0	0	-260	-262	-227	-1,999	0	0	2,306	387	3
2003	59	0	0	0	-260	-262	-228	-2,000	1	0	0	-59	-2,749
2004	59	0	0	0	-4	4	0	0	0	0	2,306	387	2,752
2005	59	0	0	0	-256	-258	-224	-2,011	0	0	0	-59	-2,749
2006	59	0	0	0	-4	4	-2	2	1	0	0	-59	0

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
2007	59	0	0	0	-4	0	4	0	0	0	0	-59	0
2008	59	0	0	0	-4	-4	-4	14	-3	0	2,306	387	2,752
2009	59	0	0	0	-260	-262	-227	-1,999	-1	0	0	-59	-2,749
2010	59	0	0	0	-4	4	-2	3	0	0	0	-59	0
2011	59	0	0	0	-4	4	-7	7	0	0	0	-59	0
2012	59	0	0	0	-4	-4	8	0	0	0	0	-59	0
Avg	60	7	-9	-41	-106	-40	-55	-338	0	0	494	27	-1

Table 2.4-1. Summation of daily fractions for irrigation demand – Model Version 3.0 and Version 3.1.

Modesto Irrigation District Version 3.0													
WY	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
Average	1.0151	0.9905	0.6854	0.9639	0.9583	1.0098	1.0090	0.9943	1.0071	0.9932	0.9909	1.0106	11.6282
*The effect of December's value was essentially non-consequential as MID's agricultural water demand during December is typically zero.													

Modesto Irrigation District Version 3.1													
WY	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
Average	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	12.0000

Turlock Irrigation District Version 3.0													
WY	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
Average	0.9847	0.9613	1.0515	1.0382	1.0035	1.0053	0.9982	1.0024	1.0766	1.0019	1.0016	0.9977	12.1228

Turlock Irrigation District Version 3.1													
WY	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
Average	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	12.0000

Table 2.4-2. Base Case combined Districts' canal diversions (acre-feet) – Model Version 3.0 and Version 3.1.

Combined Diversions Version 3.0													
WY	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
Average	44,383	7,569	3,440	10,245	12,672	59,674	81,467	117,694	134,392	161,508	138,955	76,116	848,115

Combined Diversions Version 3.1													
WY	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
Average	44,594	7,615	3,440	10,245	12,698	59,379	81,363	117,710	127,713	161,609	139,158	75,985	841,509

Difference – Version 3.1 minus Version 3.0													
WY	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
Average	211	46	0	0	27	-295	-104	17	-6,679	100	203	-131	-6,605

2.5 Don Pedro Minimum Flow Requirements

To better reflect operations for the current flow requirements below La Grange Diversion Dam, Model Version 3.1 deployed several modifications. Note: these modifications only affect the depiction of current operations to the existing FERC requirements (Base Case). These modifications will not affect simulations (studies) using assumed flow regimes not generated by the logic depicting the Base Case.

The first modification modified the “Flow Requirement Year” (the temporal period between the first active day of the current year’s flow requirement through the last day of the current year’s flow requirement) from the beginning of April (Model Version 3.0), to April 15th.

The current flow requirements are defined by year type associated with the San Joaquin River Basin Index (602020 methodology). The base flow, April-May pulse, and October attraction components of the year type are identified in the 1995 Settlement Agreement and incorporated into the Model as summarized in Table 2.5-1.

Within the Model, a 12 month x 42 year matrix is then defined by lookup of the year type for the base flow component. Model Version 3.0 creates the matrix with the month of April being the transition from the previous year’s water year type to the current year’s water year type. Model Version 3.1 refined the month-year matrix to recognize a split-month April of year types, with 14 days of the month representing the previous year’s water year type, and 16 days of the month representing the current year’s water year type. This modification better reflects the regulatory requirement and actual operations. The base flow for February was also revised to recognize leap year within the volumes. The “cfs” requirement was maintained for February whether applied for 28 or 29 days.

To better represent the existing FERC split-month October base flow of certain water year types an additional lookup matrix was developed for the daily translator, whereby according to year type the correct pair of daily flow percentage parsing factors is used to correctly split the monthly volume of October across the potential two levels of flow. A similar additional lookup matrix for April is now also employed to correctly parse the April split-month volume correctly between the first half of April (previous year’s water year type base flow) and the second half of April (current year’s water year type base flow).

Differences in the current minimum flow requirement (Base Case) below La Grange Diversion Dam between Model Version 3.0 and Model Version 3.1 will be due to the split-year type for April, and the leap year adjustment for February. The differences are illustrated in Table 2.5-2. Minor differences will also occur due to fixing rounding errors and the flow-volume conversion computation. There is almost no change in the long-term annual average release requirement between the two models.

Table 2.5-1. Summarized minimum flow schedules.

Base Flow Schedule																
Acre-feet (1000)														Apr/May	Oct	
Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Base Total	Pulse	Attraction	Total
1	7.7	8.9	9.2	9.2	8.3	9.2	8.9	9.2	3.0	3.1	3.1	3.0	82.909	11.1	0.0	94.0
2	7.7	8.9	9.2	9.2	8.3	9.2	8.9	9.2	3.0	3.1	3.1	3.0	82.909	20.1	0.0	103.0
3	9.2	8.9	9.2	9.2	8.3	9.2	8.9	9.2	3.0	3.1	3.1	3.0	84.397	32.6	0.0	117.0
4	9.2	8.9	9.2	9.2	8.3	9.2	8.9	9.2	4.5	4.6	4.6	4.5	90.446	37.1	0.0	127.5
5	11.1	10.7	11.1	11.1	10.0	11.1	10.7	11.1	4.5	4.6	4.6	4.5	104.906	35.9	1.7	142.5
6	11.5	10.4	10.8	10.8	9.7	10.8	10.4	10.8	4.5	4.6	4.6	4.5	103.240	60.0	1.7	165.0
7	18.4	17.9	18.4	18.4	16.7	18.4	17.9	18.4	14.9	15.4	15.4	14.9	205.091	89.9	6.0	300.9

Table 2.5-2. Minimum flow requirement (acre-feet) below La Grange Diversion Dam – change from Model Version 3.0.

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1971	0	0	0	0	0	0	3,500	27	0	0	0	0	3,526
1972	-56	0	0	0	347	0	695	0	0	0	0	0	986
1973	0	0	0	0	0	0	-4,164	1	0	0	0	0	-4,165
1974	0	0	0	0	0	0	1	1	0	0	0	0	0
1975	0	0	0	0	0	0	1	1	0	0	0	0	0
1976	0	0	0	0	595	0	4,166	0	0	0	0	0	4,760
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	-4,164	1	0	0	0	0	-4,164
1979	0	0	0	0	0	0	1	1	0	0	0	0	0
1980	0	0	0	0	595	0	1	1	0	0	0	0	595
1981	0	0	0	0	0	0	3,333	1	0	0	0	0	3,332
1982	0	0	0	0	0	0	-3,331	1	0	0	0	0	-3,332
1983	0	0	0	0	0	0	1	1	0	0	0	0	0
1984	0	0	0	0	595	0	1	1	0	0	0	0	595
1985	0	0	0	0	0	0	4,166	1	0	0	0	0	4,164
1986	0	0	0	0	0	0	-4,164	1	0	0	0	0	-4,165
1987	0	0	0	0	0	0	4,166	0	0	0	0	0	4,164
1988	0	0	0	0	297	0	0	0	0	0	0	0	298
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	297	0	0	0	0	0	0	0	298

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1993	0	0	0	0	0	0	-4,164	1	0	0	0	0	-4,164
1994	0	0	0	0	0	0	4,166	0	0	0	0	0	4,164
1995	0	0	0	0	0	0	-4,164	1	0	0	0	0	-4,165
1996	0	0	0	0	595	0	1	1	0	0	0	0	595
1997	0	0	0	0	0	0	1	1	0	0	0	0	0
1998	0	0	0	0	0	0	1	1	0	0	0	0	0
1999	0	0	0	0	0	0	1	1	0	0	0	0	0
2000	0	0	0	0	595	0	1	1	0	0	0	0	595
2001	0	0	0	0	0	0	4,166	1	0	0	0	0	4,164
2002	0	0	0	0	0	0	1	1	0	0	0	0	0
2003	0	0	0	0	0	0	-665	27	0	0	0	0	-639
2004	-56	0	0	0	347	0	695	1	0	0	0	0	986
2005	0	0	0	0	0	0	-4,164	1	0	0	0	0	-4,165
2006	0	0	0	0	0	0	1	1	0	0	0	0	0
2007	0	0	0	0	0	0	4,166	0	0	0	0	0	4,164
2008	0	0	0	0	297	0	1	0	0	0	0	0	298
2009	0	0	0	0	0	0	-665	27	0	0	0	0	-639
2010	-56	0	0	0	0	0	-3,470	1	0	0	0	0	-3,526
2011	0	0	0	0	0	0	1	1	0	0	0	0	0
2012	0	0	0	0	595	0	4,166	0	0	0	0	0	4,760
Avg	-4	0	0	0	123	0	102	3	0	0	0	0	222

3.0 CHANGE TO BASE CASE

Any modification to the logic or data of a model such as the Tuolumne River Daily Operations Model will lead to changes in results; however, in the instance of the modifications described in this Addendum, the changes in results are not significant and are almost unnoticeable. In summary the following changes occur to the Base Case.

Regarding Modeled CCSF Operation Changes:

- Hetch Hetchy Reservoir minimum release schedule corrections affect several years, adding additional water immediately below the reservoir, affecting timing and volume of other reservoir releases during a year. A net sum zero difference over the hydrologic study period occurs.
- The Lake Eleanor schedule refinement refines the daily distribution of minimum releases during April and September.
- Don Pedro Reservoir inflows follow changes in CCSF system releases, affecting timing of inflow. However, there is a net sum zero difference in inflow over the hydrologic study period.

Concerning Don Pedro Project and District Changes:

- Current FERC schedule better represented during October with mid-month refinement – same monthly volume; Mid-month April year type change better represents current operations; the leap year correction better reflects current FERC schedule.
- District Diversions – Correction of daily factors better translates monthly water demands, results in a modeled decrease in water demand of approximately 6,600 acre-feet per year.

To illustrate the only minor difference in results between the two models the following figures are provided. Figure 3.0-1 illustrates the annual required flow below La Grange Diversion Dam as derived by Model Version 3.0 (labeled as “Base_Case”) and Model Version 3.1 (labeled as “Revised”). Figure 3.0-2 illustrates the Districts’ combined total canal diversions for the Base Case for the two models.

The combined effects of different inflow, canal diversions, minimum flow requirements and resultant differing system operations will ultimately manifest in changes in reservoir storage. Figure 3.0-3 and Figure 3.0-4 illustrate the almost unnoticeable difference in Don Pedro Reservoir storage resulting for the modifications previously described. Most differences are the result of an accumulated reduction in the modeled Districts’ diversions.

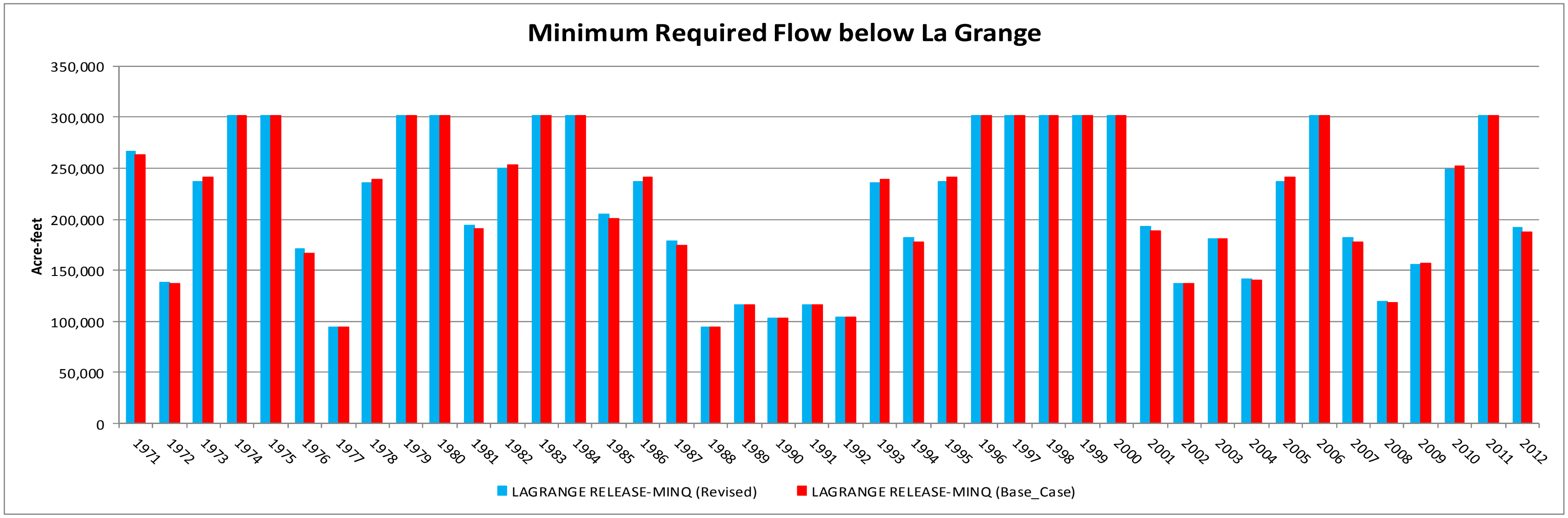


Figure 3.0-1. Minimum required flow below La Grange Diversion Dam – Model Version 3.0 and Version 3.1.

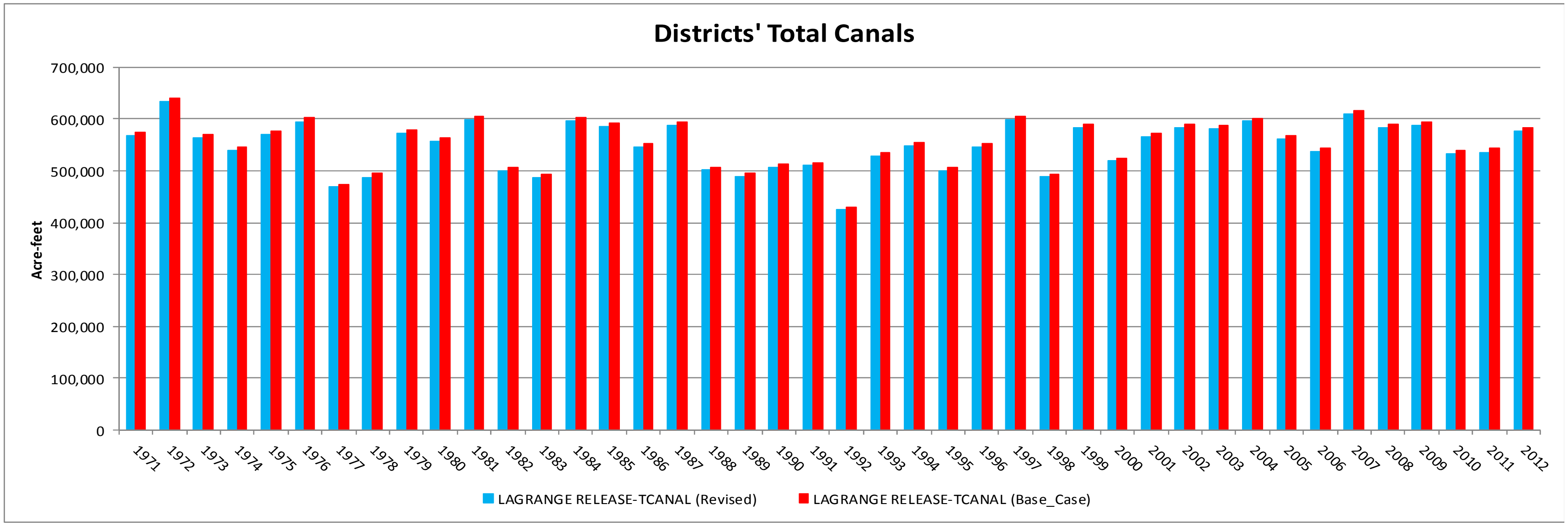
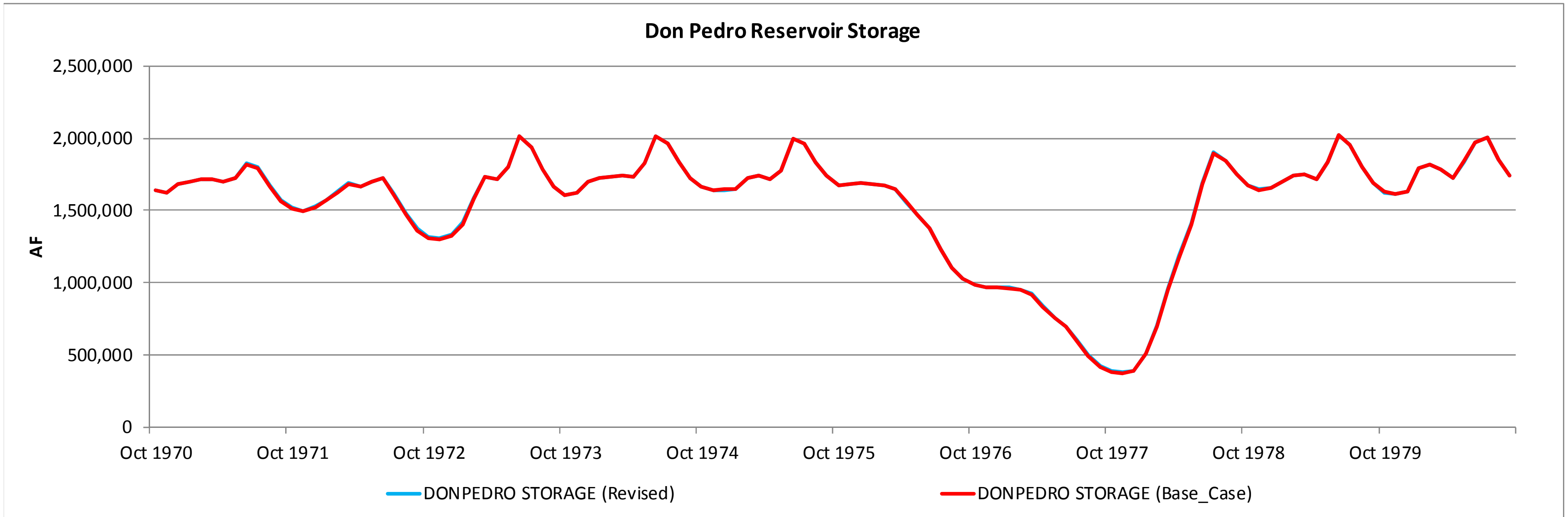


Figure 3.0-2. Districts' combined canal diversions – Model Version 3.0 and Version 3.1.

WY 1971-1980



WY 1981 - 1990

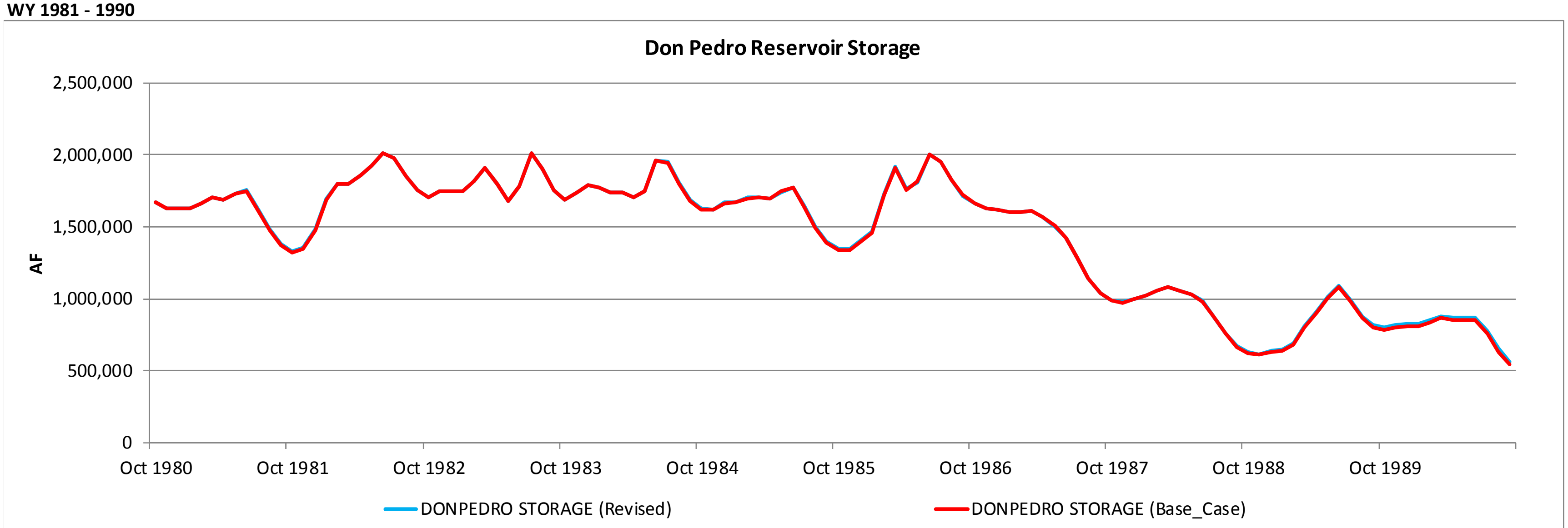
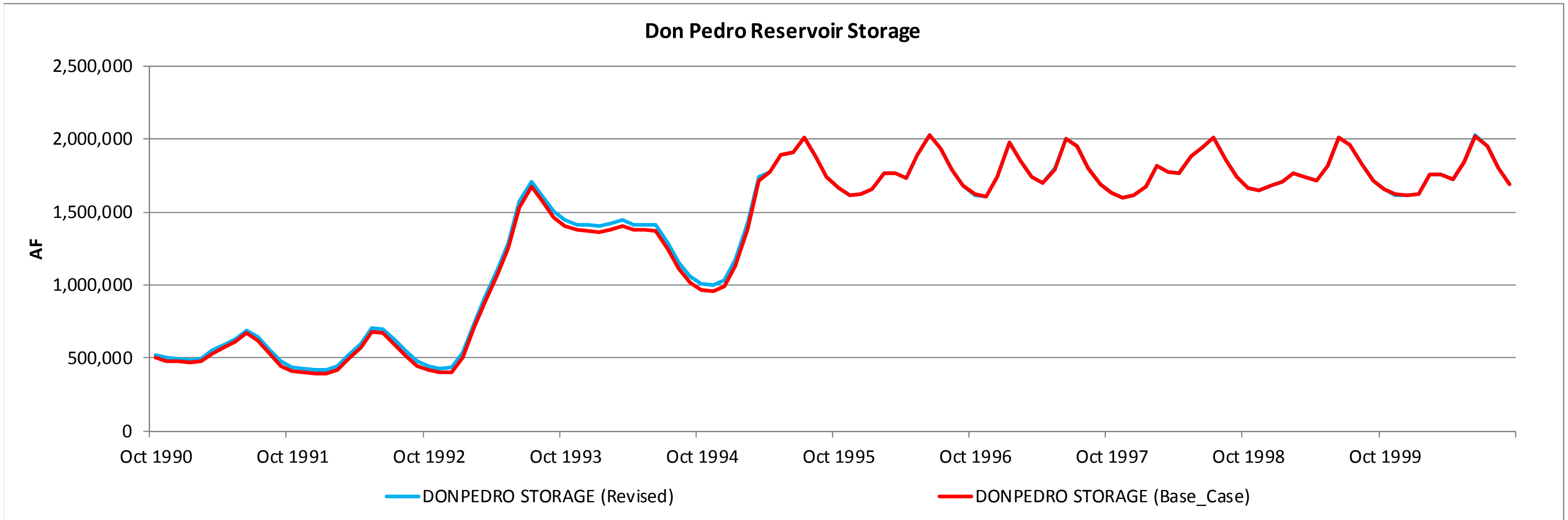


Figure 3.0-3. Don Pedro Reservoir storage – Model Version 3.0 and Version 3.1 (WY 1971-WY 1990).

WY 1991 - 2000



WY 2001 - 2012

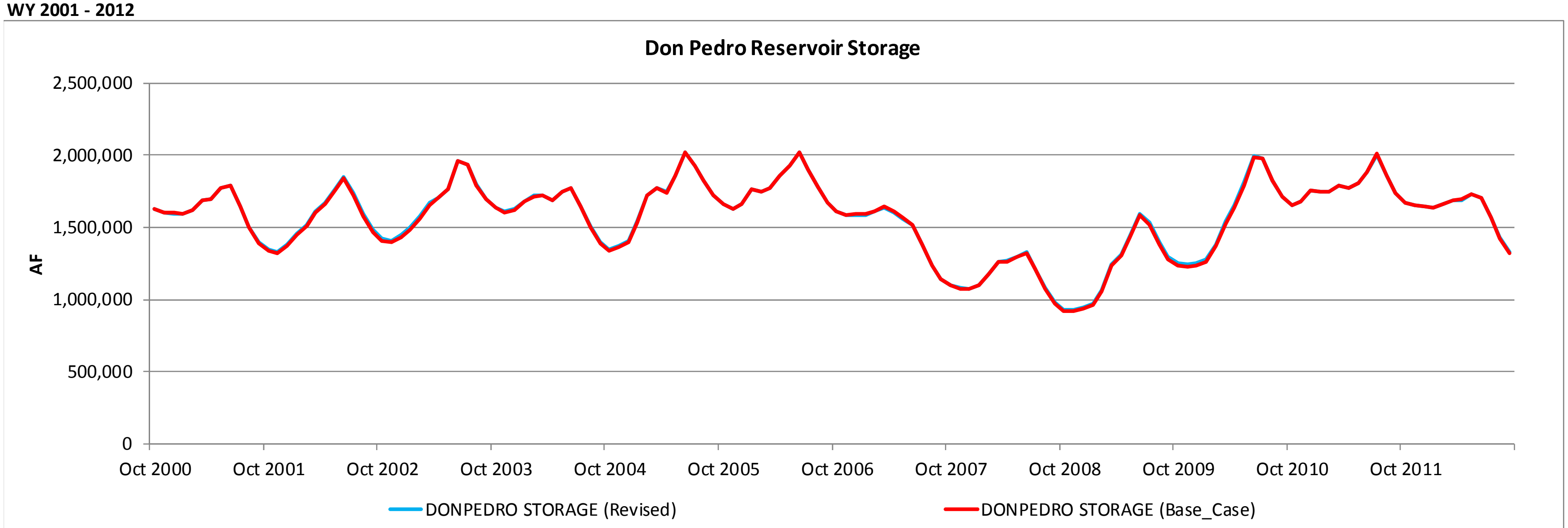


Figure 3.0-4. Don Pedro Reservoir storage – Model Version 3.0 and Version 3.1 (WY 1991-WY 2012).

4.0 METHOD FOR SIMULATING CCSF DROUGHT RESPONSE IN TUOLUMNE RIVER DAILY OPERATIONS MODEL

A method for simulating CCSF water supply operations during shortage conditions was developed for use with the Tuolumne River Daily Operations Model. This method allows the model user to estimate the water supply rationing that would be implemented by CCSF in alternative scenarios that include a water supply contribution made by CCSF to stream flow at the La Grange gage. This approach was used to estimate CCSF water supply rationing in the alternatives that were simulated for the Amended Final License Application. The method is described here so that it can be applied by model users if other alternatives are evaluated.

CCSF drought planning methodology was used to develop the CCSF water supply rationing that is included with the Base Case simulations. The method described here is intended to be used along with a compatible base case simulation, and will allow users of the Tuolumne River Daily Operations Model to estimate the additional water supply rationing that CCSF would implement if additional flow contributions are required to be made by CCSF on the Tuolumne River. The CCSF rationing that is included in the Base Case, plus the additional rationing identified through using this method, will be the total CCSF rationing that is estimated to be necessary in the alternative scenario being evaluated.

CCSF uses a drought planning methodology that includes a “design drought” sequence to estimate appropriate levels of water supply rationing. This sequence includes the historical drought hydrology from 1987 through 1992, with the historical drought from 1976 to 1977 appended consecutively after the 1987-1992 period, to create an 8-year drought. The Tuolumne River Daily Operations Model does not specifically simulate the CCSF design drought as a consecutive 8-year sequence, but it does include the historical hydrology for all 8 years. Therefore, in the method described here, the user will select the relevant information from these years and apply it so that it emulates the CCSF drought planning method to estimate the effects of CCSF contribution to a Tuolumne River flow requirement.

The Tuolumne River Daily Operations Model calculates the CCSF contribution to alternative flow schedules at La Grange on a daily basis. This is calculated in the model as 51.7% of the difference between the current flow requirement and the alternative flow requirement being evaluated. These values are labeled “La Grange Credit Adj in SF WB”, and are available on tab “WaterBankRel” of the model file, in column Q. They are presented in units of acre-feet.

The first step in estimating the additional CCSF water supply rationing is to sum the value of CCSF contribution to the flow requirement for the period of the CCSF design drought sequence. This period is July 1, 1986 through April 14, 1993, followed by April 15, 1976 through December 31, 1977. These dates describe the hydrologic periods that are used in the CCSF design drought sequence, and the transition between the two periods is adjusted here to reflect the flow schedule changes that occur on April 15 in the Tuolumne River Daily Operations Model. If different transition points between annual flow schedules are evaluated, the same transition point should be used in summing the CCSF contributions. For example, if flow schedules are evaluated that include a fraction of unimpaired flow from February through June of each year, the transition point used should capture February 1976 conditions.

In the special case in which a flow schedule is reduced in a critical water year that follows a critical water year, the CCSF contribution for 1977 should be used twice and the contribution calculated for 1976 should not be used. Specifically, the CCSF contribution calculated for the period of April 15, 1977 to December 31, 1977 plus the contribution for the period of April 15, 1977 through April 14, 1978 should be used in place of the contribution calculated for April 15, 1976 through December 31, 1977. This modification will avoid using the CCSF contribution values calculated for the first critical year in 1976 when simulating the 8-year design drought sequence with a required flow schedule that is reduced in subsequent critical water years.

The next step in calculating the additional CCSF rationing is to multiply the sum from step one by 75% to estimate the volume of additional rationing that CCSF will need to apply in the 6-year drought from 1987-1992. Here it is assumed that the additional rationing would be split evenly across all 8 years of the design drought sequence. Given that assumption, 75% of the additional rationing would be applied in years one through six of the design drought sequence, and the remaining 25% would be applied in years 7 and 8. Applying 75% of the sum from step one in the period from 1987-1992 will approximate the CCSF system operation that would be developed using the CCSF drought planning method. In the Tuolumne River Daily Operations Model, the San Joaquin Pipeline delivery to the CCSF service area should be reduced by this volume during the 6-year drought from 1987 – 1992. These reductions should be made in addition to any reductions that occur in the compatible base case during this same period.

The final step in this method is to check for the need to apply additional rationing in other years, based on CCSF total system storage. The CCSF drought planning methodology includes applying designated levels of water supply rationing when the total system storage is at or below specific designated levels on July 1 of each year. In using the method described here to approximate the CCSF methodology in the Tuolumne River Daily Operations Model, the user should note the total system storage level on July 1 of the years in which the additional rationing is applied. CCSF total system storage is the sum of total CCSF Tuolumne River system water supply storage and CCSF Bay Area reservoir storage; these values are available in the "CCSF" tab of the Tuolumne River Daily Operations Model. The highest July 1 value of total CCSF system storage for which the additional rationing is applied in the period from 1987 – 1992 should be considered the storage trigger that initiates the additional rationing. Once the user has determined the new storage trigger for increased rationing, the rest of the simulation should be reviewed for other instances in which the trigger is reached. For all such years, the same level of rationing should be applied.

The CCSF rationing in the Base Case simulation at a demand of 238 million gallons per day (mgd) is applied as 10% system-wide rationing for 5 years in the 6-year sequence from 1987-1992. The 238 mgd demand is equivalent to 266,594 acre feet per year, so a 10% cut is equivalent to a 26,659 acre-foot reduction. Additional rationing can be expressed as a percent of the annual delivery volume in the same way, by relating it to the total CCSF system demand.