



— BUREAU OF —
RECLAMATION

Central Valley Project
Final Cost Allocation Study

Hydrological Modeling Appendix

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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Attachment 1 – CalSim 2 Model Description

Attachment 2 – CalSim 2 Inputs, Assumptions, and Results

Attachment 3 – Hydrology Sensitivity Analysis

Introduction

This appendix documents the hydrological modeling tools used and analysis performed to support the Central Valley Project (CVP) Cost Allocation Study (CAS). The CAS uses the Separable Cost Remaining Benefits (SCRB) method for determining the appropriate distribution of CVP facilities' costs among the purposes for which the CVP was authorized. The parameters used by the SCRB methodology include single purpose alternative (SPA) costs, separable costs, and economic benefits. Hydrological modeling and analyses were used to determine SPA and omitted-purposes sizes for multi-purpose facilities, which are key components of the SPA and separable cost estimates (see *Cost Estimate Summary Tables Appendix*), and to develop inputs for economic benefit analyses (see *Economic Benefit Analysis Appendix*).

Hydrological model applications used in the CAS analysis include CalSim 2, Flow Tracker, and the Single Purpose Facility Sizing Model (Sizing Model). CalSim 2 is a reservoir-river simulation model developed by the California Department of Water Resources (DWR) and U.S. Bureau of Reclamation (Reclamation) that is commonly used for long-term water supply reliability planning. See Attachment 1 (*CalSim 2 Model Description*) and Attachment 2 (*CalSim 2 Inputs, Assumptions, and Results*) to this *Hydrological Modeling Appendix* for general information about CalSim 2 and specific assumptions and data used for the CVP CAS. Sensitivity analysis related to hydrological conditions under climate change was also conducted (see Attachment 3 *Hydrology Sensitivity Analysis*).

The Flow Tracker model was developed to identify State Water Project (SWP) storage releases made specifically for Delta outflow as input to the Sizing Model. The Flow Tracker and Sizing Model are described below. Additional analysis included post-processing of CalSim 2 results and evaluation of Central Valley Project Improvement Act (CVPIA) records. A spreadsheet post-processor for CalSim 2 results refined the model's representation of drought year allocation decisions to ensure that delivery results reflect recent operations. An evaluation was made of CVPIA 3406(b)(2) accounting records to determine the use of storage to accomplish the goals of this program.

The CAS analysis used CalSim 2 to estimate project deliveries and flows under a range of regulatory environments, and these results were used as the basis for water supply, water quality, flood control, and hydropower economic benefit and multi-purpose facility SPA sizing analyses. Flood control benefit and hydropower SPA facility sizing analyses did not directly use CalSim 2 output. Details on model assumptions, algorithms, and other analyses are provided for the water supply, water quality, hydropower, and flood control purposes below. In addition, sizing facilities to meet CVPIA and omitted-purpose analysis are described, as well as additional details on the hydrological model tools used, including the Sizing Model and Flow Tracker.

Water Supply Purpose

The Central Valley Project has agreements and contractual obligations to deliver water to agricultural, municipal and industrial, and refuge water users throughout the Sacramento River and San Joaquin River watersheds. Water deliveries constitute the water supply purpose of the CVP. The capacity of the system to deliver water is affected by regulations that govern operations to meet water quality and flow standards at multiple locations. Deliveries are affected by water supply allocation, which is determined by contract terms, delivery category, and operator decisions on managing water supply to meet competing priorities.

For the water supply purpose, analysis served two needs. One was to quantify the deliveries that define the water supply purpose, and the other was to determine the water supply single purpose alternative storage sizes of the major CVP reservoirs. Figure 1 shows the flow of data, analysis, and modeling tools used to address the water supply purpose for the CVP CAS.

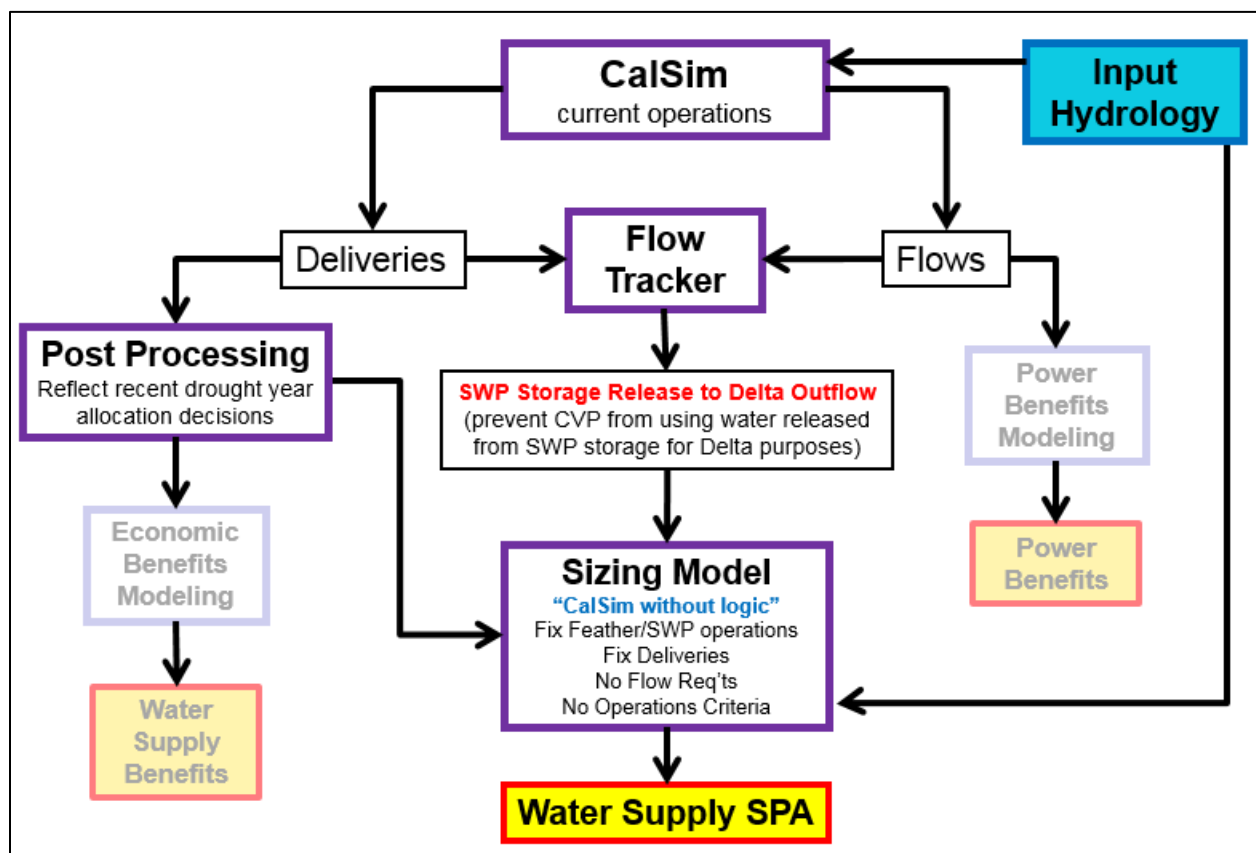


Figure 1. Hydrology Modeling and Analysis for the CVP Water Supply Purpose

Quantifying the water supply purpose. The historical record of CVP water deliveries cannot be used to characterize the water supply purpose of the project because demand has increased over time due to the progressive buildout of project facilities and because basin-wide regulations have evolved over time, mostly decreasing delivery capacity. The CalSim 2 planning model was used to

simulate delivery that is possible 1) over a range of hydrologic conditions, 2) given a consistent level of demand (land use and population), and 3) under the current regulatory environment. The delivery results of this “current operations” scenario characterize the water supply reliability of the CVP.

CalSim 2 is a planning model typically used to compare an operational alternative to a base study to discern the impact of a particular facility or regulation. Its general operations logic does not include the ability to make unique decisions under extreme drought conditions. Results were therefore post-processed to better reflect allocation decisions such as those made in 2014 and 2015, when allocations were reduced to preserve north-of-Delta storage. If modeled end-of-September storage in Lake Shasta was below 1.1 MAF, the post-processing analysis calculated the storage shortfall and made commensurate reductions to delivery results. First, Central Valley Project Agricultural deliveries were cut, then San Joaquin Exchange Contractor deliveries were cut below the Shasta Critical allocation of 77 percent. Friant Kern Project deliveries were appropriated to make up for San Joaquin Exchange Contractor deliveries lower than the CVP contract obligation, taking into consideration San Joaquin River losses incurred to facilitate conveyance to Mendota Pool. After additional delivery cuts were established, lower Jones exports, Sacramento River flows, and Shasta releases were re-calculated accordingly. No modifications were made based on assumptions for meeting Delta water quality standards or other flow standards. These assumptions result in conservative estimates of water supply delivery capability.

In Figure 1, the modeling analysis that captures the water supply purpose is represented by the CalSim 2 and Post Processing boxes. CalSim 2 results for deliveries are inputs to the Post-Processor. Results from the Post-Processor are the best possible estimate of CVP capacity to deliver water under the current regulatory environment over a range of hydrologic conditions. These deliveries are used to calculate inputs to the economics models which calculate water supply benefits for irrigation and municipal and industrial (M&I) contractor types. Table 1 displays estimated irrigation, M&I, and Level 2 refuge deliveries by water year type. Note these deliveries are summarized from the post-processed CalSim 2 delivery results and not the economic models inputs (see *Economic Benefit Analysis Appendix* for more details).

Table 1. Estimated Annual Water Supply Deliveries by Water Year Types (TAF)

Type	Wet	Above Normal	Below Normal	Dry	Critical
Irrigation	6118	5603	4946	4353	3121
M&I	606	606	506	447	357
Level 2 Refuge	369	369	369	362	291

Calculating water supply purpose SPAs. Five multi-purpose CVP reservoirs serve the water supply purpose – Friant, New Melones, Trinity, Shasta, and Folsom. Friant serves direct diversions into the Madera Canal and Friant Kern Canal. New Melones must satisfy CVP contracts with Stockton East Water District and Central San Joaquin Water District along with settlement obligations to Oakdale Irrigation District and South San Joaquin Irrigation District. Trinity, Shasta, and Folsom collectively meet the needs of CVP water users in the Sacramento and American river basins and exports at Jones Pumping Plant. The Sizing Model was used to determine the size that each multi-purpose facility must be in order to satisfy the modeled deliveries determined by the CalSim 2 run and post-processing logic.

Figure 1 shows the pathway of model applications and data that calculates the SPA sizes for water supply. CalSim 2 determines deliveries and flows under current operating conditions. CalSim 2 output for delivery and flow are inputs to the Flow Tracker (see the separate section on the Flow Tracker for detailed information) which determines SWP storage releases made to meet Delta obligations. Inputs to the Sizing Model are: 1) post-processed CalSim 2 delivery results, 2) Flow Tracker results for SWP storage release to Delta outflow, and 3) input hydrology.

The Sizing Model is described in further detail in a separate section. All SWP operations, CVP deliveries, and non-project deliveries were fixed. Stream-groundwater interaction, weir flows, and Delta Cross Channel gate operations were dynamic. The only flow requirement in place was to convey the SWP storage release for Delta outflow to its intended destination. With no other flow requirements and no operational constraints, the sizing model does not release water from CVP storage except when this is necessary in order to meet the fixed deliveries. Iterations of the sizing model tested successively smaller CVP reservoir storage capacities until the reduced conservation storage was *fully utilized* to supply all deliveries in at least one year in the period of record. Table 2 displays the water supply SPA storage facility sizes. Note that water supply SPA sizes calculated by the Sizing Model do not include volumes associated with CVPIA B2 management actions. Volumes associated with CVPIA B2 management actions were estimated separately, as discussed below, and included in the CVP reservoir sizes used in cost estimates.

Table 2. Water Supply SPA Storage Facility Sizes

CVP Reservoirs	Full Size	Water Supply SPA (without CVPIA B2)¹	CVPIA B2	Water Supply SPA Size
Trinity	2447	709	24	733
Shasta	4552	1391	44	1435
Folsom	967	181	10	191
New Melones	2420	640	2	642
Friant	524	476	0	476

For a system which operates in a highly integrated manner, it was not realistic to determine SPA sizes based on a “Shasta only” scenario or other similar perspective. SPA sizes were determined assuming the integrated use of Trinity, Shasta, and Folsom. The ratios of active storage capacities between north-of-Delta reservoir facilities were kept proportionally the same in developing the sizing results. Dead pool is included in the SPA sizes.

Figure 2 shows the time series of total north-of-Delta storage for the final Sizing Model iteration. In almost every year of the simulation, the system draws on stored water to satisfy delivery and then storage refills to capacity. The red circle indicates the one point in the period of record when the storage condition reached collective dead pool. This is the year with the largest drawdown, so it defines the single purpose alternative storage. The grey circles identify multiple other years with similar storage needs.

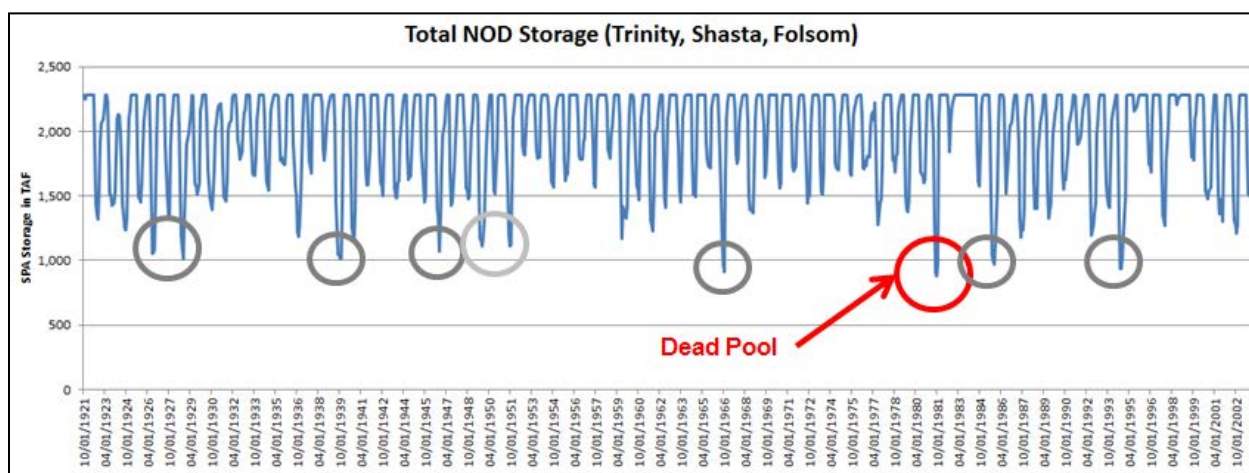


Figure 2. Sequence of Single Purpose Storage Operations for Water Supply

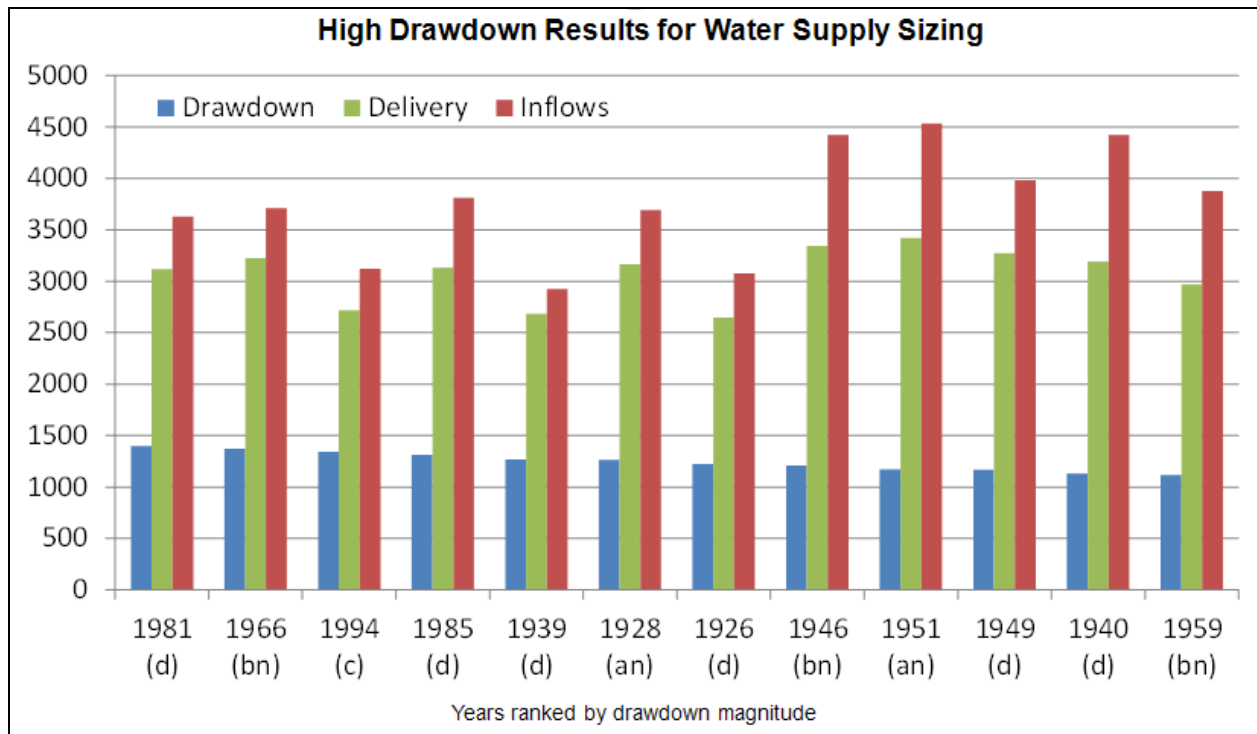


Figure 3. Multiple Years Have Drawdown Needs Similar to the Year Which Defines NOD SPA Sizes

Figure 3 shows the relationship between drawdown, delivery, and inflow for these high-drawdown years. Note that these years are neither extremely dry nor extremely wet. CVP agricultural allocations in these years vary around the 50 percent mark. It is in these somewhat drier years where the system needs to fully utilize its storage resources to satisfy project water supply needs.

This analysis is purely theoretical, performed for the unique purpose of providing specialized information for economics analysis for the CAS. The Sizing Model does not depict actual operations. It simply allows the calculation of the storage volume needed to ensure that the delivery time series is able to happen.

Water Quality Purpose

CVP operations to meet water quality standards under State Water Resources Control Board (SWRCB) D-1485 are joint costs in the SCRB analysis, while incremental operations to meet the stricter standards of D-1641 are non-reimbursable. Quantifying the differences between CVP operations to meet D-1485 and D-1641, and determining the storage necessary to accomplish this, were the goals of the hydrology analysis for the Central Valley Project's Water Quality Purpose.

Water quality responsibilities of the CVP are expressed both by salinity standards, which are met by flow, and by flow requirements that can be surrogates for temperature or dissolved oxygen. Under the complex combined operations of the CVP and SWP, water that is provided to meet a water quality standard at one location can also be used to satisfy a delivery or water quality standard at another location. It can thus be difficult to discern a specific operation for incremental water quality.

Separate CalSim 2 studies were developed to represent system operations under both D-1485 and D-1641. A comparison of results between these scenarios shows differences in river flows, Delta outflow, deliveries, exports, and storage conditions, particularly in the Sacramento River basin.

The Delta outflow that is required to meet water quality standards in the Delta depends on export level. In order to correctly identify the *increment* of SPA storage required to satisfy the D-1641 water quality standards as compared to those in D-1485, the increment had to be defined given the same level of export and delivery. Two new CalSim 2 studies were constructed that fixed CVP and SWP project allocations to the time series of results from the Current Operations scenario but which used D-1485 and D-1641 regulatory environments respectively to guide other system operations. This provided a consistent delivery basis upon which to discern the difference in storage resources required to meet the different water quality standards. These studies were designated as "Hybrid" CalSim 2 runs (H-1485 and H-1641), since they combined current operation delivery levels with prior regulatory criteria.

Quantifying the Water Quality Purpose. In Figure 4, the modeling analysis that captures the differences between the D-1485 and D-1641 environments is represented by the box labeled "CalSim D1485 D1641." The differences in deliveries between these studies reflect the water deliveries that are foregone in order to meet the higher water quality standards of D-1641. These foregone deliveries were used as inputs to economic benefits models to calculate the representation of economic benefit for the water quality purpose. Table 3 displays estimated annual Delta outflows and foregone irrigation and M&I water deliveries by water year type.

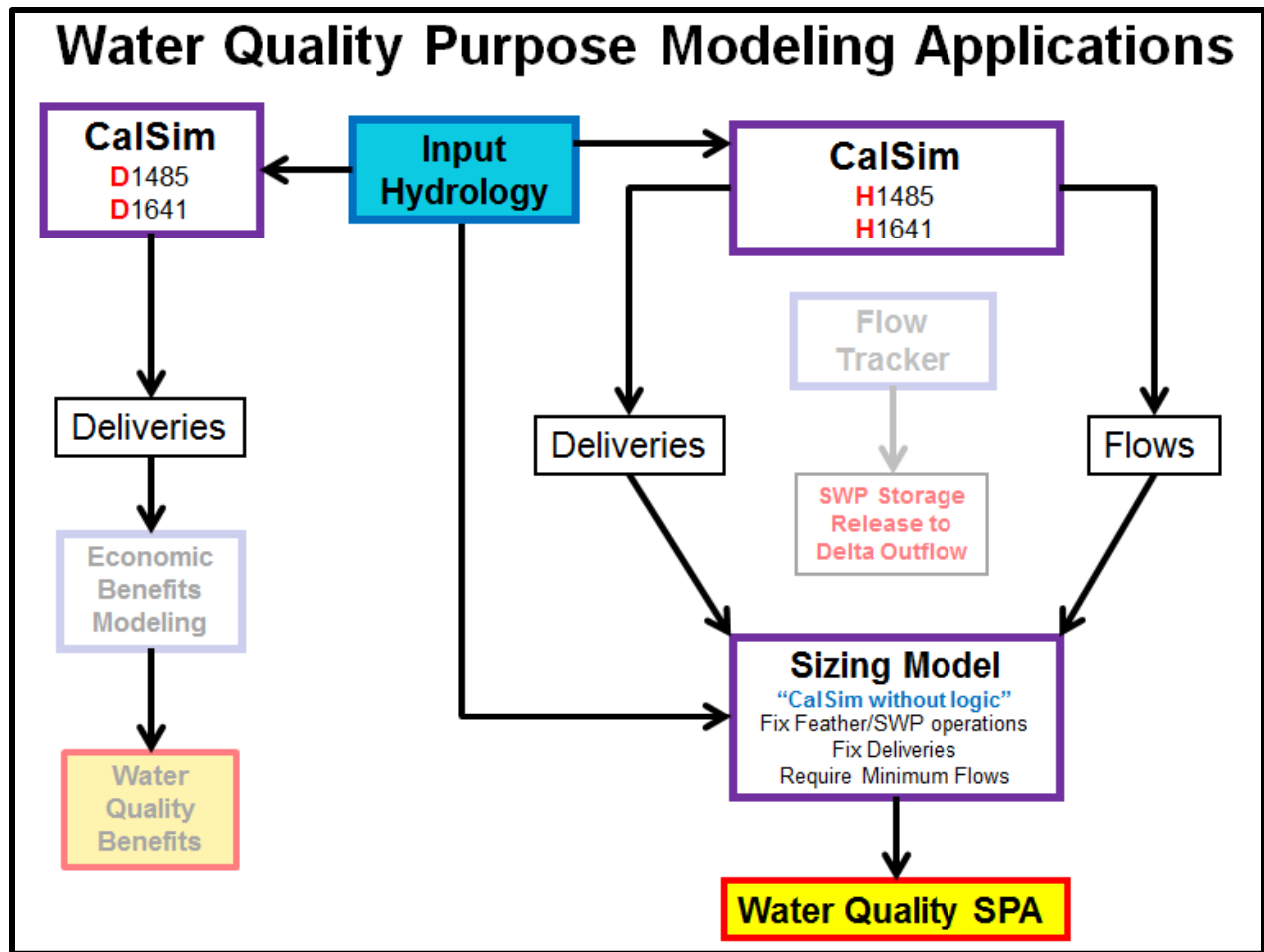


Figure 4. Hydrology Modeling and Analysis for the CVP Water Quality Purpose

Table 3. D-1641 Estimated Annual Water Requirements by Source and Water Year Type (TAF)

D-1641 Water Requirements	Wet	Above Normal	Below Normal	Dry	Critical
Delta Outflows ^{1,2}	0	0	206	338	449
Foregone Irrigation Deliveries	34	114	167	118	171
Foregone M&I Deliveries	2	5	7	4	10
Total	36	119	380	460	630

1. Represents CVP portion of Delta outflow requirement

2. CalSim 2 modeling shows that estimated Delta outflow requirements in wet and above normal years are negative; these values have been adjusted to zero.

Calculating the Water Quality SPA Sizes. Figure 4 shows that the analysis pathway for determining the SPA sizes for water quality starts with the Hybrid CalSim 2 studies. This is represented by the box labeled “CalSim H1485 H1641.” The H1485 and H1641 scenarios resulted in identical delivery and export levels but different flows and Delta outflow. The SPA sizes for satisfying flows *and* delivery were used as inputs to the sizing model. Separate runs of the Sizing Model were done for each hybrid scenario, and the differences between the SPA sizes were calculated.

The Sizing Model runs for the water quality purpose did not size for flow only – deliveries were input as well. Because the input hydrology in CalSim is intrinsically tied to land use, and thus demand, it would be problematic to develop a scenario that met only flow and not any delivery. The sizing model runs for water quality are still devoid of any operations logic, just as in the sizing model for water supply. The difference is that in addition to meeting delivery, storage reserves are also needed to meet minimum flows at key locations and Delta outflow requirements. Note that the role of the Flow Tracker in this figure is grayed out. Feather River operations, which are still fixed, include releases for SWP responsibilities in the Delta, but Delta outflow is now a requirement in these Sizing Model runs and the SWP release helps to serve that outflow requirement. Table 2 shows the Sizing Model results for the Hybrid studies and the differences which describe the SPAs for water quality.

New Melones does not appear in Table 4 because the difference in SPA is negligible. New Melones does meet water quality standards at Vernalis and dissolved oxygen standards at Ripon, but overall differences in the combinations of criteria between D-1485 and D-1641 resulted in the reservoir needing to be the same size under both regulatory environments. Friant does not serve a water quality purpose.

Table 4. SPA Storage Size Results for the Water Quality Purpose (TAF)

	Full Size	H-1485 (D-1485 with Current Deliveries)	H-1641 (D-1641 with Current Deliveries)	Difference = SPA storage size for water quality	Minimum Storage (Deadpool)	Water Quality SPA Size
Trinity	2447	1793	1905	112	240	353
Shasta	4552	3361	3567	206	550	756
Folsom	967	718	757	39	90	129

1. Includes storage requirements for CVPIA B2 water quality objectives

Figure 5 shows the time series of total north-of- Delta storage operations performed to meet delivery and flow requirements in the sizing model. Similar to the water supply analysis, the SPA is defined by the largest drawdowns necessary to meet the combined flows and deliveries. The red circle indicates the point at which both the H1485 and H1641 sizing model storage results reached

dead pool. This drawdown happened over the time span of three years leading into one of the driest years on record.

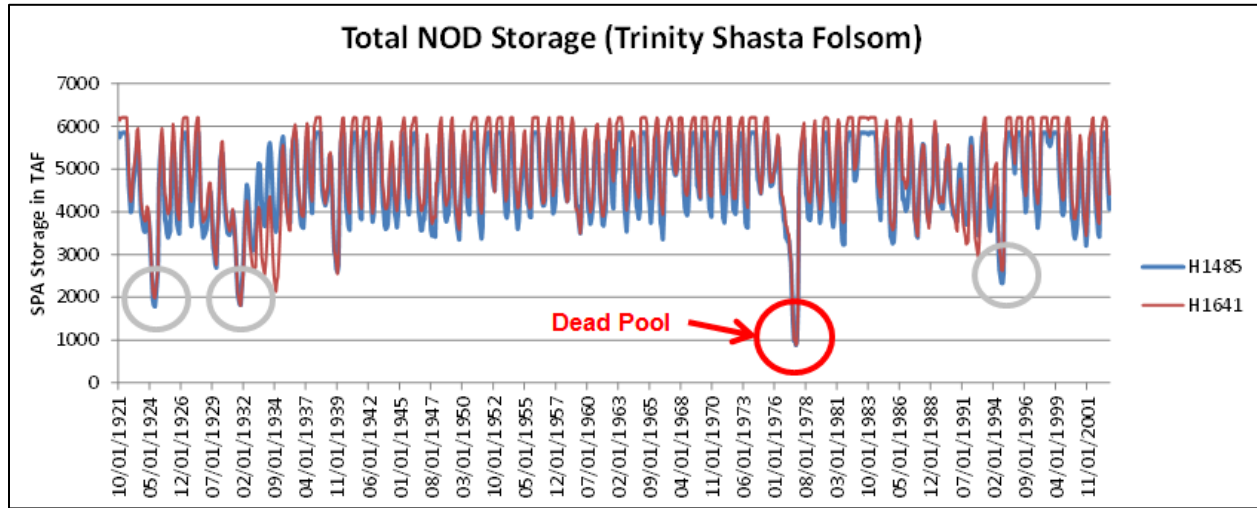


Figure 5. Sequence of Single Purpose Storage Operations for Water Quality

Figure 6 focuses on the *difference* between the two sizing runs, since for the water quality purpose it is not the size of the largest drawdown in either H1485 or H1641 that matters, but rather the difference in the size of the largest drawdown in each run. Note the SPAs are much larger than for the water supply purpose, due to the fact that the water quality sizing runs have to meet both delivery and flow. For both the H1485 and H1641 runs, the SPA is determined by the three-year period from 1975 to 1977. Figure 6 highlights the increment of storage capacity that is necessary to meet D-1641 criteria over D-1485 criteria over the period of the drawdown. Both scenarios start with full SPA reservoirs in 1975, and both end at dead pool by the end of water year 1977. The difference in the required storage capacities is the SPA for water quality.

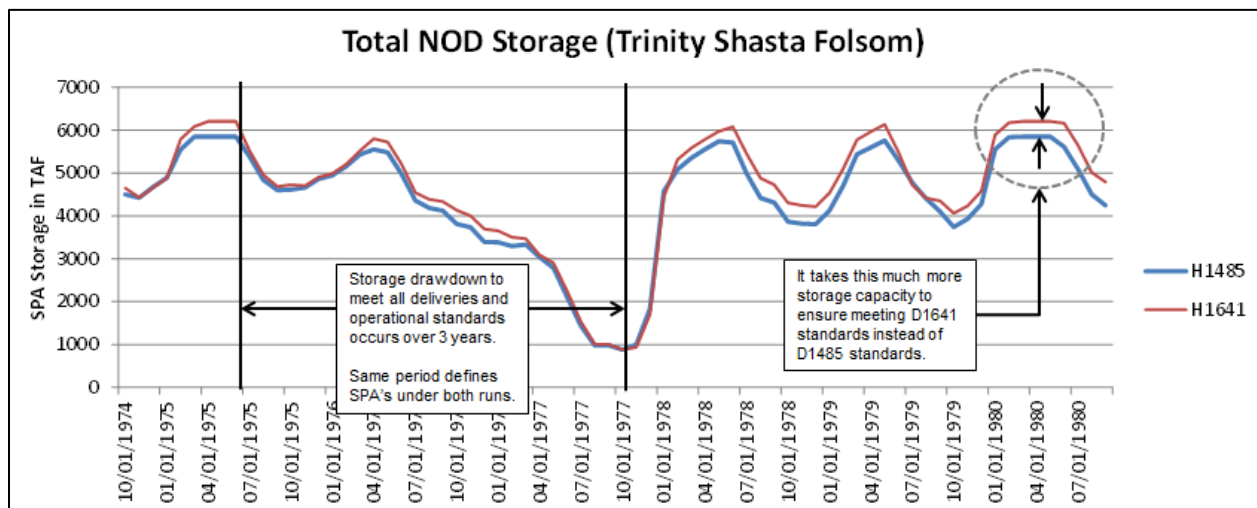


Figure 6. Expanded View of the Time Period Which Defines the SPA for Water Quality

Hydropower Purpose

The hydropower purpose in the CVP reflects hydropower generation at project facilities that are used for both commercial and project use purposes. Project use energy (PUE) is the power required to operate CVP facilities, such as pumping plants. Any power generated that is not used by the project is considered commercial power, which is marketed by the Western Area Power Administration (WAPA).

CalSim 2 output was used as input to the long-term generation (LTGEN) model (developed by Reclamation and WAPA) to estimate power generation and consumption in the CVP system. CalSim 2 outputs include reservoir releases, conveyance flow rates, and end-of-month reservoir storages. The LTGEN is a monthly model that simulates both power generation and consumption in the CVP system resulting from a CalSim 2 simulation. Powerplants included in the LTGEN model are Trinity, Lewiston, Carr, Spring Creek, Shasta, Keswick, Folsom, Nimbus, and New Melones powerplants; and O'Neill and the CVP portion of Gianelli pumping-generating plants. Included pumping plants are C. W. "Bill" Jones, the CVP portion of Harvey O. Banks, Contra Costa, Pacheco, Dos Amigos, Folsom, Corning, and Red Bluff pumping plants; San Luis, Delta-Mendota Canal, and Tehama-Colusa relift pumping plants; and O'Neill and the CVP portion of Gianelli pumping-generating plants.

The Microsoft Excel-based LTGEN model reads reservoir storage and releases, as well as powerhouse and pump station monthly flows from CalSim 2 outputs. The total monthly energy generation, or usage, is computed for each powerhouse and pump station in the system. The total energy is then divided into on- and off-peak periods, with the goal to maximize on-peak generation and off-peak pumping. The functions and parameters assumed in LTGEN were developed by WAPA and Reclamation. Table 5 displays the CVP system estimated annual energy generation and consumption by water year type. Estimated energy generation is the basis of the hydropower economic benefit analysis and Thermal Plant SPA sizing for the hydropower purpose.

Table 5. Estimated Annual Power Generation and Consumption by Water Year Type (GWh)

Power Component	Wet	Above Normal	Below Normal	Dry	Critical
Energy Generation	6463	5211	4226	3909	3024
Energy Use	1417	1216	1126	1017	694
Net Generation	5046	3995	3100	2891	2330

Flood Control Purpose

The CVP storage facilities which operate for flood control are Trinity, Shasta, Folsom, New Melones, and Friant (Millerton). All of these facilities except for Trinity include flood control in their authorizing legislation. Trinity provides protection to downstream assets under guidelines set by the Trinity River Mainstem Fishery Restoration Record of Decision (ROD).

Flood control rules limit the volume of water that may occupy space in a reservoir, mandating that a certain amount of empty space be maintained in order to accommodate anticipated seasonal runoff. Figure 7 provides a conceptual diagram. Flood control rule curves are the time-varying values for flood control rules through the water year. Space requirements are typically highest in the late fall and may be determined annually depending on runoff forecasts for the reservoir catchment area. A high space requirement translates to a lower rule curve. Rule curve values over the course of any water year also depend on operating strategies and safety considerations for individual storage facilities. Limits are set by the Army Corps of Engineers or local flood protection authorities. Figure 8 shows a portion of the historical flood control rule curve for Folsom Lake, as used by the CalSim 2 planning model.

The flood control rule method for determining the single purpose size of a reservoir is simply to select the largest value for required flood space in a reservoir from the historical flood control diagrams and add this to the dead pool space. The largest flood space is found by taking the lowest value for the cumulative storage at which the bottom of the flood space begins from the time series of flood control rules used in the CalSim 2 planning model. This value is subtracted from the storage capacity of the reservoir to define the maximum required flood space. This is then added to the minimum operating storage level in the reservoir, representing the dead pool, to calculate the single purpose alternative size for the reservoir. Table 3 provides a summary of sizing results produced by this method, and Figure 11 shows the rule curves used by CalSim 2.

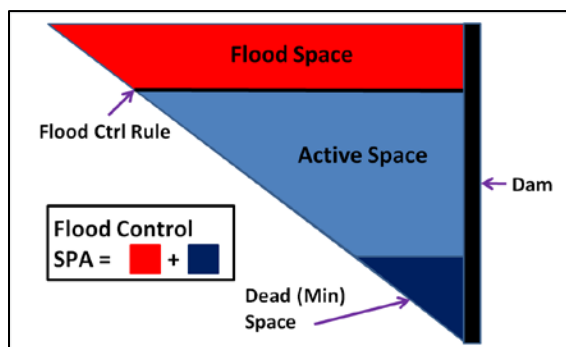


Figure 7. Flood Control Rule Concept

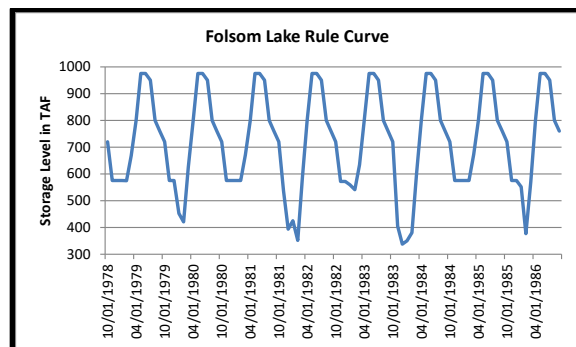


Figure 8. Flood Control Rule Curve Example

Table 6. SPA Storage Size Results for the Flood Control Purpose (TAF)

	Minimum Flood Control Rule	Storage Capacity	Flood Space Required	Minimum Storage (Dead Pool)	Flood Control SPA Size
Shasta	3250	4552	1302	550	1852
Folsom	367	967	670	90	690
New Melones	1970	2420	450	80	530
Millerton	351	524	174	135	309

All values in TAF

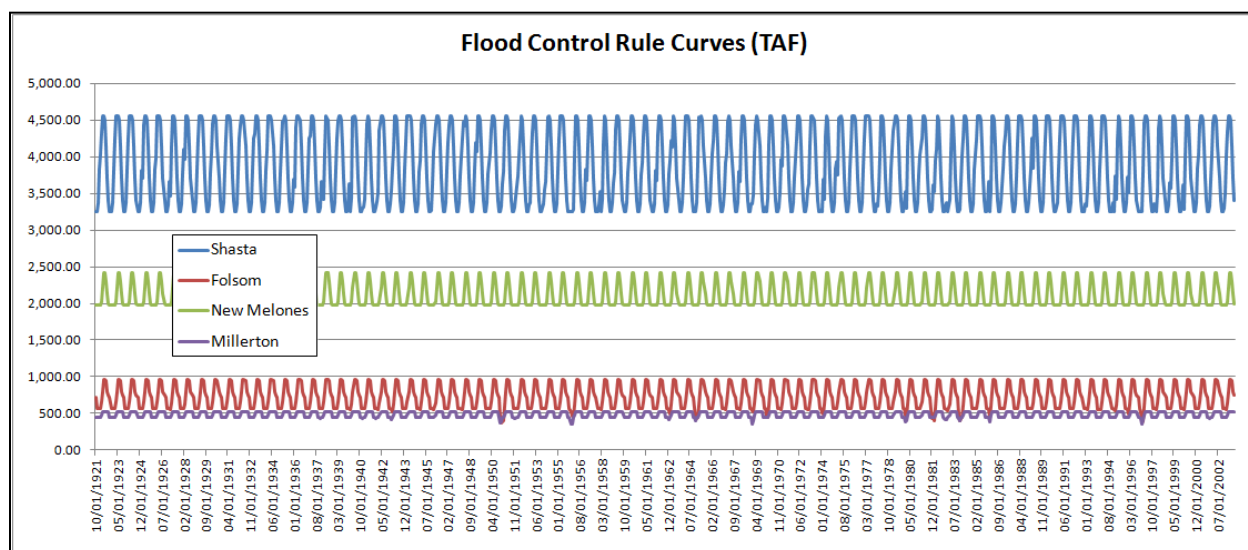


Figure 9. Flood Control Rule Curves Used for CalSim 2 Planning Studies

The flood control rule analysis approach does not necessarily provide a pure single-purpose or single-facility perspective, as the historical trace of required space in a reservoir may consider normal operations such as releases for water supply deliveries, flow standards, and other criteria, as well as the integration of that facility's operation with other facilities in the system. However, this approach is also not affected by outlier hydrology events that might exceed the scope of the project intent. The rule curve method was used for the four CVP facilities that have an authorized flood control purpose.

Trinity has a unique flood control mandate relative to the other four facilities; flood control is not an explicitly authorized purpose but the dam operates to protect downstream assets under the Trinity River Mainstem Fishery Restoration ROD. Due to the unique nature of the flood control mandate

for Trinity, a daily hydrology model analysis was used to determine the flood control SPA for Trinity of 578 TAF.

Trinity Lake Model

Historical daily data for computed inflows to Trinity Lake were available from November 1962 through the present day. Monthly input data from the CalSim 2 planning model was disaggregated to a daily average and used to represent the small local accretion between Trinity Dam and Lewiston Dam. No export of water through Clear Creek Tunnel was assumed. Trinity Dam is operated to avoid damages that would occur to downstream assets at flows above 11,000 cfs, so this was used as the flow threshold for initiating the flood control operation.

The daily model run for Trinity Dam starts on November 1, 1962, assuming a minimum regulated storage rule of 240 TAF. Release capacity as a function of reservoir storage is shown in Figure 10. Reservoir releases are limited to prevent flows above 11,000 downstream of Lewiston Dam. Daily storage is determined as:

Previous Day Storage + Inflow – Evaporation

– min(Discharge Capacity, 11000-Trinity_Lewiston_Accretion, (Inflow-Evap+CarryoverStorage)).

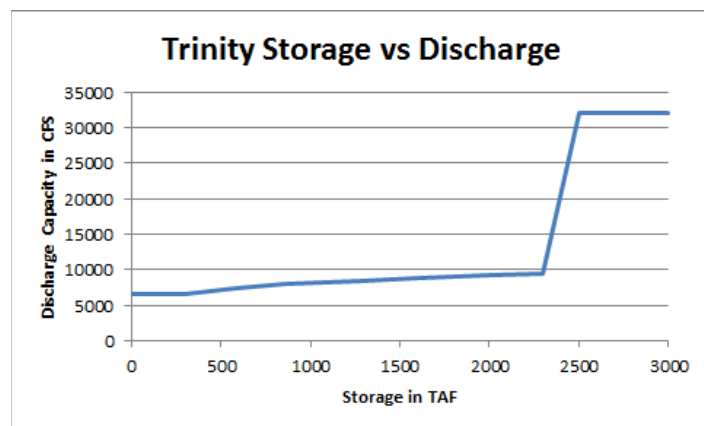


Figure 10. Trinity Storage vs. Discharge Capacity

The maximum storage attained in Trinity Lake in the daily hydrology model investigation is 577.9 TAF, occurring in January of 1997. Other extreme inflow events in 1964, 1974, 1983, and 2006 result in needs for storage capacities of 564 TAF, 533 TAF, 539 TAF, and 524 TAF respectively. A time series plot of Trinity inflow, release, and storage is shown in Figure 11, and an exceedance plot of the same data is shown in Figure 12. Instances of higher reservoir storage requirements to contain extreme inflow events are evident in the sharp spikes in the green lines in the time series plot. The overall frequency of storage requirement for flood control is about 11 percent. The 11,000 CFS flow threshold for preventing damages in the Trinity River never actually controls, as discharge capacity is always below that level for the storage levels attained in the operation.

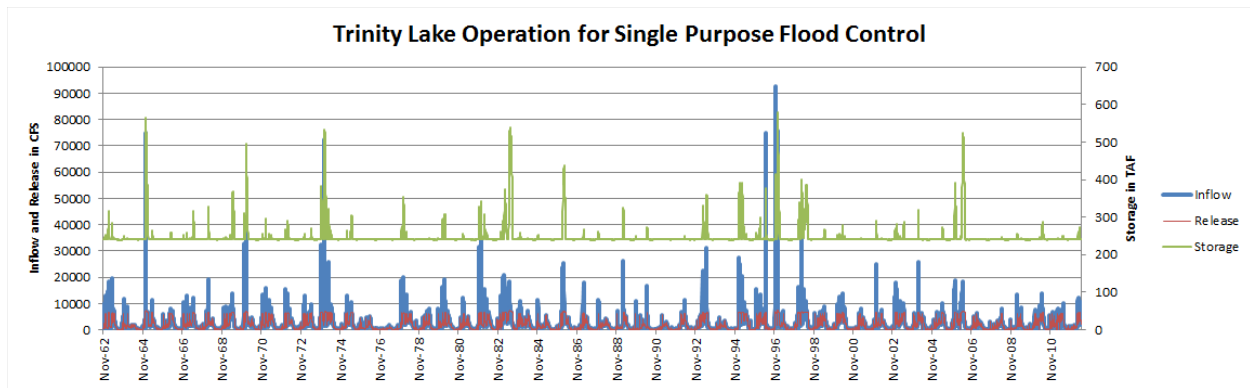


Figure 11. Time Series of Trinity Lake Operation for Flood Control

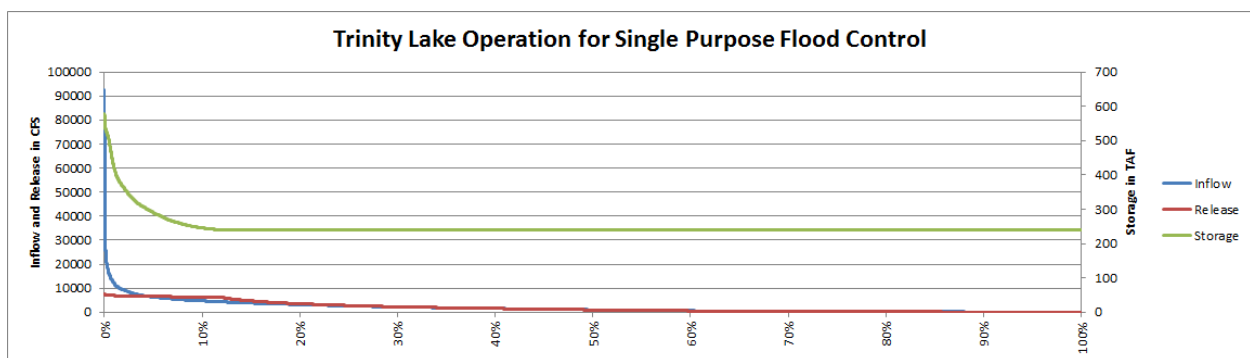


Figure 12. Exceedance of Trinity Lake Operation for Flood Control

Sizing Storage Facilities to Meet the Central Valley Improvement Act

The CAS considers the storage cost of producing CVPIA instream flow actions and of exports that are foregone due to CVPIA Delta actions. The continuous and evolving nature of CVPIA accounting methodologies makes it impossible to include a consistent long-term plan for CVPIA 3406(b)(2) – abbreviated as B2 – actions in the CalSim 2 model. Consequently, daily accounting records detailing historical storage releases and export reductions used for actions from 2008 to 2014 were analyzed.

The designated reservoir releases to meet instream flow actions were classified as:

- releases under balanced conditions able to be recaptured for other water supply purposes and not considered B2 use of storage
- releases under excess conditions that could not be recaptured were designated as
 - action to meet D-1641 standard that was counted as a B2 action
 - action to meet a Reasonable and Prudent Alternative (RPA) standard that was counted as a B2 action
 - action that was performed solely to meet the CVPIA purpose

The designated export reductions were classified as:

- reductions under excess conditions, indicating that storage was not affected by the reduction and therefore would not have been considered B2 use of storage
- reductions under balanced conditions, indicating that additional use of stored water would have been necessary to meet the foregone export, were designated as
 - export reduction to meet a D-1641 standard that was counted as a B2 action
 - export reduction to meet an RPA standard that was counted as a B2 action
 - export reduction performed solely to meet the CVPIA purpose

These elements for historical B2 actions are shown in Figure 13:

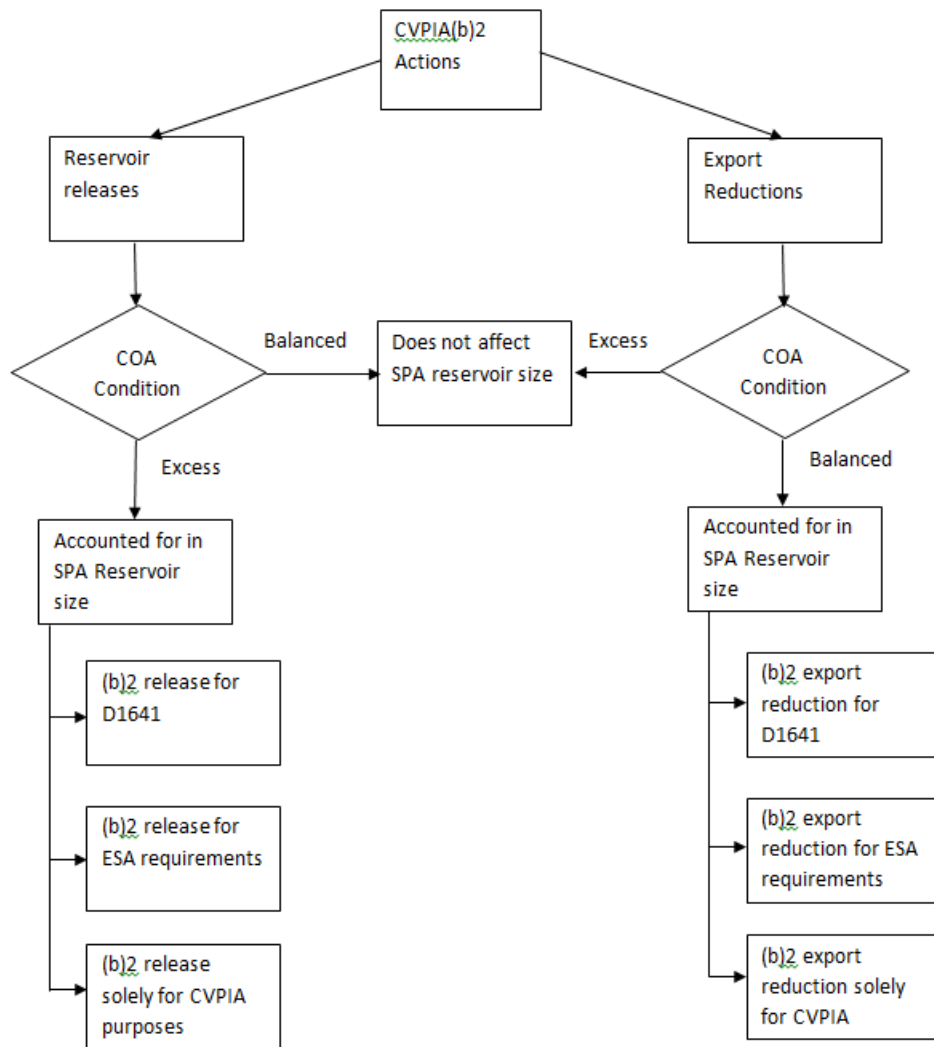


Figure 13. Diagram Describing the Classification of B2 Actions for CVPIA Cost Allocation

Reclamation records of annual B2 accounting specify how much B2 water is ultimately used by purpose, although water that is ultimately exported is not included in the accounting. Existing analysis identified the water storage requirements specifically for B2 to be 208 TAF, excluding B2 water that is ultimately exported as irrigation or M&I water. This figure can be broken into three pieces: B2 actions attributed to the water supply purpose (79 TAF), B2 for RPA mitigation (69 TAF), and B2 for water quality (60 TAF).

The required storage for B2 water supply actions was calculated as the 2008-2014 average annual total of the volume of releases designated to have been made for B2 actions during excess conditions and the average annual volume of exports reduced for B2 actions during balanced conditions. This average annual volume can be distributed among the storage facilities based on proportional B2 releases from each reservoir (instream release element) and distribution of north-of-Delta CVP reservoir sizes (export reduction element). Figure 14 depicts the impact on CVP storage of meeting CVPIA actions. It is recognized that the suite of actions over the years 2008-2014 reflect

different water year hydrology conditions, different environmental needs, and evolving perspectives on B2 action management by Reclamation and the Fish and Wildlife Service. Table 7 displays the estimated storage reserves used to meet B2 action management for Trinity, Shasta, Folsom, and New Melones storage facilities.

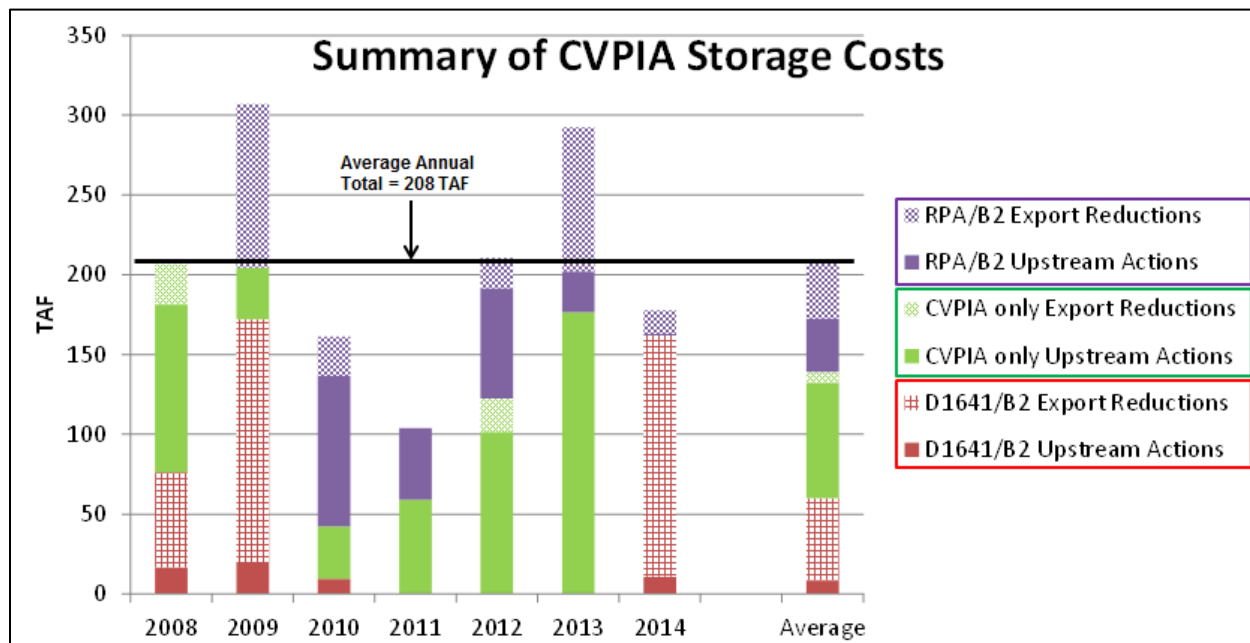


Figure 14. Components of the Storage Costs for Meeting CVPIA Responsibilities, 2008-2014

Table 7. Estimated Average Annual Storage Requirements Used to Meet B2 Water Supply Objectives (TAF)

B2 Objective	Trinity	Shasta	Folsom	New Melones	Total
B2 – Water Supply	24.1	43.7	9.6	1.6	79.0

Omitted-Purpose Analysis

The omitted-purpose analysis considered the size of the multi-purpose project with a single purpose hypothetically removed. The multi-purpose project without a given purpose (omitted-purpose project) would exclude the size (storage capacity) required to meet omitted-purpose benefit levels, while maintaining the storage capacity to provide the benefits for all other purposes. For all purposes, it was concluded that the multi-purpose without sizes were all full capacity. The quantitative background to support that conclusion is summarized below.

- Multi-purpose without water supply, multi-purpose without water quality, and multi-purpose without flood control can be identified as full capacity since these sizes are driven by the need for the reservoirs to operate through their full range of elevations in order to generate an equivalent amount of power as provided by the full multi-purpose project. In other words, the power purpose is what drives the multi-purpose-without sizes for water supply, water quality, and flood control.
- Multi-purpose without power is also full capacity, since CalSim 2 model results demonstrate at least one period where the reservoirs operate from full capacity to dead pool without re-filling in order to satisfy the water supply, flood control, and water quality purposes. Power is an ancillary benefit of reservoir releases in CalSim 2 – i.e., there is no logic to produce releases that target power production – it is a byproduct of releases to satisfy other operational criteria.
 - Figure 15 shows two multi-purpose without power sequences for Friant. The June 1922–August 1924 period shows the without-power use of full capacity driven by water supply. The June 1982–October 1983 period shows an extreme case of the without power use of full capacity driven by flood control.
 - Figure 16 shows the period of June 1983 through October 1991 for New Melones Reservoir, where the full capacity of the conservation pool is used to meet multiple purposes other than power.
 - Figure 17 and Tables 8 and 9 show the period from May 1975 through October 1977 for the north-of-Delta facilities Trinity, Shasta, and Folsom. Note that Trinity does not exactly meet the criteria, as its storage in this period has a max of 2431 (full capacity is 2447) and a min of 372 (dead pool is 240). However, considering the integrated nature of CVP reservoir operations, the divergence from absolute max and absolute min for total NOD storage is well within the sensitivity of the costing analysis which would inform this aspect of the SCRB analysis.

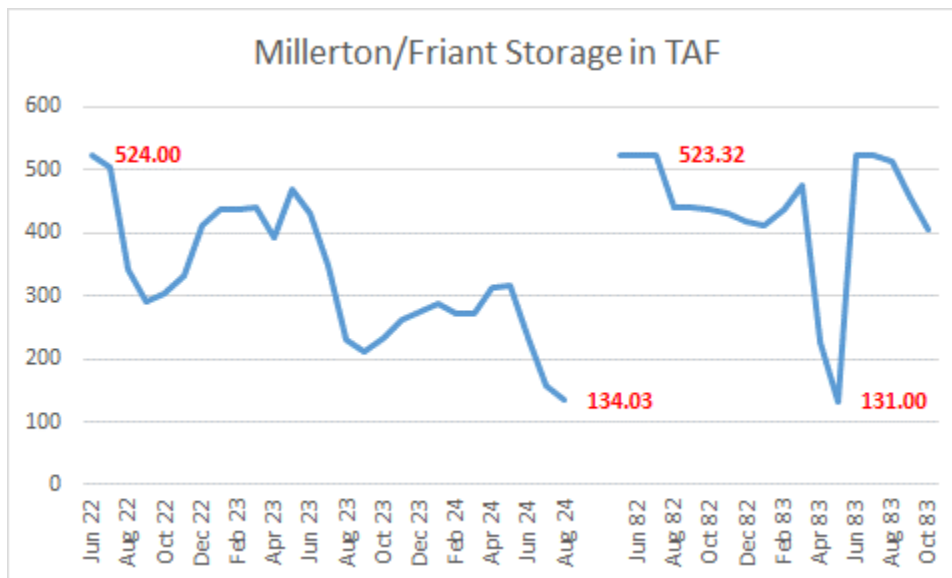


Figure 15. Two Examples of Multi-Purpose Without Power Use of Full Conservation Storage in Millerton

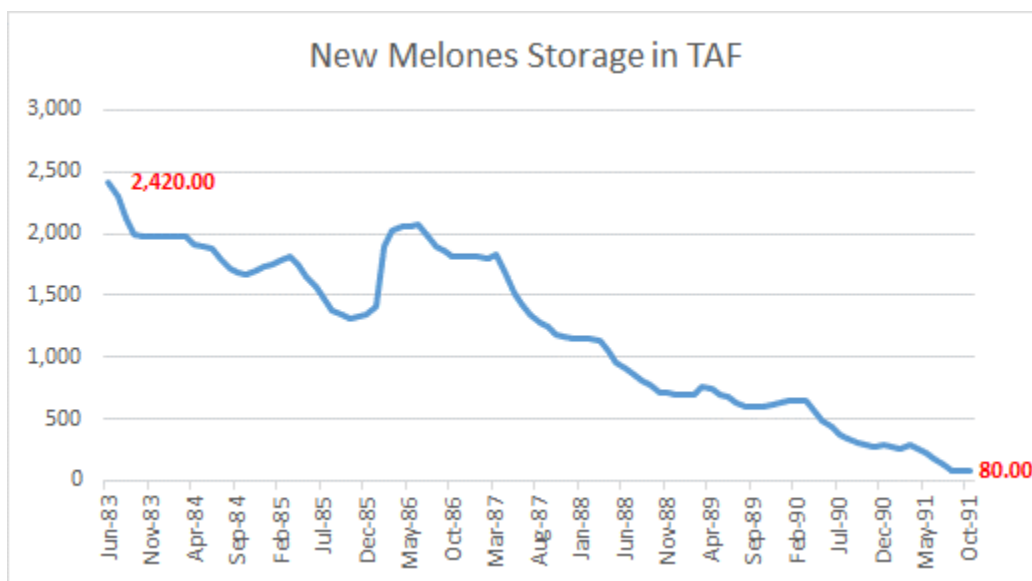


Figure 16. Example of Multi-Purpose Without Power Use of Full Conservation Storage in New Melones

Table 8. CVP NOD Max and Min Storage for the Period in Figure 17

Storage Facility	Max. Physical Capacity	Min. Physical Capacity	Max. Model Results	Min. Model Results
Trinity	2447	240	2431	372
Shasta	4552	550	4552	550
Folsom	967	90	967	90
Totals	7966	880	7950	1012
Difference (actual-ideal)			-16	132

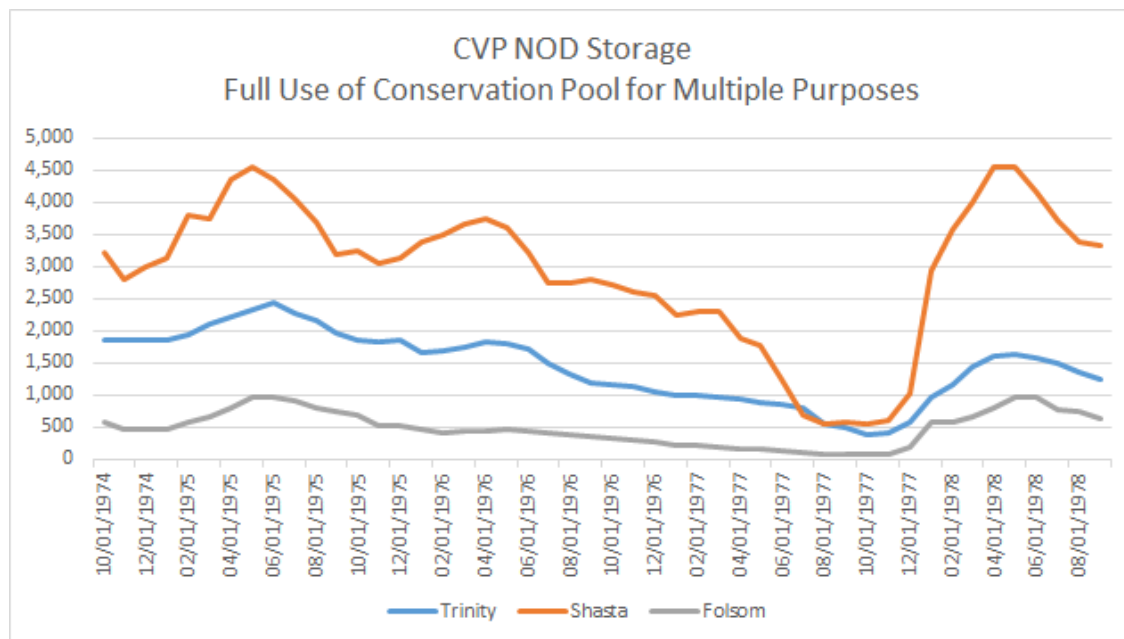


Figure 17. Example of Multi-Purpose Without Power Use of Full Conservation Storage by CVP NOD Facilities

Table 9. Full Data for the Figure 17 Plot

Date	Trinity	Shasta	Folsom
5/31/1975	2,321	4,552	967
6/30/1975	2,431	4,349	967
7/31/1975	2,270	4,042	919
8/31/1975	2,150	3,700	792
9/30/1975	1,969	3,189	733
10/31/1975	1,850	3,243	695
11/30/1975	1,841	3,039	529
12/31/1975	1,850	3,134	526
1/31/1976	1,663	3,369	461
2/29/1976	1,694	3,480	415
3/31/1976	1,742	3,668	428
4/30/1976	1,819	3,740	434
5/31/1976	1,793	3,601	456
6/30/1976	1,714	3,222	434
7/31/1976	1,495	2,757	408
8/31/1976	1,314	2,737	385
9/30/1976	1,178	2,811	357
10/31/1976	1,154	2,711	334
11/30/1976	1,132	2,608	308
12/31/1976	1,044	2,545	267
1/31/1977	1,000	2,254	230
2/28/1977	991	2,293	215
3/31/1977	977	2,286	197
4/30/1977	947	1,877	174

Date	Trinity	Shasta	Folsom
5/31/1977	894	1,770	167
6/30/1977	861	1,251	134
7/31/1977	790	702	95
8/31/1977	545	550	90
9/30/1977	491	570	90
10/31/1977	372	550	90

Single Purpose Facility Sizing Model

The single purpose facility Sizing Model is essentially CalSim 2 with no operations logic. It uses nearly the same schematic network as CalSim 2, removing only the details of canal operations below the south Delta pumping plants (Delta-Mendota Canal below Jones Pumping Plant and California Aqueduct below Banks Pumping Plant). Inputs to the Sizing Model include all of the hydrology – rim inflows, local inflows, and Depletion Service Area (DSA) accretion/depletion terms. Stream-groundwater interactions are dynamic, as are weir spills. Delta Cross Channel gates are closed if the flow at Hood exceeds 25,000 cfs, but otherwise there are no rules about closures.

All Sizing Model runs fix all SWP operations using pre-set time series. This includes Feather River operations such as Oroville and Thermolito release and evaporation, all deliveries, channel flows, and stream groundwater interaction. Inflows from the Yuba River and Bear River systems, SWP deliveries to the North Bay Aqueduct, and exports at Banks Pumping Plant are fixed. The outcome of this locked operation is a pre-determined set of flows entering the Sacramento River from the Feather River – flows which, depending on the time step, reflect some combination of controlled release for delivery or Delta outflow and uncontrolled flow which may be available for CVP purposes. Flows that were the result of a specific action to enable delivery are delivered at the North Bay Aqueduct or Banks. Flows that were the result of a specific action to meet a Delta standard under a Coordinated Operations Agreement (COA) sharing relationship are identified by the Flow Tracker and set as a requirement for Delta outflow so that CVP deliveries do not have access to this flow resource.

All Sizing Model runs fix all CVP deliveries and associated groundwater pumping and return flow. Non-project deliveries are also fixed.

The list below summarizes the preceding discussion of Sizing Model inputs and assumptions:

- CalSim 2 schematic network (minus Delta-Mendota Canal below Jones and California Aqueduct below Banks)
- CalSim 2 hydrology
 - rim inflows,
 - local inflows,
 - local accretions,
 - DSA accretions/depletions,
 - local loss assumptions
- Dynamic stream-groundwater interactions
- Weir spills determined by flow/spill relationships
- Delta Cross Channel Gates closed if flow at Hood exceeds 25,000 CFS
- Fixed SWP operations (Feather River, North Bay Aqueduct, Banks Pumping Plant)

- Fixed non-project deliveries (Delta consumptive use, all other non-project deliveries)
- Fixed CVP delivery operations
 - surface diversion
 - groundwater pumping
 - return flow

Sizing Model functionality is illustrated by the example in Figures 18, 19, and 20. A simple example system has one inflow, one reservoir, one delivery, and one flow requirement. For this simple example, the reservoir has no dead pool.

Figure 18 represents a normal operation, equivalent to a general CalSim 2 scenario run. Delivery is affected by an allocation strategy, outflow is a combination of a requirement and spill, and conservation storage is tapped to satisfy system requirements when inflow is not sufficient. The full range of storage capacity is exercised during the range of water supply conditions portrayed.

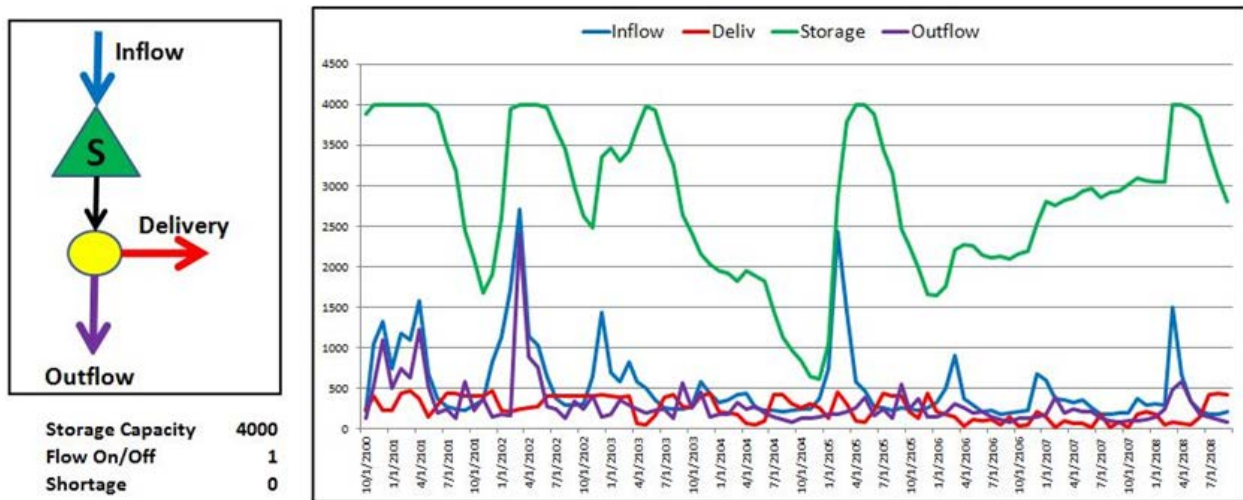


Figure 18. Normal Operation of the Simple Example System, Equivalent to a Normal CalSim 2 Run

Figure 19 represents the first step in the Sizing Model analysis. To find the single purpose facility size for the deliveries determined in Figure 18, all other project purposes are removed from required operations; in this case the required outflow is no longer imposed. As long as inflows can meet delivery, storage stays full, and inflow that is not needed for delivery and cannot be stored goes to outflow as spill. Once the inflow is not sufficient to meet delivery needs, releases are made from storage to satisfy the delivery. Under these conditions, outflow is zero because there is no requirement to meet a flow standard – it is a *single purpose water supply operation*. Figure 19 shows a modest need for reservoir storage to meet the deliveries; much of the storage capacity is not used, so clearly a smaller size reservoir would do.

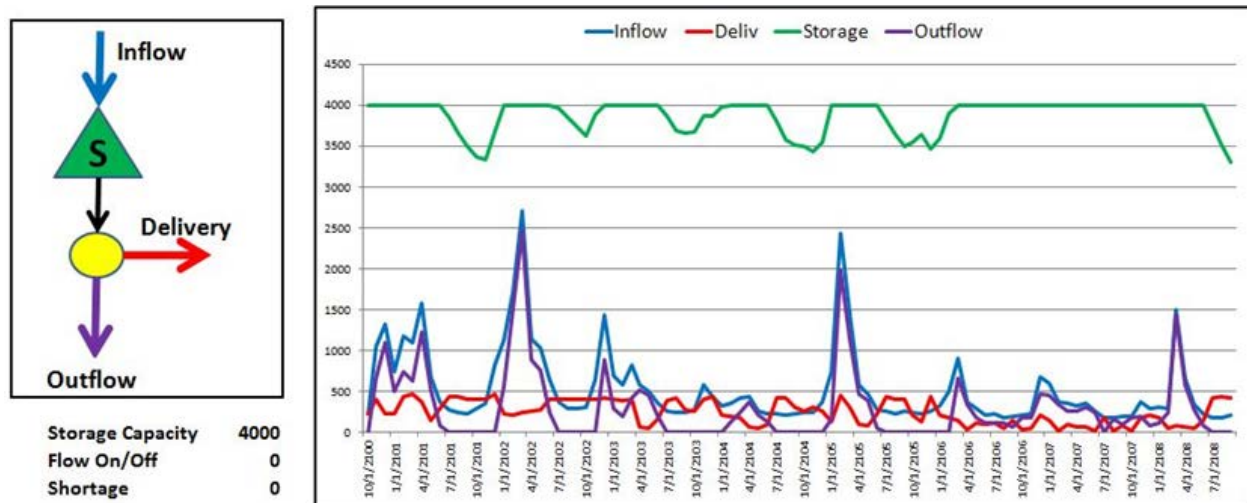


Figure 19. Removal of Operations Unrelated to Single Purpose in Question in Simple Example System

Figure 20 shows the final step of the Sizing Model analysis. The reservoir size has been dropped from 4000 to 697, which is just large enough to always be able to satisfy the delivery capabilities determined under the normal operation in Figure 18. During the period of record of this example study, there is one point, indicated by the black circle, when the reservoir storage is completely used up. This is what defines the single purpose alternative storage for this simple example system. In a real reservoir with non-zero dead pool, storage would be reduced so that the largest depletion reached the top of dead pool.

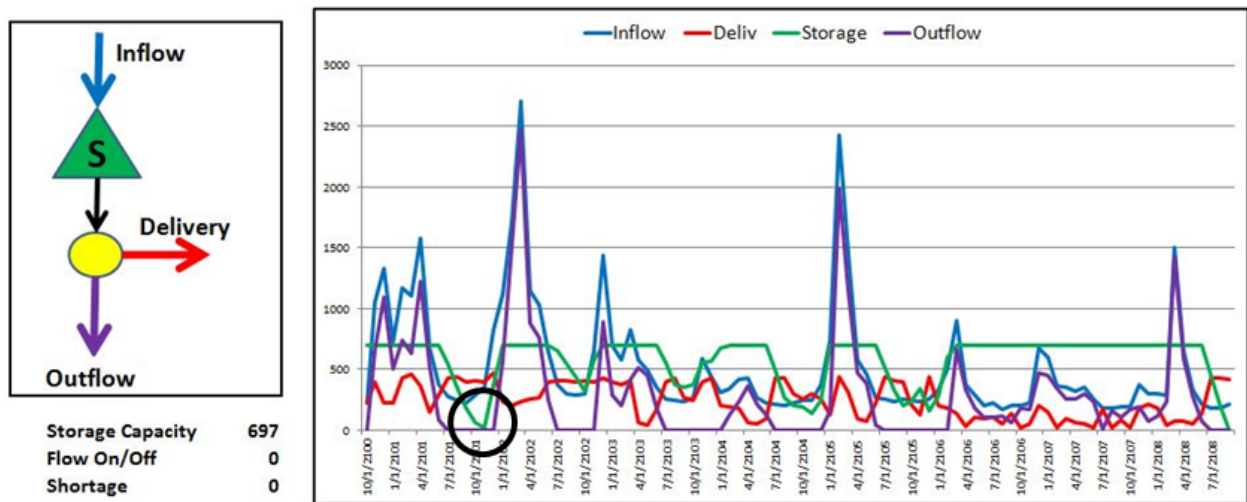


Figure 20. Sizing Model Applied to Simple Example System, Identifying Minimum Required Storage

Flow Tracker

The Flow Tracker was created to identify SWP releases of stored water from Oroville that were specifically to meet Delta requirements for water quality or outflow. As discussed previously, the Sizing Model was developed to fix SWP operations on the Feather River, deliveries to the North Bay Aqueduct, and Banks Pumping Plant exports. Any SWP release for its own water supply would be taken as SWP delivery, and other water from the Feather River would be available to the fixed CVP deliveries in the lower Sacramento River or at Jones Pumping Plant. But if an SWP storage release was made specifically to meet a Delta standard, the Sizing Model would need to know this so it could avoid making this water available to meet the CVP water supply purpose. Without considering this, the CVP water supply SPA would be underestimated.

Seven types of flows were identified and tracked:

- CVP release of water that passes through a reservoir without being stored
- CVP release of previously stored water
- SWP release of water that passes through a reservoir without being stored
- SWP release of previously stored water
- Non-Project flow – accretions or other local inflow that has not passed through a reservoir
- Groundwater – seepage to stream channels from groundwater
- Return flow – flow in any channel that is the result of return flow from delivery operations

The Flow Tracker, like the Sizing Model, uses the same network schematic as CalSim 2. It takes as input the merged inputs and outputs of a CalSim 2 run. The Flow Tracker determines what flow types are for each channel and delivery arc in the system by following just two principles: One, that every channel or diversion arc is the sum of its flow types, and two, that mass balance of each flow type at each node must be maintained. Storage nodes need specific logic, depending on their characteristics, to assign flow types to evaporation, delivery, and release.

The user determines the disposition of flow types throughout the system through weights assigned to each flow type for each diversion. This enables the tool to be used for a wide variety of purposes in CVP/SWP system analysis. For this application, the ultimate goal of the analysis was to determine the SWP release for Delta standards, but there were additional sensible considerations as well. Non-project deliveries and weir flows would be expected to be satisfied without stored water releases, for example. A matrix of flow types and delivery types was constructed, with each flow type having a progression of weights for the delivery types that it could serve.

Non-project inflow, groundwater, and return flow were given the highest weights so these types of flow would be used first. The idea was to use it as high up in the system as possible – even by project delivery – while at the same time reserving what was necessary to meet non-project demands system-wide. Pass-through inflow was encouraged to be used first by non-project uses and then by project deliveries, considering the source of the release. For example, CVP release of pass-through

inflow (CVPI) would have a higher weight for a CVP delivery than for SWP export. Diversions of stored water releases were weighted lower than all other flow types. Penalties were imposed for use of another project's stored water release. No weights were imposed on flow types for Delta outflow. The outcome of this weighting scheme was that the only time that stored water release would go to Delta outflow was if all other water types had been used already by deliveries and exports, and the release was actually necessary to meet a Delta requirement. This was the information needed for the Sizing Model.

RECLAMATION

Managing Water in the West

CVP Cost Allocation Study

November 19, 2013

Description of Analytical Tools

Name

CalSim2

Author/Developer

California Department of Water Resources and U.S. Bureau of Reclamation

Category

Reservoir-river simulation model, long term water supply reliability planning model

Main Features and Capabilities

- Monthly time step; 82-year period of record
- Spatial scale – CVP/SWP project extent. Extended Sacramento/San Joaquin river basins and associated imported water sources and export delivery areas.
- Simulation of CVP/SWP operations
 - using historical rainfall and runoff hydrology that has been adjusted to represent water supply and demands at a consistent level of development, and
 - depicting a consistent regulatory environment.
- Developed in WRIMS – a general-purpose river system modeling environment with a LP/MILP solution algorithm

Applications

CalSim2 is widely accepted as the planning model for depicting CVP/SWP system operations and has been used in numerous system-wide studies since it was first released in 2002, including multiple CALFED storage investigations, Operations Criteria and Plan (OCAP) 2004, OCAP 2008, DWR Delivery Reliability Reports, San Joaquin River Restoration, and the Bay Delta Conservation Plan (BDCP).

Calibration/Validation/Sensitivity Analysis

Because of the evolving nature of CVP/SWP facilities, demands, and governing regulations, true calibration/validation practices are not feasible with a model like CalSim2. DWR performed an historical simulation study (DWR, 2003) which demonstrated the model's ability to match historical operations when driven by time-evolving inputs reflecting historical demand levels and operating criteria.



Attachment 1 - CalSim 2 Model Description

Sensitivity/uncertainty analysis has been performed to determine sensitivity to a broad range of input data (DWR 2005).

Peer Review

Peer reviews of CalSim2 were conducted under the CALFED study program for the system-wide model (Close et al, 2003), and following an update to San Joaquin basin representation (Ford et al, 2006).

Anatomy of CalSim2

Conceptual Basis

CalSim2 depicts the water supply reliability of the CVP/SWP system, operating within the extended Sacramento and San Joaquin River Basins at a specific level of development and given fixed assumptions about project facilities and operations criteria.

Hydrology

The historical hydrology record has been affected by a particular sequence of natural characteristics (rainfall, temperature, runoff) and human impact (facility development, land use, population, regulations). Historical data is “unimpaired” by backing out the impacts of human activity to return to a data set that reflects a native condition, and then it is “re-impaired” by imposing a particular assumption about land use and urban demand. The resulting data set thus reflects the historical trace of precipitation and temperature, but local accretions/depletions, consumptive use demand, and urban demand reflect a consistent current or future level of irrigation and urban land use. The period of record used by the CalSim2 model is 1922-2003. The spatial resolution at which the hydrology balances and land-use analysis is performed is shown in Figure 1.

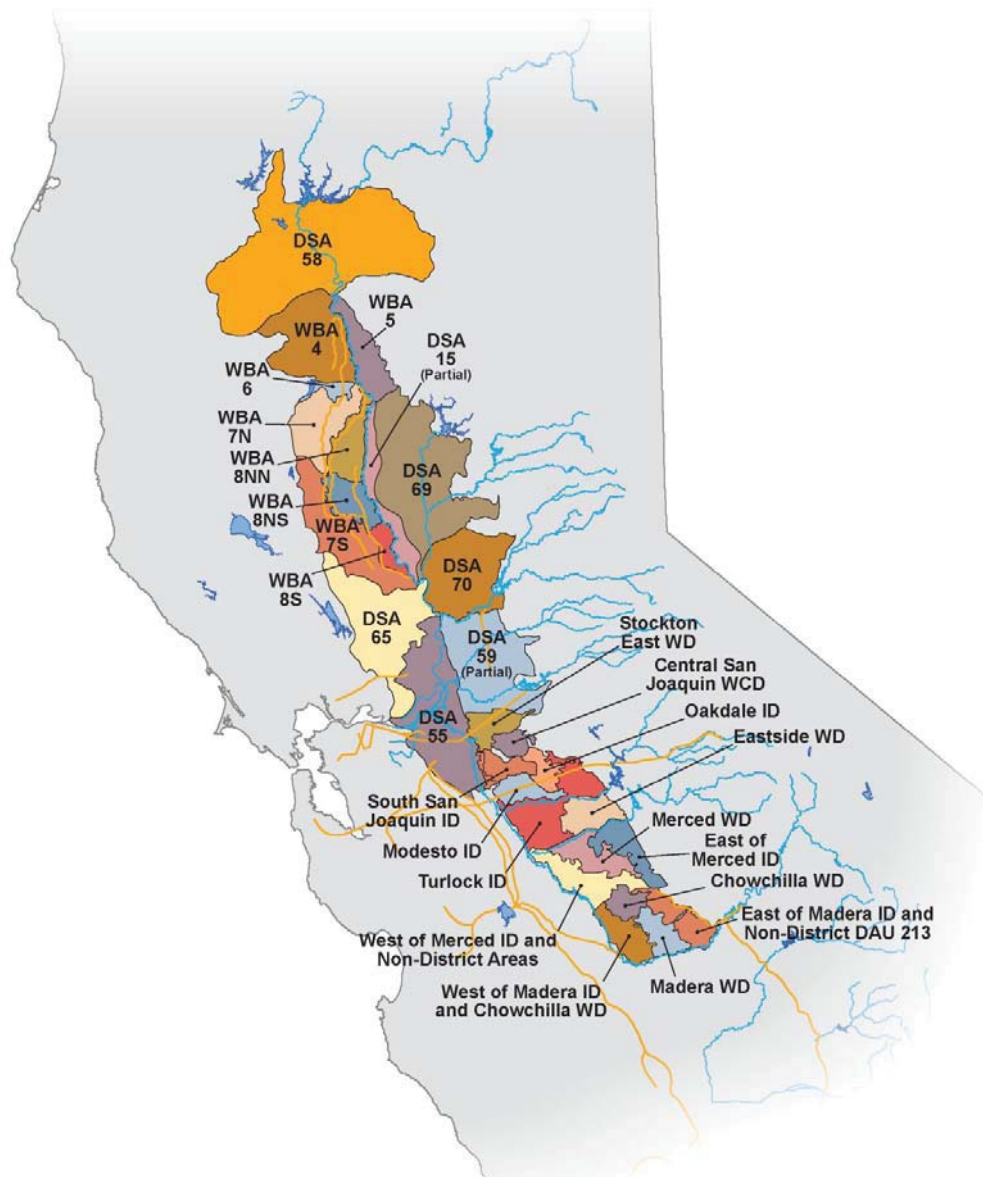


Figure 1 – Depletion Analysis Regions used by CalSim2 (Depletion Study Areas, Water Budget Areas)

Surface Water/Groundwater Interaction

Groundwater has a limited representation in CalSim2. Within the Sacramento Valley floor, groundwater is explicitly modeled using a multiple-cell approach based on depletion study area boundaries. There are a total of 12 groundwater cells. Stream-aquifer interaction, groundwater pumping, recharge from irrigation, and sub-surface flow between groundwater cells are calculated dynamically. All other groundwater flow components are preprocessed as part of the hydrology development and represented in CalSim2 as fixed time series'. In areas of high groundwater, CalSim2 calculates groundwater inflow to the stream as a function of the groundwater head and stream stage. In areas of low groundwater elevation

Attachment 1 - CalSim 2 Model Description

where the groundwater table lies below the streambed, CalSim2 assumes a hydraulic disconnect between the stream and aquifer. In this case seepage is only a function of stream stage.

Agriculture Demands

CalSim2 demands north of the Delta (NOD) are determined in the hydrology development process and depicted as lumped time series (monthly) values for the areas shown above. Land use-based demands are calculated using the Consumptive Use (CU) model, which simulates soil moisture conditions for 13 different crop types over the historical period. Irrigation demand is triggered when soil moisture falls below a specified minimum. The CU model calculates the crop consumptive use of applied water. The consumptive use is subsequently multiplied by water use efficiency factors to obtain the regional water requirement to be met from stream diversions or groundwater pumping. Agricultural demands in the Delta are represented more simply as an overall mass balance between precipitation and crop evapotranspiration.

Non-recoverable losses are assumed to be 10 to 15 percent of the crop consumptive use of applied water. Non-recoverable loss factors are used to determine the portion of the supply that will return to the system as surface return flow or as deep percolation to groundwater. Efficiency factors may vary by month and by year.

Agricultural demands south of the Delta (SOD) are depicted as project contract obligations. SOD CVP demands are assumed to be fixed at maximum contract amount and do not vary year to year. SWP agricultural demands on the west side of the San Joaquin Valley are capped to the full assigned amount, but are reduced in wetter years using an index developed from annual Kern River inflows to Lake Isabella.

M&I Demands

Indoor urban water use is considered non-consumptive and is not dynamically represented by the model. Outdoor urban water use is treated as an irrigation demand and is combined with the agricultural demands. M&I diversions, although not entirely consumptive, can have a large influence on reservoir operations. Surface water diversions serving both indoor and outdoor M&I uses for the American and Lower Sacramento River areas have therefore been included in CalSim2 because they partially determine the operation of Folsom Lake. Outdoor urban demand is calculated by the CU model, with the irrigated area computed as a fixed fraction of the total urban area as measured by DWR in land use surveys.

CVP and SWP SOD M&I demands are based on contract amounts. CVP demands are assumed to equal contract amounts and do not vary. SWP M&I demands south of the Delta are split into Metropolitan Water District of Southern California (MWDSC) and others. MWDSC demands are either set at full contract amounts or are determined through a process of iteration between CalSim2 and MWDSC's

integrated resource planning simulation (IRPSIM) model, and vary from year to year. Other SWP M&I contractors' demands are fixed at their full designated amount.

Project/Non-Project Split

Demands are disaggregated in CalSim2 into project demands and non-project demands. Project demands are subject to reduced water allocations based on CVP and SWP contract provisions, while non-project demands are satisfied from sources other than project storage and project conveyance facilities and are reduced as a function of water availability in the absence of project operations. For each Depletion Study Area (DSA), project demands are calculated as a fixed percentage of the total land use-based demand. The split between project and non-project demands is determined by comparing project acreage within each DSA to the total crop acreage within the DSA.

Total Demands/Contracts

Model diversions represent CVP project, SWP project, local project, or non-project operations which collectively meet the depletion area demands. Annual total CVP and SWP demands are summarized in Table 1 by category.

Table 1 – CVP and SWP Demands at a 2020 Level of Development

	2020 LOD	
	North of Delta	South of Delta
CVP		
• Settlement/Exchange	2194	840
• Agriculture	378	1937
• M&I	557	164
• Refuges	189	281
SWP		
• Feather River Service Area	796	0
• Agriculture	0	1032
• M&I	114	3024

CVP/SWP Project Allocation

CalSim2 assesses project water supplies based on storage conditions and forecasted inflow and determines project allocations based on rule curves that depict tradeoffs between current year delivery and carryover water supply. Estimates of export capacity through south delta pumps also affect allocation determination. SWP allocation is first determined in January, and updated every month based on evolving forecast data until May. CVP allocation is first determined in March and updated in April and May.

Storage Operations

- Flood Control: Flood control rules are imposed on all system reservoirs, maintaining required flood space in anticipation of spring runoff.
- CVP reservoir balancing: CalSim2 seeks to maintain a balance amongst storage levels in Trinity, Shasta, and Folsom, based on rules that consider the time of year, water supply conditions, and refill potential of each facility.
- San Luis Rule Curve: Target storage levels are set through the filling period (~ Oct-Mar) to guide the projects' releases from north of delta reservoirs for storage in San Luis Reservoir. The same philosophy is also used to dole out the use of storage reserves to each project through the water operations year, considering both seasonal demands and projected export capacities.

Delta Water Quality

The State Water Resources Control Board (SWRCB) specifies water quality standards for the Delta. Currently the CVP and SWP share the obligation to meet these standards as defined by the Coordinated Operation Agreement. Salinity standards must be translated into flow equivalents to be modeled in CalSim-II. However flow-salinity relationships in the Delta are non-linear. CalSim2 uses DWR's Artificial Neural Network (ANN) model to simulate the flow-salinity relationships for the Delta by estimating the salinity at water quality stations in the Delta. The ANN model correlates DWR's Delta Simulation Model (DSM2) model-generated salinity at key locations in the Delta with Delta inflows, Delta exports, and Delta Cross Channel operations by estimating electrical conductivity at the following four locations for the purpose of modeling Delta water quality standards: Old River at Rock Slough, San Joaquin River at Jersey Point, Sacramento River at Emmaton, and Sacramento River at Collinsville. In its estimates, the ANN model considers antecedent conditions up to 148 days, and considers a "carriage-water" type of effect associated with Delta exports. CalSim2 passes antecedent (previous month) flow conditions and known (or estimated) current month flows to an ANN dynamic link library (DLL). The DLL returns coefficients for a linear constraint that binds Sacramento River Delta inflows to Delta exports based on a piecewise linear approximation of the flow-salinity relationship

Coordinated Operations Agreement (COA)

The COA is both an operations agreement and a water rights settlement defined by the SWRCB Decision 1485. Decision 1485 ordered the CVP and SWP to guarantee certain conditions for water quality protection for agricultural, M&I, and fish and wildlife use. The purpose of the COA is to ensure that the CVP and the SWP each obtains its share of water from the Delta and bears its share of obligations to protect the other beneficial uses of water in the Delta and Sacramento Valley. The COA balance equations and COA sharing formulas are coded in the model as goals, used as constraints in the LP problem formulation. CalSim2 uses mixed integer programming to determine in which of the two

possible conditions the model is operating under for the given month – Balanced Water Conditions or Excess Water Conditions.

Other Operations Criteria

Multiple state water resources control board plans and decisions, environmental regulations, water rights, and legislative mandates collectively guide and constrain the operations of both the CVP/SWP.

- Joint Point of Diversion – SWP wheeling of 128 taf/yr for CVP Cross-Valley Canal users through Banks Pumping Plant is represented in all simulations as the first priority after SWP discretionary operations are satisfied. Further wheeling by SWP of CVP water when unused Banks capacity exists is possible under (1) surplus conditions when SWP has filled San Luis and satisfied its Article 21 demand, and (2) balanced conditions when SWP no longer wishes to move Oroville water to San Luis.
- D-1641 – significant elements include the 1995 WQCP standards, net Delta outflow requirements, the Vernalis Adaptive Management Plan, X2 standard, export/inflow (E/I) ratio, pulse period export limits, Delta cross-channel gate closure requirements, and Rio Vista and Vernalis flow standards.
- CVPIA 3406(b)(2) – the 800,000 acre-feet of Central Valley Project yield dedicated through the Central Valley Project Improvement Act for fish, wildlife, and habitat restoration purposes is managed to augment river flows and curtail Delta exports. Flows reflecting the dynamic (b)(2) operation depicted in the 2008 OCAP studies are incorporated into current versions of CalSim2 as flow requirements. Export curtailments are not represented specifically, as it is commonly understood that these criteria are covered by the more recent constraints of the Biological Opinions.
- Reasonable and prudent actions (RPA's) in the 2008 Fish and Wildlife Service (FWS) and 2009 National Marine Fisheries Service (NMFS) Biological Opinions – certain RPA's are implemented in CalSim2, as developed through a coordinated process between Federal and State agencies.

A comprehensive list of all criteria for the CalSim2 study used to define CVP deliveries for Cost Allocation Study reservoir sizing analysis is provided at the end of this Tech Memo.

Theoretical Basis

Flows, deliveries, and storage conditions in the reservoir river system are defined as decision variables and weighted to designate system priorities. Constraints on the values of these decision variables can be expressed as hard constraints that cannot be violated (such as canal capacity, maximum reservoir storage), or as soft constraints with penalties for deviating from user-specified target values. Soft constraints are converted to auxiliary slack and surplus variables with weights set by the associated penalties. Weighted decision variables and the slack and

Attachment 1 - CalSim 2 Model Description

surplus variables all become elements of the objective function. The dynamic evaluation of constraint coefficients at run time allows both hard and soft constraints to be conditionally determined based on the state of the system – they can vary with water supply, water year type, timestep, or any other user-defined category.

Multiple simulations can be layered within a single timestep to accommodate constraints that tier off of interim conditions. Previously determined values for decision variables, from previous cycles or timesteps, can be accessed for use in constructing current cycle or timestep constraints.

The use of a mixed-integer programming solver enables the use of binary integers to construct “either-or” type constraints, which are useful for such applications as weir operations or dynamic switch settings.

Numerical Basis

Solutions in CalSim2 are resolved by the XA solver, which is tasked with maximizing the value of the objective function constructed as the sum of each decision variable multiplied by its weight and each slack or surplus variable multiplied by its associated penalty. Solutions are also conditioned by the values of several integer variables depicting the status of weir flows and the COA balance. An Artificial Neural Network (ANN) depicts the relationships between flow and salinity at several locations in the interior Delta, based on and serving as a surrogate for the DSM2 model.

Input and Output

Inputs include rim inflows, local accretions/depletions, delivery requirements, consumptive use requirements, irrigation efficiencies, return flow functions, stream/groundwater interaction parameters, contract amounts, reservoir bathymetry, flood control rules, physical capacities, and environmental and legal criteria which control operations. Outputs include average monthly river channel flows and deliveries, including Delta outflows and exports, end-of-month storage conditions, and information on governing regulations.

Data Management

ASCII text “.wresl” files contain scripting language variable definitions and goals statements. ASCII text “.table” files contain relational (lookup) input data. HEC-DSS (USACE 1995) files hold input time series data and store time series results.

Software

CalSim2 is developed in WRIMS (Water Resources Integrated Modeling System) – a generalized reservoir-river basin simulation modeling environment that allows for specification of user-defined system variables and associated constraints or goals. Solutions are determined by the XA Linear Programming/Mixed Integer Linear Programming (LP/MILP) solver (Byer 2001) which is integrated with WRIMS as a dynamic linked library. WRIMS is produced and

Attachment 1 - CalSim 2 Model Description

maintained by the California Department of Water Resources. The software platform is free, and links to the latest available versions can be acquired by contacting wrims2.group.developers@gmail.com. A hardware license (~ \$1200) is required to use XA, and this solver is necessary to run CalSim2 models. Smaller models may be run using free public-domain LP solvers that are available with the WRIMS package. WRIMS runs under Microsoft Windows.

References

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CVP CAS CalSim2 Input and Assumptions Table

	Current Operations	H-1641	H-1485
Planning horizon ^a	2030	Same as Current Operations	Same as Current Operations
Period of simulation	82 years (1922-2003)	Same as Current Operations	Same as Current Operations
Hydrology			
Inflows/Supplies	Historical with modifications for operations upstream of rim reservoirs	Same as Current Operations	Same as Current Operations
Level of development	Projected 2020/2030 level ^b	Same as Current Operations	Same as Current Operations
Demands, Water Rights, CVP/SWP Contracts			
Sacramento River Region (excluding American River)			
CVP ^c	Land-use based, full build-out of contract amounts	Same as Current Operations	Same as Current Operations
SWP (FRSA) ^d	Land-use based, limited by contract amounts	Same as Current Operations	Same as Current Operations
Non-CVP/SWP	Land use based, limited by water rights and SWRCB Decisions	Same as Current Operations	Same as Current Operations
Antioch Water Works	Pre-1914 water right	Same as Current Operations	Same as Current Operations
Federal refuges ^e	Firm Level 2 water needs	Same as Current Operations	Same as Current Operations
Sacramento River Region - American River ^f			
Water rights	Year 2025, full water rights	Same as Current Operations	Same as Current Operations
CVP	Year 2025, full contracts, including Freeport Regional Water Project	Same as Current Operations	Same as Current Operations
San Joaquin River Region ^g			
Friant Unit	Limited by contract amounts, based on Friant-specific allocation policy	Same as Current Operations	Same as Current Operations

Attachment 2 – CalSim 2 Inputs, Assumptions, and Hydrology Data

	Current Operations	H-1641	H-1485
Lower Basin	Land-use based, based on district level operations and constraints	Same as Current Operations	Same as Current Operations
Stanislaus River	Land-use based for water rights, full contracts for CVP contractors ^h	Same as Current Operations	Same as Current Operations
San Francisco Bay, Central Coast, Tulare Lake and South Coast Regions (CVP/SWP project facilities)			
CVP ^c	Demand based on contract amounts	Same as Current Operations	Same as Current Operations
CCWD ⁱ	195 TAF/yr CVP contract supply and water rights	Same as Current Operations	Same as Current Operations
SWP ^{e,j}	Demand based on Table A amounts	Same as Current Operations	Same as Current Operations
Article 56	Based on 2001-08 contractor requests	Same as Current Operations	Same as Current Operations
Article 21	MWD demand up to 200 TAF/month from December to March subject to conveyance capacity, KCWA demand up to 180 TAF/month and other contractor demands up to 34 TAF/month in all months, subject to conveyance capacity	Same as Current Operations	Same as Current Operations
North Bay Aqueduct (NBA)	77 TAF/yr demand under SWP contracts, up to 43.7 cfs of excess flow under Fairfield, Vacaville and Benicia Settlement Agreement	Same as Current Operations	Same as Current Operations
Federal refuges ^e	Firm Level 2 water needs	Same as Current Operations	Same as Current Operations
Facilities			
North Coast Region			
Trinity Lake	2,447 TAF capacity	Same as Current Operations	Same as Current Operations
Sacramento River Region			
Shasta Lake	4,552 TAF capacity	Same as Current Operations	Same as Current Operations
Red Bluff Diversion Dam	Diversion dam operated with gates out all year, NMFS BiOp (Jun 2009) Action I.3.1 ^k ; assume permanent facilities in place	Diversion dam operated with gates out all year, per 2013 condition	Diversion dam operated with gates out all year, per 2013 condition

Attachment 2 – CalSim 2 Inputs, Assumptions, and Hydrology Data

	Current Operations	H-1641	H-1485
Upper American River ^f	PCWA American River Pump Station ^l	Same as Current Operations	Same as Current Operations
Lower Sacramento River	Freeport Regional Water Project	Same as Current Operations	Same as Current Operations
San Joaquin River Region			
Millerton Lake (Friant Dam)	524 TAF capacity	Same as Current Operations	Same as Current Operations
New Melones Reservoir	2,420 TAF capacity	Same as Current Operations	Same as Current Operations
Lower San Joaquin River	City of Stockton Delta Water Supply Project, 30-mgd capacity	Same as Current Operations	Same as Current Operations
Delta Region			
SWP Banks Pumping Plant (South Delta)	Physical capacity is 10,300 cfs but 6,680 cfs permitted capacity in all months up to 8,500 cfs during Dec 15 – Mar 15 depending on Vernalis flow conditions ^m ; additional capacity of 500 cfs (up to 7,180 cfs) allowed for Jul – Sep for reducing impact of NMFS BiOp (Jun 2009) Action IV.2.1 Phase II ^k on SWP ⁿ	Physical capacity is 10,300 cfs but permitted capacity 6,680 cfs in all months plus an additional 1/3 of Vernalis flow (up to 8,500 cfs) from Dec 15 through Mar 15 per SWRCB D-1641 ^m	Physical capacity is 10,300 cfs but permitted capacity 6,680 cfs in all months; limited to 3,000 cfs in May-June and 4,000 cfs in July per SWRCB D-1485.
CVP C.W. Bill Jones Pumping Plant (Tracy PP)	Permit capacity is 4,600 cfs in all months (allowed for by the Delta-Mendota Canal–California Aqueduct Intertie)	Same as Current Operations	Same as Current Operations
Upper Delta-Mendota Canal Capacity	Full capacity 4,600 cfs including 400 cfs Delta-Mendota Canal–California Aqueduct Intertie	Same as Current Operations	Same as Current Operations
CCWD Intakes	Los Vaqueros storage capacity, 160 TAF; Rock Slough, Old River and Middle River intakes (Alternative Intake Project or AIP)	Same as Current Operations	Same as Current Operations
Head of Old River Gate	Temporary Head of Old River Barrier installed in the fall months	Same as Current Operations	Same as Current Operations
Fremont Weir	Spills above 54,274 cfs Sacramento River flow at Verona; Assumes an operable notch ^o in the Fremont Weir, which allows spills above 15,530 cfs Sacramento River flow at Verona of up to 6,000 cfs during Dec 1 – Apr 30. 100 cfs spills during Sep 1 – Jun 30 to support fish passage.	No Weir Notch	No Weir Notch

Attachment 2 – CalSim 2 Inputs, Assumptions, and Hydrology Data

	Current Operations	H-1641	H-1485
San Francisco Bay Region			
South Bay Aqueduct (SBA)	SBA rehabilitation, 430 cfs capacity from junction with California Aqueduct to Alameda County FC&WSD Zone 7 diversion point	Same as Current Operations	Same as Current Operations
Regulatory Standards			
North Coast Region			
<u>Trinity River</u>			
Minimum flow below Lewiston Dam	Dec 2000 Trinity River Record of Decision (369-815 TAF/yr); August-September release of 50 TAF for Lower Klamath River Flows assumed in every year	Pre-ROD condition; Annual release volume of 340 TAF/yr.	Pre-ROD condition; Annual release volume of 340 TAF/yr.
Trinity Reservoir end-of-September minimum storage	Trinity EIS Preferred Alternative (600 TAF as able)	Same as Current Operations ^t	Same as Current Operations ^t
Sacramento River Region			
<u>Clear Creek</u>			
Minimum flow below Whiskeytown Dam	Downstream water rights, 1963 Reclamation Proposal to USFWS and NPS, predetermined CVPIA 3406(b)(2) flows ^p , and NMFS BiOp (Jun 2009) Action I.1.1 ^k	Downstream water rights, 1963 Reclamation Proposal to USFWS and NPS	Downstream water rights, 1963 Reclamation Proposal to USFWS and NPS
<u>Upper Sacramento River</u>			
Shasta Lake end-of-September minimum storage	NMFS 2004 Winter-run Biological Opinion, (1900 TAF in non-critically dry years), and NMFS BiOp (Jun 2009) Action I.2.1 ^k	None	None
Minimum flow below Keswick Dam	SWRCB WR 90-5, predetermined CVPIA 3406(b)(2) flows ^p , and NMFS BiOp (Jun 2009) Action I.2.2 ^k	3250 cfs	SWRCB WR 90-5
<u>Feather River</u>			
Minimum flow below Thermalito Diversion Dam	2006 Settlement Agreement (700 / 800 cfs)	1983 DWR, DFG Agreement (600 cfs)	1983 DWR, DFG Agreement (600 cfs)
Minimum flow below Thermalito Afterbay outlet	1983 DWR, DFG Agreement (750-1,700 cfs)	Same as Current Operations	Same as Current Operations

Attachment 2 – CalSim 2 Inputs, Assumptions, and Hydrology Data

	Current Operations	H-1641	H-1485
<u>Yuba River</u>			
Minimum flow below Daguerre Point Dam	D-1644 Operations (Lower Yuba River Accord) ⁿ	Same as Current Operations ^t	Same as Current Operations ^t
<u>American River</u>			
Minimum flow below Nimbus Dam	American River Flow Management Standard as required by NMFS BiOp (Jun 2009) Action II.1 ^k	SWRCB D-893	SWRCB D-893
Minimum Flow at H Street Bridge	SWRCB D-893	Same as Current Operations	Same as Current Operations
<u>Lower Sacramento River</u>			
Minimum flow near Rio Vista	SWRCB D-1641	SWRCB D-1641	SWRCB D-1485
San Joaquin River Region			
<u>Mokelumne River</u>			
Minimum flow below Camanche Dam	FERC 2916-029, 1996 (Joint Settlement Agreement) (100-325 cfs)	Same as Current Operations	Same as Current Operations
Minimum flow below Woodbridge Diversion Dam	FERC 2916-029, 1996 (Joint Settlement Agreement) (25-300 cfs)	Same as Current Operations	Same as Current Operations
<u>Stanislaus River</u>			
Minimum flow below Goodwin Dam	Flows required for NMFS BiOp (Jun 2009) Action III.1.3 ^k	1987 USBR, DFG Agreement	1987 USBR, DFG Agreement
Minimum dissolved oxygen	SWRCB D-1422	Same as Current Operations	Same as Current Operations
<u>Merced River</u>			
Minimum flow below Crocker-Huffman Diversion Dam	Davis-Grunsky (180-220 cfs, Nov-Mar), and Cowell Agreement	Same as Current Operations	Same as Current Operations
Minimum flow at Shaffer Bridge	FERC 2179 (25-100 cfs)	Same as Current Operations	Same as Current Operations
<u>Tuolumne River</u>			
Minimum flow at Lagrange Bridge	FERC 2299-024, 1995 (Settlement Agreement) (94-301 TAF/yr)	Same as Current Operations	Same as Current Operations

Attachment 2 – CalSim 2 Inputs, Assumptions, and Hydrology Data

	Current Operations	H-1641	H-1485
<u>San Joaquin River</u>			
San Joaquin River below Friant Dam/ Mendota Pool	San Joaquin River Restoration Program releases from Friant are represented, as they affect delivery capability. Noted that the program recapture/recirculation component is yet to be defined, so releases proceed down the San Joaquin River.	Release of 117 TAF/yr for losses and water rights	Release of 117 TAF/yr for losses and water rights
Maximum salinity near Vernalis	SWRCB D-1641	Same as Current Operations	SWRCB D-1422
Minimum flow near Vernalis	SWRCB D-1641 ^q	SWRCB D-1641	None
Sacramento River – San Joaquin Delta Region			
Delta Outflow Index (Flow and Salinity)	SWRCB D-1641 and USFWS BiOp (Dec 2008) Action 4 (Fall X2 Requirement)	SWRCB D-1641	SWRCB D-1485
Delta Cross Channel gate operation	SWRCB D-1641 with additional days closed from Oct 1 – Jan 31 based on NMFS BiOp (Jun 2009) Action IV.1.2 ^k (closed during flushing flows from Oct 1 – Dec 14 unless adverse water quality conditions)	SWRCB D-1641	SWRCB D-1485
South Delta exports (Jones PP and Banks PP)	SWRCB D-1641. Vernalis flow-based export limits Apr 1 – May 31 as required by NMFS BiOp (Jun, 2009) Action IV.2.1 ^k (additional 500 cfs allowed for Jul – Sep for reducing impact on SWP) ⁿ	SWRCB D-1641	SWRCB D-1485
Combined Flow in Old and Middle River (OMR)	FWS BiOp (Dec 2008) Actions 1 through 3 and NMFS BiOp (Jun 2009) Action IV.2.3 ^k	None	None
Operations Criteria: River-Specific			
Sacramento River Region			
<u>Upper Sacramento River</u>			
Flow objective for navigation (Wilkins Slough)	NMFS BiOp (Jun 2009) Action I.4 ^k ; 3,500 – 5,000 cfs based on CVP water supply condition	3,500 – 5,000 cfs based on CVP water supply condition	3,500 – 5,000 cfs based on CVP water supply condition
<u>American River</u>			

Attachment 2 – CalSim 2 Inputs, Assumptions, and Hydrology Data

	Current Operations	H-1641	H-1485
Folsom Dam flood control	Variable 400/600 flood control diagram (without outlet modifications) as a surrogate for upcoming water control manual update	Same as Current Operations	Same as Current Operations
<u>Feather River</u>			
Flow at Mouth of Feather River (above Verona)	Maintain CDFW/DWR flow target of 2,800 cfs for Apr – Sep dependent on Oroville inflow and FRSA allocation	Same as Current Operations	Same as Current Operations
Operations Criteria: Systemwide			
CVP water allocation			
Settlement / Exchange	100% (75% in Shasta critical years); Exchange Contractors CVP allocation reduced in a post-processed analysis to maintain Shasta storage above 1.1 MAF, with water supply replaced up to CVP allocation by Friant resources, as available.	Fixed Allocations to Current Operations for unique purposes of this study	Fixed Allocations to Current Operations for unique purposes of this study
Refuges	100% (75% in Shasta critical years)	Fixed Allocations to Current Operations for unique purposes of this study	Fixed Allocations to Current Operations for unique purposes of this study
Agriculture Service	100%-0% based on supply; South-of-Delta allocations are additionally limited due to D-1641,USFWS BiOp (Dec 2008) and NMFS BiOp (Jun 2009) export restrictions ^k	Fixed Allocations to Current Operations for unique purposes of this study	Fixed Allocations to Current Operations for unique purposes of this study
Municipal & Industrial Service	100%-50% based on supply; South-of-Delta allocations are additionally limited due to D-1641,USFWS BiOp (Dec 2008) and NMFS BiOp (Jun 2009) export restrictions ^k	Fixed Allocations to Current Operations for unique purposes of this study	Fixed Allocations to Current Operations for unique purposes of this study
SWP water allocation			
North of Delta (FRSA)	Contract specific	Fixed Allocations to Current Operations for unique purposes of this study	Fixed Allocations to Current Operations for unique purposes of this study
South of Delta (including North Bay Aqueduct)	Based on supply; equal prioritization between Ag and M&I based on Monterey Agreement; allocations are additionally limited due to D-1641 and USFWS BiOp (Dec 2008) and NMFS BiOp (Jun 2009) export restrictions ^k	Fixed Allocations to Current Operations for unique purposes of this study	Fixed Allocations to Current Operations for unique purposes of this study

Attachment 2 – CalSim 2 Inputs, Assumptions, and Hydrology Data

	Current Operations	H-1641	H-1485
CVP/SWP coordinated operations			
Sharing of responsibility for in-basin-use	1986 Coordinated Operations Agreement (FRWP EBMUD and 2/3 of the North Bay Aqueduct diversions considered as Delta Export; 1/3 of the North Bay Aqueduct diversion as in-basin-use)	Same as Current Operations	Same as Current Operations
Sharing of surplus flows	1986 Coordinated Operations Agreement	Same as Current Operations	Same as Current Operations
Sharing of total allowable export capacity for project-specific priority pumping	Equal sharing of export capacity under SWRCB D-1641,USFWS BiOp (Dec 2008) and NMFS BiOp (Jun 2009) export restrictions ^k	Equal sharing of export capacity under SWRCB D-1641 export limits	None Assumed
Water transfers	Acquisitions by SWP contractors are wheeled at priority in Banks Pumping Plant over non-SWP users; LYRA included for SWP contractors ⁿ	None Assumed	None Assumed
Sharing of total allowable export capacity for lesser priority and wheeling-related pumping	Cross Valley Canal wheeling (max of 128 TAF/yr), CALFED ROD defined Joint Point of Diversion (JPOD)	Same as Current Operations	Banks “payback” wheeling for CVP capacity reduced by D-1485 striped bass export limits
San Luis Reservoir	San Luis Reservoir is allowed to operate to a minimum storage of 100 TAF	Same as Current Operations	Same as Current Operations
CVPIA 3406(b)(2)^p			
Policy Decision	Per May 2003 Dept. of Interior Decision:	No representation	No representation
Allocation	800 TAF, 700 TAF in 40-30-30 dry years, and 600 TAF in 40-30-30 critical years as a function of Ag allocation	No representation	No representation
Actions	Pre-determined upstream fish flow objectives below Whiskeytown and Keswick Dams, non-discretionary NMFS BiOp (Jun 2009) actions for the American and Stanislaus Rivers, and NMFS BiOp (Jun 2009) and USFWS BiOp (Dec 2008) actions leading to export restrictions ^k	No representation	No representation
Accounting	Releases for non-discretionary USFWS BiOp (Dec 2008) and NMFS BiOp (Jun 2009) ^k actions may or may not always be	No representation	No representation

Attachment 2 – CalSim 2 Inputs, Assumptions, and Hydrology Data

	Current Operations	H-1641	H-1485
	deemed (b)(2) actions; in general, it is anticipated, that accounting of these actions using (b)(2) metrics, the sum would exceed the (b)(2) allocation in many years; therefore no additional actions are considered and no accounting logic is included in the model ^p		
Water Management Actions			
Water Transfer Supplies (long term programs)			
Lower Yuba River Accord ^f	Yuba River acquisitions for reducing impact of NMFS BiOp export restrictions ^k on SWP	No representation	No representation
Phase 8	None	None	None

^a These assumptions were developed by the Department of the Interior, Bureau of Reclamation for the November 2015 Coordinated Long-Term Operation of the Central Valley Project and State Water Project Final Environmental Impact Statement. Restoration of at least 8,000 acres of intertidal and associated subtidal habitat in the Delta and Suisun Marsh required by the 2008 USFWS BiOp and restoration of at least 17,000 to 20,000 acres of floodplain rearing habitat for juvenile winter-run and spring-run Chinook salmon and Central Valley steelhead in the Yolo Bypass and/or suitable areas of the lower Sacramento River required by the NMFS 2009 BiOp are not included in the assumptions because environmental documents of projects regarding these actions were not completed. Fremont Weir notch was assumed as a placeholder for Action I.6.1.

^b The San Joaquin Valley hydrology reflects draft 2030 land-use assumptions developed by Reclamation. The Sacramento Valley hydrology reflects 2020 land-use assumptions associated with Bulletin 160-98.

^c CVP contract amounts have been updated according to amended contracts as appropriate. Assumptions regarding CVP agricultural and M&I service contracts, exchange contract amounts, Refuge Level 2 contract amounts and Settlement Contract amounts are documented in the Delivery Specifications section, Appendix 5A of the November 2015 Coordinated Long-Term Operation of the Central Valley Project and State Water Project Final EIS (LTO-App5A).

^d SWP contract amounts have been updated as appropriate based on recent Table A transfers/agreements. Assumptions regarding SWP agricultural and M&I contract amounts are documented in the Delivery Specifications attachments of the LTO-App5A.

^e Water needs for federal refuges have been reviewed and updated as appropriate. Assumptions regarding firm Level 2 refuge water needs are documented in the Delivery Specifications attachments of the LTO-App5A. Refuge Level 4 (and incremental Level 4) water is not analyzed.

^f Assumptions regarding American River water rights and CVP contracts are documented in the Delivery Specifications attachments of the LTO-App5A. The Sacramento Area Water Forum agreement, and any diversion reductions, are not included except for federal actions.

^g The CalSim II representation of the San Joaquin River model reflects the difficulties of on-going groundwater overdraft problems. The 2030 level of development representation of the San Joaquin River Basin does not make any attempt to offer solutions to groundwater overdraft problems. In addition a dynamic groundwater simulation is not yet developed for the San Joaquin River Valley. Groundwater extraction/ recharge and stream-groundwater interaction are static assumptions and may not accurately reflect a response to simulated actions. These limitations should be considered in the analysis of results.

^h The model operates the Stanislaus River by allocating water for SEWD & CSJWCD, Vernalis water quality dilution and Vernalis D1641 base flow requirements based on the New Melones Index. OID & SSJID deliveries are based on their 1988 agreement and Ripon DO requirements are represented by a static set of minimum instream flow requirements during Jun thru Sep. Instream flow requirements for fish below Goodwin are based on NMFS BiOp Action III.1.3.

ⁱ The actual amount diverted is operated in conjunction with supplies from the Los Vaqueros project. The Los Vaqueros storage capacity is 160 TAF and associated water rights for Delta excess flows are included.

^j It is assumed that SWP Contractors exercise full demand for Table A allocations of 4.1 MAF/year and that SWP Contractors can take delivery of all Table A allocations and Article 21 supplies. Article 56 provisions are assumed and allow for SWP Contractors to manage storage and delivery conditions such that full Table A allocations can be delivered. Article 21 deliveries are limited in wet years under the assumption that demand is decreased in these conditions. Article 21 deliveries for the NBA are dependent on excess conditions only, all other Article 21 deliveries also require that San Luis Reservoir be at capacity and that Banks PP and the California Aqueduct have available capacity to divert from the Delta for direct delivery.

^k Assumptions developed in cooperation among Reclamation, National Marine Fisheries Service, Fish and Wildlife Service, and CA Department of Fish and Wildlife for implementation of the USFWS BiOp (Dec 15th 2008) and NMFS BiOp (June 4th 2009).

^l The American River pumping facility upstream of Folsom Lake is included. The diversion is assumed to be 35.5 TAF/yr.

^m USACE permit for Clifton Court Forebay Intakes (assumed for Banks PP in CalSim II) allows for an average diversion rate of 6,680 cfs in all months. Diversion rate can increase up to 1/3 of the rate of San Joaquin River flow at Vernalis during Dec 15th – Mar 15th up to a maximum diversion of 8,500 cfs, if Vernalis flow exceeds 1,000 cfs.

ⁿ Acquisitions of Component 1 water under the Lower Yuba River Accord, and use of 500 cfs dedicated capacity at Banks PP during Jul – Sep, are assumed to be used to reduce as much of the impact of the Apr – May Delta export actions on SWP contractors as possible.

Attachment 2 – CalSim 2 Inputs, Assumptions, and Hydrology Data

- ^o Fremont Weir notch assumed to represent the NMFS BO (Jun, 2009) Action I.6.1: Restoration of Floodplain Rearing Habitat action, and is only for use in the modeling as a placeholder, while the proposed changes associated with this RPA are still in development under a separate multi-agency process.
- ^p CVPIA (b)(2) fish actions are not dynamically determined in the CalSim2 model, nor is (b)(2) accounting done in the model. Since the USFWS BiOp and NMFS BiOp were issued, the Department of the Interior (Interior) has exercised its discretion to use (b)(2) in the delta by accounting some or all of the export reductions required under those biological opinions as (b)(2) actions. It is therefore assumed for modeling purposes that (b)(2) availability for other delta actions will be limited to covering the CVP's VAMP export reductions. Similarly, since the USFWS BiOp and NMFS BiOp were issued, Interior has exercised its discretion to use (b)(2) upstream by accounting some or all of the release augmentations (relative to the hypothetical (b)(2) base case) below Whiskeytown, Nimbus and Goodwin as (b)(2) actions. It is therefore assumed for modeling purposes that (b)(2) availability for other upstream actions will be limited to covering Sacramento releases, in the fall and winter. For modeling purposes, pre-determined timeseries of minimum instream flow requirements are specified below Whiskeytown and Keswick. The timeseries are based on the Aug 2008 BA Study 7.0 and Study 8.0 simulations which did include dynamically determined (b)(2) actions.
- ^q Vernalis base flows as required by D1641 Table 3 are included in the model. Vernalis pulse flow requirements are not included. However, pulse flows required by NMFS BO (Jun, 2009) Action III.1.3 are included in the model.
- ^r The Yuba River is not dynamically modeled in CalSim2. Yuba River hydrology and availability of water acquisitions under the Lower Yuba River Accord and D-1644 are based on modeling performed and provided by the Lower Yuba River Accord EIS/EIR study team.
- ^s Only acquisitions of Lower Yuba River Accord Component 1 water are included.
- ^t Where the purpose of identifying operational differences incurred by the Water Quality Control Plan were not influenced by CalSim2 assumptions, specific inputs for D-1641 or D-1485 era conditions were not developed.

Attachment 2 – CalSim 2 Inputs, Assumptions, and Hydrology Data

Table 1. Trinity												
TAF												
	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1922	1781	1754	1755	1751	1766	1815	1918	1997	2043	1931	1782	1609
1923	1554	1526	1529	1546	1569	1621	1740	1698	1630	1491	1299	1161
1924	1144	1136	1127	1016	1076	1068	1012	931	878	800	698	630
1925	623	699	746	649	920	1058	1358	1343	1262	1113	1034	974
1926	956	954	975	979	1126	1229	1450	1344	1274	1139	1045	963
1927	927	1085	1284	1393	1631	1809	2036	2025	2051	1929	1789	1622
1928	1531	1560	1568	1617	1726	1933	2089	2027	1935	1830	1652	1481
1929	1419	1347	1339	1147	1174	1225	1241	1284	1215	1041	940	858
1930	833	819	950	969	1071	1200	1316	1219	1177	1116	960	873
1931	848	837	827	839	861	922	945	905	886	815	624	557
1932	508	468	471	418	440	593	682	706	708	632	535	470
1933	451	449	446	444	446	563	712	700	818	773	677	614
1934	596	587	597	658	748	893	977	948	917	845	600	534
1935	451	516	553	529	613	674	888	922	933	871	773	694
1936	680	674	677	790	928	1044	1217	1147	1108	1033	944	866
1937	840	826	814	802	804	905	1128	1273	1340	1236	1079	1008
1938	991	1139	1358	1450	1607	1868	2175	2349	2294	2265	2123	1905
1939	1811	1796	1813	1824	1838	1946	2021	1911	1714	1483	1239	1081
1940	1002	930	996	1174	1500	1802	2029	1966	1850	1670	1495	1360
1941	1304	1284	1408	1629	1880	2100	2300	2420	2447	2270	2150	1975
1942	1850	1837	1850	1900	2000	2079	2266	2325	2397	2270	2150	1975
1943	1850	1845	1850	1900	2000	2100	2283	2173	2100	1956	1811	1640
1944	1552	1522	1510	1464	1498	1557	1596	1652	1564	1349	1160	1080
1945	1055	1085	1162	1220	1383	1431	1569	1534	1442	1299	1141	1069
1946	1064	1119	1311	1441	1496	1618	1837	1832	1738	1607	1436	1298
1947	1238	1231	1243	1235	1301	1420	1508	1416	1402	1277	1088	1009
1948	1029	1043	1043	1238	1263	1288	1473	1467	1547	1512	1375	1329
1949	1275	1282	1284	1277	1309	1526	1786	1787	1737	1592	1419	1280
1950	1218	1185	1172	1203	1262	1383	1537	1541	1523	1401	1241	1103
1951	1204	1320	1577	1667	1885	1986	2172	2104	2020	1890	1715	1545
1952	1492	1497	1644	1704	1894	2060	2300	2411	2447	2270	2150	1975
1953	1850	1845	1850	1900	2000	2100	2262	2222	2315	2270	2150	1960
1954	1850	1850	1850	1900	2000	2100	2300	2272	2204	2067	1931	1769
1955	1712	1733	1774	1792	1821	1851	1897	1896	1881	1661	1485	1346
1956	1283	1267	1575	1900	2000	2100	2283	2386	2304	2187	2077	1924
1957	1850	1826	1818	1808	1956	2100	2218	2234	2211	2067	1923	1759
1958	1847	1850	1850	1900	2208	2100	2300	2420	2430	2270	2150	1975
1959	1850	1850	1835	1900	2000	2100	2272	2171	2053	1825	1613	1418
1960	1357	1318	1296	1295	1428	1616	1738	1683	1690	1517	1359	1220
1961	1159	1170	1232	1276	1468	1565	1756	1784	1819	1673	1500	1363
1962	1303	1278	1285	1302	1400	1459	1785	1751	1685	1537	1384	1247
1963	1349	1397	1563	1604	1884	1959	2216	2240	2181	2036	1890	1721
1964	1627	1697	1732	1800	1805	1835	1858	1750	1691	1558	1358	1226
1965	1172	1205	1724	1900	1988	2054	2278	2185	2114	1977	1846	1713
1966	1653	1707	1729	1800	1860	2058	2300	2301	2226	2090	1859	1697
1967	1608	1685	1819	1900	2000	2100	2205	2310	2401	2270	2150	1975
1968	1850	1850	1850	1900	2000	2100	2191	2077	1971	1791	1618	1452
1969	1396	1389	1445	1582	1699	1854	2176	2414	2334	2210	2066	1927
1970	1850	1850	1850	1900	2000	2100	2161	2061	1917	1742	1566	1398
1971	1321	1415	1540	1763	1893	2081	2238	2272	2281	2257	2116	1975
1972	1850	1850	1850	1900	2000	2100	2234	2163	2113	1964	1790	1622
1973	1568	1604	1708	1861	2000	2100	2269	2318	2265	2125	1902	1734
1974	1705	1850	1850	1900	2000	2100	2300	2384	2367	2270	2150	1975
1975	1850	1843	1847	1859	1948	2100	2225	2321	2431	2270	2150	1969
1976	1850	1841	1850	1663	1694	1742	1819	1793	1714	1495	1314	1178
1977	1154	1132	1044	1000	991	977	947	894	861	790	545	491
1978	372	400	590	976	1154	1427	1618	1622	1567	1480	1345	1235
1979	1174	1168	1160	1185	1236	1382	1493	1560	1526	1402	1243	1105
1980	1109	1171	1238	1457	1745	1877	2037	1942	1844	1721	1546	1408

Table 1. Trinity												
TAF												
	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1981	1346	1321	1350	1447	1585	1703	1811	1744	1688	1541	1346	1208
1982	1146	1389	1713	1801	2000	2100	2300	2318	2187	2071	2012	1962
1983	1850	1850	1850	1900	2000	2100	2300	2420	2447	2270	2150	1975
1984	1850	1850	1850	1900	1991	2100	2218	2183	2124	1989	1797	1658
1985	1569	1698	1755	1732	1770	1819	1965	1888	1813	1587	1348	1210
1986	1148	1141	1157	1286	1760	2092	2101	1998	1887	1711	1536	1400
1987	1346	1313	1303	1312	1388	1590	1737	1691	1546	1320	1109	1001
1988	953	937	1090	1171	1256	1336	1367	1311	1299	1138	1041	963
1989	940	963	981	919	947	1291	1495	1386	1271	1108	1010	933
1990	955	958	953	1019	1044	1132	1172	1141	1159	1105	1007	930
1991	907	894	879	863	868	944	993	1017	1017	954	858	781
1992	758	746	741	746	884	1000	1233	1227	1192	1127	891	780
1993	757	744	766	825	964	1339	1520	1689	1804	1787	1656	1520
1994	1460	1450	1459	1385	1419	1487	1532	1507	1395	1216	1011	934
1995	911	899	885	1285	1539	1972	2211	2286	2271	2270	2150	1975
1996	1850	1840	1850	1900	2000	2100	2259	2215	2151	2014	1866	1727
1997	1664	1670	1850	1900	1985	2076	2117	1930	1732	1551	1344	1206
1998	1129	1145	1187	1497	1820	2100	2276	2410	2447	2270	2150	1975
1999	1850	1850	1850	1900	2000	2100	2294	2334	2355	2221	2087	1950
2000	1850	1850	1850	1900	2000	2100	2300	2292	2306	2176	2029	1819
2001	1759	1727	1716	1716	1747	1917	2016	1978	1805	1593	1371	1237
2002	1168	1216	1289	1519	1629	1731	1938	1848	1749	1600	1424	1286
2003	1223	1186	1369	1682	1793	1948	2148	2214	2289	2173	1965	1800

Table 2. Shasta												
TAF												
	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1922	2759	2628	2769	2911	3287	3731	4332	4552	4182	3700	3302	3069
1923	2965	2764	2899	3106	3249	3385	3846	3623	3286	2878	2584	2567
1924	2476	2395	2375	2524	2732	2752	2537	2246	1886	1564	1255	1100
1925	1080	1242	1351	1684	2866	3236	3916	4051	3793	3340	2929	2811
1926	2696	2672	2703	2744	3489	3647	3926	3780	3344	2790	2284	2162
1927	2112	2565	3003	3452	3571	4214	4552	4552	4224	3734	3340	2669
1928	2581	2675	2785	3012	3506	3965	4541	4494	3965	3276	2869	2491
1929	2319	2247	2318	2583	2768	2939	2983	2859	2583	2102	1765	1674
1930	1551	1474	2014	2213	2611	3105	3246	3222	2862	2428	2170	2121
1931	2007	1984	1973	2053	2138	2348	2109	1914	1651	1256	1075	1100
1932	1064	1070	1248	1476	1592	2049	2176	2382	2218	2003	1759	1663
1933	1561	1539	1533	1542	1578	2175	2344	2441	2256	1959	1427	1264
1934	1168	1134	1257	1542	1857	2130	2141	2027	1725	1307	1130	1100
1935	1073	1168	1202	1559	1870	2260	3299	3618	3297	2876	2515	2415
1936	2322	2263	2255	2912	3796	4091	4309	4236	3982	3457	3042	2907
1937	2734	2607	2571	2547	2626	3290	3987	4231	4060	3701	3401	3271
1938	3215	3732	3790	4104	4039	3894	4058	4552	4422	3977	3625	3069
1939	3091	2949	3108	3242	3367	3783	3647	3447	3116	2568	2205	2185
1940	2102	2007	2142	3034	3252	3435	4131	4139	3750	3150	2769	2631
1941	2540	2300	3263	3317	3423	3940	4456	4552	4442	4150	3700	3173
1942	3068	2725	3316	3389	3516	3795	4451	4552	4467	4103	3700	3159
1943	3030	2706	2958	3541	3848	4118	4552	4552	4275	3703	3350	2902
1944	2817	2422	2410	2500	2814	3140	3175	3197	3010	2568	2321	2259
1945	2190	2337	2609	2817	3514	3762	3929	4070	3863	3428	3116	2991
1946	2959	3216	3265	3622	3805	4124	4297	4269	3900	3429	3099	3026
1947	2838	2882	2999	3007	3268	3792	3917	3646	3426	2808	2513	2415
1948	2488	2499	2502	3067	3149	3485	4380	4552	4500	3943	3564	3400
1949	3234	3195	3212	3205	3351	4071	4398	4447	4047	3402	3027	2972
1950	2853	2776	2715	2950	3290	3666	4050	4047	3745	3334	3039	3008
1951	3176	3252	3322	3624	3794	4221	4279	4434	3999	3334	2973	2754
1952	2657	2614	3306	3604	3739	4022	4290	4552	4466	4150	3700	3322
1953	3198	2848	3292	3366	3654	4086	4440	4552	4500	4026	3700	3172
1954	3116	2922	3033	3552	3661	4106	4546	4552	4253	3650	3305	3019
1955	2916	2819	3069	3157	3310	3479	3710	3895	3624	3125	2858	2880
1956	2850	2940	3252	3252	3288	3970	4503	4552	4334	3998	3700	3105
1957	3079	2661	2601	2675	3334	4129	4406	4552	4240	3637	3293	3152
1958	3250	3156	3338	3531	4433	3416	4173	4552	4500	4150	3700	3295
1959	3181	2778	2765	3648	3777	4221	4263	4148	3635	3092	2702	2846
1960	2678	2501	2439	2651	3363	4035	4124	4265	3798	3200	2932	2895
1961	2758	2838	3287	3487	3914	4280	4408	4423	4061	3423	2985	2893
1962	2692	2782	3078	3180	3675	4199	4420	4358	4013	3420	3067	2995
1963	3250	3252	3349	3461	3944	4226	4137	4552	4289	3712	3382	2811
1964	2882	3102	3159	3503	3723	3871	3738	3633	3440	2897	2681	2696
1965	2658	2744	3252	3368	3713	3874	4500	4546	4207	3770	3502	3046
1966	2887	2935	3055	3539	3934	4229	4552	4436	3889	3260	2927	2694
1967	2600	2937	3335	3551	3920	4033	4479	4552	4500	4114	3700	3264
1968	3200	2935	3014	3190	3654	4226	4290	4226	3775	3181	2968	2953
1969	2909	2980	3318	3358	3480	4030	4434	4552	4331	3935	3578	3200
1970	3200	3034	3317	3252	3431	4021	4065	4008	3756	3180	2920	2357
1971	2233	2645	3319	3515	3848	3873	4369	4552	4469	3974	3685	3244
1972	3200	2864	3008	3344	3726	4249	4505	4461	4006	3392	3087	3148
1973	3146	3252	3346	3552	3636	4162	4461	4532	4088	3471	3223	3034
1974	3107	3252	3267	3252	3694	3416	4289	4552	4351	4150	3700	3311
1975	3218	2809	2984	3141	3790	3756	4341	4552	4349	4042	3700	3189
1976	3243	3039	3134	3369	3480	3668	3740	3601	3222	2757	2737	2811
1977	2711	2608	2545	2254	2293	2335	1976	1938	1509	1064	1015	1100
1978	1078	1122	1557	3467	4093	4526	4552	4552	4167	3718	3382	3319
1979	3164	2887	2792	2869	3193	3697	3965	4179	3796	3293	3121	3097
1980	3135	3244	3367	3528	3292	3940	4231	4226	3847	3413	3124	3109

Attachment 2 – CalSim 2 Inputs, Assumptions, and Hydrology Data

Table 2. Shasta												
TAF												
	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1981	3047	2736	2859	3138	3546	4148	4385	4217	3562	2934	2601	2584
1982	2595	3252	3276	3616	3530	3953	4094	4488	4343	4029	3700	3400
1983	3250	3252	3328	3371	3252	3667	4074	4552	4500	4150	3700	3400
1984	3250	3252	3285	3650	3994	4246	4491	4503	4198	3595	3407	2827
1985	2903	3252	3360	3459	3631	3843	3945	3671	3230	2790	2496	2477
1986	2463	2437	2590	3135	3252	3534	3969	3962	3563	3206	2920	2948
1987	2975	2686	2654	2792	3132	3867	3803	3510	2934	2409	2211	2206
1988	2037	2016	2510	2883	2908	3045	3080	3058	2628	2006	1721	1654
1989	1526	1725	1806	1992	2096	3470	3923	3656	3301	2687	2355	2389
1990	2521	2506	2504	2747	2841	3106	2924	3092	2945	2254	1979	1929
1991	1875	1857	1842	1722	1752	2175	2337	2319	2055	1742	1538	1480
1992	1373	1236	1233	1268	1911	2392	2655	2364	1849	1473	1082	1100
1993	1002	909	1136	1784	2510	3969	4450	4552	4500	3895	3623	3291
1994	3154	2750	2823	3071	3296	3469	3308	3219	2774	2154	1791	1717
1995	1551	1519	1564	3252	3743	3417	4217	4552	4500	4150	3700	3400
1996	3250	2836	3201	3567	3503	4010	4432	4552	4340	3904	3640	3210
1997	2972	2779	3252	3252	3737	3956	4015	3779	3431	2918	2746	2297
1998	2087	2045	2287	3339	3252	3504	4329	4552	4500	4150	3700	3400
1999	3250	3252	3349	3640	3570	3980	4518	4552	4322	3847	3573	3196
2000	3024	2642	2638	3336	3282	3976	4552	4552	4191	3618	3304	3105
2001	2976	2636	2612	2768	3205	3700	3810	3615	3166	2680	2510	2577
2002	2324	2477	3142	3678	4022	4411	4475	4289	3812	3295	3002	2930
2003	2735	2650	3291	3515	3772	4253	4552	4552	4245	3531	3281	3081

Table 3. Folsom												
TAF												
	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1922	489	430	457	460	567	662	792	967	967	942	792	556
1923	512	463	567	567	511	599	792	967	967	773	734	707
1924	533	485	434	367	431	432	465	484	448	324	317	306
1925	317	352	413	467	567	656	792	967	904	681	535	502
1926	452	418	408	367	505	609	792	779	602	442	355	355
1927	318	465	559	565	553	647	792	967	967	789	739	607
1928	554	442	458	455	478	635	792	915	813	508	449	399
1929	343	325	314	272	280	377	418	479	462	381	329	297
1930	269	269	425	529	567	659	792	816	675	480	418	382
1931	319	311	274	246	233	282	307	327	334	315	300	228
1932	154	169	268	363	567	664	792	967	967	900	792	659
1933	503	439	400	344	302	321	378	457	463	286	307	319
1934	300	302	380	474	562	655	620	492	299	255	218	143
1935	90	146	190	290	381	469	792	967	967	832	792	752
1936	676	567	539	567	562	651	792	967	967	771	734	706
1937	521	473	443	399	567	664	792	967	967	845	770	710
1938	592	567	567	567	567	662	792	967	967	942	792	707
1939	592	507	484	436	414	536	621	615	539	367	316	314
1940	298	289	286	567	557	626	792	967	957	710	627	436
1941	381	388	567	567	566	658	792	967	967	942	792	563
1942	515	454	567	564	556	650	792	967	967	942	792	581
1943	527	449	567	556	529	625	792	967	967	777	734	510
1944	454	389	349	305	337	447	498	629	576	452	395	356
1945	316	403	496	509	558	656	792	967	967	742	681	591
1946	558	567	567	564	558	649	792	967	939	692	610	577
1947	493	519	540	487	547	661	755	776	657	448	401	384
1948	367	361	344	444	445	463	783	956	967	866	781	743
1949	673	567	558	503	498	664	792	967	892	667	552	514
1950	455	422	382	567	565	658	792	967	949	736	695	663
1951	584	449	367	384	407	599	792	967	918	639	577	470
1952	438	427	567	567	566	661	792	967	967	942	792	627
1953	591	483	526	566	558	622	792	967	967	896	792	676
1954	569	501	495	512	564	656	792	866	789	481	432	395
1955	339	326	388	451	468	503	587	741	714	577	512	477
1956	425	404	524	460	458	616	792	967	967	942	792	714
1957	559	438	419	382	546	652	732	967	967	718	629	579
1958	542	529	567	567	557	656	792	967	967	942	792	619
1959	566	466	436	477	567	650	735	752	709	382	338	350
1960	298	261	228	222	441	654	710	745	701	573	508	482
1961	420	408	396	337	346	403	471	530	502	292	238	233
1962	213	226	260	262	567	664	792	907	903	673	602	536
1963	712	567	567	544	499	629	792	967	967	781	730	652
1964	592	544	567	567	564	556	623	707	686	525	464	427
1965	366	387	428	425	443	612	792	967	945	837	792	583
1966	506	504	525	546	549	644	792	827	765	500	462	451
1967	404	448	567	563	552	636	792	967	967	942	792	610
1968	592	504	500	520	547	640	715	735	680	394	368	352
1969	316	374	499	543	527	637	792	967	967	942	792	592
1970	569	515	567	453	446	611	691	785	760	502	458	362
1971	320	445	567	567	558	648	792	952	961	877	792	605
1972	560	487	551	561	567	646	745	845	793	529	482	455
1973	415	470	567	559	555	652	792	967	876	664	615	547
1974	515	567	567	505	499	622	792	967	967	942	792	624
1975	578	474	468	462	567	662	792	967	967	919	792	733
1976	695	529	526	461	415	428	434	456	434	408	385	357
1977	334	308	267	230	215	197	174	167	134	95	90	90
1978	90	90	197	567	567	657	792	967	960	783	732	627
1979	562	492	456	535	567	657	792	967	773	626	580	547
1980	519	544	567	481	457	621	792	967	967	942	792	592

Table 3. Folsom												
TAF												
	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1981	544	456	431	421	417	566	654	679	620	417	387	383
1982	366	546	433	459	402	590	792	967	967	942	792	752
1983	712	565	565	556	543	628	792	967	967	942	792	752
1984	712	472	406	427	458	615	786	967	944	708	661	592
1985	563	567	567	538	557	639	792	829	651	496	416	396
1986	349	378	477	551	440	593	792	967	967	775	731	523
1987	484	444	414	372	401	519	571	554	465	265	212	212
1988	208	216	302	414	434	469	515	514	462	386	326	299
1989	265	332	387	409	456	642	792	826	621	461	393	378
1990	357	381	385	416	435	550	635	662	579	448	392	386
1991	312	275	227	213	205	331	418	492	491	420	299	226
1992	227	251	288	281	464	592	636	560	440	241	202	173
1993	157	149	238	567	553	637	792	967	967	848	761	618
1994	560	452	430	362	360	393	450	495	477	364	306	265
1995	244	274	383	546	530	618	792	967	967	942	792	752
1996	592	475	567	557	494	621	792	967	967	851	792	595
1997	502	430	512	370	394	591	774	933	906	647	592	378
1998	337	339	362	567	555	646	792	967	967	942	792	750
1999	712	567	567	560	560	654	782	967	967	830	792	591
2000	534	431	407	564	558	656	792	967	903	612	563	537
2001	495	430	416	378	390	501	603	655	571	447	395	402
2002	378	426	567	567	563	655	792	906	859	627	540	503
2003	442	433	555	562	551	646	793	967	967	707	660	559

Table 4. Friant												
TAF												
	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1922	215	233	292	360	439	424	196	276	524	503	342	292
1923	303	333	413	439	439	441	392	468	430	347	229	211
1924	235	261	275	287	271	273	314	316	233	159	134	159
1925	160	177	207	239	313	292	293	365	360	283	191	182
1926	207	226	247	262	294	295	382	496	433	277	171	176
1927	180	219	267	307	423	438	349	442	490	402	255	213
1928	233	309	348	378	387	438	450	515	436	277	183	183
1929	165	158	166	174	168	145	161	244	228	171	142	176
1930	153	135	138	149	163	147	213	222	239	168	140	175
1931	158	148	153	162	166	133	184	205	162	131	131	151
1932	155	153	216	287	439	441	325	356	473	424	268	220
1933	231	255	268	292	282	278	264	193	258	227	164	181
1934	183	179	213	253	276	314	402	382	284	188	158	169
1935	160	167	195	253	314	281	242	374	508	388	243	209
1936	227	258	275	311	439	479	448	523	501	380	242	205
1937	213	235	268	300	439	479	358	524	524	421	265	220
1938	238	266	428	439	429	479	362	307	524	524	422	346
1939	357	374	394	434	439	478	523	505	387	251	158	168
1940	183	177	179	294	387	449	389	523	504	336	180	156
1941	166	188	274	383	439	479	348	364	463	475	324	243
1942	247	271	351	439	439	466	402	354	466	442	287	229
1943	241	295	336	412	439	479	456	523	496	379	244	210
1944	217	243	262	289	301	310	260	323	319	251	177	184
1945	199	246	299	338	439	458	346	416	470	406	265	226
1946	273	354	439	439	439	453	417	524	494	360	225	201
1947	226	296	379	424	439	466	456	521	417	266	172	180
1948	177	178	184	193	185	131	136	225	292	216	165	189
1949	194	192	210	227	236	211	239	336	355	234	160	176
1950	193	202	218	256	320	298	338	410	398	278	175	181
1951	202	357	381	439	439	456	378	380	347	256	178	184
1952	192	198	261	398	439	397	291	485	524	521	408	343
1953	336	341	373	439	439	442	415	369	314	269	187	189
1954	189	191	204	230	264	275	316	440	410	294	191	178
1955	192	206	236	273	299	284	240	258	316	226	165	179
1956	181	180	351	351	439	479	392	388	446	412	289	240
1957	265	294	312	344	367	364	293	302	369	282	188	188
1958	206	220	261	298	378	426	348	474	524	502	371	313
1959	310	317	323	359	407	475	523	497	400	254	147	178
1960	179	170	169	176	200	189	274	308	272	185	155	172
1961	153	151	176	188	198	166	230	235	198	136	136	161
1962	167	175	205	234	401	367	320	393	466	389	249	214
1963	233	259	270	304	439	452	325	341	424	379	252	222
1964	243	315	355	383	371	369	358	357	315	210	161	175
1965	161	176	299	439	439	417	286	298	326	289	240	220
1966	236	339	412	439	439	478	520	523	425	261	157	163
1967	151	162	367	439	439	399	292	326	524	524	444	363
1968	302	290	299	323	306	351	405	435	354	219	167	187
1969	167	179	223	351	372	326	191	375	524	524	445	354
1970	318	320	344	439	439	479	415	426	414	290	200	197
1971	197	219	288	353	386	376	336	339	323	240	172	186
1972	201	218	272	308	332	386	354	359	319	199	133	176
1973	175	189	227	294	385	379	257	493	524	398	254	216
1974	243	336	426	439	439	479	424	478	495	377	246	209
1975	229	262	294	329	365	395	239	319	496	390	240	212
1976	256	302	327	342	339	370	391	380	269	162	132	176
1977	182	182	194	211	217	219	240	213	181	141	131	152
1978	152	152	230	388	439	479	393	413	524	524	434	439
1979	393	391	400	439	439	479	438	523	509	363	228	200
1980	222	262	291	380	405	479	475	452	461	524	416	349

Table 4. Friant												
TAF												
	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1981	354	368	388	422	437	462	465	512	432	268	177	184
1982	178	230	286	392	439	447	524	524	524	523	440	440
1983	439	432	418	412	439	475	228	131	524	524	515	456
1984	406	437	407	439	439	478	385	440	401	296	209	207
1985	231	283	324	360	375	380	434	487	396	252	159	179
1986	182	202	262	341	393	479	421	491	524	456	313	273
1987	301	322	335	359	362	389	443	457	356	205	140	152
1988	135	139	157	205	224	219	277	295	251	174	149	172
1989	154	143	156	170	186	209	320	363	304	196	156	179
1990	175	173	184	201	213	207	297	287	230	171	152	166
1991	152	140	142	143	136	146	152	193	240	175	143	184
1992	170	168	183	201	244	239	343	388	287	194	158	173
1993	158	151	175	347	439	479	313	387	450	437	291	236
1994	252	270	289	317	321	356	392	409	349	229	156	172
1995	195	219	259	439	439	479	333	288	524	524	489	385
1996	293	270	286	337	434	479	371	488	490	381	246	211
1997	226	325	429	351	422	479	447	523	432	290	159	150
1998	170	204	239	334	439	479	440	350	524	524	452	363
1999	308	309	330	380	392	419	364	423	449	312	204	198
2000	213	225	238	306	382	439	407	519	519	360	226	199
2001	219	246	262	285	289	332	341	449	379	241	164	177
2002	167	171	222	276	304	288	353	404	375	260	168	173
2003	166	212	250	303	339	327	273	331	399	269	182	182

Table 5. New Melones												
TAF												
	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1922	1649	1654	1679	1700	1807	1800	1766	1935	2133	2074	1979	1918
1923	1865	1877	1943	1970	1970	1895	1900	1977	1960	1897	1799	1756
1924	1713	1703	1715	1726	1727	1669	1563	1445	1358	1281	1206	1178
1925	1145	1146	1155	1161	1293	1367	1350	1459	1488	1427	1329	1281
1926	1223	1211	1212	1210	1269	1281	1303	1238	1162	1072	989	946
1927	913	927	979	1020	1157	1224	1253	1326	1353	1273	1180	1140
1928	1119	1148	1169	1179	1220	1384	1383	1447	1383	1278	1179	1128
1929	1082	1084	1088	1090	1100	1085	1027	966	927	850	776	737
1930	697	687	688	705	735	787	772	728	739	677	611	573
1931	550	565	566	574	581	564	481	382	331	280	224	199
1932	154	160	210	238	343	376	386	558	642	625	567	529
1933	495	486	495	503	509	503	451	425	450	388	319	280
1934	255	255	272	291	322	345	260	157	109	80	80	80
1935	80	80	80	100	80	129	265	472	544	501	437	400
1936	386	394	407	478	655	733	830	995	1072	1011	932	897
1937	868	864	879	899	996	1096	1118	1285	1315	1225	1132	1080
1938	1039	1041	1122	1194	1377	1516	1647	1921	2140	2108	2023	1979
1939	1941	1931	1940	1954	1967	1986	1876	1745	1659	1567	1478	1436
1940	1381	1359	1360	1456	1588	1672	1740	1845	1820	1722	1630	1574
1941	1523	1513	1548	1597	1678	1705	1716	1853	1906	1848	1757	1698
1942	1652	1644	1688	1774	1849	1827	1900	2039	2181	2148	2052	2000
1943	1950	1970	1970	1970	1970	2030	2125	2142	2144	2066	1971	1907
1944	1849	1835	1833	1829	1835	1856	1754	1686	1656	1568	1470	1413
1945	1386	1416	1437	1470	1595	1677	1633	1715	1801	1738	1645	1599
1946	1576	1600	1682	1742	1794	1762	1780	1855	1816	1725	1635	1588
1947	1543	1554	1571	1582	1597	1582	1458	1347	1280	1190	1105	1063
1948	1043	1039	1039	1037	1007	1021	1022	1062	1169	1108	1034	998
1949	975	972	983	990	996	1021	978	1001	991	917	845	805
1950	758	739	745	790	853	906	908	1014	1086	1023	949	921
1951	907	1182	1573	1678	1772	1861	1841	1836	1779	1688	1596	1542
1952	1499	1510	1560	1697	1784	1814	1866	2140	2322	2300	2130	2000
1953	1927	1927	1943	1970	1970	1903	1846	1766	1820	1770	1683	1628
1954	1573	1571	1581	1593	1600	1644	1583	1629	1579	1487	1396	1342
1955	1285	1290	1304	1331	1336	1337	1300	1238	1215	1123	1032	981
1956	934	939	1189	1448	1564	1553	1565	1704	1808	1762	1673	1634
1957	1579	1572	1584	1598	1635	1671	1559	1575	1616	1528	1442	1385
1958	1330	1328	1330	1376	1452	1527	1673	1969	2115	2065	1973	1912
1959	1849	1844	1854	1876	1927	1943	1824	1672	1596	1508	1420	1408
1960	1348	1334	1334	1337	1374	1387	1341	1269	1222	1144	1071	1018
1961	954	971	988	992	1000	996	950	892	838	778	718	684
1962	641	646	653	657	736	769	772	797	853	800	723	674
1963	646	652	672	722	835	873	902	1087	1137	1086	1011	980
1964	968	998	1016	1049	1060	1046	977	913	885	810	737	688
1965	667	688	903	1105	1208	1263	1315	1401	1490	1449	1381	1336
1966	1275	1305	1336	1369	1399	1418	1371	1351	1267	1172	1083	1022
1967	974	979	1055	1153	1177	1206	1279	1474	1761	1817	1734	1683
1968	1623	1631	1642	1660	1717	1761	1653	1561	1492	1399	1308	1247
1969	1212	1233	1239	1536	1737	1792	1934	2174	2320	2279	2130	2000
1970	1958	1964	1970	1970	1970	1986	1928	1918	1912	1813	1714	1664
1971	1616	1641	1704	1758	1799	1760	1706	1691	1722	1653	1561	1508
1972	1452	1464	1507	1540	1558	1556	1428	1401	1340	1251	1162	1120
1973	1085	1091	1117	1225	1365	1478	1439	1547	1538	1443	1347	1302
1974	1284	1330	1404	1514	1589	1651	1740	1857	1889	1823	1725	1669
1975	1637	1644	1665	1688	1749	1786	1756	1765	1894	1827	1746	1689
1976	1661	1672	1689	1695	1703	1646	1556	1449	1358	1277	1209	1163
1977	1129	1126	1121	1108	1078	1017	944	883	853	791	732	706
1978	654	643	659	733	816	956	1059	1193	1295	1260	1171	1160
1979	1108	1117	1133	1195	1308	1429	1392	1494	1397	1296	1200	1154
1980	1128	1141	1150	1450	1698	1715	1746	1790	1862	1852	1761	1710

Table 5. New Melones												
TAF												
	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1981	1667	1657	1674	1717	1725	1764	1678	1556	1453	1353	1266	1226
1982	1198	1253	1381	1583	1881	2030	2220	2326	2389	2300	2130	2000
1983	1970	1970	1970	1970	1970	2030	2080	2204	2420	2300	2130	2000
1984	1970	1970	1970	1970	1970	1977	1908	1902	1874	1800	1725	1686
1985	1669	1705	1741	1753	1787	1819	1743	1648	1564	1469	1385	1349
1986	1320	1327	1341	1416	1889	2030	2056	2056	2078	1983	1895	1861
1987	1821	1814	1821	1809	1807	1828	1697	1529	1428	1347	1277	1241
1988	1187	1168	1156	1155	1151	1127	1055	959	909	857	809	771
1989	719	705	700	695	694	769	745	701	686	640	594	600
1990	607	614	635	643	651	642	567	491	438	379	334	309
1991	285	271	285	278	261	299	266	221	183	121	80	80
1992	80	80	95	101	145	182	142	80	80	80	80	80
1993	80	80	80	222	320	473	529	661	761	695	639	610
1994	601	625	661	686	705	670	610	554	492	417	352	315
1995	285	292	322	508	582	897	993	1230	1496	1612	1558	1538
1996	1513	1510	1544	1619	1807	1919	1935	2046	2051	1968	1891	1849
1997	1842	1875	1970	2116	1970	1977	1917	1900	1842	1757	1675	1647
1998	1611	1623	1648	1759	1962	2030	2060	2120	2349	2300	2130	2000
1999	1970	1970	1970	1970	1970	1993	1975	1976	1992	1916	1846	1812
2000	1785	1780	1794	1849	1958	1972	1956	1936	1895	1806	1731	1701
2001	1699	1711	1741	1750	1779	1811	1729	1625	1530	1426	1327	1271
2002	1210	1209	1243	1283	1283	1330	1304	1241	1165	1086	1013	981
2003	951	967	1018	1067	1075	1104	1094	1091	1060	991	926	894

Table 6. NOD CVP Ag Deliveries												
CFS												
	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1922	80	0	0	0	0	8	745	941	1221	1340	1077	540
1923	17	0	0	0	0	83	243	504	578	690	556	155
1924	75	7	0	0	0	7	34	37	42	46	37	18
1925	0	0	0	0	0	0	117	366	657	816	653	266
1926	123	0	0	0	0	11	27	135	210	229	179	91
1927	11	0	0	0	0	8	566	963	1173	1415	1144	569
1928	28	0	0	0	0	0	195	498	640	706	570	280
1929	99	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	0	0	0	47	120	185	201	163	67
1931	26	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	0	0	0	5	240	383	416	336	161
1936	25	2	0	0	0	3	172	378	450	599	486	228
1937	89	14	0	0	0	0	125	325	367	450	365	182
1938	15	0	0	0	0	0	281	914	1364	1485	1200	480
1939	74	2	0	0	79	76	210	171	236	255	208	81
1940	26	5	0	0	0	0	313	623	1067	1182	955	458
1941	23	0	0	0	0	0	114	606	1331	1538	1244	617
1942	44	0	0	0	0	0	123	737	1369	1520	1228	594
1943	186	0	0	0	0	1	247	707	934	1043	847	422
1944	133	3	0	0	0	6	95	147	208	242	196	97
1945	22	0	0	0	0	0	248	377	557	690	557	277
1946	1	0	0	0	0	16	592	724	899	959	791	382
1947	136	0	0	0	0	0	229	344	386	504	405	204
1948	2	0	0	0	9	18	47	460	940	1341	1078	463
1949	99	7	0	0	0	0	294	488	739	806	649	318
1950	130	1	0	0	0	2	186	254	303	338	272	124
1951	3	0	0	0	0	22	587	632	1013	1110	894	441
1952	7	0	0	0	0	0	458	970	1128	1398	1144	559
1953	217	0	0	0	0	42	421	901	1206	1429	1050	578
1954	169	0	0	0	0	0	305	850	1135	1302	917	513
1955	171	0	0	0	0	38	173	284	344	377	305	127
1956	45	0	0	0	0	86	647	774	1203	1412	1142	502
1957	89	27	0	0	0	38	467	575	870	950	768	146
1958	0	2	0	0	0	0	133	681	1231	1467	1228	601
1959	210	27	0	0	0	25	525	646	753	820	646	137
1960	133	20	0	0	0	0	149	221	324	353	285	141
1961	48	0	0	0	0	0	201	367	466	546	433	189
1962	78	0	0	0	0	0	434	679	828	962	769	368
1963	0	0	0	0	0	0	106	756	1361	1526	1233	606
1964	41	0	0	0	0	34	235	242	262	311	247	107
1965	12	0	0	0	0	34	164	722	923	1013	671	407
1966	163	0	0	0	0	24	585	755	886	963	776	381
1967	158	0	0	0	0	2	122	873	1041	1503	1214	595
1968	206	0	0	0	0	1	393	631	735	900	621	361
1969	60	0	0	0	0	2	528	1025	1209	1370	1110	543
1970	89	4	0	0	0	1	397	620	669	809	653	325
1971	59	0	0	0	0	38	695	633	916	1043	840	399
1972	149	1	0	0	3	145	361	375	449	513	415	157
1973	2	0	0	0	0	0	476	884	1146	1249	1009	473
1974	19	0	0	0	0	0	331	1026	1351	1253	1212	606
1975	62	2	0	0	0	0	387	1016	1312	1382	1126	575
1976	9	4	0	0	74	37	54	71	79	87	60	30
1977	13	1	0	0	2	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	175	932	1364	1490	1201	452
1979	242	0	0	0	0	0	165	366	482	525	413	192
1980	9	0	0	0	0	0	333	649	855	1016	830	403

Table 6. NOD CVP Ag Deliveries												
CFS												
	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1981	132	11	0	0	0	0	234	557	868	946	766	325
1982	6	0	0	0	0	0	202	943	1167	1520	1233	368
1983	0	0	0	0	0	0	124	818	1298	1532	1179	481
1984	167	0	0	0	0	30	654	867	981	1095	827	427
1985	39	0	0	0	0	0	370	647	793	873	698	221
1986	86	0	0	0	0	0	218	510	730	796	643	213
1987	115	14	0	0	0	0	154	210	249	270	218	108
1988	28	0	0	0	0	1	6	7	0	0	0	0
1989	0	0	0	0	0	0	182	320	360	422	338	18
1990	9	1	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0
1993	5	2	0	0	0	0	470	647	1148	1547	1229	631
1994	116	0	0	0	0	26	443	443	749	821	663	325
1995	92	0	0	0	0	0	361	703	1181	1490	1204	595
1996	241	32	0	0	0	0	386	563	1339	1518	1230	570
1997	58	0	0	0	0	52	648	710	810	961	715	346
1998	84	0	0	0	0	0	270	240	1173	1484	1197	535
1999	104	0	0	0	0	0	490	962	1164	1399	1116	559
2000	187	0	0	0	0	0	357	750	1259	1518	1245	527
2001	2	2	0	0	0	1	135	253	305	354	286	122
2002	32	0	0	0	0	34	636	610	849	927	749	371
2003	151	0	0	0	0	0	169	708	1370	1530	1076	615

Table 7. NOD CVP M&I Deliveries												
CFS												
	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1922	309	245	211	186	220	234	416	444	529	528	485	416
1923	282	245	211	186	146	225	282	387	394	405	372	275
1924	167	144	106	155	179	203	337	301	366	351	256	167
1925	91	94	175	150	180	202	325	364	430	435	380	234
1926	164	109	96	157	188	207	250	343	403	372	308	201
1927	98	220	167	142	172	241	384	461	518	533	490	419
1928	288	181	211	186	212	201	329	387	407	411	381	332
1929	235	117	99	156	186	155	271	284	286	294	208	139
1930	95	79	148	124	151	180	295	343	376	379	324	228
1931	128	87	79	141	170	191	321	311	322	335	238	158
1932	100	85	166	141	75	215	330	353	407	376	313	207
1933	139	103	88	149	180	171	288	295	330	318	228	153
1934	87	87	155	130	159	209	327	341	378	361	286	196
1935	117	220	87	149	96	169	219	399	446	446	405	325
1936	147	107	94	155	179	208	333	373	414	421	372	289
1937	156	123	93	155	186	184	323	390	414	428	394	319
1938	183	237	180	155	186	234	383	462	535	531	488	342
1939	207	249	141	186	220	195	335	317	401	399	365	285
1940	136	126	94	153	177	214	405	452	521	525	483	413
1941	286	203	211	186	220	235	305	428	560	563	515	372
1942	291	244	211	186	220	234	300	429	556	555	508	366
1943	238	181	211	186	220	233	347	466	516	524	481	413
1944	310	206	139	184	211	201	316	347	376	378	337	210
1945	123	226	170	145	175	202	355	364	392	407	373	355
1946	137	228	180	155	186	222	435	445	513	512	475	377
1947	228	180	211	186	220	199	343	373	404	426	374	237
1948	121	106	94	155	100	190	266	424	541	566	516	402
1949	254	181	211	186	220	199	375	362	437	438	404	336
1950	210	128	116	165	197	192	335	385	432	423	373	225
1951	117	236	180	155	186	248	433	431	521	524	482	411
1952	238	181	211	186	212	234	396	465	501	531	491	345
1953	241	243	211	186	220	231	379	449	508	529	476	355
1954	290	181	141	186	220	220	366	470	513	531	473	417
1955	317	207	211	186	220	176	329	378	421	421	371	275
1956	151	106	179	155	179	275	410	422	521	523	482	337
1957	199	264	202	186	220	202	369	391	499	501	459	350
1958	177	238	199	174	207	235	302	456	526	544	512	361
1959	240	263	203	186	220	241	394	400	453	453	419	290
1960	210	178	124	173	198	183	341	370	430	400	325	222
1961	146	233	180	155	186	202	300	345	402	406	375	307
1962	185	118	182	110	188	202	413	423	499	493	446	362
1963	273	262	203	178	211	234	319	456	547	553	506	426
1964	275	181	202	186	141	222	374	362	402	414	362	295
1965	129	236	179	154	185	223	291	462	517	511	447	394
1966	267	175	207	182	216	258	426	437	501	503	466	377
1967	237	270	210	186	220	234	302	481	518	556	502	363
1968	237	243	141	186	212	202	386	422	452	462	412	369
1969	234	254	196	171	203	235	403	471	517	521	480	411
1970	214	243	211	186	220	205	400	415	423	441	406	354
1971	216	154	192	167	199	234	439	429	510	515	475	341
1972	315	242	211	186	212	224	351	379	399	410	379	293
1973	157	237	180	155	186	234	422	469	520	523	482	399
1974	239	270	211	186	220	234	377	485	531	491	497	362
1975	211	243	141	186	220	234	391	478	533	527	481	356
1976	182	248	203	186	214	217	303	315	346	343	290	190
1977	119	91	81	81	91	201	304	280	337	323	118	57
1978	43	87	168	143	172	218	329	478	536	535	491	400
1979	322	207	141	186	220	202	325	386	407	404	369	323
1980	177	237	180	155	179	230	382	445	495	497	468	399

Table 7. NOD CVP M&I Deliveries												
CFS												
	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1981	270	189	136	182	216	203	376	417	473	473	435	361
1982	212	256	198	173	205	234	308	506	551	569	520	315
1983	284	271	211	186	220	234	306	473	548	560	507	414
1984	333	271	211	186	212	264	433	465	495	516	469	404
1985	247	270	211	186	220	189	389	428	453	462	422	319
1986	187	158	195	171	203	202	343	395	430	432	398	300
1987	201	135	111	161	192	178	324	356	404	404	357	278
1988	147	104	180	156	100	192	273	275	308	307	229	154
1989	107	78	159	72	80	169	345	385	431	443	376	222
1990	128	106	94	155	186	178	278	261	331	301	248	136
1991	94	72	64	64	153	183	311	346	382	383	328	265
1992	105	94	80	80	164	201	321	386	415	436	381	293
1993	139	122	187	163	194	220	403	424	507	541	493	426
1994	302	253	205	186	220	241	390	381	442	439	393	319
1995	194	154	192	168	200	232	364	417	509	550	506	403
1996	253	177	211	186	212	241	385	388	559	568	508	380
1997	193	145	217	192	227	290	448	459	499	506	389	276
1998	169	143	219	194	229	235	371	354	558	580	532	441
1999	205	271	211	186	220	236	415	476	530	500	424	270
2000	185	137	126	188	214	239	414	458	541	552	479	357
2001	136	144	125	186	220	207	331	391	426	433	379	284
2002	161	237	187	163	103	214	432	426	465	506	467	403
2003	317	249	209	184	218	217	324	456	553	546	471	391

Table 8. CVP Settlement Contract Deliveries												
CFS												
	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1922	1113	411	0	20	0	12	5691	5002	7139	6737	4974	1408
1923	884	133	0	0	0	515	4192	5347	6990	6866	5076	889
1924	1190	527	218	0	0	353	5019	4556	5891	5608	4211	1107
1925	694	359	0	53	0	0	3842	3935	6858	6913	5087	1234
1926	1341	437	168	0	0	239	2902	4902	7410	6847	4965	1424
1927	929	86	182	0	0	19	4910	5026	6764	6796	5033	1425
1928	942	261	67	0	0	0	4258	5150	7067	6725	4969	1368
1929	1276	223	79	101	0	132	5559	5543	6096	6713	4964	1381
1930	1292	634	0	0	0	0	4026	4751	7238	6798	5020	1185
1931	1243	428	263	0	0	480	5227	3991	5471	5736	4318	1131
1932	975	352	0	13	0	123	4676	3942	5869	5785	4334	1138
1933	1133	470	110	0	0	270	5196	4200	5901	5628	4223	1106
1934	901	556	0	71	0	74	4660	4326	5826	5767	4346	1165
1935	922	168	130	0	0	0	2608	5010	7440	6880	5098	1397
1936	994	436	138	0	0	31	4390	4796	6379	6780	5034	1355
1937	1306	634	140	0	0	0	4365	5295	6738	6815	5053	1437
1938	1003	173	30	0	0	0	3773	4844	7294	6834	5063	1192
1939	984	473	215	58	232	715	6645	4828	7121	6676	4975	1143
1940	1132	593	190	0	0	0	4245	4355	7216	6830	5059	1384
1941	948	353	0	0	0	0	2352	3974	7334	6972	5174	1463
1942	974	356	0	0	0	0	2491	4424	7436	6921	5131	1426
1943	1264	367	36	0	0	2	3997	5135	7101	6775	5034	1420
1944	1262	482	142	0	0	102	4929	4589	6932	6782	5021	1411
1945	1084	202	110	20	0	0	4903	4428	6728	6849	5067	1440
1946	789	301	0	90	0	73	5923	5114	7079	6580	4938	1329
1947	1231	353	24	118	0	27	5031	5122	6482	6883	5077	1469
1948	808	412	191	109	108	189	2060	3513	6569	7083	5224	1285
1949	1165	500	39	67	7	0	4832	4592	7133	6727	4956	1360
1950	1329	452	196	0	0	70	5353	5340	7123	6753	4995	1297
1951	810	244	0	0	0	56	5621	4364	7212	6785	5013	1399
1952	853	240	0	0	0	0	4499	5116	6597	6728	5025	1370
1953	1331	362	0	0	0	169	4384	4853	6897	6869	4685	1460
1954	1243	290	252	0	0	0	3587	5104	7090	6846	4584	1401
1955	1283	189	45	0	0	374	4857	5214	7104	6690	4946	1157
1956	1205	337	0	0	0	268	5099	4405	6953	6800	5036	1273
1957	945	595	272	0	0	179	4918	4574	7421	6936	5156	727
1958	822	521	101	0	0	0	2587	4321	6949	6764	5128	1436
1959	1323	597	197	0	0	124	6061	5444	7059	6710	4869	581
1960	1315	632	174	0	0	5	4873	4705	7160	6741	5002	1392
1961	1271	183	137	0	0	0	4800	4977	6869	6779	4951	1261
1962	1290	284	93	83	0	0	5322	5161	6949	6780	4978	1356
1963	719	477	89	0	0	0	2344	4598	7385	6948	5152	1438
1964	931	145	241	0	0	422	6366	5347	6667	6661	4884	1246
1965	949	165	45	0	0	253	4008	5254	7205	6808	4317	1427
1966	1353	141	128	3	0	111	5884	5330	6995	6610	4887	1338
1967	1314	92	63	0	0	0	2147	5081	6236	6943	5138	1421
1968	1301	428	190	0	0	0	5124	5135	6694	6804	4515	1421
1969	1040	261	3	0	0	5	4827	5322	6956	6714	4974	1369
1970	1046	479	0	0	0	8	5543	5367	6674	6715	4967	1377
1971	1027	66	38	45	0	175	6152	4451	6997	6739	4973	1319
1972	1278	446	53	78	22	692	5999	5245	6938	6778	5024	1100
1973	825	107	114	0	0	0	4849	5155	7170	6748	4993	1298
1974	878	82	75	0	0	0	3974	5235	7195	5982	5123	1486
1975	973	460	24	113	0	0	4272	5259	7247	6630	4921	1425
1976	800	504	238	123	233	924	5687	5578	7055	6742	4430	1219
1977	1310	492	216	0	134	581	5613	3444	5970	5729	4360	699
1978	1087	270	40	0	0	0	3252	5034	7280	6839	5054	1115
1979	1376	365	232	0	0	2	4492	5188	7265	6797	4975	1343
1980	843	261	0	0	0	0	4481	4837	6878	6718	5044	1384

Table 8. CVP Settlement Contract Deliveries												
CFS												
	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1981	1235	545	60	0	0	0	4225	4789	7317	6863	5099	1247
1982	821	107	39	0	0	0	2879	5235	6754	6981	5186	944
1983	768	138	112	0	0	0	2568	4782	7132	6972	4989	1172
1984	1217	50	0	113	0	142	5928	5489	6973	6736	4732	1344
1985	927	52	163	83	0	0	5052	5314	7104	6789	4975	944
1986	1091	179	115	0	0	0	4301	4988	7221	6813	5048	977
1987	1292	587	194	0	5	11	5167	5394	7088	6669	4932	1356
1988	1165	289	0	0	0	476	5000	4562	6712	6755	4996	1395
1989	1333	316	93	106	78	16	4792	5574	7012	6989	5137	368
1990	882	452	275	0	0	189	6169	3454	7202	6778	4796	1352
1991	1290	529	206	112	58	0	3594	4234	6062	5994	4499	1181
1992	1004	445	88	0	0	0	3702	4553	5742	5995	4534	1201
1993	777	446	0	0	0	0	4589	3841	6420	6882	5044	1454
1994	1092	342	167	0	0	153	4775	3609	6115	5815	4375	1132
1995	1046	155	68	0	0	0	4147	3990	6668	6846	5068	1419
1996	1389	628	0	0	0	0	4088	3408	7320	6900	5130	1370
1997	1028	353	0	0	0	284	6244	5207	6795	6750	4676	1279
1998	1045	110	134	0	0	0	3725	2294	7047	7077	5264	1417
1999	1178	304	216	9	0	0	4394	5139	6747	6759	4964	1385
2000	1239	353	271	0	0	2	4186	4166	6890	6878	5132	1214
2001	795	479	255	0	0	0	4407	5309	6912	6772	5012	1249
2002	1170	134	0	0	0	155	6193	4671	7065	6665	4926	1358
2003	1320	321	0	0	0	0	3114	4328	7439	6943	4559	1469

Table 9. NOD CVP Refuge Deliveries												
CFS												
	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1922	209	234	137	65	59	17	19	66	102	138	188	244
1923	195	234	137	65	59	17	19	66	102	138	188	244
1924	218	234	137	65	57	11	10	19	37	46	51	184
1925	35	177	104	49	45	17	19	66	102	138	188	244
1926	234	234	137	65	59	17	19	66	102	138	188	244
1927	207	234	137	65	59	17	19	66	102	138	188	244
1928	195	234	137	65	57	17	19	66	102	138	188	244
1929	190	234	137	65	59	17	19	66	102	138	188	244
1930	188	184	137	65	59	17	19	66	102	138	188	244
1931	189	187	137	65	59	9	10	19	37	46	51	184
1932	15	87	104	49	43	13	10	19	37	46	51	184
1933	12	68	104	49	45	10	10	19	37	46	51	184
1934	14	101	104	49	45	13	10	19	37	46	51	184
1935	17	177	104	49	45	17	19	66	102	138	188	244
1936	219	234	137	65	57	17	19	66	102	138	188	244
1937	218	234	137	65	59	17	19	66	102	138	188	244
1938	206	234	137	65	59	17	19	66	102	138	188	244
1939	210	234	137	65	59	17	19	66	102	138	188	244
1940	188	234	137	65	57	17	19	66	102	138	188	244
1941	193	234	137	65	59	17	19	66	102	138	188	244
1942	194	234	137	65	59	17	19	66	102	138	188	244
1943	195	234	137	65	59	17	19	66	102	138	188	244
1944	191	234	137	65	57	17	19	66	102	138	188	244
1945	193	234	137	65	59	17	19	66	102	138	188	244
1946	192	234	137	65	59	17	19	66	102	138	188	244
1947	187	234	137	65	59	17	19	66	102	138	188	244
1948	194	234	137	65	57	17	19	66	102	138	188	244
1949	199	186	137	65	59	17	19	66	102	138	188	244
1950	232	234	137	65	59	17	19	66	102	138	188	244
1951	191	234	137	65	59	17	19	66	102	138	188	244
1952	193	234	137	65	57	17	19	66	102	138	188	244
1953	221	234	137	65	59	17	19	66	102	138	188	244
1954	222	234	137	65	59	17	19	66	102	138	188	244
1955	227	234	137	65	59	17	19	66	102	138	188	244
1956	191	234	137	65	57	17	19	66	102	138	188	244
1957	190	184	137	65	59	17	19	66	102	138	188	244
1958	191	234	137	65	59	17	19	66	102	138	188	244
1959	212	186	137	65	59	17	19	66	102	138	188	244
1960	226	183	137	65	57	17	19	66	102	138	188	244
1961	227	234	137	65	59	17	19	66	102	138	188	244
1962	191	234	137	65	59	17	19	66	102	138	188	244
1963	196	234	137	65	59	17	19	66	102	138	188	244
1964	192	234	137	65	57	17	19	66	102	138	188	244
1965	191	234	137	65	59	17	19	66	102	138	188	244
1966	215	234	137	65	59	17	19	66	102	138	188	244
1967	188	234	137	65	59	17	19	66	102	138	188	244
1968	197	187	137	65	57	17	19	66	102	138	188	244
1969	210	234	137	65	59	17	19	66	102	138	188	244
1970	207	234	137	65	59	17	19	66	102	138	188	244
1971	191	234	137	65	59	17	19	66	102	138	188	244
1972	226	234	137	65	57	17	19	66	102	138	188	244
1973	192	234	137	65	59	17	19	66	102	138	188	244
1974	191	234	137	65	59	17	19	66	102	138	188	244
1975	192	234	137	65	59	17	19	66	102	138	188	244
1976	192	234	137	65	57	17	19	66	102	138	188	244
1977	188	234	137	65	59	9	10	19	37	46	51	181
1978	12	177	104	49	45	17	19	66	102	138	188	244
1979	193	234	137	65	59	17	19	66	102	138	188	244
1980	199	234	137	65	57	17	19	66	102	138	188	244

Table 9. NOD CVP Refuge Deliveries

CFS												
	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1981	190	234	137	65	59	17	19	66	102	138	188	244
1982	192	234	137	65	59	17	19	66	102	138	188	244
1983	193	234	137	65	59	17	19	66	102	138	188	244
1984	194	234	137	65	57	17	19	66	102	138	188	244
1985	202	234	137	65	59	17	19	66	102	138	188	244
1986	187	234	137	65	59	17	19	66	102	138	188	244
1987	192	234	137	65	59	17	19	66	102	138	188	244
1988	192	234	137	65	57	17	19	66	102	138	188	244
1989	192	196	137	65	59	17	19	66	102	138	188	225
1990	191	205	137	65	59	17	19	66	102	138	188	244
1991	191	185	137	65	59	13	10	19	37	46	51	184
1992	17	71	104	49	43	13	10	19	37	46	51	184
1993	28	70	104	49	45	17	19	66	102	138	188	244
1994	188	194	137	65	59	13	10	19	37	46	51	184
1995	14	177	104	49	45	17	19	66	102	138	188	244
1996	204	184	137	65	57	17	19	66	102	138	188	244
1997	191	193	137	65	59	17	19	66	102	138	188	244
1998	187	234	137	65	59	17	19	66	102	138	188	244
1999	193	196	137	65	59	17	19	66	102	138	188	244
2000	193	193	137	65	57	17	19	66	102	138	188	244
2001	192	217	137	65	59	17	19	66	102	138	188	244
2002	191	210	137	65	59	17	19	66	102	138	188	244
2003	185	195	137	65	59	17	19	66	102	138	188	244

Table 10. SOD CVP Ag Deliveries												
CFS												
	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1922	922	703	973	1708	2154	1165	1894	2598	4335	5214	3757	1232
1923	780	595	823	1444	1821	717	1023	1515	2529	3041	2191	719
1924	455	347	480	842	1026	56	80	115	192	231	166	55
1925	94	72	100	175	221	487	798	1515	2529	3042	2192	719
1926	455	347	480	843	1062	227	324	467	779	937	675	221
1927	140	107	148	259	327	710	1133	1628	2716	3267	2354	772
1928	488	373	516	905	1102	378	1050	1506	2514	3023	2178	715
1929	452	345	477	837	1056	0	0	0	0	0	0	0
1930	0	0	0	0	0	128	286	424	707	850	613	201
1931	127	97	134	235	297	0	0	0	0	0	0	0
1932	0	0	0	0	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	0	0	0	89	834	1392	1674	1206	396
1936	250	191	264	464	564	614	876	1263	2108	2536	1827	599
1937	379	289	400	702	886	176	645	956	1596	1919	1383	454
1938	287	219	303	532	670	1493	2130	3073	5128	6167	4444	1458
1939	922	703	973	1708	2154	263	465	671	1120	1346	970	318
1940	201	154	212	373	454	430	829	1247	2081	2503	1803	592
1941	374	285	395	693	874	1093	1809	2540	4239	5098	3673	1205
1942	762	581	804	1412	1781	1223	1978	2755	4598	5530	3318	1307
1943	827	631	873	1532	1932	1101	1571	2266	3781	4547	3277	1075
1944	680	519	718	1260	1534	257	366	528	882	1061	764	251
1945	159	121	167	294	371	531	979	1412	2357	2835	2043	670
1946	424	323	447	785	990	942	1349	1921	3207	3856	2779	911
1947	577	440	609	1068	1347	341	753	1087	1813	2181	1571	515
1948	326	249	344	604	736	244	631	864	1443	1735	1250	410
1949	259	198	274	481	606	342	1239	1787	2982	3587	2585	848
1950	536	409	566	994	1253	267	536	773	1291	1552	1119	367
1951	232	177	245	430	542	942	1349	1937	3232	3887	2801	919
1952	581	443	613	1077	1311	1405	2130	3073	5128	6167	4444	1458
1953	922	703	973	1708	2154	580	996	1422	2373	2853	2056	674
1954	427	325	450	790	997	587	935	1352	2256	2714	1955	641
1955	406	309	428	752	948	429	613	884	1475	1773	1278	419
1956	265	202	280	491	598	1350	1864	2523	4210	5063	3280	1197
1957	757	577	799	1403	1769	538	809	1149	1918	2307	1662	545
1958	345	263	364	639	806	1195	1937	3034	5063	6088	4387	1439
1959	910	694	961	1687	2127	471	774	1140	1902	2288	1648	541
1960	342	261	361	634	772	164	550	793	1324	1592	1147	376
1961	238	182	251	441	556	351	825	1190	1986	2388	1721	564
1962	357	272	377	662	834	520	878	1270	2119	2548	1836	602
1963	381	291	402	706	890	725	1142	1630	2721	3272	2358	773
1964	489	373	516	906	1104	367	524	756	1261	1517	1093	359
1965	227	173	239	420	530	620	885	2214	3694	4443	3202	1050
1966	664	507	701	1231	1552	737	1132	1647	2748	3305	2381	781
1967	494	377	522	916	1155	1343	2130	3073	5128	6167	4444	1458
1968	922	703	973	1708	2080	525	875	1245	2078	2499	1801	591
1969	374	285	394	692	873	1493	2130	3073	5128	6167	4444	1458
1970	922	703	973	1708	2154	776	1278	1843	3075	3698	2665	874
1971	553	422	584	1024	1292	420	776	1116	1862	2240	1614	529
1972	335	255	353	620	755	613	874	1261	2104	2530	1823	598
1973	378	289	399	701	884	757	1289	1865	3112	3743	2697	885
1974	560	427	591	1037	1308	1164	1897	2608	4353	5235	2392	1237
1975	783	597	826	1450	1829	910	1510	2026	3381	4067	2022	961
1976	608	464	642	1126	1372	110	157	226	378	454	327	107
1977	68	52	72	126	159	0	0	0	0	0	0	0
1978	0	0	0	0	0	935	2130	3073	5128	6167	4444	1458
1979	922	703	973	1708	2154	425	778	1123	1874	2253	1624	533
1980	337	257	356	624	760	1073	1531	2207	3684	4430	3192	1047

Table 10. SOD CVP Ag Deliveries												
CFS												
	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1981	662	505	699	1227	1548	507	1047	1528	2549	3066	1653	725
1982	458	350	484	849	1071	1300	2130	3073	5128	6167	4444	1458
1983	922	703	973	1708	2154	1493	2130	3073	5128	6167	4444	1458
1984	922	703	973	1708	2080	943	1349	1947	3249	3908	2816	924
1985	584	446	617	1083	1365	627	1054	1556	2598	3124	2251	738
1986	467	356	493	865	1091	601	1173	1691	2822	3394	2446	802
1987	508	387	536	940	1186	36	447	645	1077	1295	933	306
1988	194	148	204	359	437	13	18	26	0	0	0	0
1989	0	0	0	0	0	0	598	863	1440	1732	1248	409
1990	259	198	273	480	605	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	951	1805	2399	4003	4814	1772	1138
1994	720	549	760	1334	1682	840	1180	1692	2639	3019	1866	803
1995	508	387	536	941	1186	1090	1999	2856	4766	5732	4130	1355
1996	857	654	905	1588	1933	976	1712	2331	3889	4677	2008	1106
1997	699	533	738	1296	1634	1096	1564	2256	3765	4528	1894	1070
1998	677	516	715	1254	1582	1364	2130	3073	5128	6167	4444	1458
1999	922	703	973	1708	2154	677	1179	1680	2804	3372	2430	797
2000	504	385	532	934	1137	720	1237	1769	2953	3551	2151	839
2001	531	405	560	984	1241	344	539	777	1297	1559	1124	369
2002	233	178	246	432	545	782	1124	1580	2637	3172	2286	750
2003	474	362	501	879	1108	597	936	1307	2182	2624	1890	620

Table 11. SOD CVP M&I Deliveries												
CFS												
	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1922	178	239	237	156	80	245	206	184	190	216	239	268
1923	178	239	237	156	80	183	154	138	143	162	180	201
1924	133	180	178	117	58	147	124	111	115	130	144	161
1925	107	144	143	94	48	183	154	138	143	162	180	201
1926	133	180	178	117	60	159	134	120	124	140	156	175
1927	116	156	155	102	52	183	161	143	148	168	187	209
1928	139	187	185	122	60	183	154	138	143	162	180	201
1929	133	180	178	117	60	122	103	92	95	108	120	134
1930	89	120	119	78	40	143	130	117	121	137	153	171
1931	114	153	151	100	51	138	116	103	107	121	135	151
1932	100	135	134	88	44	173	146	130	135	153	170	190
1933	126	170	168	111	57	126	114	102	105	119	132	148
1934	98	132	131	86	44	160	134	120	124	141	156	175
1935	116	156	155	102	52	122	111	138	143	162	180	201
1936	133	180	178	117	58	183	154	138	143	162	180	201
1937	133	180	178	117	60	151	154	138	143	162	180	201
1938	133	180	178	117	60	245	206	184	190	216	239	268
1939	178	239	237	156	80	165	148	132	137	155	172	193
1940	128	172	170	112	56	183	154	138	143	162	180	201
1941	133	180	178	117	60	240	206	184	190	216	239	268
1942	178	239	237	156	80	245	206	184	190	216	239	268
1943	178	239	237	156	80	242	203	181	188	213	236	265
1944	176	236	234	154	77	164	138	123	128	145	161	180
1945	120	161	159	105	54	183	154	138	143	162	180	201
1946	133	180	178	117	60	215	182	161	166	189	210	235
1947	156	210	208	137	70	178	154	138	143	162	180	201
1948	133	180	178	117	58	162	154	138	143	162	180	201
1949	133	180	178	117	60	178	171	153	158	179	199	223
1950	148	199	197	130	67	166	154	138	143	162	180	201
1951	133	180	178	117	60	215	182	162	167	190	211	236
1952	157	211	209	138	68	245	206	184	190	216	239	268
1953	178	239	237	156	80	183	154	138	143	162	180	201
1954	133	180	178	117	60	183	154	138	143	162	180	201
1955	133	180	178	117	60	183	154	138	143	162	180	201
1956	133	180	178	117	58	245	206	184	190	216	239	268
1957	178	239	237	156	80	183	154	138	143	162	180	201
1958	133	180	178	117	60	245	206	184	190	216	239	268
1959	178	239	237	156	80	183	154	138	143	162	180	201
1960	133	180	178	117	58	149	154	138	143	162	180	201
1961	133	180	178	117	60	180	154	138	143	162	180	201
1962	133	180	178	117	60	183	154	138	143	162	180	201
1963	133	180	178	117	60	183	162	143	148	168	187	209
1964	139	187	185	122	60	182	153	137	142	161	179	200
1965	133	179	177	117	60	183	154	178	185	209	232	260
1966	173	232	230	152	78	183	161	144	149	169	188	211
1967	140	188	186	123	63	245	206	184	190	216	239	268
1968	178	239	237	156	78	183	154	138	143	162	180	201
1969	133	180	178	117	60	245	206	184	190	216	239	268
1970	178	239	237	156	80	188	175	156	162	183	203	228
1971	151	203	201	133	68	183	154	138	143	162	180	201
1972	133	180	178	117	58	183	154	138	143	162	180	201
1973	133	180	178	117	60	185	176	157	163	185	205	230
1974	153	205	203	134	69	245	206	184	190	216	239	268
1975	178	239	237	156	80	210	197	167	173	196	218	244
1976	162	218	216	142	70	140	118	105	109	124	137	154
1977	102	137	136	90	46	133	112	100	104	117	130	146
1978	97	130	129	85	44	214	206	184	190	216	239	268
1979	178	239	237	156	80	183	154	138	143	162	180	201
1980	133	180	178	117	58	237	199	178	184	209	232	260

Table 11. SOD CVP M&I Deliveries

CFS												
	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1981	172	232	230	151	78	183	154	138	143	162	0	201
1982	133	180	178	117	60	245	206	184	190	216	239	268
1983	178	239	237	156	80	245	206	184	190	216	239	268
1984	178	239	237	156	78	216	182	162	168	190	212	237
1985	157	212	210	138	71	183	154	139	144	163	181	203
1986	135	181	179	118	61	183	165	147	152	173	192	215
1987	142	192	190	125	64	128	146	130	135	153	170	190
1988	126	170	168	111	55	124	105	93	97	110	122	136
1989	91	122	121	79	41	122	154	138	143	162	180	201
1990	133	180	178	117	60	122	103	92	95	108	120	134
1991	89	120	119	78	40	149	132	117	122	138	153	171
1992	114	153	152	100	50	167	154	138	143	162	180	201
1993	133	180	178	117	60	217	206	184	190	216	239	268
1994	178	239	237	156	80	199	165	147	152	173	33	215
1995	143	192	190	125	64	240	206	184	190	216	239	268
1996	178	239	237	156	78	221	206	184	190	216	239	268
1997	178	239	237	156	80	241	202	181	187	212	236	264
1998	175	236	233	154	79	245	206	184	190	216	239	268
1999	178	239	237	156	80	183	165	146	152	172	191	214
2000	142	191	189	124	62	183	171	152	157	178	198	221
2001	147	198	196	129	66	179	154	138	143	162	180	201
2002	133	180	178	117	60	189	160	140	145	165	183	205
2003	136	183	181	119	61	183	154	138	143	162	180	201

Table 12. CVP Exchange Contractor Deliveries

CFS												
	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1922	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1923	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1924	979	336	148	154	427	868	901	1204	1641	1865	1826	1227
1925	754	259	114	118	341	1127	1170	1563	2132	2421	2372	1594
1926	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1927	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1928	979	336	148	154	427	1127	1170	1563	2132	2421	2372	1594
1929	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1930	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1931	979	336	148	154	443	435	452	604	823	935	916	616
1932	754	259	114	118	329	868	901	1204	1641	1865	1826	1227
1933	754	259	114	118	341	868	901	1204	1641	1865	1826	1227
1934	754	259	114	118	341	867	901	1203	1641	1864	1826	1227
1935	754	259	114	118	341	1127	1170	1563	2132	2421	2372	1594
1936	979	336	148	154	427	1127	1170	1563	2132	2421	2372	1594
1937	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1938	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1939	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1940	979	336	148	154	427	1127	1170	1563	2132	2421	2372	1594
1941	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1942	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1943	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1944	979	336	148	154	427	1127	1170	1563	2132	2421	2372	1594
1945	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1946	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1947	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1948	979	336	148	154	427	1127	1170	1563	2132	2421	2372	1594
1949	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1950	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1951	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1952	979	336	148	154	427	1127	1170	1563	2132	2421	2372	1594
1953	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1954	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1955	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1956	979	336	148	154	427	1127	1170	1563	2132	2421	2372	1594
1957	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1958	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1959	979	336	148	154	443	1127	1155	1563	2132	2421	2372	1594
1960	979	336	148	154	427	1127	1170	1563	2132	2421	2372	1594
1961	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1962	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1963	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1964	979	336	148	154	427	1127	1170	1563	2132	2421	2372	1594
1965	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1966	979	336	148	154	443	1127	1037	1563	2132	2421	2372	1594
1967	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1968	979	336	148	154	427	1127	1170	1563	2132	2421	2372	1594
1969	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1970	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1971	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1972	979	336	148	154	427	1127	1170	1563	2132	2421	2372	1594
1973	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1974	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1975	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1976	979	336	148	154	427	1127	1170	1563	2132	2421	2372	1594
1977	979	336	148	154	443	348	361	483	658	748	732	492
1978	754	259	114	118	341	1127	1170	1563	2132	2421	2372	1594
1979	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1980	979	336	148	154	427	1127	1170	1563	2132	2421	2372	1594

Table 12. CVP Exchange Contractor Deliveries

CFS												
	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1981	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1982	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1983	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1984	979	336	148	154	427	1127	1170	1563	2132	2421	2372	1594
1985	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1986	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1987	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1988	979	336	148	154	427	1127	1170	1563	2132	2421	2372	1594
1989	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1990	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1991	979	336	148	154	443	868	901	1204	1641	1865	1826	1227
1992	754	259	114	118	329	867	901	1203	1641	1864	1826	1227
1993	754	259	114	118	341	1127	1170	1563	2132	2421	2372	1594
1994	979	336	148	154	443	868	901	1204	1641	1865	1826	1227
1995	754	259	114	118	341	1127	1170	1563	2132	2421	2372	1594
1996	979	336	148	154	427	1127	1170	1563	2132	2421	2372	1594
1997	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1998	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
1999	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
2000	979	336	148	154	427	1127	1170	1563	2132	2421	2372	1594
2001	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
2002	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594
2003	979	336	148	154	443	1127	1170	1563	2132	2421	2372	1594

Table 13. SOD CVP Refuge Deliveries												
CFS												
	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1922	1071	690	315	141	106	90	208	418	469	115	192	836
1923	1071	690	315	141	106	90	208	418	469	115	192	836
1924	1071	690	315	141	102	68	156	314	352	86	144	627
1925	803	517	236	106	80	90	208	418	469	115	192	836
1926	1071	690	315	141	106	90	208	418	469	115	192	836
1927	1071	690	315	141	106	90	208	418	469	115	192	836
1928	1071	690	315	141	102	90	208	418	469	115	192	836
1929	1071	690	315	141	106	90	208	418	469	115	192	836
1930	1071	690	315	141	106	90	208	418	469	115	192	836
1931	1071	690	315	141	106	68	156	314	352	86	144	627
1932	803	517	236	106	77	68	156	314	352	86	144	627
1933	803	517	236	106	80	68	156	314	352	86	144	627
1934	803	517	236	106	80	68	156	314	352	86	144	627
1935	803	517	236	106	80	90	208	418	469	115	192	836
1936	1071	690	315	141	102	90	208	418	469	115	192	836
1937	1071	690	315	141	106	90	208	418	469	115	192	836
1938	1071	690	315	141	106	90	208	418	469	115	192	836
1939	1071	690	315	141	106	90	128	418	469	115	192	836
1940	1071	690	315	141	102	90	208	418	469	115	192	836
1941	1071	690	315	141	106	90	208	418	469	115	192	836
1942	1071	690	315	141	106	90	208	418	469	115	192	836
1943	1071	690	315	141	106	90	208	418	469	115	192	836
1944	1071	690	315	141	102	90	208	418	469	115	192	836
1945	1071	690	315	141	106	90	208	418	469	115	192	836
1946	1071	690	315	141	106	90	208	418	469	115	192	836
1947	1071	690	315	141	106	90	208	418	469	115	192	836
1948	1071	690	315	141	102	90	208	418	469	115	192	836
1949	1071	690	315	141	106	90	208	418	469	115	192	836
1950	1071	690	315	141	106	90	208	418	469	115	192	836
1951	1071	690	315	141	106	90	208	418	469	115	192	836
1952	1071	690	315	141	102	90	208	418	469	115	192	836
1953	1071	690	315	141	106	90	208	418	469	115	192	836
1954	1071	690	315	141	106	90	208	418	469	115	192	836
1955	1071	690	315	141	106	90	208	418	469	115	192	836
1956	1071	690	315	141	102	90	208	418	469	115	192	836
1957	1071	690	315	141	106	90	208	418	469	115	192	836
1958	1071	690	315	141	106	90	208	418	469	115	192	836
1959	1071	690	315	141	106	90	108	418	469	115	192	836
1960	1071	690	315	141	102	90	208	418	469	115	192	836
1961	1071	690	315	141	106	90	208	418	469	115	192	836
1962	1071	690	315	141	106	90	208	418	469	115	192	836
1963	1071	690	315	141	106	90	208	418	469	115	192	836
1964	1071	690	315	141	102	90	208	418	469	115	192	836
1965	1071	690	315	141	106	90	208	418	469	115	192	836
1966	1071	690	315	141	106	90	108	418	469	115	192	836
1967	1071	690	315	141	106	90	208	418	469	115	192	836
1968	1071	690	315	141	102	90	208	418	469	115	192	836
1969	1071	690	315	141	106	90	208	418	469	115	192	836
1970	1071	690	315	141	106	90	208	418	469	115	192	836
1971	1071	690	315	141	106	90	208	418	469	115	192	836
1972	1071	690	315	141	102	90	208	418	469	115	192	836
1973	1071	690	315	141	106	90	208	418	469	115	192	836
1974	1071	690	315	141	106	90	208	418	469	115	192	836
1975	1071	690	315	141	106	90	208	418	469	115	192	836
1976	1071	690	315	141	102	90	208	418	469	115	192	836
1977	1071	690	315	141	106	68	156	314	352	86	144	627
1978	803	517	236	106	80	90	208	418	469	115	192	836
1979	1071	690	315	141	106	90	208	418	469	115	192	836
1980	1071	690	315	141	102	90	208	418	469	115	192	836

Table 13. SOD CVP Refuge Deliveries												
CFS												
	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1981	1071	690	315	141	106	90	208	418	469	115	82	836
1982	1071	690	315	141	106	90	208	418	469	115	192	836
1983	1071	690	315	141	106	90	208	418	469	115	192	836
1984	1071	690	315	141	102	90	208	418	469	115	192	836
1985	1071	690	315	141	106	90	208	418	469	115	192	836
1986	1071	690	315	141	106	90	208	418	469	115	192	836
1987	1071	690	315	141	106	90	208	418	469	115	192	836
1988	1071	690	315	141	102	90	208	418	469	115	192	836
1989	1071	690	315	141	106	90	208	418	469	115	192	836
1990	1071	690	315	141	106	90	208	418	469	115	192	836
1991	1071	690	315	141	106	68	156	314	352	86	144	627
1992	803	517	236	106	77	68	156	314	352	86	144	627
1993	803	517	236	106	80	90	208	418	469	115	192	836
1994	1071	690	315	141	106	68	156	314	352	86	144	627
1995	803	517	236	106	80	90	208	418	469	115	192	836
1996	1071	690	315	141	102	90	208	418	469	115	192	836
1997	1071	690	315	141	106	90	208	418	469	115	192	836
1998	1071	690	315	141	106	90	208	418	469	115	192	836
1999	1071	690	315	141	106	90	208	418	469	115	192	836
2000	1071	690	315	141	102	90	208	418	469	115	192	836
2001	1071	690	315	141	106	90	208	418	469	115	192	836
2002	1071	690	315	141	106	90	208	418	469	115	192	836
2003	1071	690	315	141	106	90	208	418	469	115	192	836

Table 14. SOD CVP Losses

CFS												
	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1922	114	83	85	110	181	167	232	329	512	568	472	185
1923	114	83	85	110	181	167	232	329	512	568	472	185
1924	114	83	85	110	174	167	232	329	512	568	472	185
1925	114	83	85	110	181	167	232	329	512	568	472	185
1926	114	83	85	110	181	167	232	329	512	568	472	185
1927	114	83	85	110	181	167	232	329	512	568	472	185
1928	114	83	85	110	174	167	232	329	512	568	472	185
1929	114	83	85	110	181	167	232	329	512	568	472	185
1930	114	83	85	110	181	167	232	329	512	568	472	185
1931	114	83	85	110	181	167	232	329	512	568	472	185
1932	114	83	85	110	174	167	232	329	512	568	472	185
1933	114	83	85	110	181	167	232	329	512	568	472	185
1934	114	83	85	110	181	167	232	329	512	568	472	185
1935	114	83	85	110	181	167	232	329	512	568	472	185
1936	114	83	85	110	174	167	232	329	512	568	472	185
1937	114	83	85	110	181	167	232	329	512	568	472	185
1938	114	83	85	110	181	167	232	329	512	568	472	185
1939	114	83	85	110	181	167	104	329	512	568	472	185
1940	114	83	85	110	174	167	232	329	512	568	472	185
1941	114	83	85	110	181	167	232	329	512	568	472	185
1942	114	83	85	110	181	167	232	329	512	568	472	185
1943	114	83	85	110	181	167	232	329	512	568	472	185
1944	114	83	85	110	174	167	232	329	512	568	472	185
1945	114	83	85	110	181	167	232	329	512	568	472	185
1946	114	83	85	110	181	167	232	329	512	568	472	185
1947	114	83	85	110	181	167	232	329	512	568	472	185
1948	114	83	85	110	174	167	232	329	512	568	472	185
1949	114	83	85	110	181	167	232	329	512	568	472	185
1950	114	83	85	110	181	167	232	329	512	568	472	185
1951	114	83	85	110	181	167	232	329	512	568	472	185
1952	114	83	85	110	174	167	232	329	512	568	472	185
1953	114	83	85	110	181	167	232	329	512	568	472	185
1954	114	83	85	110	181	167	232	329	512	568	472	185
1955	114	83	85	110	181	167	232	329	512	568	472	185
1956	114	83	85	110	174	167	232	329	512	568	472	185
1957	114	83	85	110	181	167	232	329	512	568	472	185
1958	114	83	85	110	181	167	232	329	512	568	472	185
1959	114	83	85	110	181	167	104	329	512	568	472	185
1960	114	83	85	110	174	167	232	329	512	568	472	185
1961	114	83	85	110	181	167	232	329	461	568	472	185
1962	114	83	85	110	181	167	232	329	512	568	472	185
1963	114	83	85	110	181	167	232	329	512	568	472	185
1964	114	83	85	110	174	167	232	329	512	568	472	185
1965	114	83	85	110	181	167	232	329	512	568	472	185
1966	114	83	85	110	181	167	104	329	512	568	472	185
1967	114	83	85	110	181	167	232	329	512	568	472	185
1968	114	83	85	110	174	167	232	329	512	568	472	185
1969	114	83	85	110	181	167	232	329	512	568	472	185
1970	114	83	85	110	181	167	232	329	512	568	472	185
1971	114	83	85	110	181	167	232	329	512	568	472	185
1972	114	83	85	110	174	167	232	329	512	568	472	185
1973	114	83	85	110	181	167	232	329	512	568	472	185
1974	114	83	85	110	181	167	232	329	512	568	472	185
1975	114	83	85	110	181	167	232	329	512	568	472	185
1976	114	83	85	110	174	167	232	329	512	568	472	185
1977	114	83	85	110	181	167	232	329	512	568	472	185
1978	114	83	85	110	181	167	232	329	512	568	472	185
1979	114	83	85	110	181	167	232	329	512	568	472	185
1980	114	83	85	110	174	167	232	329	512	568	472	185

Table 14. SOD CVP Losses												
CFS												
	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1981	114	83	85	110	181	167	232	329	512	568	472	185
1982	114	83	85	110	181	167	232	329	512	568	472	185
1983	114	83	85	110	181	167	232	329	512	568	472	185
1984	114	83	85	110	174	167	232	329	512	568	472	185
1985	114	83	85	110	181	167	232	329	512	568	472	185
1986	114	83	85	110	181	167	232	329	512	568	472	185
1987	114	83	85	110	181	167	232	329	512	568	472	185
1988	114	83	85	110	174	167	232	329	512	568	472	185
1989	114	83	85	110	181	167	232	329	512	568	472	185
1990	114	83	85	110	181	167	232	329	512	568	472	185
1991	114	83	85	110	181	167	232	329	512	568	472	185
1992	114	83	85	110	174	167	232	329	512	568	472	185
1993	114	83	85	110	181	167	232	329	512	568	472	185
1994	114	83	85	110	181	167	232	329	461	568	472	185
1995	114	83	85	110	181	167	232	329	512	568	472	185
1996	114	83	85	110	174	167	232	329	512	568	472	185
1997	114	83	85	110	181	167	232	329	512	568	472	185
1998	114	83	85	110	181	167	232	329	512	568	472	185
1999	114	83	85	110	181	167	232	329	512	568	472	185
2000	114	83	85	110	174	167	232	329	512	568	472	185
2001	114	83	85	110	181	167	232	329	512	568	472	185
2002	114	83	85	110	181	167	232	329	512	568	472	185
2003	114	83	85	110	181	167	232	329	512	568	472	185

Table 15. Friant Kern Canal Deliveries

CFS												
	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1922	81	67	16	16	234	963	3099	3528	4436	3653	3199	1789
1923	626	161	107	682	1305	816	1652	2074	2951	3102	2719	1526
1924	541	146	93	93	690	247	312	437	918	1141	707	428
1925	318	149	16	16	167	616	1122	1556	2269	2382	2155	1156
1926	422	126	73	73	413	570	1037	1435	2090	2195	1987	1069
1927	393	121	68	68	382	891	1744	2208	4017	3289	2882	1615
1928	570	151	98	98	731	638	1163	1613	2351	2468	2232	1195
1929	434	128	75	75	427	368	463	657	1425	1780	1075	630
1930	466	200	16	16	249	359	452	640	1386	1730	1046	615
1931	454	196	16	16	242	161	207	284	568	702	419	288
1932	217	114	16	16	193	899	1811	2292	3263	3429	3004	1682
1933	591	155	101	101	789	580	1055	1463	2134	2241	2028	1090
1934	400	122	69	69	389	327	412	581	1248	1557	946	560
1935	414	182	16	16	220	802	1624	2041	2905	3053	2676	1503
1936	534	145	92	92	471	1169	1639	3262	3283	3130	2743	1539
1937	545	147	94	94	390	508	1356	1911	4121	3070	2691	1511
1938	536	146	430	1263	1907	326	782	1687	4462	4487	3580	2208
1939	897	278	220	220	1024	785	1925	1376	2002	2103	1904	1026
1940	380	119	66	66	353	795	1567	2217	3397	2873	2519	1417
1941	506	140	87	87	573	1541	3075	2485	4362	3777	3391	2093
1942	852	266	209	541	1926	957	1886	3466	4396	3621	3172	1774
1943	625	160	106	102	2033	508	1464	3184	3250	3203	2807	1574
1944	557	149	95	95	712	624	1137	1577	2301	2416	2186	1171
1945	427	127	74	74	390	932	1855	2360	3433	3548	3107	1739
1946	610	158	595	1218	986	778	1574	2201	2774	2916	2557	1437
1947	512	141	88	88	826	602	1096	1519	2213	2323	2103	1128
1948	413	124	72	72	389	389	588	838	1840	2302	1376	797
1949	586	241	16	16	316	541	983	1362	1985	2085	1888	1017
1950	377	118	66	66	363	601	1095	1518	2212	2323	2102	1128
1951	413	122	1271	1271	1603	631	1150	1594	2325	2441	2208	1183
1952	430	127	74	74	832	706	1735	1742	4450	3792	3405	2101
1953	856	267	210	508	1100	680	1371	1722	2448	2638	2322	1274
1954	460	132	79	79	455	576	1048	1452	2116	2222	2011	1081
1955	397	122	69	69	386	566	1030	1428	2082	2186	1979	1065
1956	392	121	68	68	1567	1725	1984	2538	4236	3851	3372	1883
1957	656	166	112	112	885	677	1365	1714	2437	2626	2312	1269
1958	458	132	79	79	453	921	1609	2435	4448	3774	3389	2091
1959	852	266	209	209	889	583	1128	1461	2128	2235	2023	1087
1960	399	122	69	69	375	345	435	616	1328	1658	1005	592
1961	438	190	16	16	233	256	325	456	962	1197	739	445
1962	331	153	16	16	174	848	1719	2158	3073	3229	2830	1587
1963	561	150	96	96	1478	919	1865	2343	3337	3507	3072	1719
1964	603	157	103	103	779	520	943	1305	1901	1997	1809	977
1965	364	116	63	1207	1549	882	1789	2247	3200	3363	2946	1650
1966	581	153	100	567	987	676	1348	2446	2340	2456	2222	1190
1967	433	128	70	119	1614	2338	1115	1554	4204	4482	3626	2520
1968	1720	551	484	484	1787	466	585	832	1824	2282	1365	790
1969	582	240	16	16	313	636	541	1223	2993	4480	3423	2238
1970	1529	495	430	1040	1758	1127	1428	1793	2549	2680	2351	1325
1971	476	135	82	82	619	643	1172	1625	2372	2489	2252	1206
1972	438	129	76	76	416	536	973	1348	1962	2061	1867	1006
1973	373	118	65	65	359	841	1637	1955	4089	3037	2662	1495
1974	531	145	91	1291	1202	1616	1710	3360	4251	3207	2811	1576
1975	557	149	96	96	739	869	1721	2176	3551	3235	2835	1589
1976	561	150	96	96	719	376	473	671	1453	1815	1095	642
1977	474	202	16	16	253	169	216	298	601	742	447	301
1978	226	117	16	16	116	846	1143	1880	4325	4486	3716	2427
1979	1657	533	467	1039	2020	1489	1631	2933	3604	3024	2651	1489
1980	529	144	91	80	377	895	1125	3308	4460	4146	3559	2195

Table 15. Friant Kern Canal Deliveries

CFS												
	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1981	892	277	219	219	934	653	1315	1650	2343	2525	2224	1222
1982	443	130	77	77	1636	2307	541	2927	4461	3969	3563	2197
1983	2093	1477	151	112	568	91	956	1480	2351	4467	3869	2873
1984	1959	1391	521	1753	2042	1257	1597	2005	2852	2998	2628	1476
1985	525	144	90	90	691	596	1084	1502	2187	2296	2078	1116
1986	409	124	71	71	390	465	3033	3448	4429	3497	3063	1714
1987	602	157	103	103	804	483	875	1209	1891	2366	1413	817
1988	601	246	16	16	313	340	428	606	1306	1630	988	583
1989	431	188	16	16	230	395	497	705	1533	1916	1153	674
1990	497	210	16	16	266	301	380	535	1144	1426	871	518
1991	384	172	16	16	204	422	530	754	1648	2060	1237	720
1992	530	222	16	16	275	363	457	646	1397	1744	1055	619
1993	458	197	16	16	336	1156	3131	3486	4349	3790	3319	1854
1994	647	165	111	111	871	491	890	1230	1790	1881	1705	923
1995	346	113	60	218	1530	1036	2631	2029	4076	4468	3874	2876
1996	1961	622	553	553	2045	829	2772	3141	4180	3268	2863	1605
1997	567	151	91	91	658	1969	1583	2591	2725	2865	2513	1413
1998	505	140	87	87	390	902	565	1578	2572	4481	3577	2657
1999	1813	578	511	511	1953	715	1445	1814	2579	2711	2378	1340
2000	481	136	83	83	604	796	1598	2007	3265	2946	2583	1452
2001	517	142	89	89	679	568	1033	1432	2085	2190	1983	1066
2002	393	121	68	68	381	518	940	1301	1892	1988	1801	972
2003	362	116	63	63	347	623	1136	1575	2297	2411	2182	1169

Table 16. Madera Canal Deliveries												
CFS												
	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1922	0	0	0	0	2	0	476	957	1250	1225	1064	400
1923	48	5	0	6	5	117	322	617	855	1000	867	322
1924	39	0	0	0	0	0	0	111	301	369	257	36
1925	0	0	0	0	0	0	0	263	793	963	665	106
1926	0	0	0	0	0	0	0	238	711	865	597	94
1927	0	0	0	0	0	116	348	671	1072	1080	937	350
1928	38	2	1	1	3	0	0	277	834	1013	699	112
1929	0	0	0	0	0	0	0	159	457	557	386	58
1930	0	0	0	0	0	0	0	155	445	543	376	56
1931	0	0	0	0	0	0	0	77	194	140	49	246
1932	0	0	0	0	4	117	366	703	974	1138	987	369
1933	48	5	0	0	0	0	0	242	726	882	609	96
1934	0	0	0	0	0	0	0	142	403	491	341	50
1935	0	0	0	0	0	65	107	645	894	1045	906	337
1936	49	0	0	0	32	59	329	824	916	1011	876	326
1937	30	5	1	1	65	43	517	791	1101	987	855	317
1938	38	0	3	12	0	9	219	1124	1250	1250	1221	462
1939	35	15	0	0	14	32	143	229	683	830	573	90
1940	0	0	0	0	0	78	302	622	1174	1250	930	145
1941	0	0	0	0	107	15	14	1016	1250	1250	1250	568
1942	75	20	10	13	11	68	391	932	1213	1231	1069	402
1943	51	5	0	52	29	168	337	820	925	1041	903	336
1944	41	1	0	0	0	0	0	268	809	983	678	108
1945	0	0	0	0	155	107	379	732	1029	1190	1033	388
1946	48	5	5	12	14	109	301	617	789	923	800	296
1947	36	0	0	0	22	0	0	255	765	929	641	102
1948	0	0	0	0	0	0	0	199	585	712	492	76
1949	0	0	0	0	0	0	0	227	676	822	568	89
1950	0	0	0	0	0	0	0	255	764	929	641	102
1951	0	0	201	62	68	0	0	272	821	998	688	110
1952	0	0	0	0	5	3	249	1076	1250	1250	1195	451
1953	67	10	0	3	15	0	0	302	916	1112	767	124
1954	0	0	0	0	0	0	0	241	720	875	604	96
1955	0	0	0	0	0	0	0	237	709	861	595	94
1956	0	0	130	274	28	221	411	795	1215	1250	1171	442
1957	59	8	0	0	0	0	0	300	911	1105	762	123
1958	0	0	0	0	0	31	3	1082	1250	1250	1183	447
1959	66	10	0	0	0	0	11	242	724	880	608	96
1960	0	0	0	0	0	0	0	150	428	521	362	54
1961	0	0	0	0	0	0	0	115	315	385	268	38
1962	0	0	0	0	0	87	343	655	908	1060	920	343
1963	43	1	0	0	31	138	379	720	998	1166	1012	379
1964	38	7	0	0	0	0	0	219	648	788	545	85
1965	0	0	0	12	78	130	359	683	947	1106	960	359
1966	43	1	0	5	9	1	0	421	829	1006	694	111
1967	0	0	0	0	50	217	14	1250	1250	1250	1250	812
1968	257	15	11	9	45	0	0	197	580	706	488	76
1969	0	0	0	114	0	3	285	1166	1250	1250	1156	646
1970	70	19	0	6	5	32	0	318	968	1175	810	131
1971	0	0	0	0	0	0	0	279	845	1026	708	113
1972	0	0	0	0	0	0	0	225	669	813	562	88
1973	0	0	0	0	0	24	326	626	1080	973	843	313
1974	29	2	1	54	21	192	338	850	1092	1043	904	337
1975	41	1	0	0	0	47	347	668	998	1073	931	347
1976	44	1	0	0	0	0	0	162	466	568	393	59
1977	0	0	0	0	0	0	0	80	204	251	49	154
1978	0	0	0	0	97	13	3	1250	1250	1250	1250	734
1979	171	10	0	6	2	21	317	755	949	967	838	311
1980	38	0	0	154	234	103	522	1064	1250	1250	1213	458

Table 16. Madera Canal Deliveries												
CFS												
	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1981	59	10	0	0	0	0	0	285	862	1047	722	116
1982	0	0	0	0	40	10	116	1169	1250	1250	1250	542
1983	232	92	217	232	2	0	34	1250	1250	1250	1250	986
1984	193	102	226	64	38	184	308	590	818	957	829	307
1985	37	0	0	0	0	0	0	251	751	913	630	100
1986	0	0	0	0	215	149	488	902	1225	1162	1008	378
1987	47	8	0	0	0	0	0	204	601	731	505	79
1988	0	0	0	0	0	0	0	148	421	513	356	53
1989	0	0	0	0	0	0	0	169	491	597	414	63
1990	0	0	0	0	0	0	0	132	371	453	315	46
1991	0	0	0	0	0	0	0	180	526	640	443	68
1992	0	0	0	0	0	0	0	157	449	547	379	57
1993	0	0	0	0	4	45	517	945	1222	1250	1134	427
1994	55	5	0	0	0	0	0	207	612	744	514	80
1995	0	0	0	1	57	78	311	1250	1250	1250	1250	1113
1996	418	21	13	10	24	227	484	821	1092	1067	926	345
1997	35	3	98	698	136	246	304	684	1060	1250	923	144
1998	0	0	0	0	94	47	83	1250	1250	1250	1250	928
1999	198	56	43	34	57	0	0	323	984	1194	823	133
2000	0	0	0	0	0	17	316	605	897	959	831	308
2001	8	7	5	4	4	0	0	238	710	863	596	94
2002	0	0	0	0	0	0	0	218	646	785	543	85
2003	0	0	0	0	0	0	0	268	807	980	676	108

Table 17. Stockton East / Central San Joaquin Deliveries

CFS												
	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1922	145	103	90	76	76	85	118	299	458	501	385	227
1923	138	103	90	76	76	111	97	284	471	515	394	195
1924	142	103	90	76	76	135	283	340	387	417	327	209
1925	117	103	90	76	76	85	97	207	470	542	414	241
1926	156	103	90	76	76	5	0	110	211	237	164	69
1927	11	0	0	0	0	85	97	300	450	521	398	239
1928	121	103	90	76	74	85	105	299	457	498	382	232
1929	155	103	90	76	76	0	81	150	147	206	142	59
1930	19	2	0	0	0	0	0	0	0	0	0	0
1931	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	0	0	0	0	0	0	0	0	0
1936	0	0	0	0	0	0	12	121	200	237	164	58
1937	12	2	0	0	0	85	97	300	458	506	388	234
1938	144	103	90	76	76	85	97	264	476	526	401	234
1939	127	105	90	76	76	85	273	295	417	450	349	206
1940	138	106	90	76	74	85	97	318	460	498	382	231
1941	139	106	90	76	76	85	97	269	469	518	396	238
1942	140	103	90	76	76	85	97	152	481	566	429	250
1943	153	103	90	76	76	85	97	286	462	510	390	236
1944	146	103	90	76	74	85	185	299	443	481	371	226
1945	125	103	90	76	76	85	148	318	451	489	377	227
1946	117	103	90	76	76	85	183	303	439	474	367	224
1947	138	103	90	76	76	85	275	351	392	439	342	214
1948	117	103	90	76	74	0	0	53	220	264	182	76
1949	11	1	0	0	0	0	60	126	179	212	146	62
1950	21	0	0	0	0	0	28	117	215	239	162	46
1951	0	0	0	0	0	85	210	294	423	472	372	228
1952	130	103	90	76	74	85	97	298	461	499	378	236
1953	158	103	90	76	76	85	208	316	390	465	375	231
1954	143	103	90	76	76	85	192	313	417	464	353	233
1955	155	103	90	76	76	93	195	296	432	462	379	208
1956	150	103	90	76	74	85	220	297	449	476	360	203
1957	123	106	90	76	76	85	228	246	420	491	379	234
1958	129	105	90	76	76	85	97	230	456	538	405	237
1959	160	107	90	76	76	88	247	363	394	463	357	147
1960	151	106	90	76	74	0	76	129	164	209	145	61
1961	21	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	76	136	171	214	149	62
1963	0	0	0	0	0	0	0	113	216	249	165	59
1964	4	0	0	0	0	2	117	135	161	200	134	56
1965	3	0	0	0	0	85	97	310	470	507	355	236
1966	152	103	90	76	76	85	262	330	402	433	340	214
1967	148	103	90	76	76	85	97	209	449	554	421	247
1968	151	103	90	76	74	85	216	320	422	459	355	221
1969	137	103	90	76	76	85	97	314	469	508	390	221
1970	129	103	90	76	76	85	180	331	422	470	363	224
1971	137	103	90	76	76	85	208	293	432	468	361	222
1972	144	103	90	76	74	148	241	346	391	429	334	194
1973	129	103	90	76	76	85	143	343	447	484	372	221
1974	117	103	90	76	76	85	97	305	460	479	410	244
1975	132	103	90	76	76	85	97	307	465	510	365	237
1976	122	105	90	76	98	203	258	330	372	403	283	197
1977	144	103	90	76	101	0	0	0	0	0	0	0
1978	0	0	0	0	0	85	97	265	477	522	399	209
1979	157	103	90	76	76	85	118	315	462	489	384	233
1980	127	103	90	76	74	85	165	292	453	456	377	230

Table 17. Stockton East / Central San Joaquin Deliveries												
CFS												
	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1981	151	106	90	76	76	85	144	295	456	499	383	231
1982	119	103	90	76	76	85	97	285	482	552	419	173
1983	117	103	90	76	76	85	97	157	501	587	431	208
1984	146	103	90	76	74	85	201	347	422	463	358	221
1985	117	103	90	76	76	85	179	339	425	481	366	206
1986	131	103	90	76	76	85	103	297	472	516	396	181
1987	157	106	90	76	76	85	188	332	429	463	358	222
1988	136	103	90	76	74	26	62	121	178	204	140	59
1989	17	0	0	0	0	0	0	0	0	0	0	0
1990	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
1992	0	0	0	0	0	0	0	0	0	0	0	0
1993	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
1995	0	0	0	0	0	85	97	231	446	540	410	245
1996	158	103	90	76	74	85	97	182	479	567	429	252
1997	122	103	90	76	76	85	152	346	428	475	360	226
1998	141	103	90	76	76	85	97	115	494	594	448	255
1999	126	103	90	76	76	85	141	332	440	480	370	218
2000	146	103	90	76	74	85	117	281	447	528	401	236
2001	117	103	90	76	76	85	148	297	443	493	381	220
2002	145	103	90	76	76	0	78	127	181	202	140	59
2003	20	0	0	0	0	0	6	101	207	240	156	71

Introduction

There is reasonable concern about how climate change might affect the economic and hydrologic parameters that determine the CVP Cost Allocation. Analysis depicting some project benefits and single-purpose facility sizing has been performed using historical hydrology. Reclamation maintains that 1) the direction and magnitude of climate change effects on cost allocation parameters are difficult to state due to multiple areas of uncertainty, and 2) it is not cost-effective or appropriate to generate multiple cost allocations based upon economic and hydrologic conditions which are not yet known with certainty. To address concerns, a statistical investigation was undertaken to determine whether historical hydrology falls within the range of potential climate futures and thus is a suitable basis from which to perform analysis that defines the Cost Allocation. It will be demonstrated that:

1. Historic inflows to the Sacramento and San Joaquin Rivers (the selected measure of water supplies) are not statistically different from the Central Tendency of projected future inflows.
2. The range of projected future inflows brackets the historic range of inflows.
3. Historic total CVP deliveries are not statistically different than the Central Tendency of projected future deliveries.
4. The range of projected future deliveries brackets the historic range of deliveries.

Climate Scenarios

The purpose of the statistical testing was to evaluate whether the historical water supplies and deliveries are significantly different than would occur under future climate conditions. To make this assessment, water supply and delivery results from the Sacramento and San Joaquin Basins Study (SSJBS) were used. Five future climate scenarios were developed for Reclamation's recently published SSJBS (Reclamation 2016) using bias-corrected and spatially downscaled global climate model simulation results from the Coupled Model Intercomparison Project Phase 5 (CMIP5). The CMIP5 dataset consist of 175 individual climate projections which are the most recent projections made by the International Panel on Climate Change (IPCC) for the IPCC Fifth Assessment Report (IPCC 2013). The five climate scenarios were based on ensembles of individual CMIP5 temperature and precipitation projections. These future climate scenarios along with a historically based reference climate were used to simulate 21st century climate-informed inflows and demands in the Sacramento and San Joaquin Basins. For the SSJBS, the WEAP-CV model was used to simulate watershed water supply and demands. The CalLite-CV model was used to simulate water deliveries based on the WEAP-CV projected reservoir inflows and water demands. The CalLite-CV model is similar to the CalSim2 model used as the basis for water deliveries in the Cost Allocation Study. Both models simulate CVP demands, but the CalLite-CV has a more simplified representation of water management

operations. Although simplified, the CalLite-CV model was calibrated to simulate CalSim2 results.

The six climate scenarios used in the statistical analyses representing potential future climate conditions include:

- No Climate Change (NoCC) – This reference climate was developed based on a historic period reconstruction developed by Liveneh (2013). The NoCC scenario has a starting date of 10/1925 and covers an 85-year period of record.
- Central Tendency (CEN, or Q5) – This ensemble includes a large number of individual projections bounded by the 25th and 75th percentiles of temperature and precipitation changes. Relative to the other potential future climate scenarios, the Q5 scenario includes a substantially greater number of individual projections than any of the other scenarios.
- Warm Dry (WD, or Q1) – This ensemble is formed from 10 individual projections that are closest to the intersection of 10th percentiles of temperature increases and precipitation decreases¹.
- Hot Dry (HD, or Q2) – This ensemble is formed from 10 individual projections that are closest to the intersection of 90th and 10th percentiles of temperature increases and percent precipitation changes respectively.
- Hot Wet (HW, or Q3) – This ensemble is formed from 10 individual projections that are closest to the intersection of 90th percentiles of temperature increases and percent precipitation changes.
- Warm Wet (HW, or Q4) – This ensemble is formed from 10 individual projections that are closest to the intersection of 10th and 90th percentiles of temperature increase and percent precipitation changes respectively.

This scenario-based approach allows the uncertainty contained in the 175 CMIP5 individual climate projections (small blue dots on Figure 1) to be represented by five future climate scenarios. Figure 1 shows the relationships between the individual climate projections and the five representative ensemble-informed climate scenarios.

¹ Note: The 10th percentile of the percent precipitation change means there are only 10% of projections that are drier. Similarly, the 90th percentile of the percent precipitation change means there are only 10% of projections that are wetter.

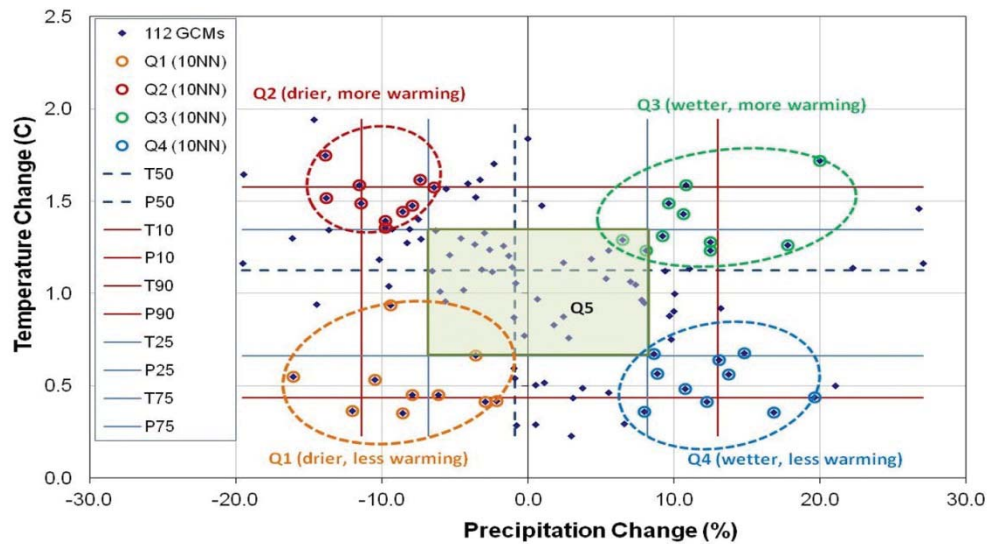


Figure 1. Relationship between changes in mean annual temperature and precipitation. The Y axis shows temperature change from 0 degrees to 2.5 degrees Celsius. The X axis shows precipitation change ranging from 30% less to 30% more. This figure is presented as an example of how the climate scenarios are formed from ensembles of projections and does not represent actual data used in the analyses.

Additional information on the future climate conditions, development of climate scenarios, and simulation of hydroclimate and water delivery is available in the SSJBS Technical Report (<http://www.usbr.gov/watersmart/bsp/>).

Statistical Tests

Using these climate scenarios (Q1, Q2, Q3, Q4, and Q5) and the historic climate reconstruction (NoCC), the SSJBS simulated both CVP water supplies and deliveries. To evaluate the significance of differences between the historic and potential future water supplies and CVP deliveries, the medians of these results were statistically compared. The statistical analyses were performed using the nonparametric Mann-Whitney test because the distribution of these water supplies and deliveries are most likely not normally distributed. And even if they were normally distributed, a non-parametric test would still provide valid results, especially for the large water supply and delivery datasets employed in the statistical testing. The Mann-Whitney analysis tests the Null hypothesis that the medians of two datasets are not equal. For the tests performed here, the Null hypothesis is that the median of the NoCC scenario is not equal to medians of Q1, Q2, Q3, Q4, and Q5 inflow and delivery data sets. All tests were performed at a 0.05 level of significance (i.e., there is a less than 5% chance of rejecting the Null hypothesis when in fact it is true). Test results were considered significant when the P-value was less than 0.05. When the P-value is greater than or equal to 0.05, the Null hypothesis is rejected. Rejecting the Null hypothesis implies the data sets being compared are statistically different, while failing to reject (accepting) the Null hypothesis implies the data sets being compared are statistically the same.

CalLite-CV Inflow Analyses

The Mann-Whitney analyses compared monthly inflows to the Sacramento and San Joaquin rivers by evaluating whether the NoCC median results in the 85-year historic period from 1925 to 2009 were statistically different than the medians of five climate scenarios results in the future period from 2014 to 2099. Boxplots of total monthly inflows for each of the climate scenarios are shown in Figures 2 and 3 below².

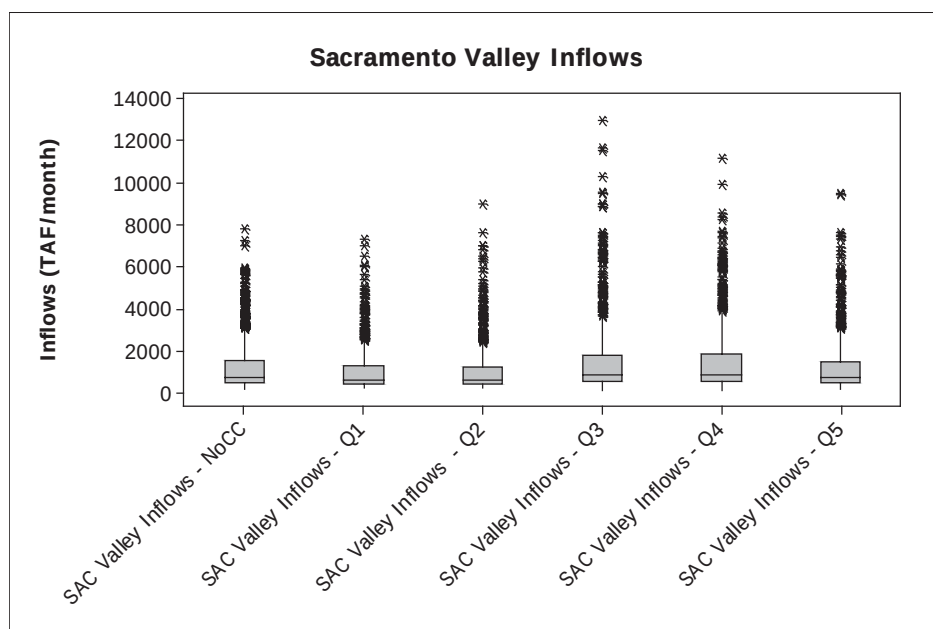


Figure 2. Simulated Sacramento Valley monthly inflows during the 2014 to 2099 simulation period.

² Note: Asterisks in Figures 2 and 3 do NOT represent statistical outliers and were included in the analyses.

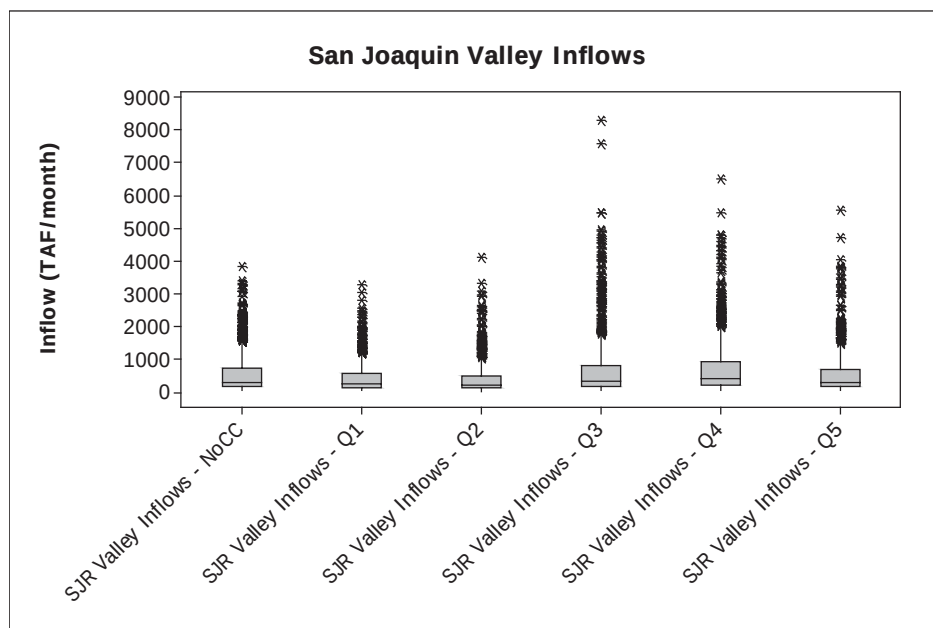


Figure 3. Simulated San Joaquin Valley monthly inflows during the 2014 to 2099 simulation period.

The total period inflows for the NoCC and percent differences between the NoCC and each of the climate scenarios are presented in Table 1 below.

Total Period 2014-2099	Climate Scenarios					
	NoCC	Q1	Q2	Q3	Q4	Q5
Total Inflows	TAF	% Change wrt NoCC				
SAC	1,232,029	-14	-15	23	23	3
SJR	557,065	-22	-24	29	33	0.3

Table 1.

Note: The Sacramento River (SAC) and San Joaquin River (SJR) inflows presented in the table are the sum of the basin inflows during the 85-year simulation period from 2014 to 2099.

Mann-Whitney tests of inflows to both the Sacramento and San Joaquin Valleys reveal that the Null hypothesis that NoCC median is not equal to Q5 median is the only comparison among the five future climate scenarios that cannot be rejected (P value > 0.05). All of the other climate scenarios are significantly different from the NoCC (P value < 0.05). Furthermore, the Q1-Q4 scenario inflows bracket NoCC scenario inflows, with the wetter scenarios Q3 and Q4 having more inflow and the drier scenarios having less inflow. The Q5 inflows are not statistically different from the NoCC inflows.

The Mann-Whitney test results for each of the comparisons of NoCC with the future climate scenarios follow³:

Mann-Whitney Test: SAC & SJR Valley Inflows – NoCC - Q1

N Median

SAC Valley Inflows - NoCC 1020 756.7

SAC Valley Inflows - Q1 1020 647.3

Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at P-value = 0.0000

N Median

N Median

SJR Valley Inflows - NoCC 1020 318.92

SJR Valley Inflows - Q1 1020 242.24

Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at P-value = 0.0000

Mann-Whitney Test: SAC & SJR Valley Inflows - NoCC - Q2

N Median

SAC Valley Inflows - NoCC 1020 756.7

SAC Valley Inflows - Q2 1020 625.1

Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at P-value = 0.0000

N Median

SJR Valley Inflows - NoCC 1020 318.92

SJR Valley Inflows - Q2 1020 223.68

Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at P-value = 0.0000

Mann-Whitney Test: SAC & SJR Valley Inflows - NoCC - Q3

N Median

SAC Valley Inflows - NoCC 1020 756.7

SAC Valley Inflows - Q3 1020 840.8

Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at P-value = 0.0001

N Median

SJR Valley Inflows - NoCC 1020 318.92

SJR Valley Inflows - Q3 1020 356.25

Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at P-value = 0.0053

³ Note: P-values > 0.05 indicate that median values of the NoCC and a particular ensemble scenario (Q1 to Q5) are NOT statistically significantly different. These P-values are highlighted in **bold** text.

Mann-Whitney Test: SAC & SJR Valley Inflows - NoCC- Q4

N Median

SAC Valley Inflows - NoCC 1020 756.7

SAC Valley Inflows - Q4 1020 857.5

Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at P-value = 0.0000

N Median

SJR Valley Inflows - NoCC 1020 318.92

SJR Valley Inflows - Q4 1020 400.59

Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at P-value = 0.0000

Mann-Whitney Test: SAC & SJR Valley Inflows - NoCC - Q5

N Median

SAC Valley Inflows - NoCC 1020 756.7

SAC Valley Inflows - Q5 1020 728.2

Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at **P-value = 0.7376**

N Median

SJR Valley Inflows - NoCC 1020 318.92

SJR Valley Inflows - Q5 1020 305.21

Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at **P-value = 0.1419**

CalLite-CV Delivery Analysis

Statistical analyses of CVP deliveries were also performed by comparing the median of annual CalLite-CV simulated CVP deliveries in the NoCC scenario (1925-2009) with the medians of each of the five climate scenarios (Q1 to Q5) in the future period from 2014-2099. Boxplots of the total annual CVP Deliveries for the NoCC and each of the climate scenarios are shown in Figure 4.

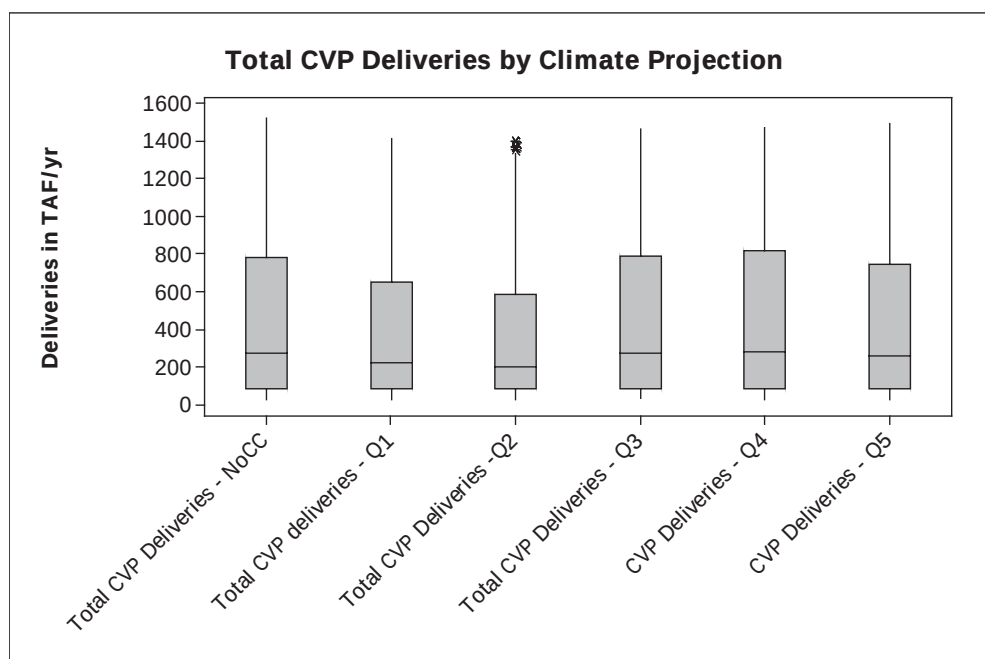


Figure 4. Total annual CVP deliveries by climate projection from 2014 to 2099.

The total period deliveries for the NoCC and percent differences for each of the climate scenarios are presented in Table 2 below.

Total Period 2014-2099	Climate Scenarios					
	NoCC	Q1	Q2	Q3	Q4	Q5
Total Deliveries	TAF	% Change wrt NoCC				
CVP	458,371	-17	-19	-1	4	-4

Table 2.

Note: The total deliveries and percent differences presented in Table 2 are based on the sum of the annual CVP deliveries during the 85-year simulation period.

The Mann-Whitney tests of total annual CVP deliveries indicate the Null hypothesis that the median NoCC deliveries are not equal to median Q3, Q4 and Q5 deliveries is rejected (P-values > 0.05). However, the Null hypothesis cannot be rejected for the Q1 and Q2 scenarios (P-values < 0.05). Therefore, the Q3, Q4, and Q5 median deliveries are not statistically different from the NoCC deliveries. The Q5 (Central Tendency) deliveries are very slightly less than under NoCC (see NoCC – Q5 test results below). The Q3 (Hot, Wet) total deliveries are nearly the same as NoCC; while the Q4 (Warm, Wet) are slightly larger than NoCC. Both the Q1 (Warm, Dry) and Q2 (Hot, Dry) median deliveries are considerably less than the NoCC median deliveries. Thus, the Q1, Q2 and Q4 scenarios bracket the NoCC scenario deliveries while the Q3 and Q5 deliveries are nearly the same as the NoCC deliveries.

The Mann-Whitney test results comparing the NoCC median deliveries to each of the climate scenario medians are presented below⁴:

Mann-Whitney Test: Total CVP Deliveries – NoCC - Q1

N Median

Total CVP Deliveries - NoCC 1020 270.30

Total CVP deliveries - Q1 1020 223.14

Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at P-value = 0.0237

Mann-Whitney Test: Total CVP Deliveries – NoCC - Q2

N Median

Total CVP Deliveries - NoCC 1020 270.30

Total CVP Deliveries -Q2 1020 200.23

Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at P-value = 0.0001

Mann-Whitney Test: Total CVP Deliveries – NoCC - Q3

N Median

Total CVP Deliveries - NoCC 1020 270.30

Total CVP Deliveries - Q3 1020 270.07

Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at **P-value = 0.9334**

Mann-Whitney Test: Total CVP Deliveries - NoCC- Q4

N Median

Total CVP Deliveries - NoCC 1020 270.30

CVP Deliveries - Q4 1020 279.56

Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at **P-value = 0.6000**

Mann-Whitney Test: Total CVP Deliveries - NoCC - Q5

N Median

Total CVP Deliveries - NoCC 1020 270.30

CVP Deliveries - Q5 1020 258.34

Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at **P-value = 0.6183**

⁴ Note: P-values > 0.05 indicate that median values of the NoCC and a particular ensemble scenario (Q1 to Q5) are NOT statistically different. These P-values are highlighted in **bold** text.

Seasonality Considerations

Climate change can affect the seasonal pattern of inflow as well as the total volume. Previous climate studies have indicated that inflows under climate change will be higher earlier in the water year and lower later in the water year, due to a shift in precipitation patterns and more precipitation falling as rain rather than snow (Reclamation 2016). The SSJBS inflows demonstrate this shift in monthly inflow pattern, as shown in Figure 5. However, CVP deliveries maintain a similar pattern for all climate scenarios (Figure 6).

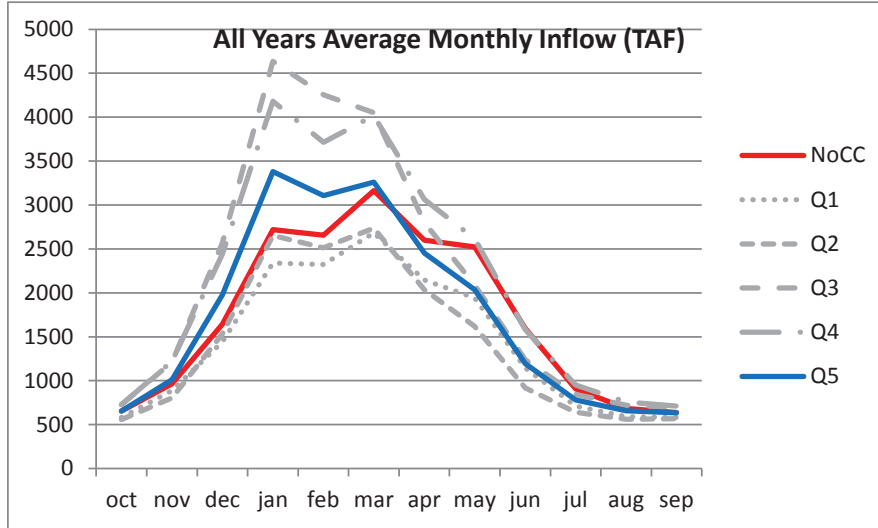


Figure 5. Inflow patterns under the SSJBS NoCC and Q1-Q5 climate scenarios.

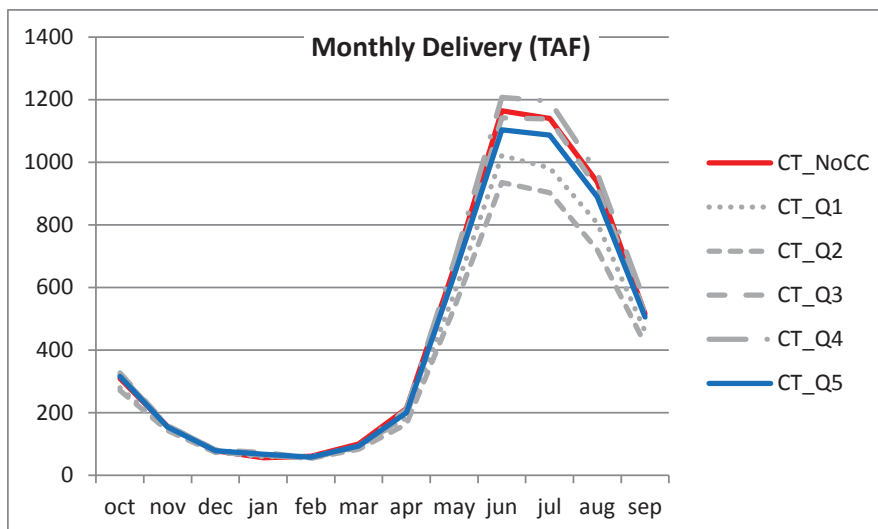


Figure 6. Delivery patterns under the SSJBS NoCC and Q1-Q5 climate scenarios.

Summary and Conclusions

In the previous sections, statistical testing demonstrated that differences between the NoCC historic reference climate and Central Tendency (Q5) future inflows were not statistically significantly different. Furthermore, the NoCC inflows were bracketed by the range of inflows exhibited by the Q1 – Q4 climate scenarios. Similarly, the NoCC deliveries were demonstrated to not be statistically significantly different from the Q3, Q4, and Q5 future climate scenario water deliveries. The NoCC water deliveries were also bracketed by the range of the Q1, Q2, and Q4 future climate scenario deliveries. Finally, changes in the seasonality of inflows occurring in the future climate scenarios were shown to not have a large impact on the delivery of CVP water supplies.

These conclusions support Reclamation's position that analysis performed with historical hydrology is a sufficient basis for determining the CVP Cost Allocation.

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Livneh, B., E. A. Rosenberg, C. Lin, V. Mishra, K. Andreadis, E. P. Maurer, and D.P. Lettenmaier. 2013. A long-term hydrologically based data set of land surface fluxes and states for the conterminous U.S.: Update and extensions, Journal of Climate, DOI: 10.1175/JCLI-D-12-00508.1.