

Central Valley Project Cost Allocation Study CalSim Modeling Documentation

DRAFT – For Discussion Purposes Only

Date

September 22, 2017

Purpose of Paper

Explain the hydrology modeling that has been used to determine single purpose alternative facility sizes which are the basis for cost estimates. Models that compute economic benefits of water supply, power, water quality, and fish and wildlife purposes use hydrology modeling results which quantify these project purposes as inputs.

Background

This section documents the hydrology modeling tools used and hydrology 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. Among the parameters used by the SCRБ methodology are single purpose alternative costs, separable costs, joint costs, and economic benefits. Hydrology modeling and analysis has been used to determine single purpose alternative facility sizes which are the basis for cost estimates. Models that compute economic benefits of water supply, power, water quality, and fish and wildlife purposes use hydrology modeling results which quantify these project purposes as inputs.

The CVP serves multiple purposes, and each CVP facility serves one or more project purposes. Most reservoirs are built to serve multiple purposes because this is more cost effective than building multiple reservoirs which each have a single purpose. SCRБ methodology uses the concept of a single purpose alternative which addresses the question “what size reservoir is required to serve only one purpose?” Single purpose facility sizing/costing for water supply, for example, ignores all other purposes for the facility in question and assumes that delivering water is its sole function. For a multi-purpose storage facility, the size that is required to satisfy a single purpose is typically smaller than the full size of the facility. On the other hand, all of the single purpose alternative (SPA) sizes of a particular project facility can add up to collectively be greater than the actual size of the facility.

Model applications used in the CAS analysis include CalSim2, a Flow Tracker, and the Single Purpose Facility Sizing Model. The CAS analysis used CalSim2 to depict project deliveries and

flows under a range of regulatory environments. These results were used as inputs to economic benefits models and to the sizing model. A Flow Tracker model was developed to identify State Water Project (SWP) storage release made specifically for Delta outflow – information needed as input to the sizing model.

Additional analysis included post-processing of CalSim2 results and evaluation of Central Valley Project Improvement Act (CVPIA) records. A spreadsheet post-processor for CalSim2 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.

Details on model assumptions and algorithms and other analyses will be provided in sections for each CVP purpose.

Water Supply Purpose

The CVP 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 depict 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.

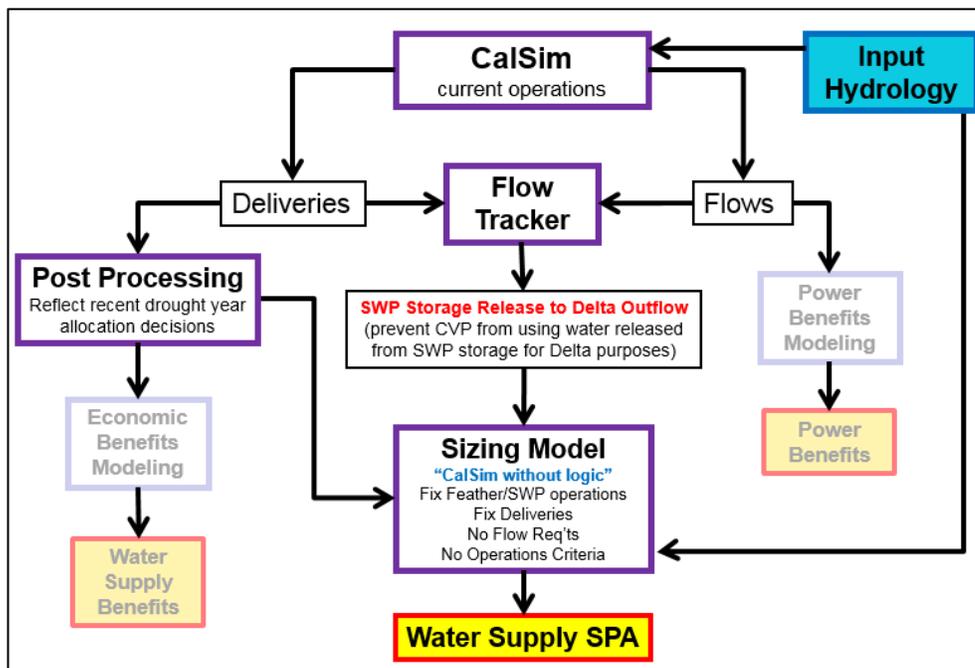


Figure 1 – Hydrology modeling and analysis for the CVP water supply purpose

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 CalSim2 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.

CalSim2 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 such as those taken in recent years 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, CVP agricultural deliveries were cut, then San Joaquin River 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 River Exchange Contractor deliveries lower than CVP contract obligation, taking into consideration San Joaquin River losses incurred to facilitate conveyance to Mendota Pool. Once 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 CalSim2 and Post Processing boxes. CalSim2 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 as inputs to the economics models which calculate water supply benefits.

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 C.W. “Bill” Jones Pumping Plant. The sizing model was used to determine the size that each facility must be in order to satisfy the modeled deliveries determined by the CalSim2 run and post-processing logic.

Figure 1 shows the pathway of model applications and data that calculates the SPA sizes for water supply. CalSim2 determines deliveries and flows under current operating conditions. CalSim2 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 CalSim2 delivery results; 2) Flow Tracker results for SWP storage release to Delta outflow; and 3) input hydrology.

The sizing model is described in 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. These are the single purpose sizes of the CVP storage facilities.

	Full Size (TAF)	Water Supply SPA (TAF)
Trinity	2447	709
Shasta	4552	1391
Folsom	967	181
New Melones	2420	640
Friant	524	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 re-fills 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.

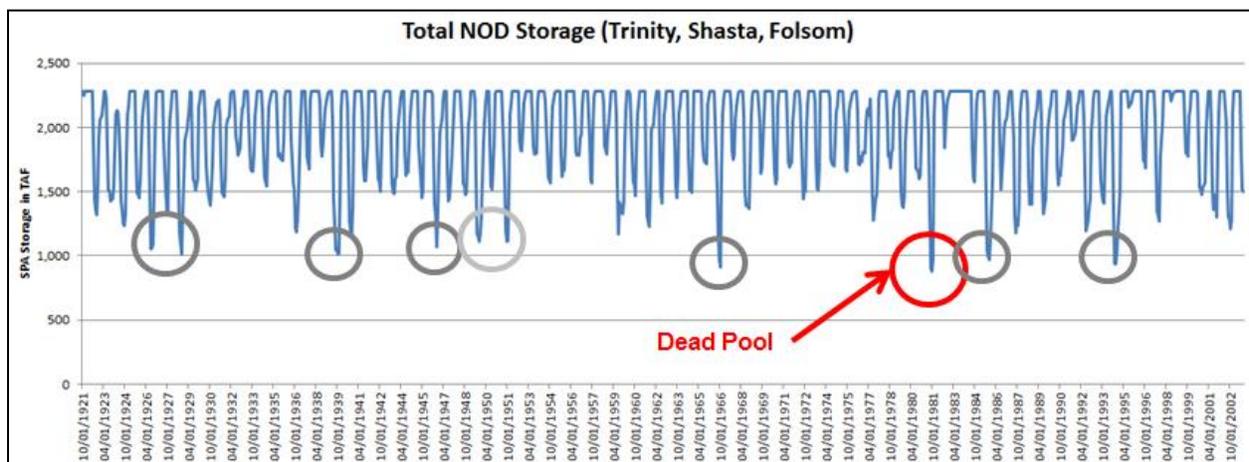


Figure 2 – Sequence of single purpose storage operations for water supply

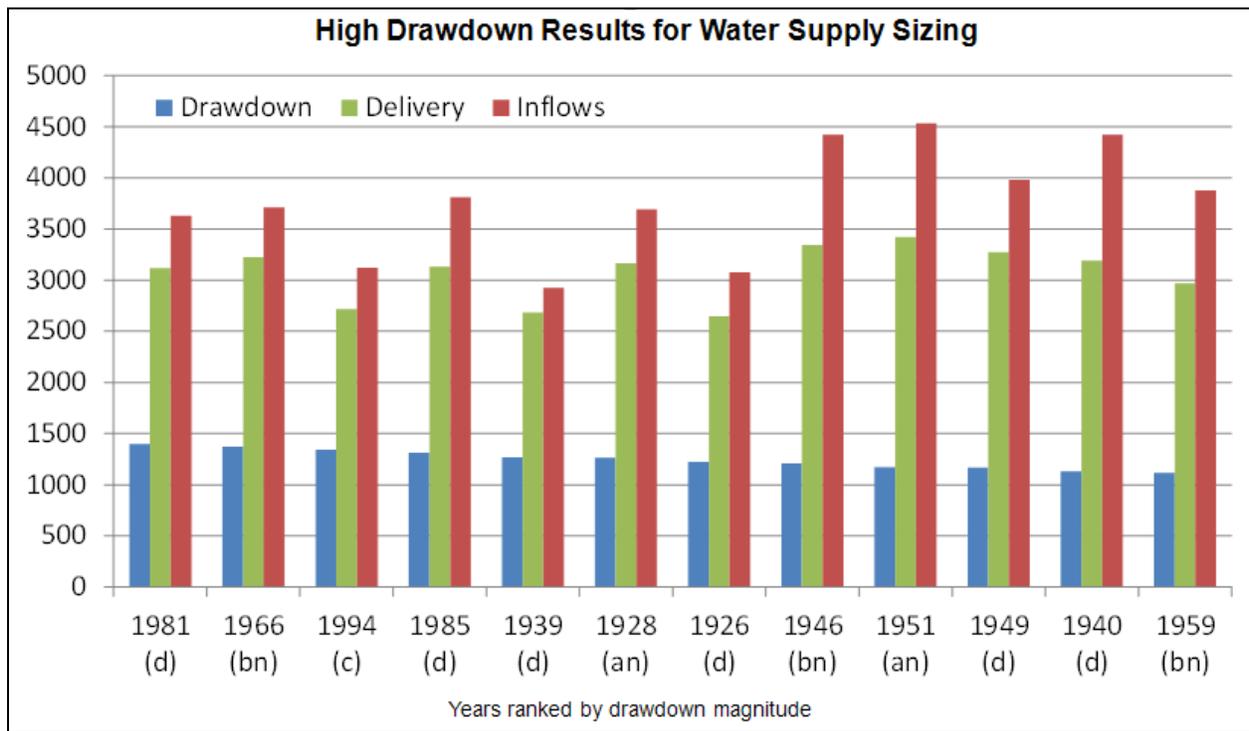


Figure 3 – Multiple years have drawdown needs similar to the year which defines NOD SPA sizes

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 Ag 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 to 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 considered to be reimbursable by water and power as joint costs in the SCR analysis, while incremental operations to meet the stricter standards of D-1641 are considered to be mitigation and therefore 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 CalSim2 studies were developed to represent system operations under both D-1641 and D-1485. 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 CalSim2 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” CalSim2 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-1641 and D-1485 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.

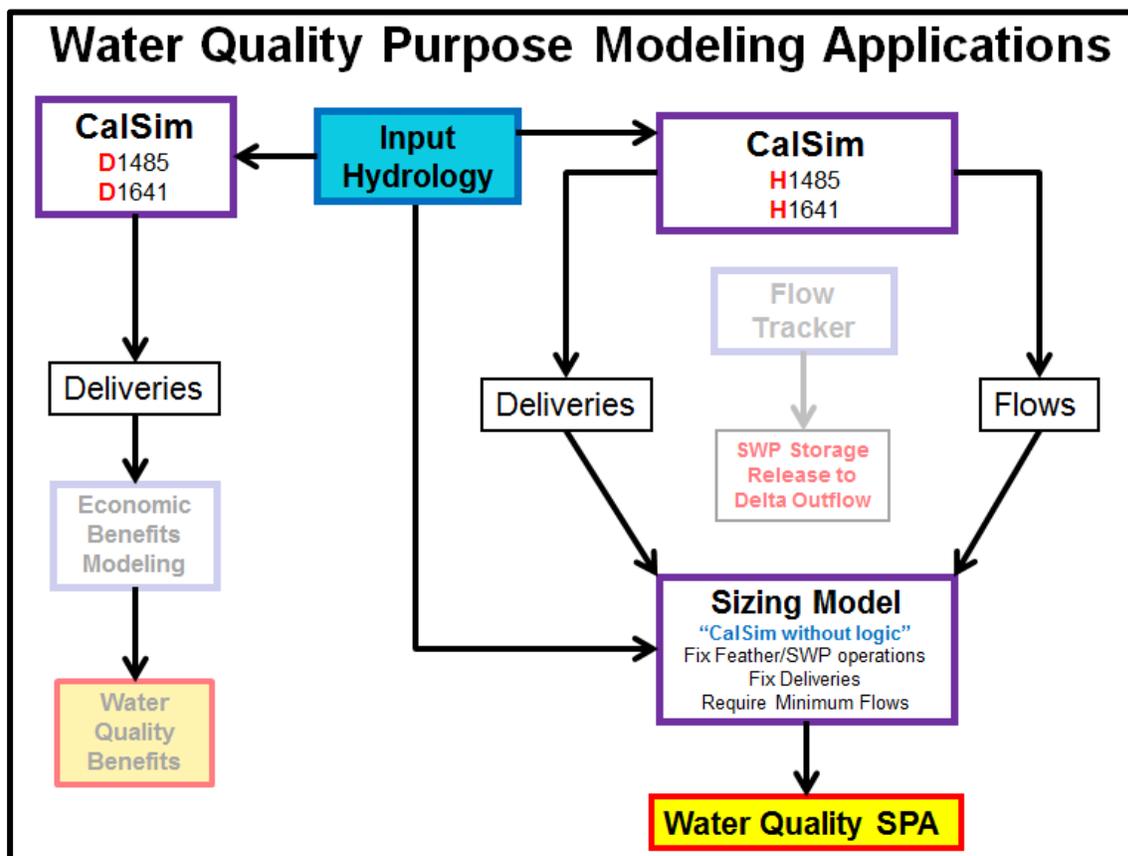


Figure 4 – Hydrology modeling and analysis for the CVP water quality purpose

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 CalSim2 studies. This is represented by the box labeled ‘CalSim H1485 H1641’. The H-1485 and H-1641 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 only flow – deliveries were inputs to the sizing model 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 greyed out. Feather River operations, which are still fixed, still 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 SPA’s for water quality.

New Melones does not appear in the table 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.

	Full Size	H-1485 (D-1485 with Current Deliveries)	H-1641 (D-1641 with Current Deliveries)	Difference = SPA storage size for water quality
Trinity	2447	1793	1905	112
Shasta	4552	3361	3567	206
Folsom	967	718	757	39

Table 2 – SPA storage size results for the water quality purpose (all values in TAF)

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 H-1485 and H-1641 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.

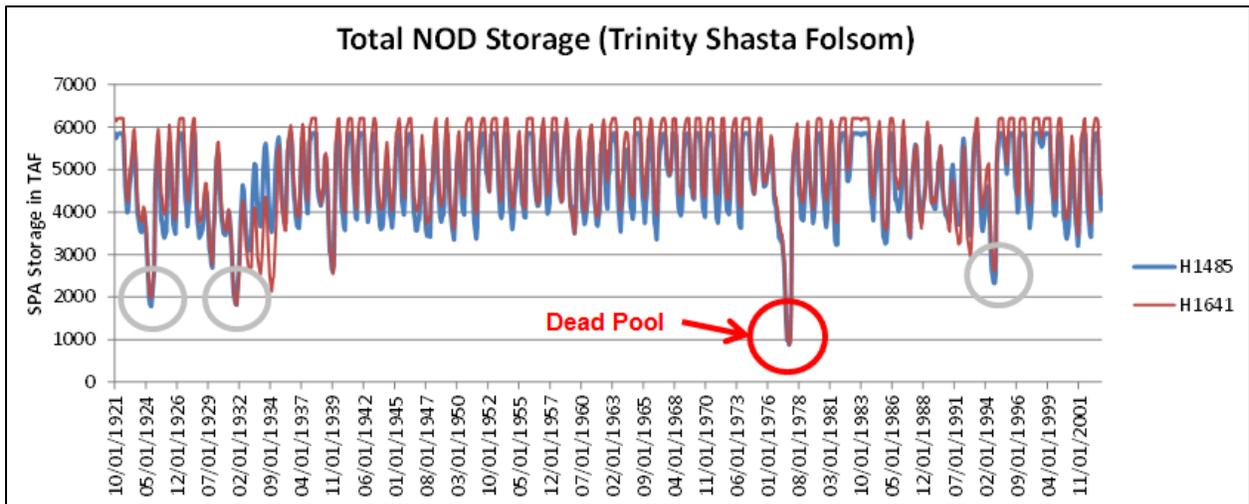


Figure 5 – Sequence of single purpose storage operations for water quality

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 H-1485 or H-1641 that matters, but rather the difference in the size of the largest drawdown in each run. Note the SPA’s 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 H-1485 and H-1641 runs, the SPA is determined by the three-year period from 1975-1977. 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.

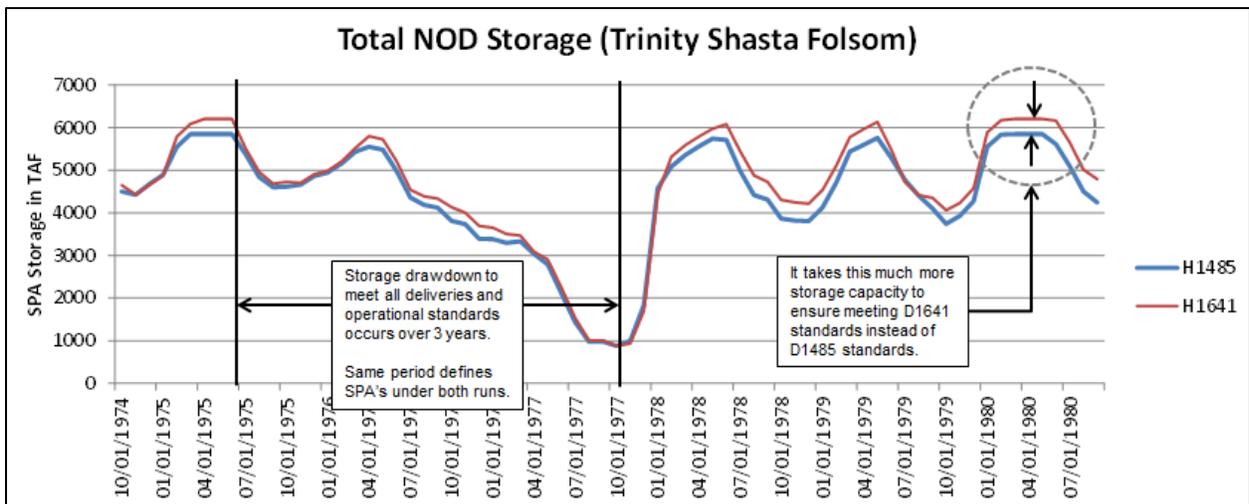


Figure 6 – Expanded view of the time period which defines the SPA for water quality

Sizing Facilities to Meet the Central Valley Improvement Act (CVPIA)

The CAS considers the single purpose alternative storage cost of producing CVPIA instream flow actions and of exports that are foregone due to CVPIA Delta actions. Due to the continuous and evolving nature of CVPIA accounting methodologies, it has not been possible to include a consistent long-term plan for CVPIA 3406(b)(2) (B2) actions in the CalSim2 model. Consequently, daily accounting records detailing historical storage releases and export

reductions used for actions from 2008-2014 were analyzed. A separate Tech Memo provided further details on the specific CVPIA B2 analysis process.

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 – 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 7:

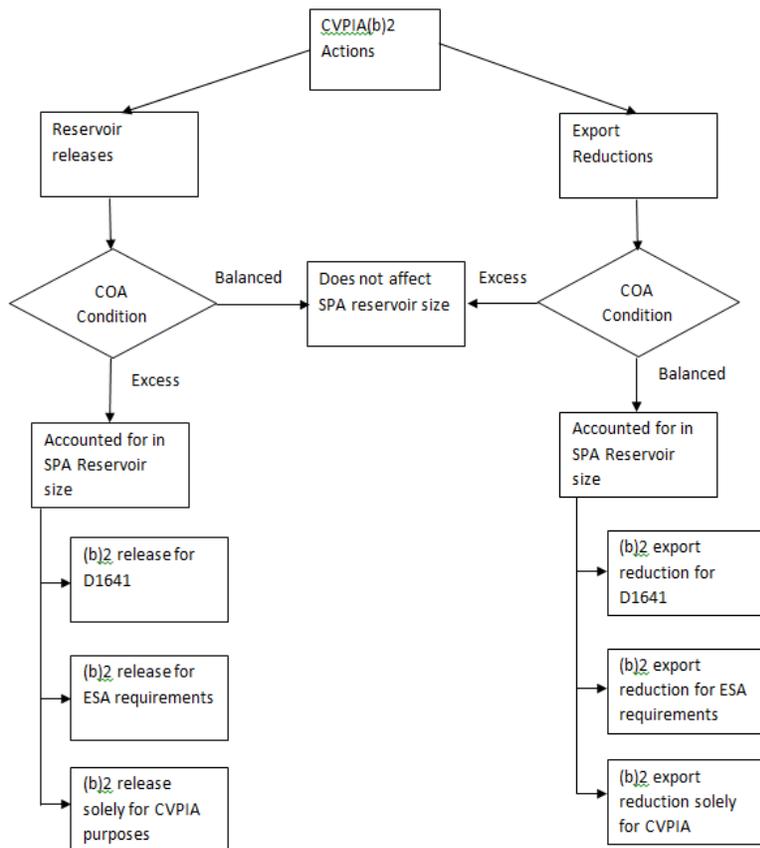


Figure 7 – Diagram describing the classification of (b)(2) actions for CVPIA cost allocation

The required storage for B2 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 8 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.

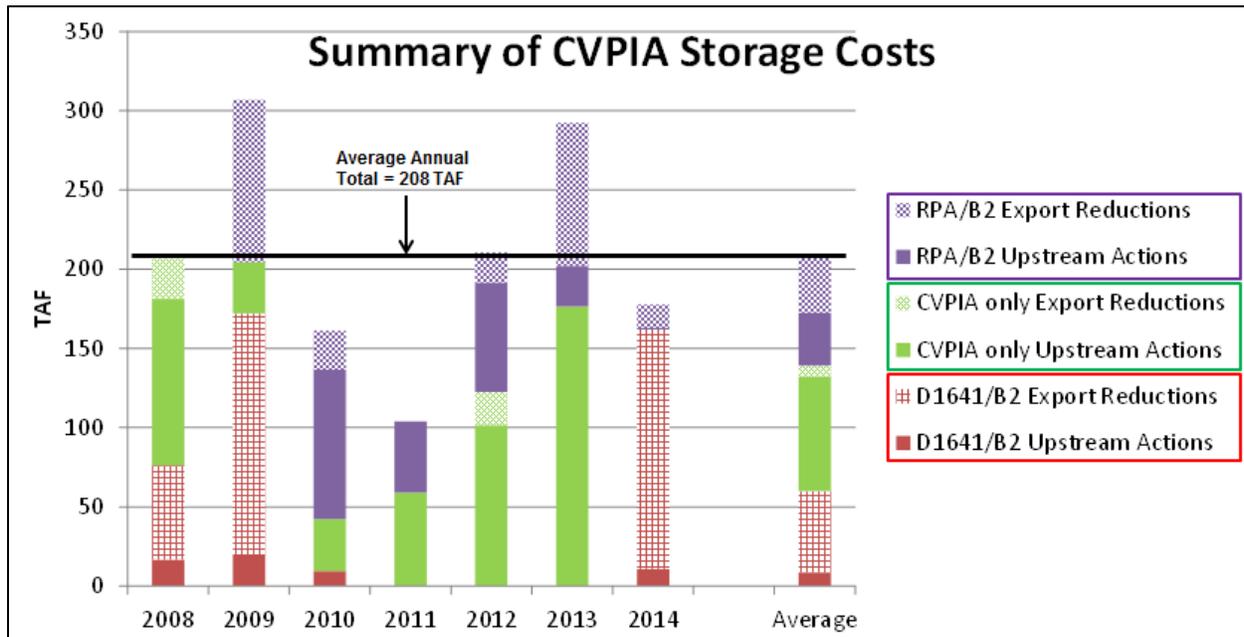


Figure 8 – Components of the storage costs for meeting CVPIA responsibilities, 2008-2014

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 9 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 U.S. Army Corps of Engineers or local flood protection authorities. Figure 10 shows a portion of the historical flood control rule curve for Folsom Lake, as used by the CalSim2 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 CalSim2 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 CalSim2.

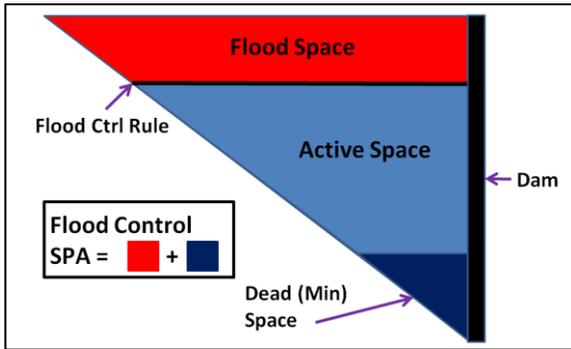


Figure 9 – Flood control rule concept

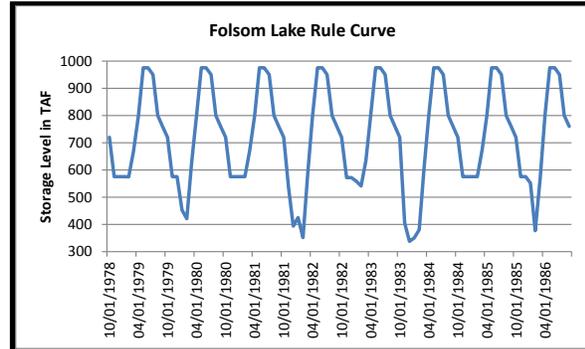


Figure 10 – Flood control rule curve example

	Minimum Flood Control Rule	Storage Capacity	Flood Space Required	Minimum Storage (Dead Pool)	Single Purpose Reservoir Size
Shasta	3250	4552	1302	550	1852
Folsom	367	967	670	90	690
New Melones	1970	2420	450	80	530
Millerton	350.5	524	173.5	135	308.5

Table 3 – Flood control rule method results - all values in TAF

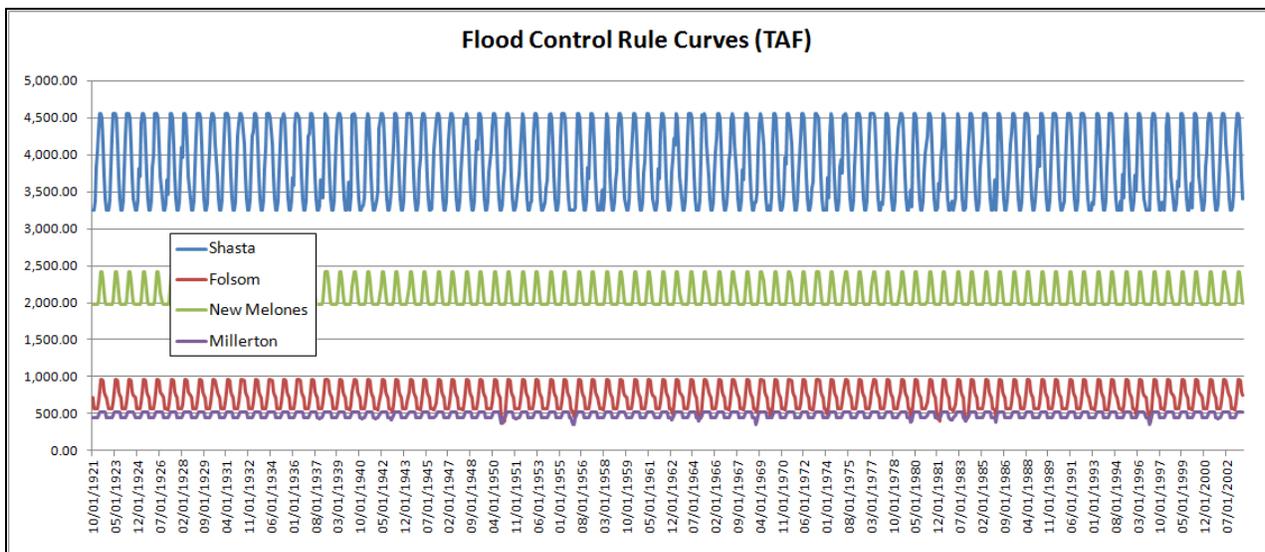


Figure 11 – Flood control rule curves used for CalSim2 planning studies

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 since flood control is not an explicitly authorized purpose but the dam instead 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 CalSim2 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 12. Reservoir releases are limited to prevent flows above 11,000 downstream of Lewiston Dam. Daily storage is determined as:

$$\text{Previous Day Storage} + \text{Inflow} - \text{Evaporation} - \min(\text{Discharge Capacity}, 11000 - \text{Trinity_Lewiston_Accretion}, (\text{Inflow} - \text{Evap} + \text{CarryoverStorage})).$$

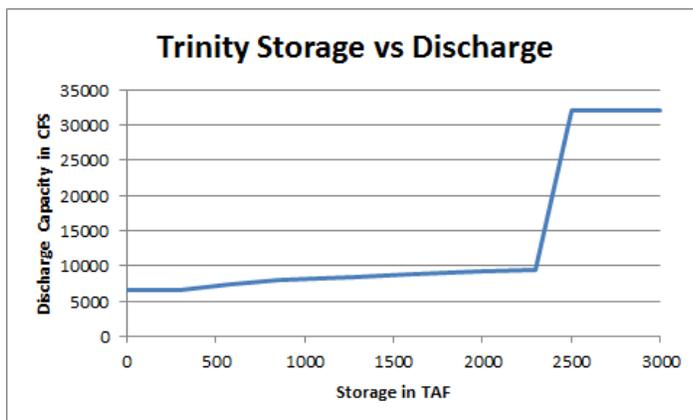


Figure 12 – Trinity storage vs. discharge capacity

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, and 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 13a, and an exceedance plot of the same data is shown in Figure 13b. 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.

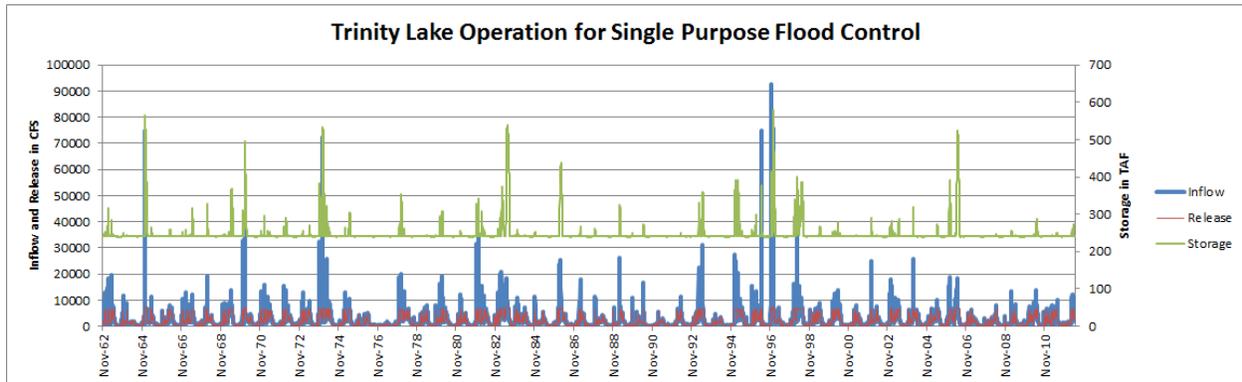


Figure 12a – Time series of Trinity Lake operation for flood control

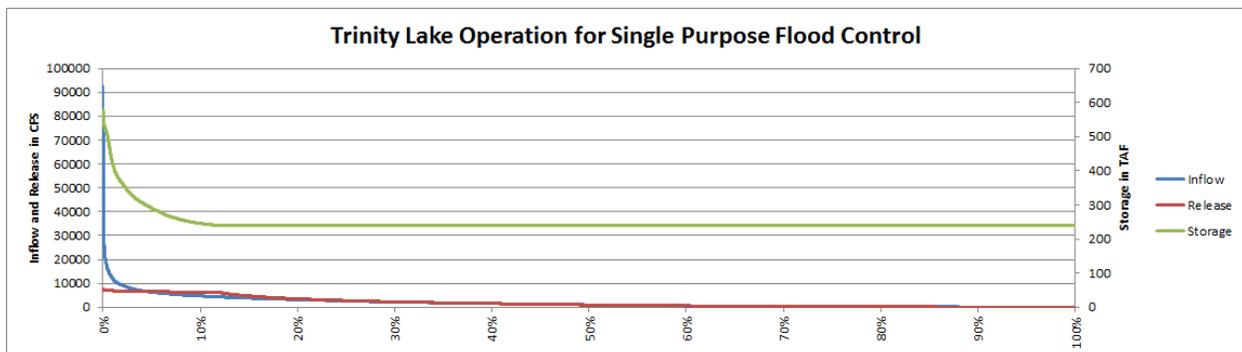


Figure 12b – Exceedance of Trinity Lake operation for flood control

Single Purpose Facility Sizing Model

The single purpose facility sizing model is essentially CalSim2 with no operations logic. It uses nearly the same schematic network as CalSim2, removing only the details of canal operations below the south delta pumping plants (Delta-Mendota Canal below Jones 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:

- CalSim2 schematic network (minus DMC below Jones and CAA below Banks)
- CalSim2 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 13a, 13b, and 13c. 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 13a represents a normal operation, equivalent to a general CalSim2 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.

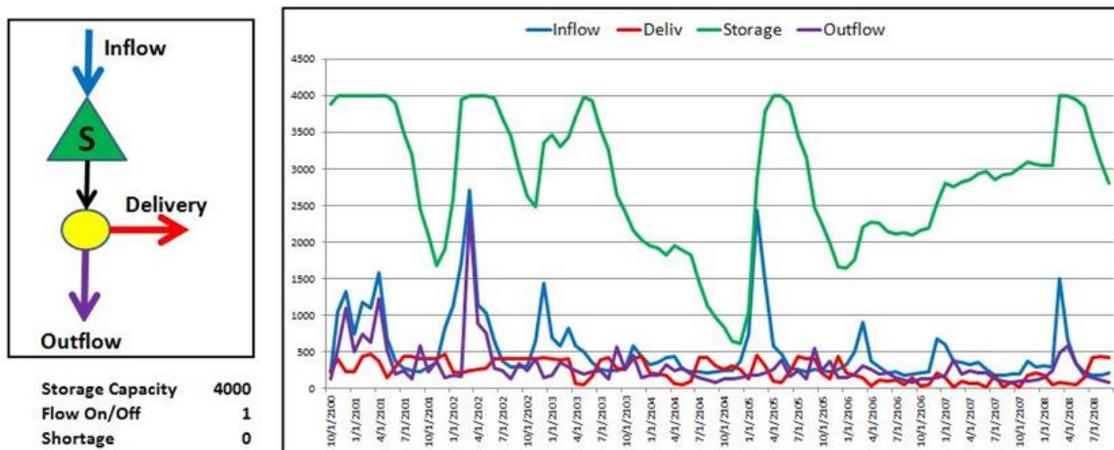


Figure 13a – Normal operation of the simple example system, equivalent to a normal CalSim2 run.

Figure 13b represents the first step in the sizing model analysis. To find the single purpose facility size for the deliveries determined in Figure 13a, 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 13b 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.

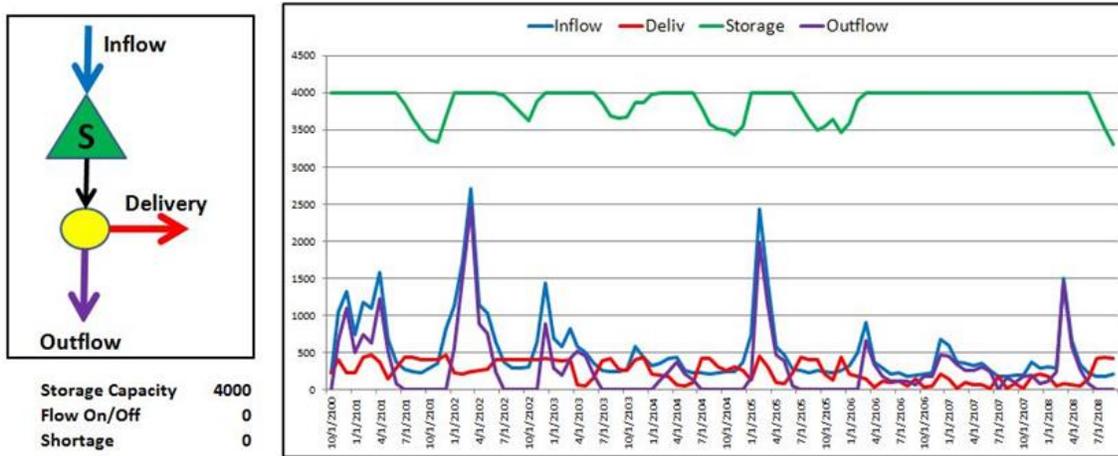


Figure 13b – Removal of operations unrelated to single purpose in question in simple example system

Figure 13c 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 13a. 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.

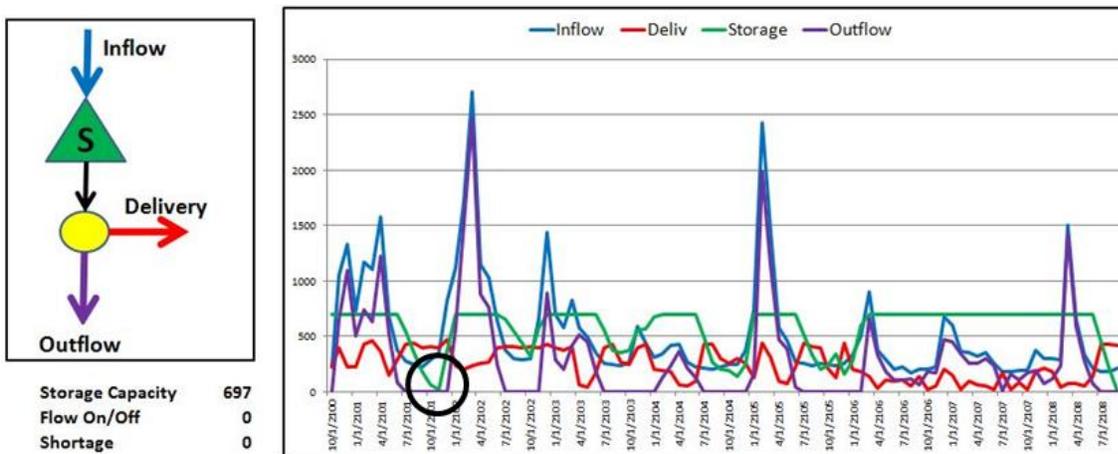


Figure 13c – Sizing model applied to simple example system, identifying minimum required storage

The 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 North

Bay Aqueduct, and Banks 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. 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 CalSim2. It takes as input the merged inputs and outputs of a CalSim2 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 be 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.