Russian River Watershed

Final Viability Assessment of the Forecast Informed Reservoir Operations at Lake Mendocino

Baseline Conditions

June 2020

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Lake Mendocino FIRO Steering Committee

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HEC-ResSim Model of the Baseline Alternative

I. Overview

This report describes the HEC-ResSim model for the existing condition alternative (named "Baseline") of the Final Viability Assessment (FVA) of Forecast Informed Reservoir Operations (FIRO) research and development project at Lake Mendocino in the Russian River watershed in the State of California. The HEC-ResSim baseline alternative represents current reservoir operation and boundary condition assumptions, such as extra-basin diversions and evaporation losses. The results serve as a "baseline" for relative comparisons to alternative reservoir operation plans.

HEC-ResSim version 3.4 Build 106, which is an unreleased development version, was used to model the reservoir operations. The reservoir systems model was developed using NGVD 29. The HEC-ResSim model contains one network named "POR" and simulates the reservoir operation for the Period of Record (POR) of 1985-2017. In addition, five scaled events were evaluated to capture possible flood events larger than those experienced: actual events from 1986, 1997, 2006, March 1995, and a synthetic event referred to as "Extended 2006".

The FVA HEC-ResSim model was derived from the HEC-ResSim model created by HEC on Feb 2018 for the Preliminary Viability Assessment (PVA) study for FIRO (HEC, 2018). HEC got the original PVA HEC-ResSim model from Sonoma Water and that watershed is the updated version of the HEC-ResSim model created by HEC on July 2012 (HEC, 2012).

II. Network Elements

Figure 1 shows the HEC-ResSim schematic displayed to the full extents of the Russian River watershed. The orange lines represent the stream alignment, with small green circles marking the endpoints and junctions. The light blue shapes indicate Lake Mendocino and Lake Sonoma. The red lines show the subbasin delineations. Red circles indicate HEC-ResSim junctions, which were created to establish locations for model inputs, outputs, or places of interest, such as gages providing observed values for model calibration. Many of the junctions indicate changes in stream flow, such as a confluence, diversion out of the river, or a contribution from a local subbasin. The white "halo" around certain junctions indicates a local flow assignment, where local flow enters the network. Some junctions also played a role in reservoir rules. Specifically, squares around a HEC-ResSim junction indicate that a reservoir operates to meet a flow requirement for that location.

The junctions are connected by reaches, dark blue lines, with small blue arrows that indicate direction of flow. Reaches are used to route flow along the river. The detail of the routing reaches are discussed in *Section VI* of this report. On the schematic (Figure 1), black arrows represent diversions, which are explained in detail in *Section VII* of this report. Each HEC-ResSim element carries a label, although the rendering is scale-dependent and usually few labels are visible unless the user has magnified a region in the schematic.

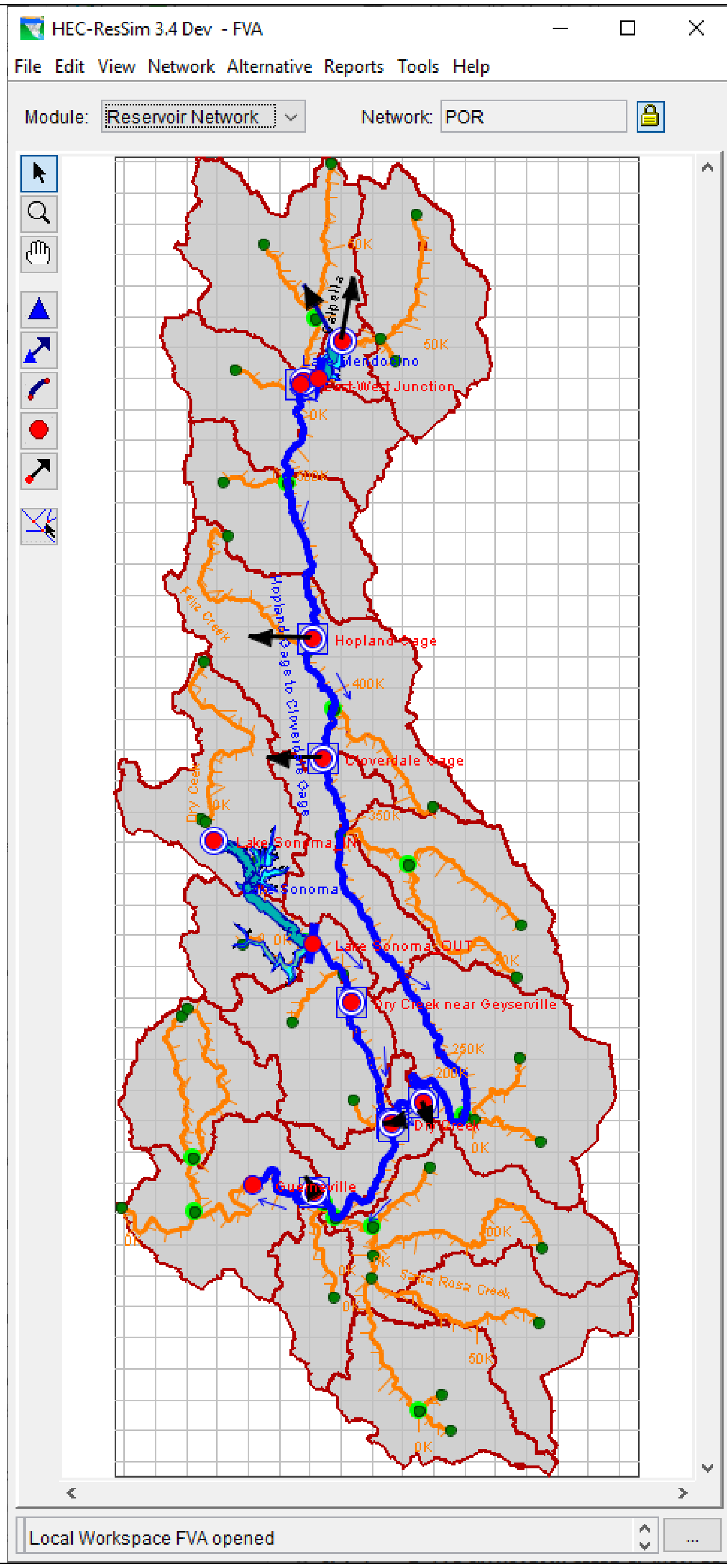


Figure 1 HEC-ResSim Schematic Display

A. Upper Watershed

Figure 2 shows an overview map of the upper part of the watershed, which includes the area above Lake Mendocino and the area below the confluence of East Fork and West Fork.

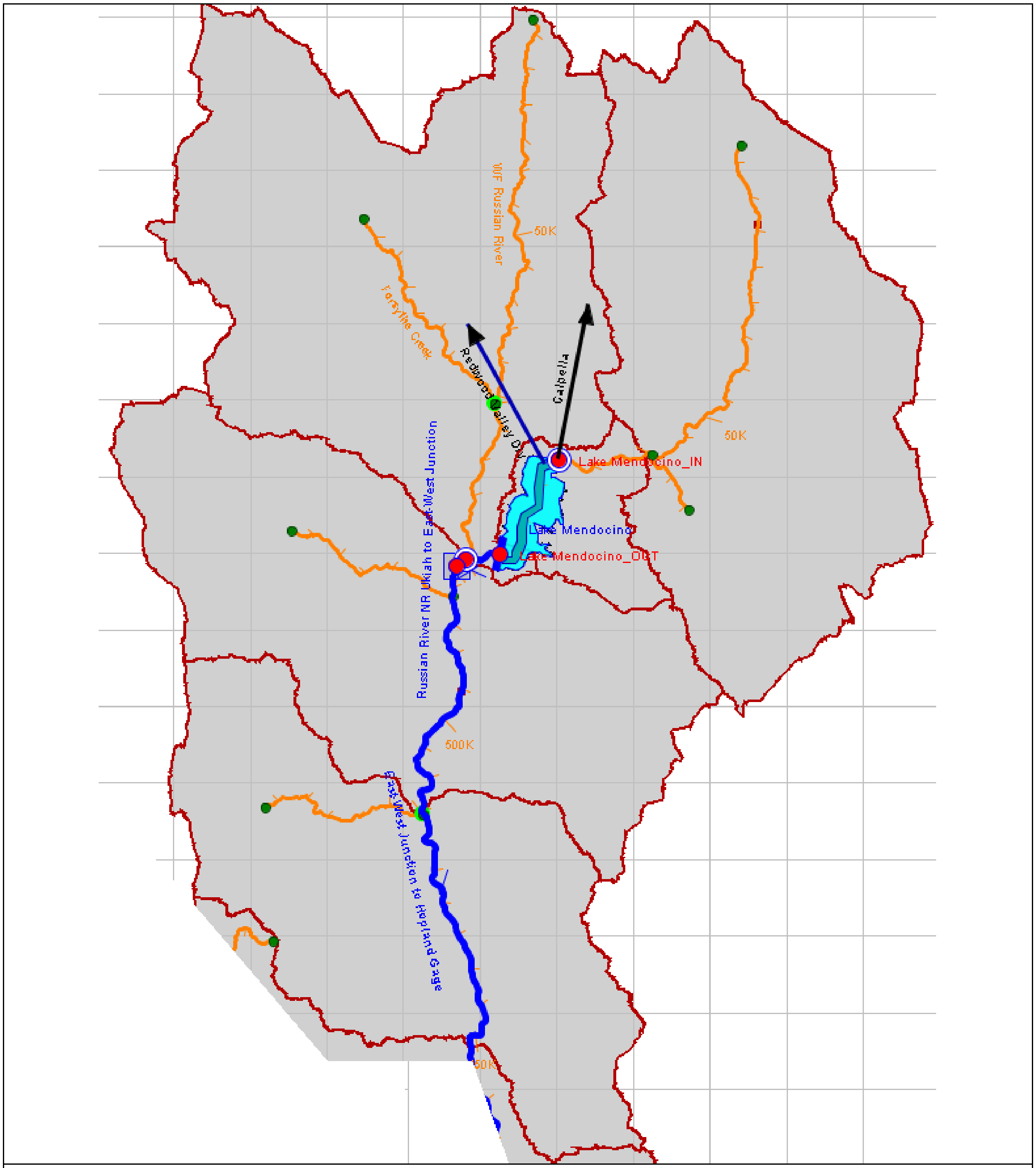


Figure 2 Overview Map_Upper Part of the Watershed

Figure 3 shows the key network elements in the upper part of the watershed.

The light blue area marked with the dotted circle in Figure 3 shows the location of Lake Mendocino. The reservoir pool contains a diversion named "Redwood Valley Div" and is shown with a dark blue arrow in Figure 3.

The "Lake Mendocino_IN" junction is the headwater junction on the East Fork Russian River and it marks the upstream end of the reservoir. Subbasin flows for the East Fork enter the HEC-ResSim model here, and provide the inflow to the reservoir. Diversion flows from the Eel River enter the Russian River at this junction (*Section VII.A*). The Calpella diversion also occurs here.

The downstream end of the reservoir is marked by the junction named "Lake Mendocino_OUT".

The "Russian River NR Ukiah Gage" junction is located very low in the West Fork, just above the confluence with the East Fork, and is the headwater junction on the West Fork Russian River. The flows for the West Fork subbasin are added at this location. Flows at this location play a role in Lake Mendocino flood operation rules.

The "East-West" junction marks the confluence of East Fork and West Fork, and Lake Mendocino operates to provide minimum flows at this location.

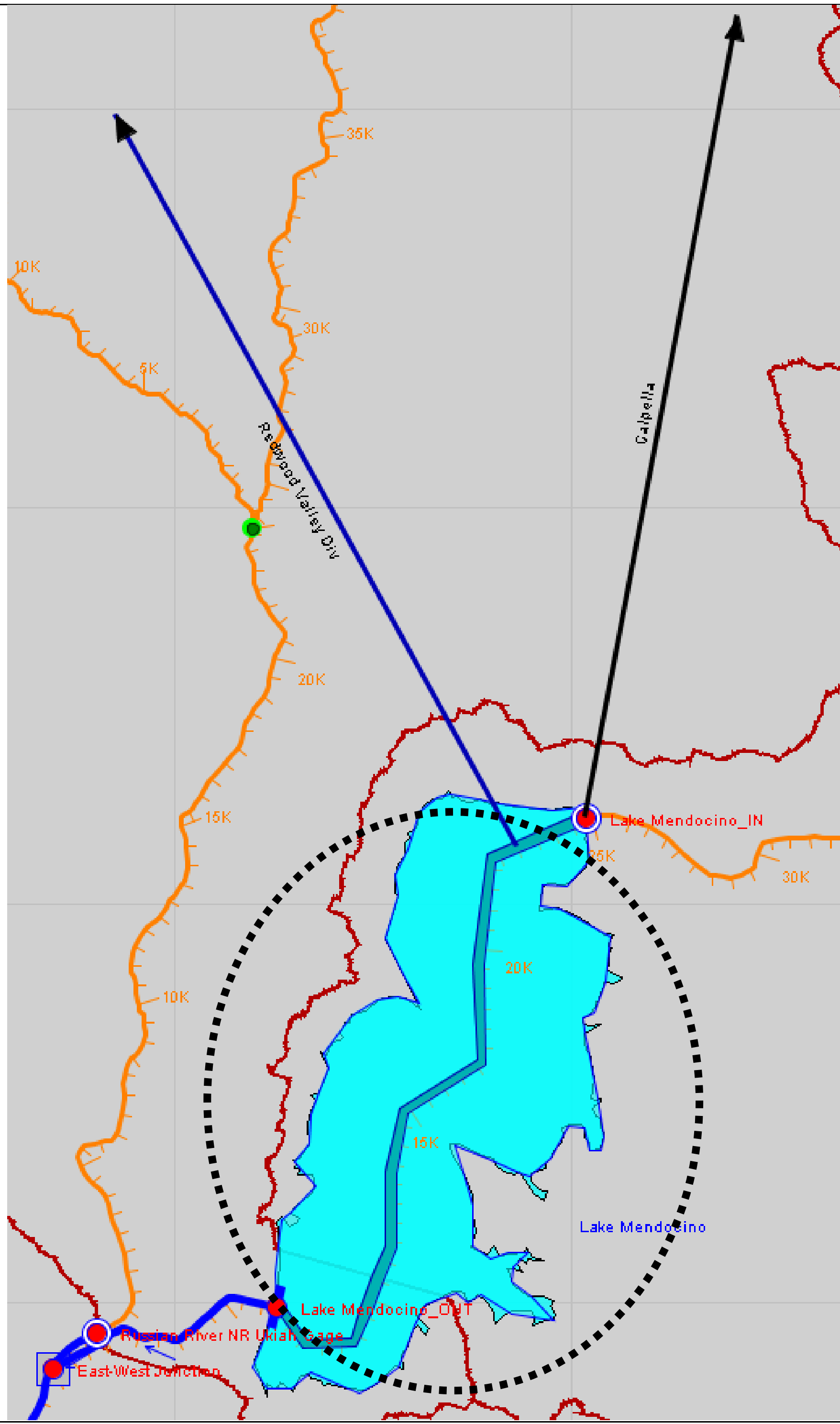


Figure 3 Network Elements_Upper Part of the Watershed

B. Middle Watershed

Figure 4 shows an overview map of the middle part of the watershed, which includes the area above Lake Sonoma to the confluence of Dry Creek with the Russian River, as well as Hopland Gage to the confluence with Dry Creek.

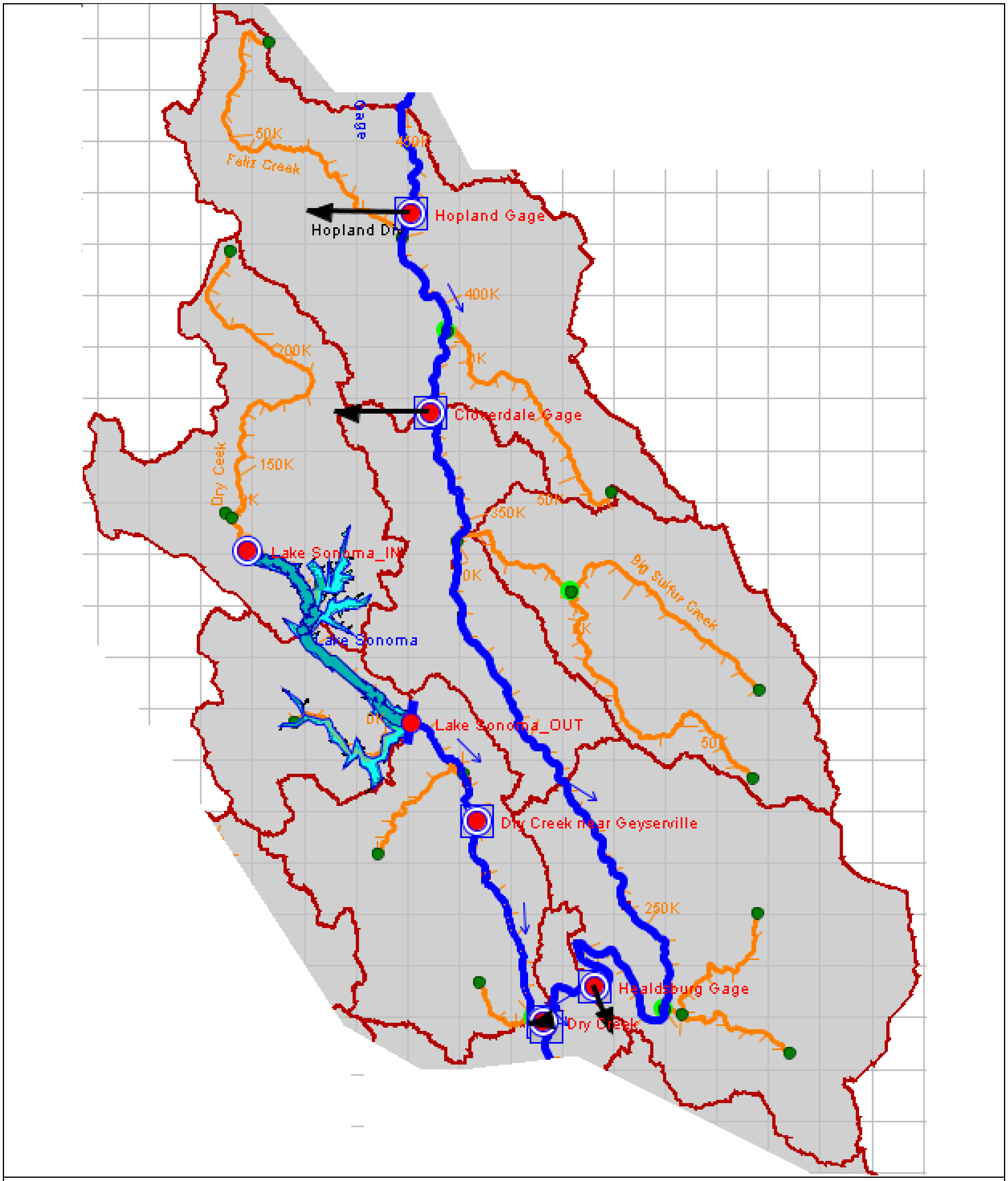


Figure 4 Overview Map_Middle Part of the Watershed

Figure 5 shows the network elements in the middle part of the watershed.

The light blue area marked with the dotted circle in Figure 5 shows the location of Lake Sonoma. The "Lake Sonoma_IN" junction is the headwater junction on Dry Creek. It marks the upstream end of the reservoir, and adds local inflow from the catchment surrounding the reservoir. The downstream end of the reservoir is marked by the junction named "Lake Sonoma_OUT".

"Dry Creek near Geyserville" is a downstream control point where Lake Sonoma operates for maximum flow. It also captures a portion (7.7%) of the local flow at Guerneville Gage junction. Another portion, 13.3%, of the local flow at Guerneville Gage enters the system at "Dry Creek" junction and the remaining 79% of the local flow at Guerneville Gage enters the system at "Guerneville Gage" junction.

Lake Mendocino operates for both minimum and maximum flows at the "Hopland Gage" junction. This location also marks the location of a diversion (Hopland Div) and adds local flows from the subbasin below East-West junction.

"Cloverdale Gage" junction represents the location of the Cloverdale stream gage and captures the local flows from a subbasin above this junction. It also marks the location of a diversion (Cloverdale Div). Lake Mendocino operates for minimum flow at this junction.

"Healdsburg Gage" is the downstream location that Lake Mendocino operates for the minimum flow. It also marks the location of a diversion (Healdsburg Div) and captures local flows from a subbasin above this junction.

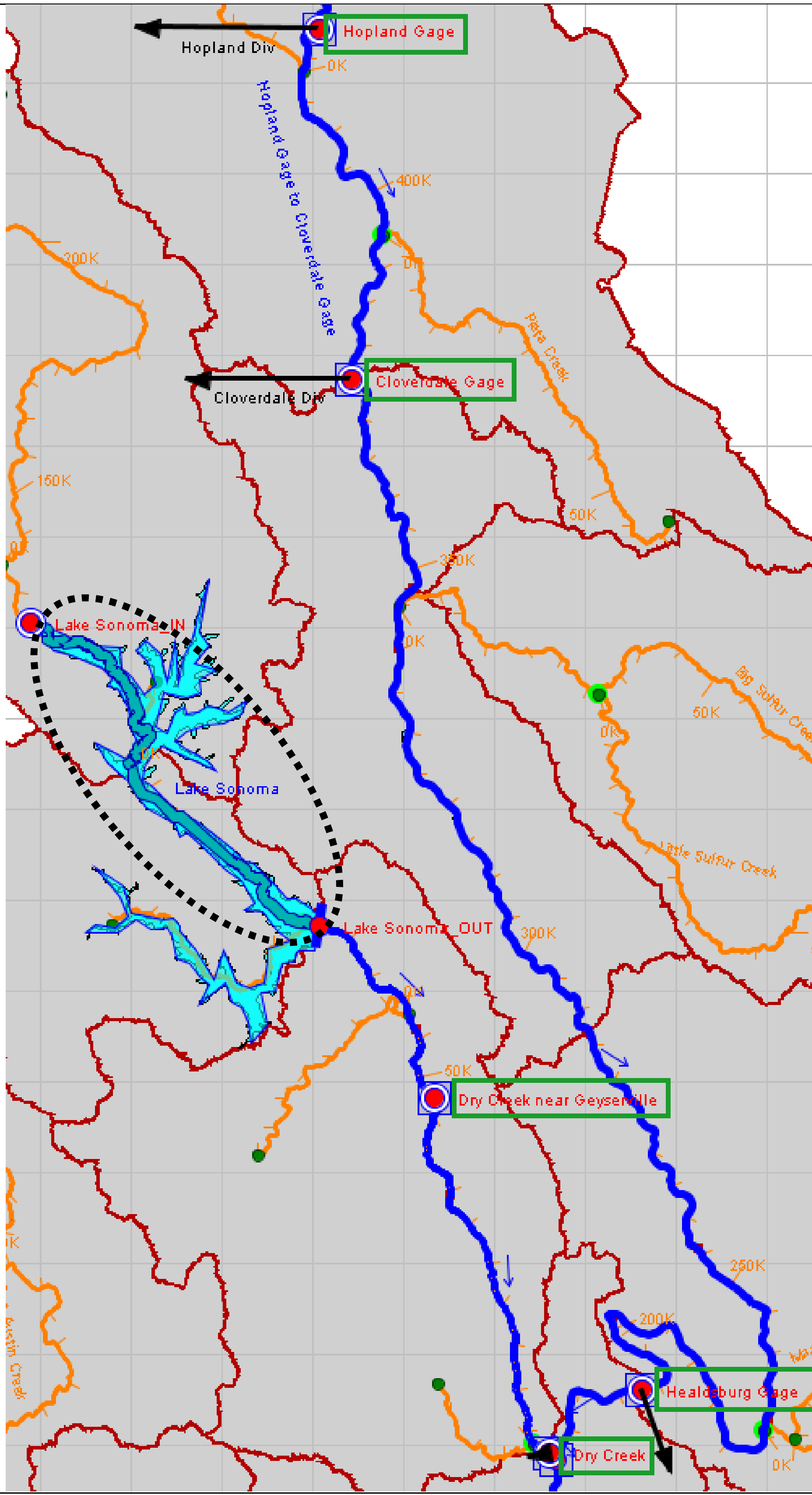


Figure 5 Network Elements_Middle Part of the Watershed

Figure 6 shows the confluence of Dry Creek and Russian River with “Dry Creek Conf” junction. “Dry Creek” and “Dry Creek Conf” junctions are downstream control locations where Lake Sonoma operates for minimum flow. A portion of the local flow at Guerneville Gage junction (13.3%) is added to the system at “Dry Creek” junction. This junction also marks the location of a diversion (“Dry Creek Div”).

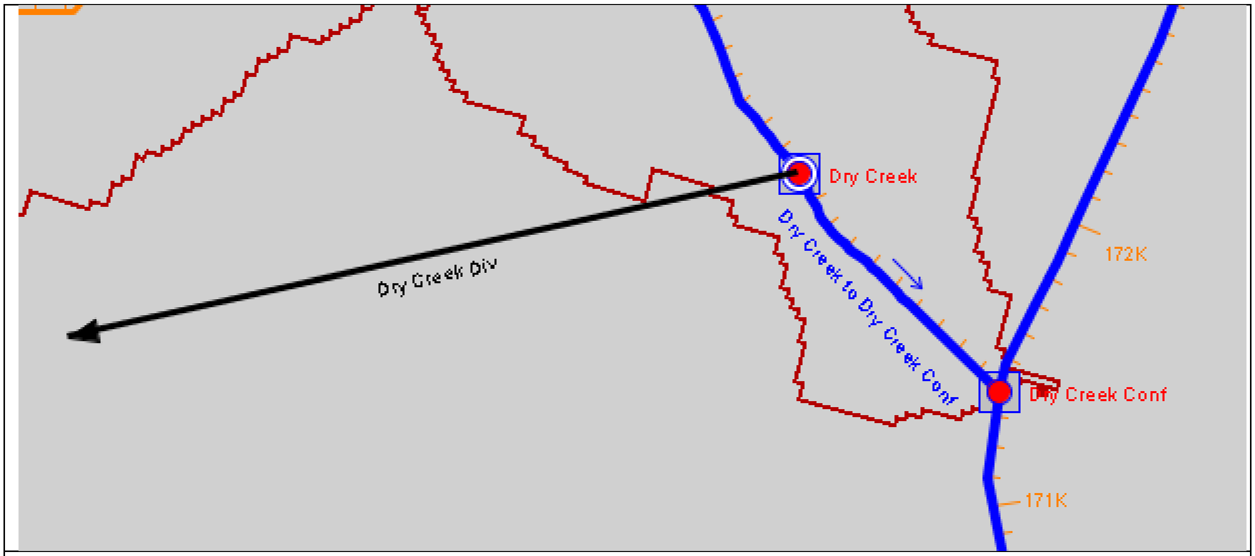


Figure 6 Network Elements_Confluence of Dry Creek and Russian River

C. Lower Watershed

Figure 7 shows an overview map of the lower part of the watershed, below the confluence of the Russian River and Dry Creek.

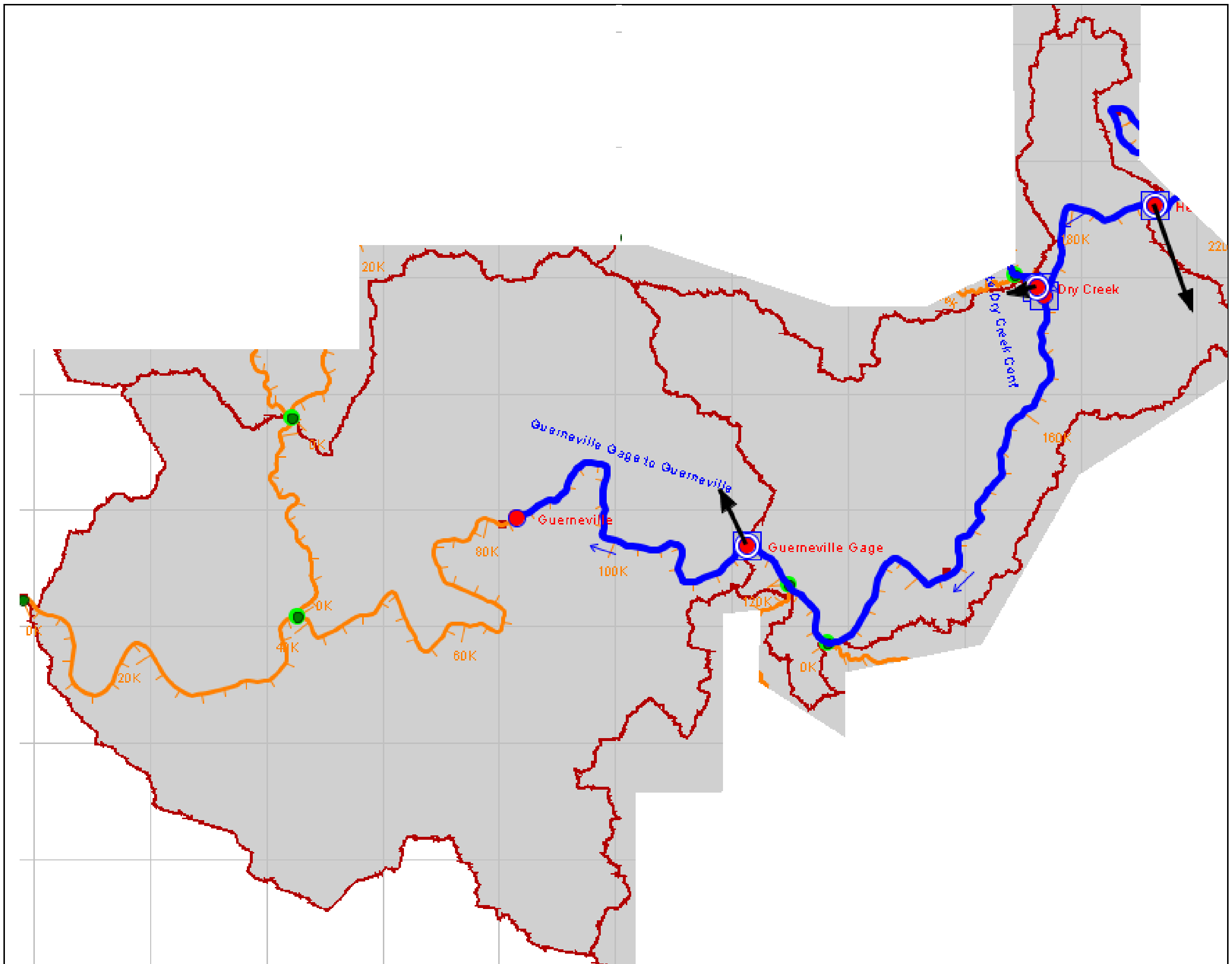


Figure 7 Overview Map_Lower Part of the Watershed

Figure 8 shows the network elements in the lower part of the watershed. “Guerneville Gage” is a downstream control location where Lake Sonoma operates for both minimum and maximum flows. The remaining portion (79%) of the local flow at Guerneville is added to this junction. It also marks the location of a diversion (Hacienda Div).

The most downstream point of the watershed is marked with the “Guerneville” junction.

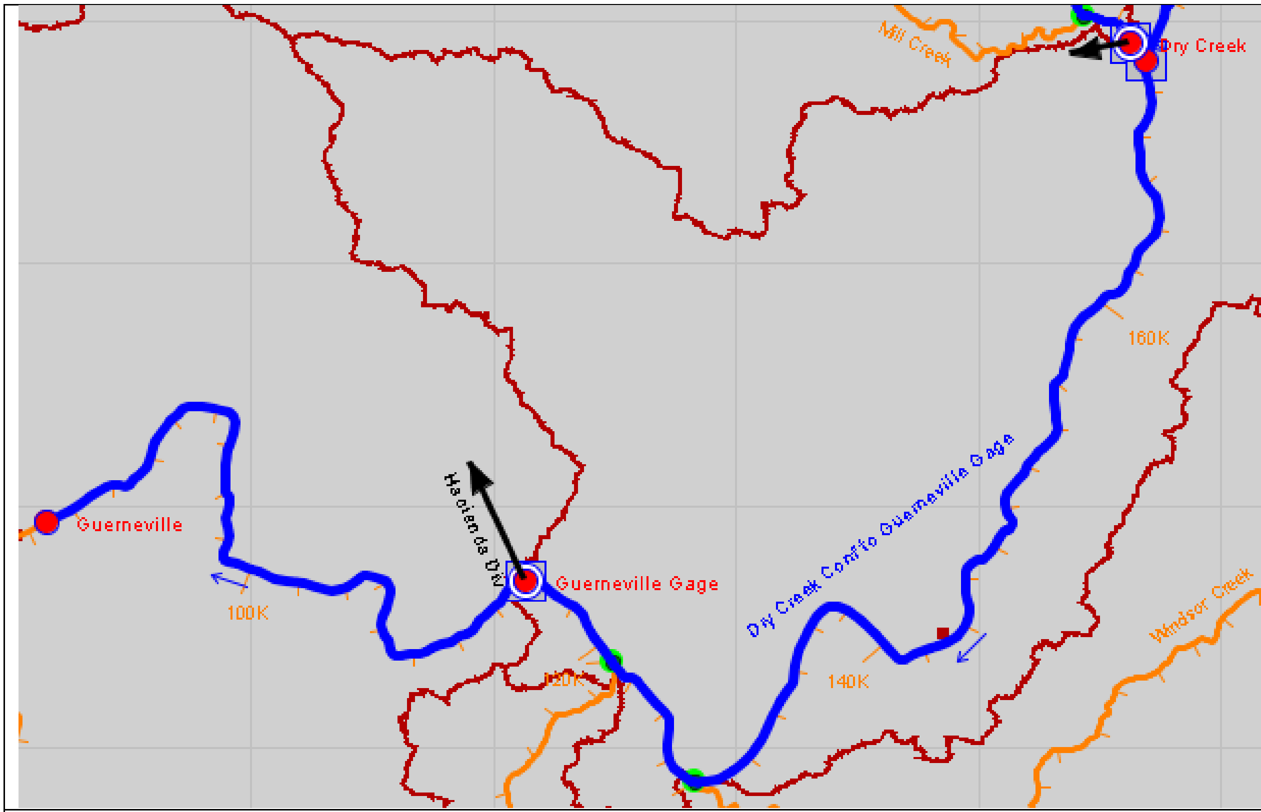


Figure 8 Network Elements_Lower Part of the Watershed

The Russian River watershed has no explicit system operation. However, Lake Sonoma operates to provide minimum flows in the lower Russian River (at the "Dry Creek Conf" and "Guerneville Gage" junctions) and to comply with maximum flow limitations at Guerneville, so Lake Mendocino releases to the Russian River can indirectly impact Lake Sonoma releases.

III. HEC-ResSim Data Development

A. Inflows

The California-Nevada River Forecast Center (CNRFC) of the National Weather Service (NWS) provided both reservoir inflows and local inflows at HEC-ResSim junctions along the Russian River and Dry Creek. The CNRFC flows resulted from a period of record hourly simulation of the watershed model used in producing streamflow forecasts for the Russian River. Some of the flows were later replaced by others computed in a mass balance approach by Sonoma Water.

The only other inflow to the system was the diversion from the Eel River through the Potter Valley Project (PVP) into the headwaters of the East Fork Russian River. The PVP flows used in this study were modeled by Sonoma Water to reflect Pacific Gas and Electric's (PG&E's) operation of the Potter Valley Hydroelectric Project since 2006 under an amended FERC license. Details are provided in the Lake Mendocino Water Supply Reliability Evaluation Report (SCWA, 2015, Section 2.2, Technical Memorandum).

B. Consumptive Withdrawals

Sonoma Water provided a time-series of estimated diversions from the Russian River (*Section VII.B*). The seven diversions out of the system (Table 1) used in the HEC-ResSim model represent simplified net aggregations of specific diversions, return flows, aquifer recharge, and a variety of distributed losses.

Table 1 list of Consumptive Diversions

Diversion Name	Location
Redwood Valley Div	Coyote Valley Dam
Calpella Div	Lake Mendocino_IN junction
Hopland Div	Hopland Gage Junction
Cloverdale Div	Cloverdale Gage Junction
Healdsburg Div	Healdsburg Junction
Dry Creek div	Dry Creek Junction
Hacienda Div	Guerneville Gage

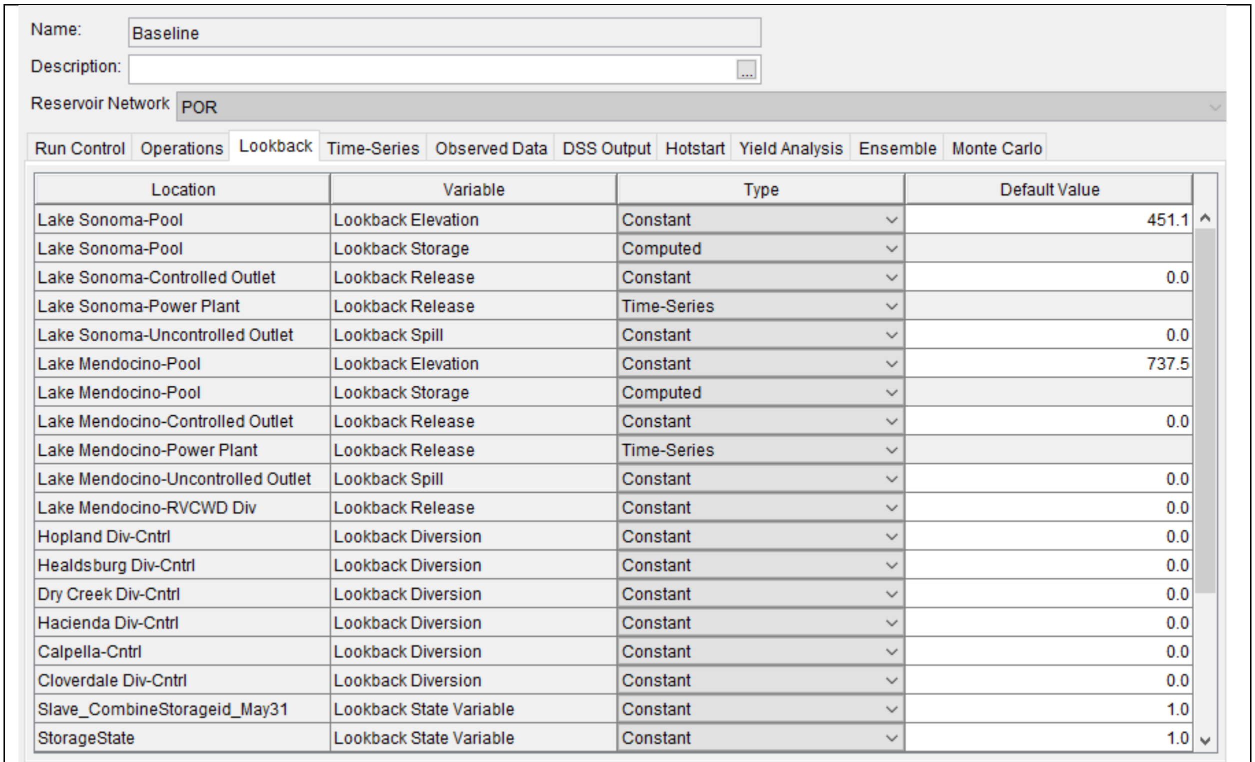
The diversion values were generally derived according to the procedures described in the Lake Mendocino Water Supply Reliability Evaluation Report, with some refinements and updates implemented for the FIRO project (SCWA, 2015).

C. Lookback Data

The initial conditions for the reservoir simulation were defined in the Lookback tab of the HEC-ResSim Alternative Editor (Figure 9). In addition to establishing the initial reservoir elevation and values for state variables, the lookback period provided a warm-up period for the reservoir simulation. The data provided during the lookback period allowed the start of the simulation to proceed with fully defined values in operational rules. The lookback period must also cover the time required to route releases to the farthest downstream control point. The longest such dependency in this study was 7 days, which was used as the lookback period for all the reservoir simulations.

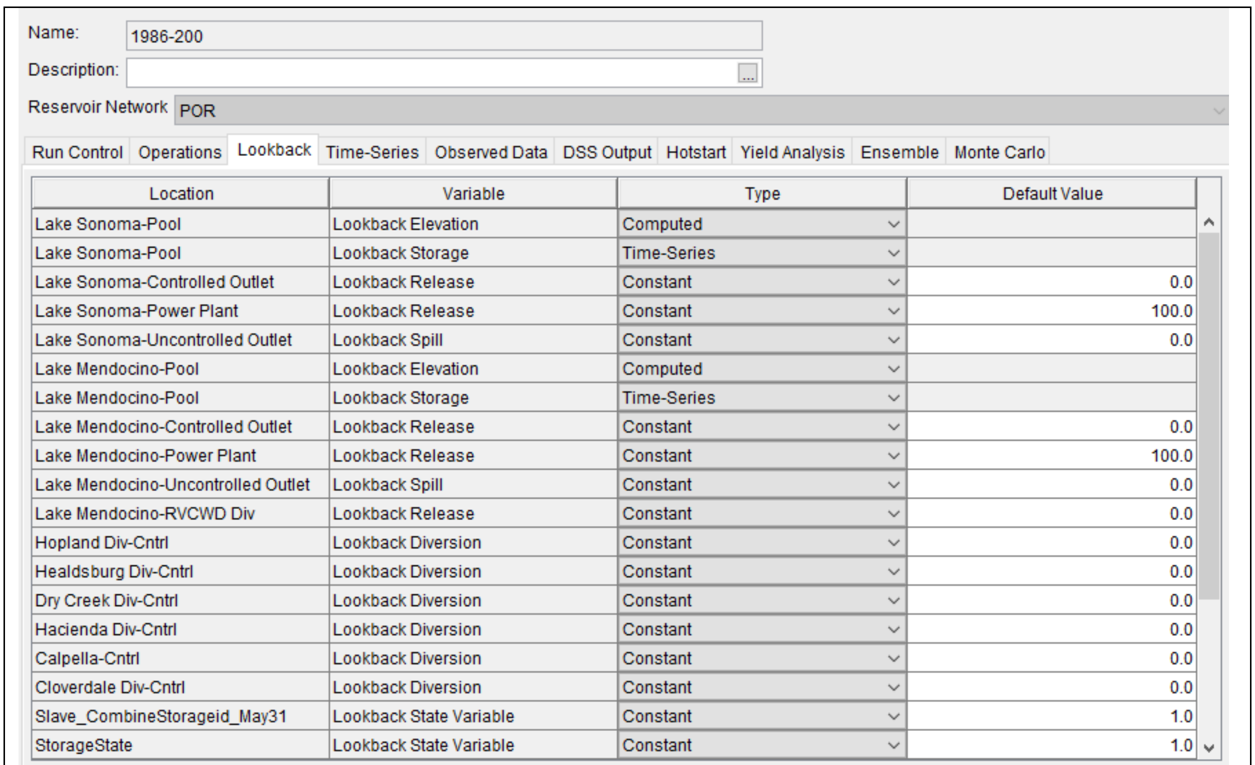
In the Lookback tab of the POR baseline simulations, diversion flows were set to zero and state variables were set to their default values. The lookback releases for Lakes Mendocino and Sonoma were taken from preliminary simulation results and set to release from the power plant outlet. The lookback elevations for Lake Mendocino and Lake Sonoma were set to their guide curve values (737.5 for Lake Mendocino and 451.1 for Lake Sonoma) (Figure 9).

In the Lookback tab of the scaled event baseline simulations, diversion flows were set to zero, and state variables were set to their default values. Constant outflows of 100 cfs from the power plant outlet were used for both Lake Sonoma and Lake Mendocino. The lookback storage values for Lakes Mendocino and Sonoma were taken from the time series of POR storage (Figure 10).



Location	Variable	Type	Default Value
Lake Sonoma-Pool	Lookback Elevation	Constant	451.1
Lake Sonoma-Pool	Lookback Storage	Computed	
Lake Sonoma-Controlled Outlet	Lookback Release	Constant	0.0
Lake Sonoma-Power Plant	Lookback Release	Time-Series	
Lake Sonoma-Uncontrolled Outlet	Lookback Spill	Constant	0.0
Lake Mendocino-Pool	Lookback Elevation	Constant	737.5
Lake Mendocino-Pool	Lookback Storage	Computed	
Lake Mendocino-Controlled Outlet	Lookback Release	Constant	0.0
Lake Mendocino-Power Plant	Lookback Release	Time-Series	
Lake Mendocino-Uncontrolled Outlet	Lookback Spill	Constant	0.0
Lake Mendocino-RVCWD Div	Lookback Release	Constant	0.0
Hopland Div-Cntrl	Lookback Diversion	Constant	0.0
Healdsburg Div-Cntrl	Lookback Diversion	Constant	0.0
Dry Creek Div-Cntrl	Lookback Diversion	Constant	0.0
Hacienda Div-Cntrl	Lookback Diversion	Constant	0.0
Calpella-Cntrl	Lookback Diversion	Constant	0.0
Cloverdale Div-Cntrl	Lookback Diversion	Constant	0.0
Slave_CombineStorageid_May31	Lookback State Variable	Constant	1.0
StorageState	Lookback State Variable	Constant	1.0

Figure 9 Lookback Data – POR Baseline



Location	Variable	Type	Default Value
Lake Sonoma-Pool	Lookback Elevation	Computed	
Lake Sonoma-Pool	Lookback Storage	Time-Series	
Lake Sonoma-Controlled Outlet	Lookback Release	Constant	0.0
Lake Sonoma-Power Plant	Lookback Release	Constant	100.0
Lake Sonoma-Uncontrolled Outlet	Lookback Spill	Constant	0.0
Lake Mendocino-Pool	Lookback Elevation	Computed	
Lake Mendocino-Pool	Lookback Storage	Time-Series	
Lake Mendocino-Controlled Outlet	Lookback Release	Constant	0.0
Lake Mendocino-Power Plant	Lookback Release	Constant	100.0
Lake Mendocino-Uncontrolled Outlet	Lookback Spill	Constant	0.0
Lake Mendocino-RVCWD Div	Lookback Release	Constant	0.0
Hopland Div-Cntrl	Lookback Diversion	Constant	0.0
Healdsburg Div-Cntrl	Lookback Diversion	Constant	0.0
Dry Creek Div-Cntrl	Lookback Diversion	Constant	0.0
Hacienda Div-Cntrl	Lookback Diversion	Constant	0.0
Calpella-Cntrl	Lookback Diversion	Constant	0.0
Cloverdale Div-Cntrl	Lookback Diversion	Constant	0.0
Slave_CombineStorageid_May31	Lookback State Variable	Constant	1.0
StorageState	Lookback State Variable	Constant	1.0

Figure 10 Lookback Data – Scaled Events Baseline

D. Miscellaneous External Data

Rules and state variables used in the simulations required certain inputs to be specified throughout the analysis period. The Lake Pillsbury storage amount was used by the state variable (*StorageState*), which computed a storage index. The details of state variables are discussed in *Section X* of this report. Also, a time series referring to a hydrologic index, which may be "Normal", "Dry", or "Critical," was used in the *WSC I-1610 Q-TUCP* If Block in the Lake Mendocino operation set (*Section IV.2.B.6*).

IV. Coyote Valley Dam (Lake Mendocino)

Coyote Valley Dam (CVD) project was authorized by the Flood Control Act of 1944 for the purposes of flood control, water supply, recreation and stream flow regulation. It was constructed by the United States Army Corps of Engineers (USACE) in 1959. Lake Mendocino was created with the construction of the CVD project on the East Fork of the Russian River.

Inflow into the reservoir consists of natural flows from the contributing watershed area and additional water from the Eel River diverted through the Potter Valley Project, a hydroelectric facility owned and operated by PG&E. The City of Ukiah operates a hydroelectric facility at the CVD that utilizes incidental releases. USACE coordinates releases from CVD during flood management operations. The operation of CVD is performed by USACE-San Francisco District project operators. As the local sponsor, Sonoma Water coordinates water supply release from CVD in accordance with its water rights permits and the State Water Resources Control Board (SWRCB) Decision 1610. The California Department of Fish and Wildlife operates a fish facility. National Marine Fisheries Service (NMFS) has an ongoing cooperation agreement with USACE regarding making modifications to ramping procedures to minimize and avoid adverse impact to listed salmonids.

The flood control and water supply operation was established in the Water Control Manual published by USACE originally in April 1959, modified in 1986 and most recently revised in 2003.

1. Physical Characteristics

Coyote Valley Dam is an earth embankment dam approximately 160 feet high with a crest length of 3,500 feet. Lake Mendocino has a total current storage capacity of 116,500 acre-feet (AF), which includes a water supply pool of between 68,400 AF and 111,000 AF, depending on the time of year. Based on reservoir bathymetric surveys (original in 1952 and most recently in 2001), the average sedimentation rate in the reservoir is estimated to be 143 acre-feet per year.

The watershed of the reservoir has an area of approximately 105 square miles, which is approximately seven percent of the total watershed area of the Russian River Basin. Average annual inflow into the reservoir since the construction of Coyote Valley Dam is approximately 230,000 AF, with a maximum annual inflow of 443,000 AF in 1983 and a minimum annual inflow of 60,000 AF in 1977. Inflow into the reservoir consists of unimpaired flows from the contributing watershed area and a portion of the water diverted though the Potter Valley Project from the Eel River.

The Coyote Valley Dam and adjacent area, looking north in a "tilted" satellite view, is displayed in Figure 11. The spillway of Lake Mendocino is located in a low saddle about 0.6 miles upstream from the southern abutment of the dam. The spillway discharges flows through Howard Creek until joining the Russian River just north of the Ukiah city limits. The spillway structure consists of an 800-foot long approach channel and a 200-foot wide rectangular weir. Since construction of Coyote Valley Dam, the spillway has only been activated once in December of 1964 when reservoir inflows exceeded 14,000 cfs.

Location of the controlled outlets for Lake Mendocino are displayed in Figure 12. Water is conveyed to the outlet works of Coyote Valley Dam by a single reinforced concrete pipe approximately 720 feet long and eleven feet and ten inches in diameter. The flow through this

Figure 11 Coyote Valley Dam Area

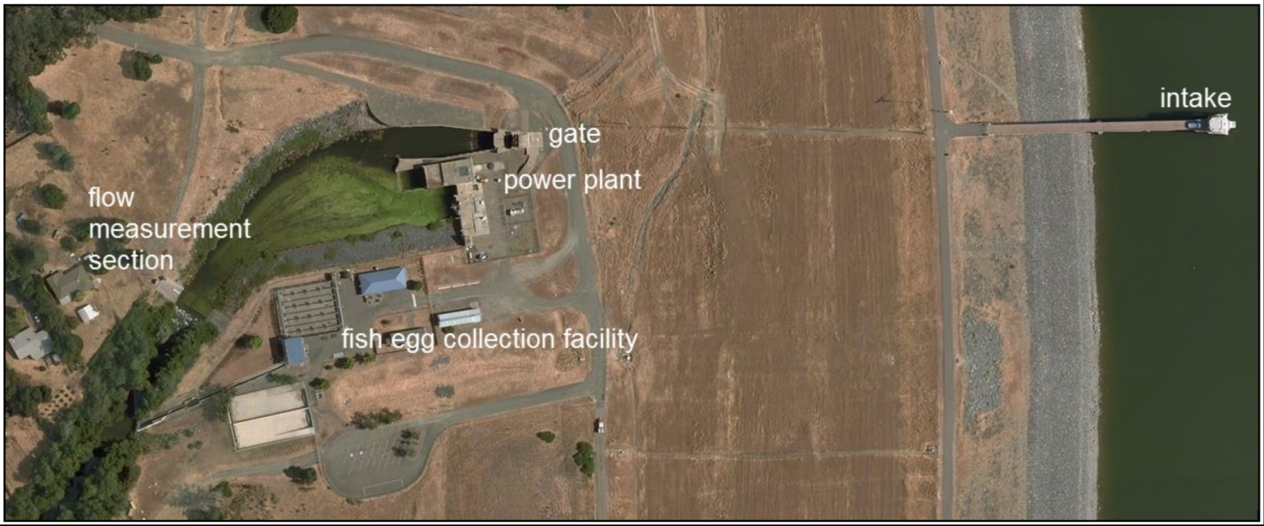


Figure 12 Coyote Valley Dam Outlet Area

tunnel may be directed to the power plant, or passed through a flood control gate. Maximum release capacity of the controlled outlet is approximately 7,500 cfs when the water surface elevation is within the Emergency Release Pool (above elevation 773 feet mean sea level). The powerhouse contains two turbine/generator units with rated power generation capacities of 2,500 and 1,000 kilowatts.

The physical characteristics of the reservoir are separated between the *Pool* and the *Dam* in the HEC-ResSim model.

A. Pool

The *Elevation-Storage-Area* defines the pool as shown in Figure 13. The Lake Mendocino elevation-storage-area relationship was taken from the 2003 version of the Coyote Valley Dam Water Control Manual, Exhibit A (USACE, 2003).

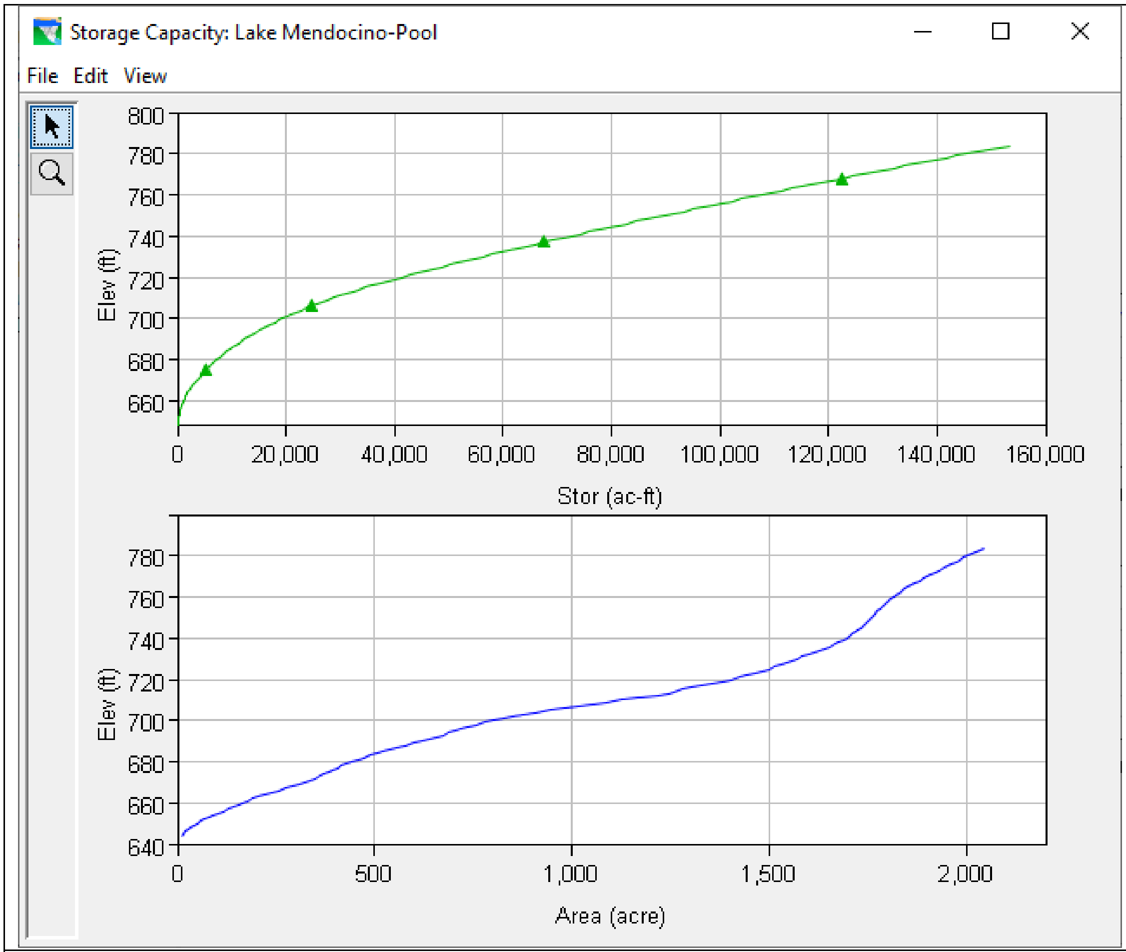


Figure 13 Reservoir Editor – Physical Tab - Lake Mendocino Pool

B. Evaporation

Monthly evaporation losses from Lake Mendocino are contained in Figure 14. These values were provided by Sonoma Water.

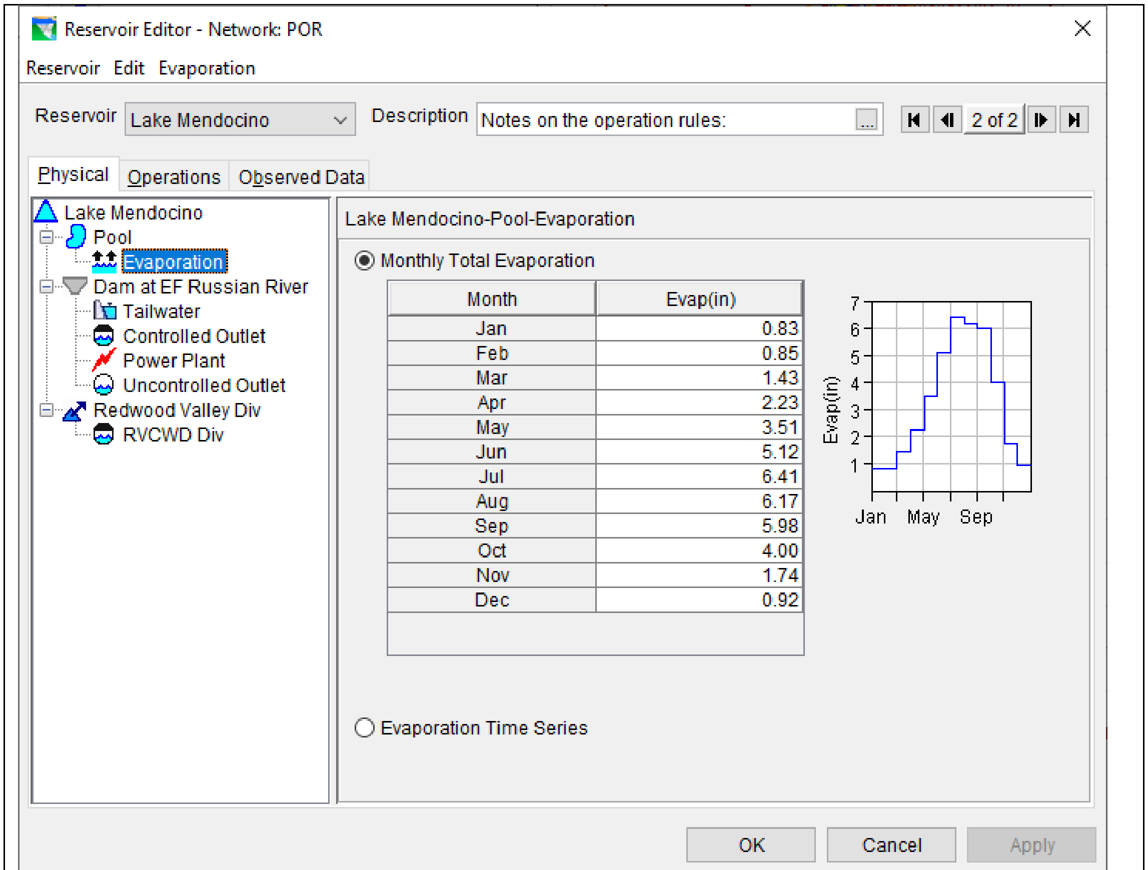
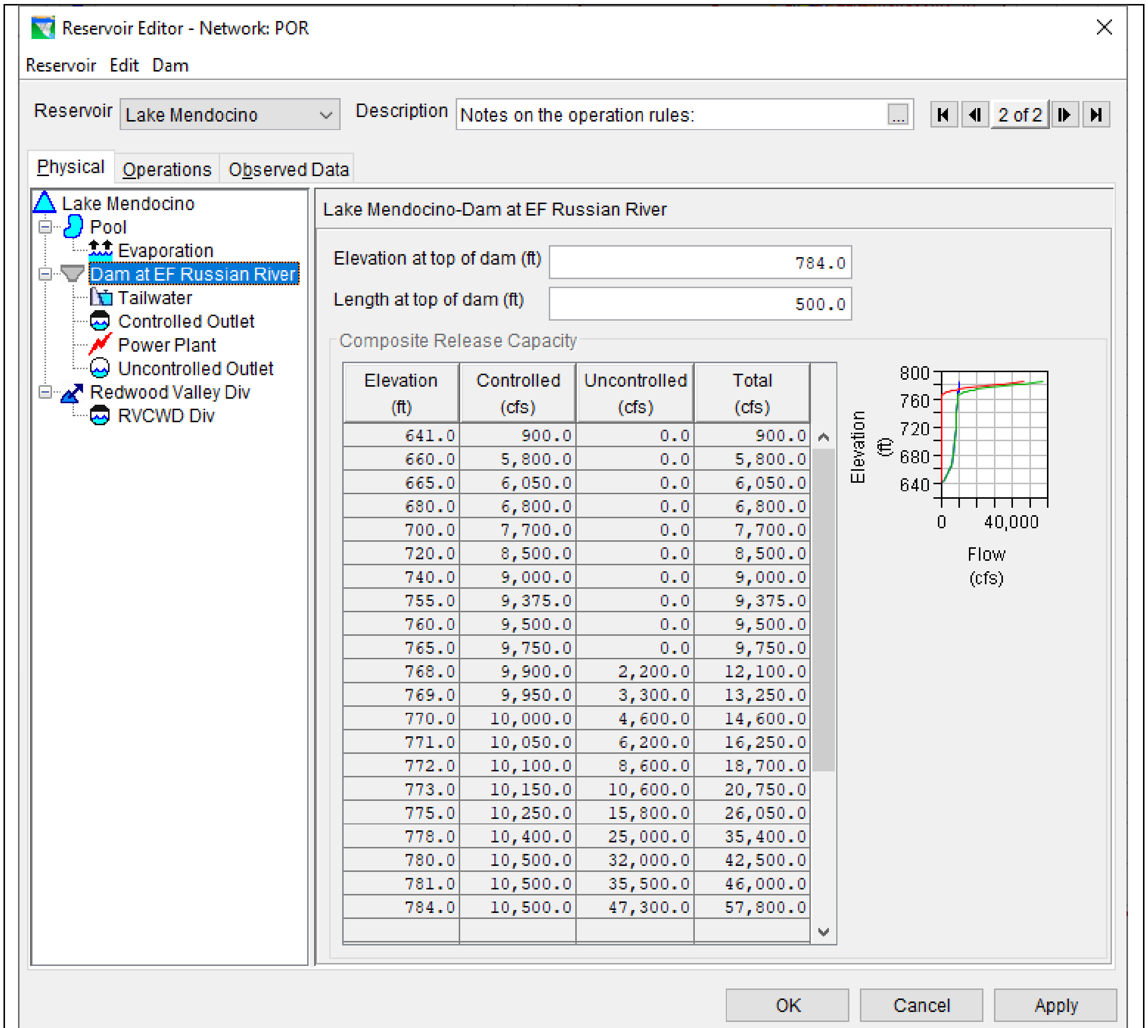


Figure 14 Reservoir Editor – Physical Tab - Lake Mendocino Evaporation

C. Dam

The dam consists of four types of outlets: (1) a controlled outlet, (2) a power plant, (3) an uncontrolled spillway, and (4) a diverted outlet. Each of these outlets is defined in the model as shown in Figure 15, and the dam release table reflects the composite release capacity of all of the outlets.



Elevation (ft)	Controlled (cfs)	Uncontrolled (cfs)	Total (cfs)
641.0	900.0	0.0	900.0
660.0	5,800.0	0.0	5,800.0
665.0	6,050.0	0.0	6,050.0
680.0	6,800.0	0.0	6,800.0
700.0	7,700.0	0.0	7,700.0
720.0	8,500.0	0.0	8,500.0
740.0	9,000.0	0.0	9,000.0
755.0	9,375.0	0.0	9,375.0
760.0	9,500.0	0.0	9,500.0
765.0	9,750.0	0.0	9,750.0
768.0	9,900.0	2,200.0	12,100.0
769.0	9,950.0	3,300.0	13,250.0
770.0	10,000.0	4,600.0	14,600.0
771.0	10,050.0	6,200.0	16,250.0
772.0	10,100.0	8,600.0	18,700.0
773.0	10,150.0	10,600.0	20,750.0
775.0	10,250.0	15,800.0	26,050.0
778.0	10,400.0	25,000.0	35,400.0
780.0	10,500.0	32,000.0	42,500.0
781.0	10,500.0	35,500.0	46,000.0
784.0	10,500.0	47,300.0	57,800.0

Figure 15 Reservoir Editor – Physical Tab - Lake Mendocino Dam

D. Power Plant

The power plant outlet capacity is defined in the model as shown in Figure 16. The power plant installed capacity is 3.5 MW with an overload factor of 1, constant efficiency of 80%, constant station use of 0 cfs, and constant hydraulic loss of 0 ft. The power plant outlet capacity is 3,000 cfs.

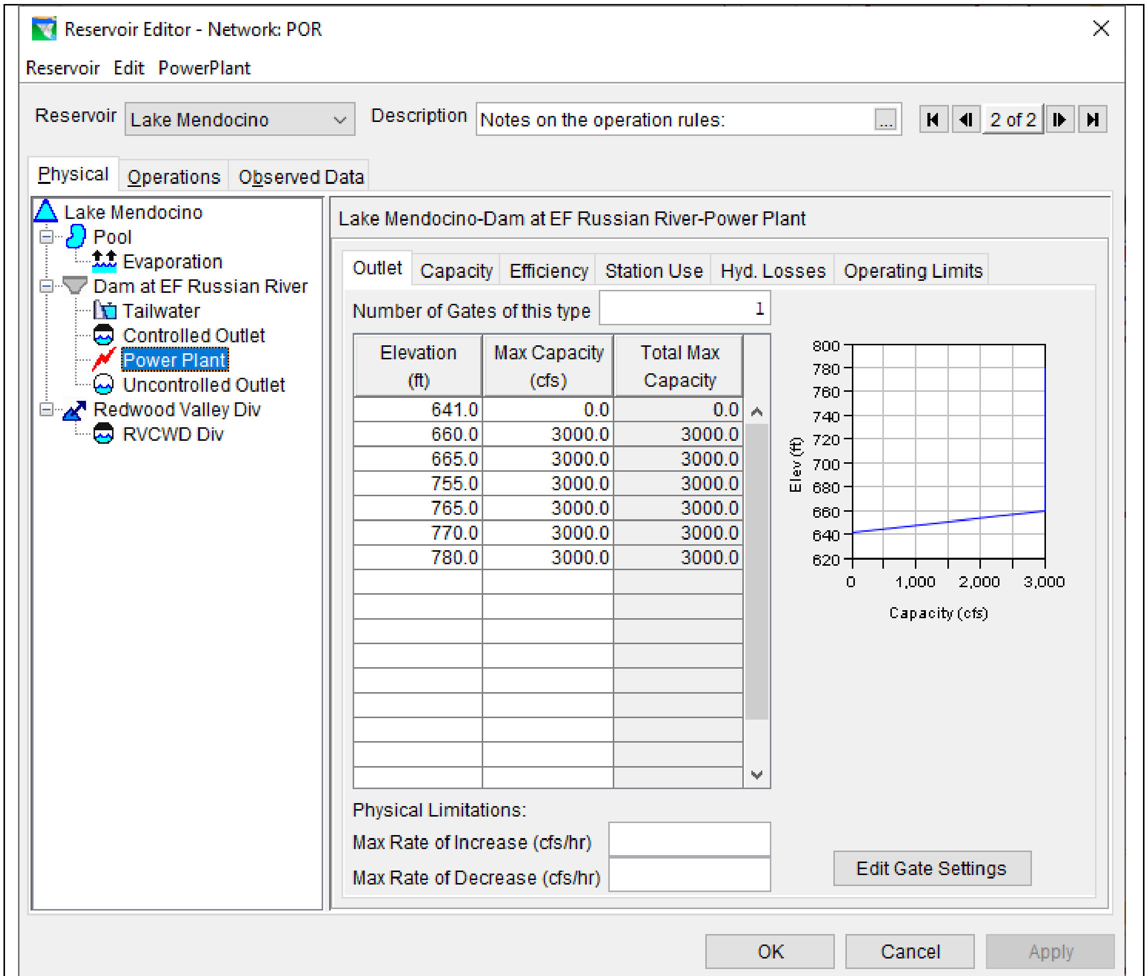


Figure 16 Reservoir Editor – Physical Tab - Lake Mendocino Power Plant

2. Operation Sets

USACE determines the schedule and amount of water released from Lake Mendocino during flood control operations, while Sonoma Water manages releases from the conservation pool. Regulation for flood control and water supply operations are described in the "Coyote Valley Dam Water Control Manual - Appendix I", which was originally published by USACE in April 1959 and revised in August 1986. Exhibit A of the Coyote Valley Dam Water Control Manual was most recently revised in September 2003 to incorporate the most recent bathymetric survey information (USACE, 2003).

Most of the river downstream relies heavily on Lake Mendocino for flow augmentation during the dry season. The Russian River is facing rising municipal and agricultural demands, while also supporting instream flow requirements for fish species that are listed as threatened. The scarcity of water has become more critical in recent years due to substantial reductions in the water diverted to Lake Mendocino from the neighboring Eel River, through the Potter Valley Project.

Operation of Lake Mendocino is described in the updated Water Control Manual and includes operations for both flood control and water supply (USACE, 2003).

Within HEC-ResSim, different operation sets can be defined for each reservoir, containing the rules for determining reservoir releases. The rules are placed in the different operating zones in order of priority. Rules describe minimum or maximum reservoir releases, which can be based on a number of factors, such as downstream flow and current reservoir storage. Below is a description of the "Baseline" operation set for Coyote Valley Dam at Lake Mendocino.

A. Baseline Operation Set

The Baseline operation set of this study is meant to represent the current operation (existing condition) of the reservoir. Zones are used to define the operational storage levels in the reservoir, to determine the reservoir release through analysis of the rules contained within each zone. Figure 17 shows the definition of Lake Mendocino's "Baseline" operational zones, which consist of zones of Emergency, Flood Control, Conservation, and Inactive zone. These zones each contain a set of operational rules for reservoir operation.

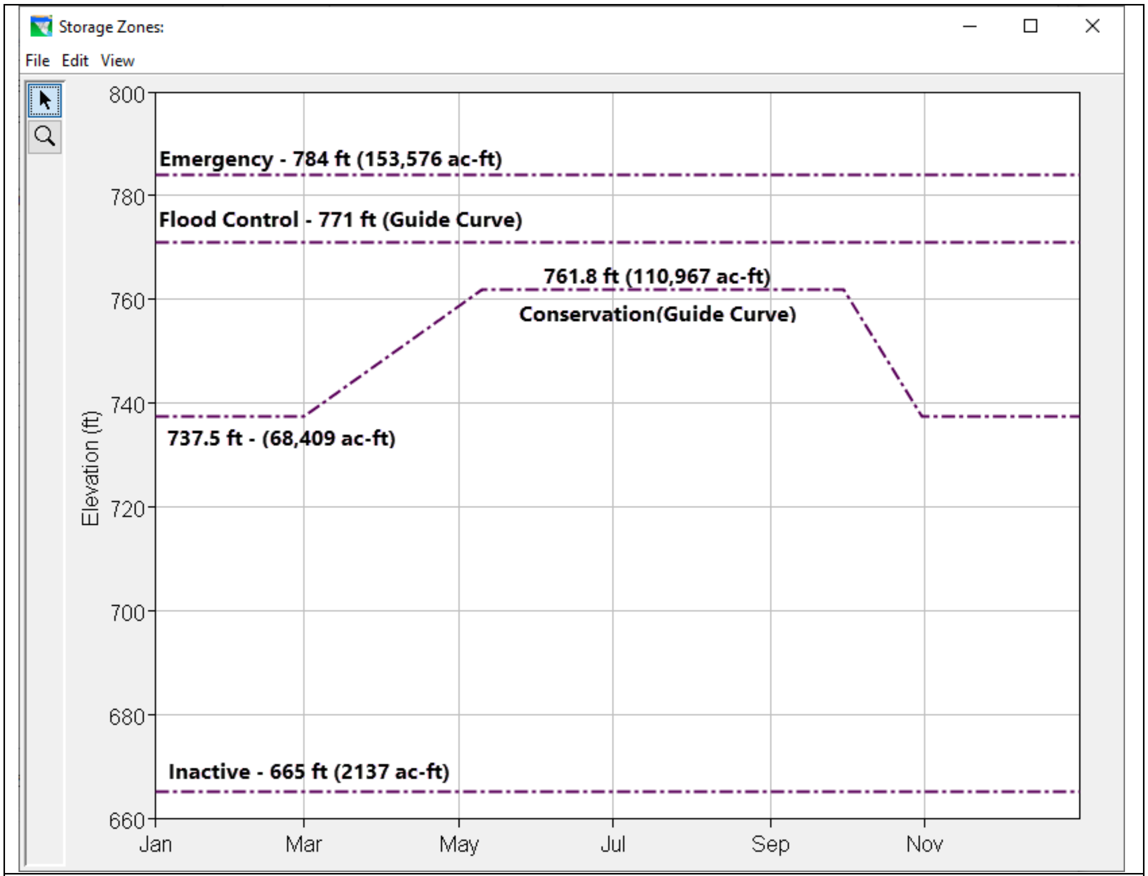


Figure 17 Zone Elevations for Baseline Operation Set - Lake Mendocino

Water management operations at Coyote Valley Dam manage water supply storage in the reservoir according to the reservoir guide curve defined in the Coyote Valley Dam Water Control Manual (Figure 17) and water needs below the reservoir. The guide curve sets the maximum threshold for storage of conservation water in the reservoir.

The top of the conservation operation zone varies seasonally (as shown in Figure 17). From January 1 to March 1 it is set to 737.5 feet (68,409 AF), and from May 10 through September 30, it is 761.8 feet (110,967 AF). The guide curve is lowered in October back to 737.5 feet to empty reservoir flood space, since the flood season in the Russian River watershed typically extends between November through the end of March. Lowering the guide curve in these months provides added flood protection (42,558 AF). The guide curve begins increasing in March because 1) it becomes less likely for large rainfall-runoff events to occur in the Russian River watershed; and 2) it is important to capture (store) any late season runoff before the drier summer and fall months.

The guide curve (Figure 17) that was explained in this section was first implemented in the spring of 2007. Prior to 2007, the increase in the conservation pool from 68,400 AF did not begin until 1 April and reached a maximum level of conservation storage of 86,400 AF (elevation 748 feet) on 20 April. Prior to 2007, the increase in the conservation pool could start on 1 March, but Sonoma Water had to provide a written request to USACE annually.

In the HEC-ResSim model, the available outlets are given an order of priority for release. Figure 18 shows a sequential release allocation approach specified for available outlets along Coyote Valley Dam. The power plant gets the release first until it reaches release capacity. After the capacity through the powerhouse is reached, the remainder of the release goes through the controlled outlet.

The Coyote Valley Dam outlets do not conform to the standard HEC-ResSim release allocation method. The reservoir can either release for power generation or for flood control, meaning the gate and the power house cannot be used at the same time. The HEC-ResSim model contains the ratings for both the gate and powerhouse. Generally, the gate would be used for flood control schedule 3 or higher levels. HEC added a new rule called "limit Rel thru Pwr Plant" to zero the power plant capacity at 755 feet, so that the total controlled outlet capacity above that level reflects only the gate rating. The HEC-ResSim model allocates the release through the powerhouse, up to its maximum of 3000 cfs, with the rest going through the gate.

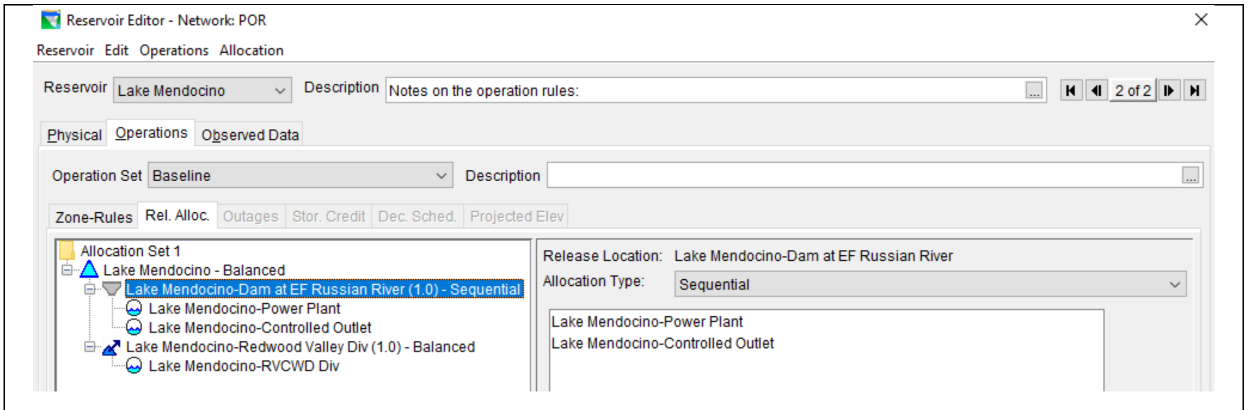


Figure 18 Release Allocation - Lake Mendocino

B. Rule Descriptions

HEC-ResSim organizes reservoir-operating criteria into "operation sets", which allowed the study to use the same reservoir model to compare different water management alternatives simply by switching to a different operation set. An overview of the *Baseline* operations set is displayed in Figure 19.

On the Operations tab of the HEC-ResSim Reservoir Editor (Figure 19), the left panel displays the storage zones described in the Coyote Valley Dam Water Control Manual, and the operating rules in each zone. Selecting a zone displays the definition for that zone throughout the calendar year. For example, Figure 19 displays the top of the conservation zone for Coyote Valley Dam. The rules for each zone were arranged in order of priority, with the highest priority on top. The rules reflected maximum releases, minimum releases, or explicitly specified releases.

The maximum flow rules generally came into play with Lake Mendocino in the flood control zone. In the conservation zone, their main application was when the Russian River rose enough to require reduced outflows. Similarly, the minimum flow rules typically only apply to operations when the reservoir pool was in the Conservation zone, with the main exception being the requirement to maintain at least 25 cfs outflow, regardless of zone, which often occurs during flood operation. Consequently, for simplicity the same rule definitions were applied to both the Flood Control and Conservation zones, even though some definitions were irrelevant at that reservoir level. Including the same full set of flow rules in both the Conservation and Flood Control zones also helped more accurately simulate times when the reservoir storage was very near to the guide curve, and could easily cross into the other zone.

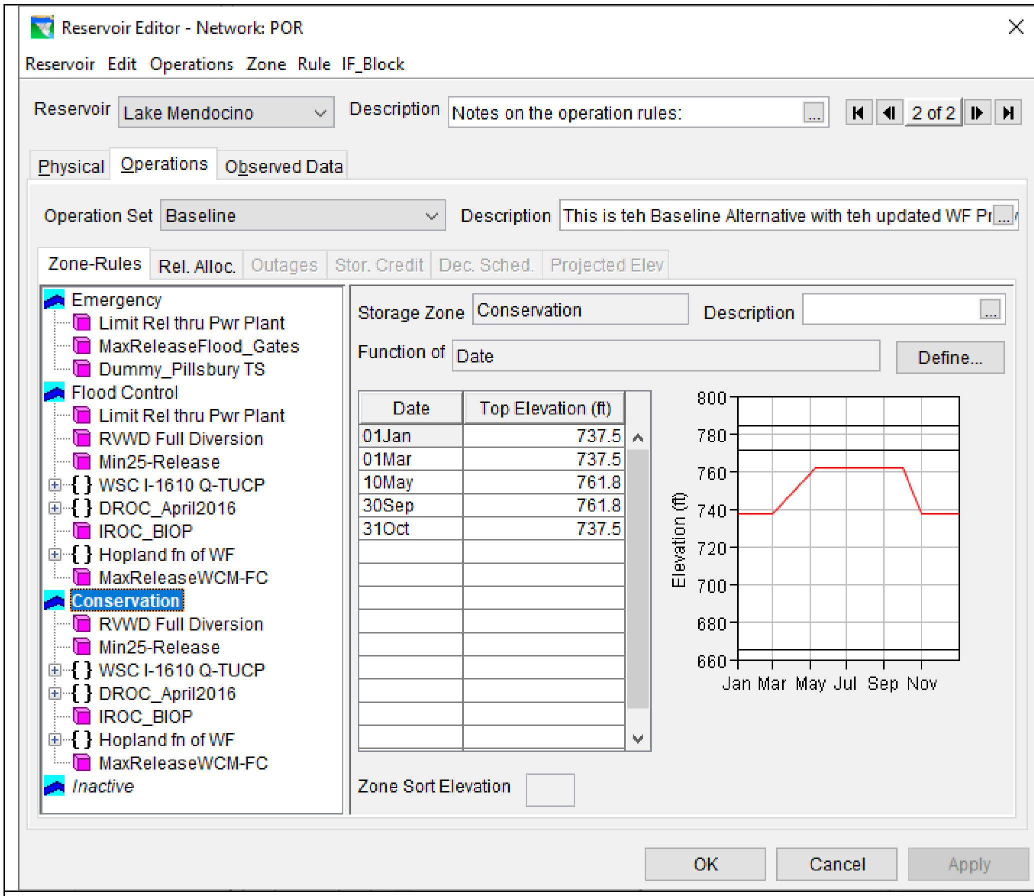


Figure 19 Zones and Rules - Lake Mendocino

1. Rule: Limit Rel thru Pwr Plant

The Lake Mendocino power plant and associated facilities are operated generally in two modes: power generation mode and flood control mode. Power generation mode is in operation when the flood pool is at or below elevation 755 feet, and flood control mode is in operation when the flood pool exceeds elevation 755 feet. In the power generation mode the tainter valve is fully closed, and the turbines and bypass valves are opened as necessary to pass the required water release. In flood operation mode, the tainter valve is fully open and the turbines and bypass valves are fully closed.

The transition operations between power generating mode and flood control operations were modeled using the *Limit Rel thru Pwr Plant* rule. This rule (Figure 20) limits the release to zero from the power plant for elevations above 755 ft. This rule zeroes the power plant capacity at 755 feet, so that the total controlled outlet capacity reflects only the gate rating (only applied to the Flood Control and Emergency zones).

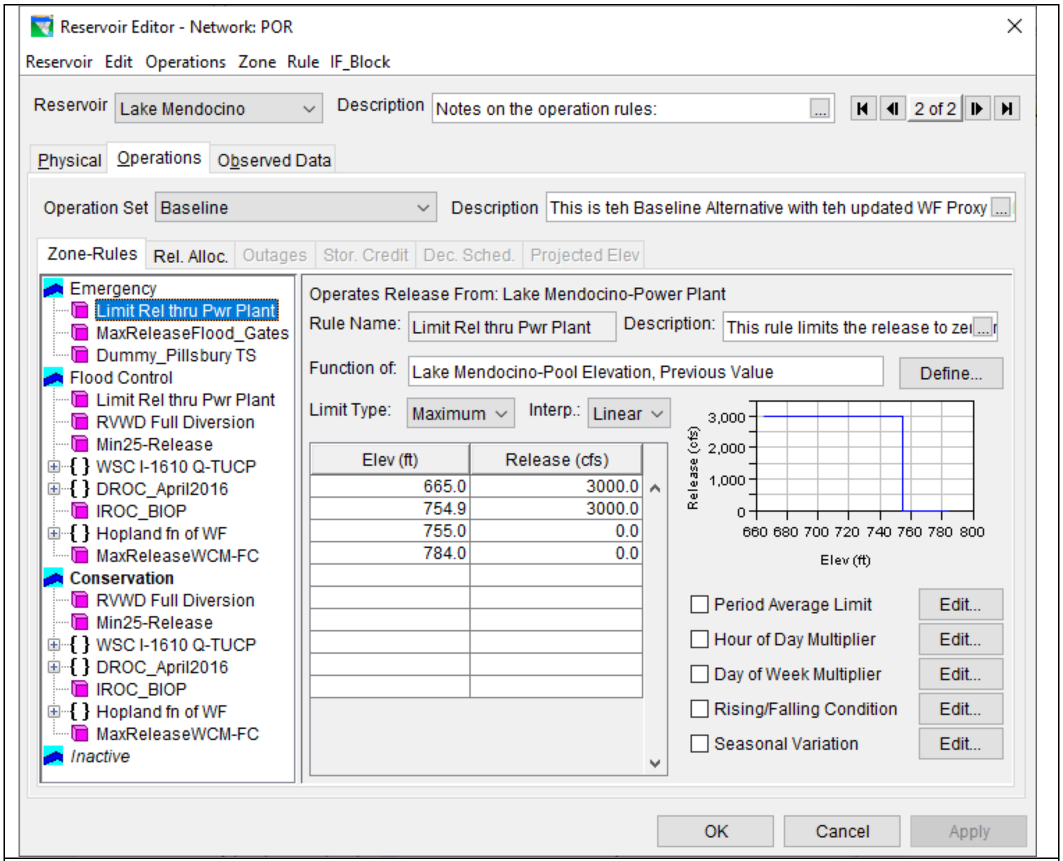


Figure 20 Limit Rel thru Pwr Plant Rule

2. Rule: MaxReleaseFlood_Gates

The rule *MaxReleaseFlood_Gates* (Figure 21) specifies releases from Lake Mendocino through the gate until the pool exceeds 773 feet, per the emergency release schedule of the Water Control Diagram (applies only in the Emergency Zone).

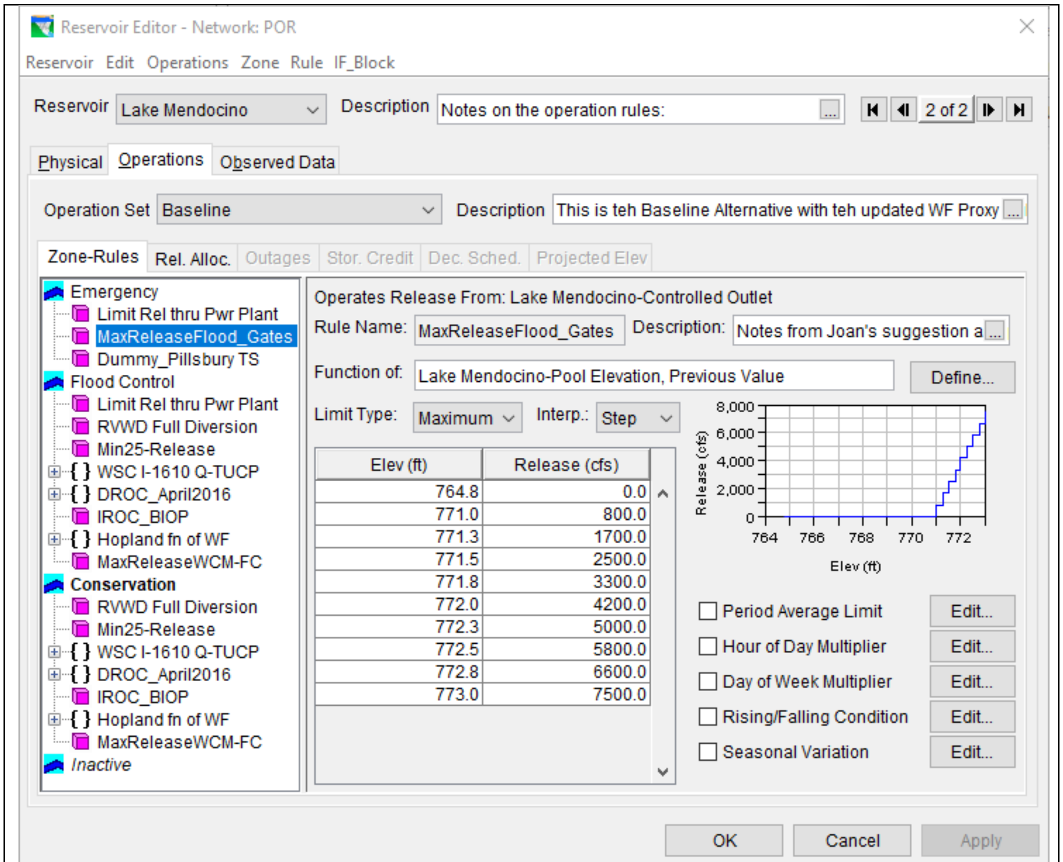


Figure 21 MaxReleaseFlood_Gates Rule

3. Rule: Dummy_Pillsbury TS

The rule *Dummy_Pillsbury TS* (Figure 22) exists to allow the HEC-ResSim model to ingest the Lake Pillsbury storage as an external time-series from an HEC-DSS file. The Pillsbury storage is used by the *StorageState* state variable. This rule calls for a minimum release of zero cfs, so it did not affect releases. The rule was applied outside the Conservation and Flood Control zones to avoid unnecessary evaluations during simulations, thereby reducing model run times.

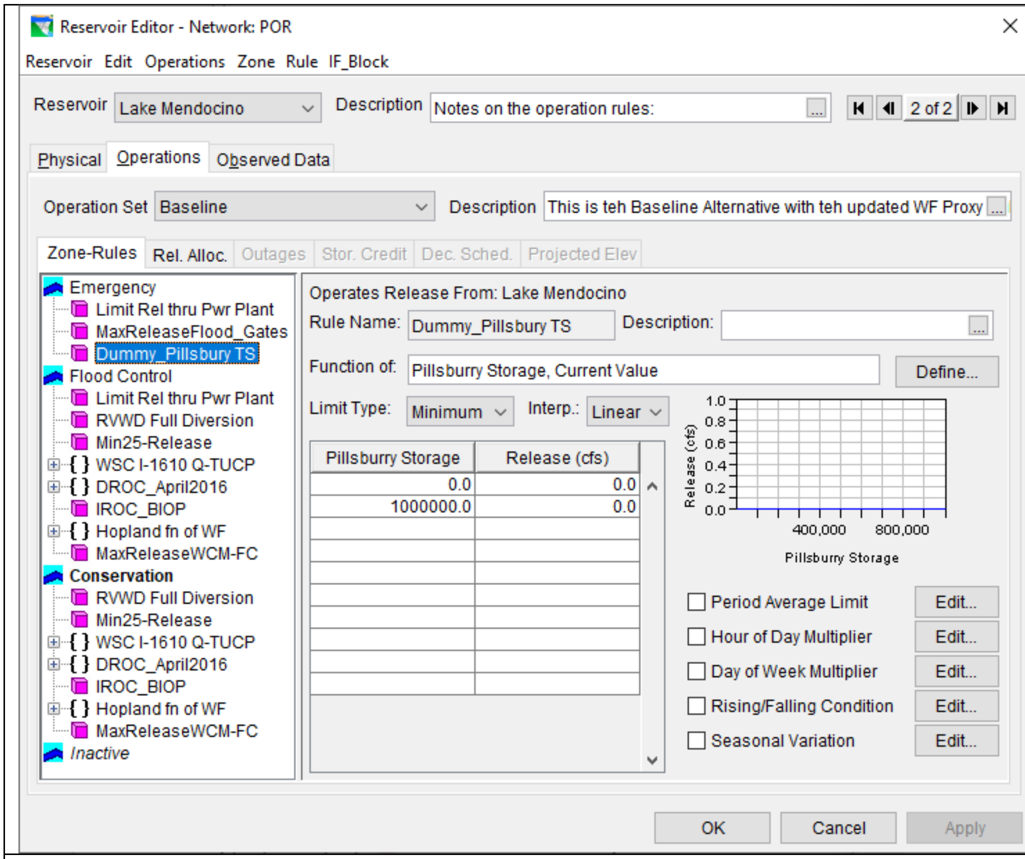


Figure 22 Dummy_Pillsbury TS Rule

4. Rule: RVWD Full Diversion

The rule *RVWD Full Diversion* (Figure 23) specifies flow for the Redwood Valley diversion out of Lake Mendocino. The flow values were provided with a time-series as described in *Section VII.B*.

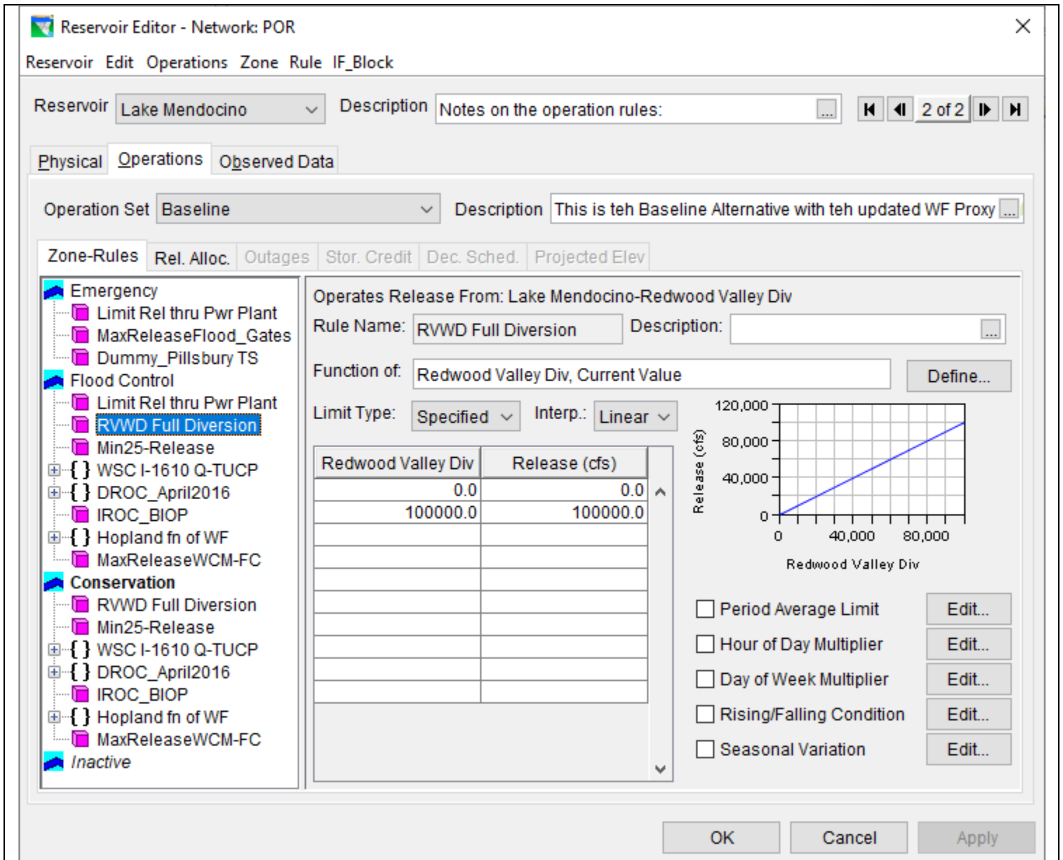


Figure 23 RVWD Full Diversion Rule

5. Rule: Min25-Release

The rule *Min25-Release* (Figure 24) forces Coyote Valley Dam to always release at least 25 cfs. The rule originates from SWRCB Decision 1610, and was modified by a Sonoma Water Temporary Urgency Change Petition (TUCP).

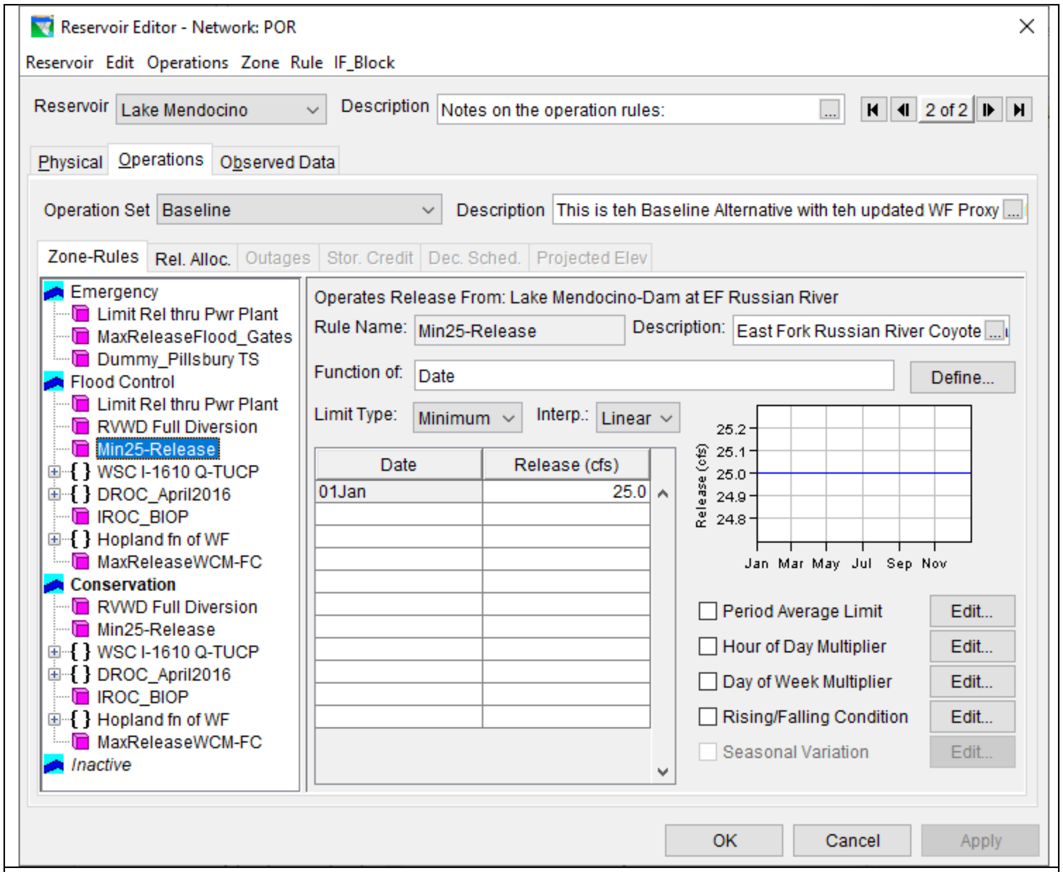


Figure 24 Min25-Release Rule

6. IF_Block: WSC I-1610 Q-TUCP

The IF_Block *WSC I-1610 Q-TUCP* (Figure 25) describes the downstream flow requirements. The first condition in the IF_Block refers to the hydrologic index, which may be "Normal", "Dry", or "Critical". The hydrologic index for each year in the POR is defined by an external time series provided by Sonoma Water. If the index is "Normal", then a second condition applies, which reflects the combined storage in Lake Mendocino on the Russian River and Lake Pillsbury on the Eel River. The state variable *StorageState* used to calculate the storage index (or state) is described in *Section X.*

Each case of the combined conditions specifies minimum flows that need to be maintained throughout the upper Russian River. The requirements were expressed for four locations (the East-West, Hopland Gage, Cloverdale Gage, and Healdsburg Gage). HEC-ResSim resolves the different flow requirements at these locations by taking the maximum of the minimums. The Sonoma Water Reliability Report (SCWA, 2015) describes the flow requirements in detail (Figure 26). Per recommendation of Sonoma Water, these flow targets were further padded by varying amounts to reflect "safety buffer" increments used in operations to overcome potential losses along the river.

The details of this rule are shown in Figure 27 to Figure 31.

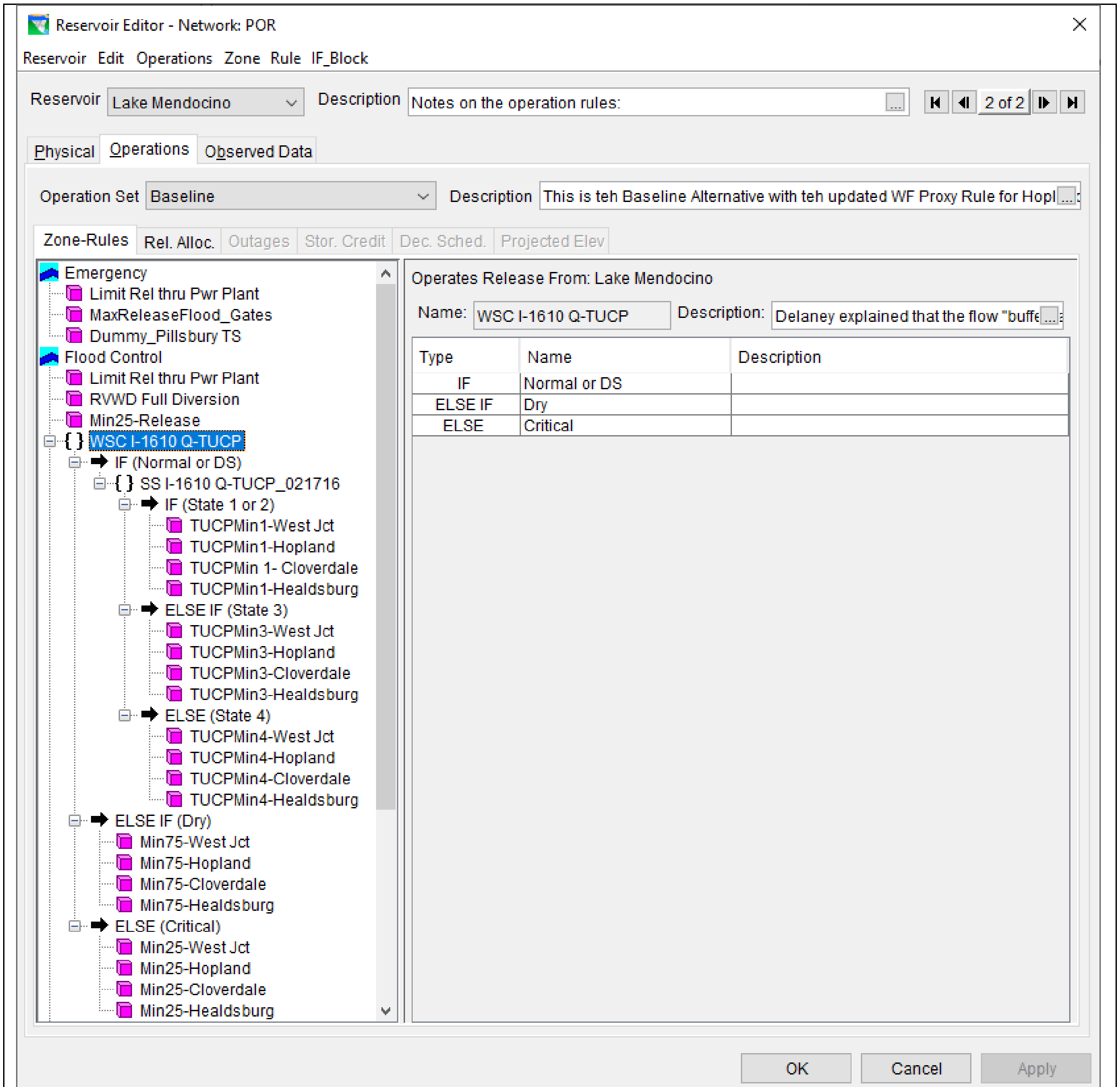


Figure 25 WSC I-1610 Q-TUCP Rule

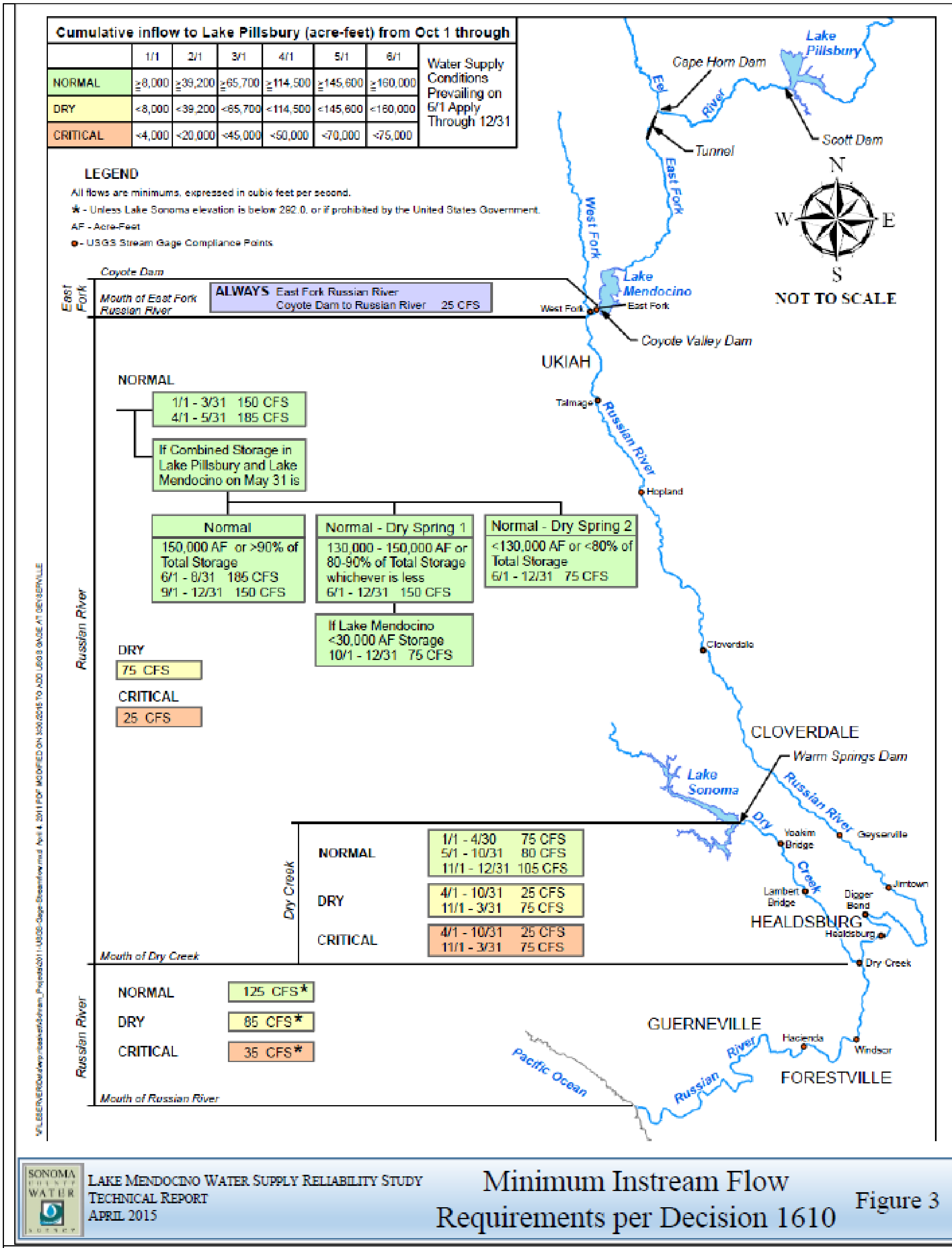


Figure 26 Minimum Requirements at Downstream Locations

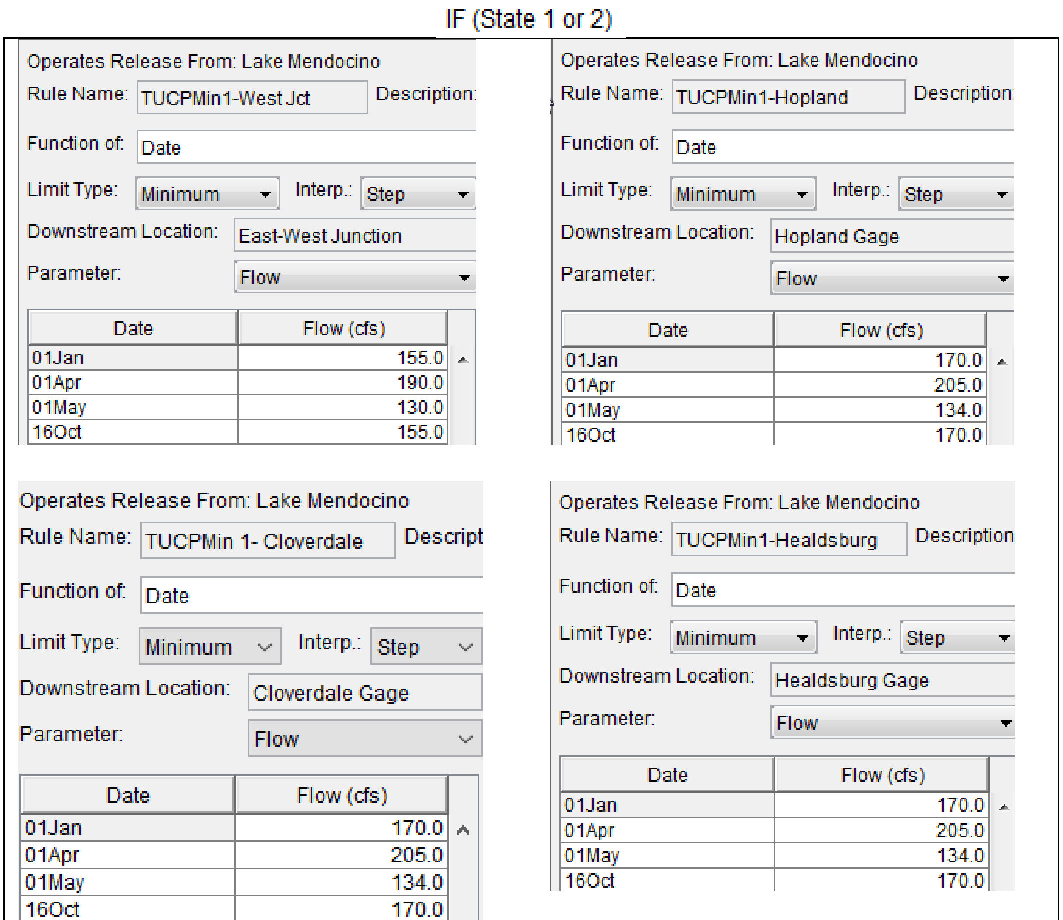


Figure 27 WSC I-1610 Q-TUCP Rule - (State 1 or 2)

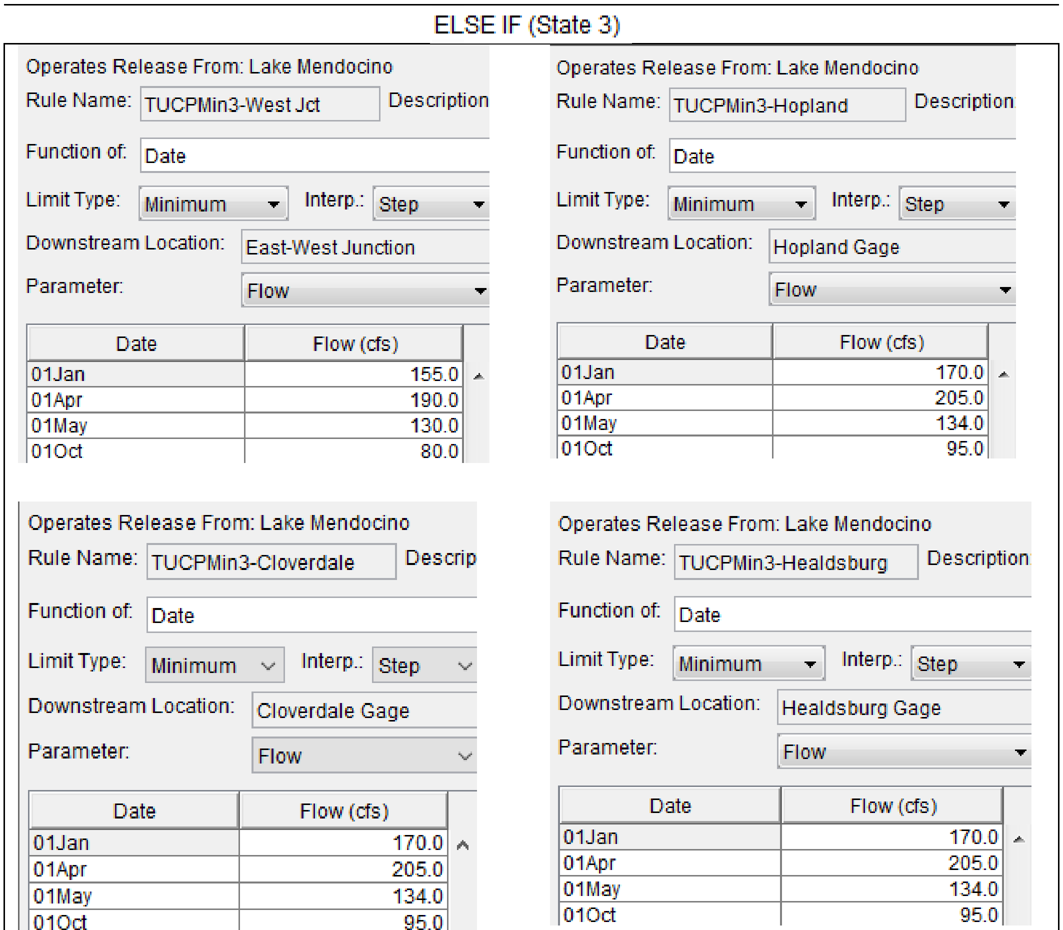


Figure 28 WSC I-1610 Q-TUCP Rule - (State 3)

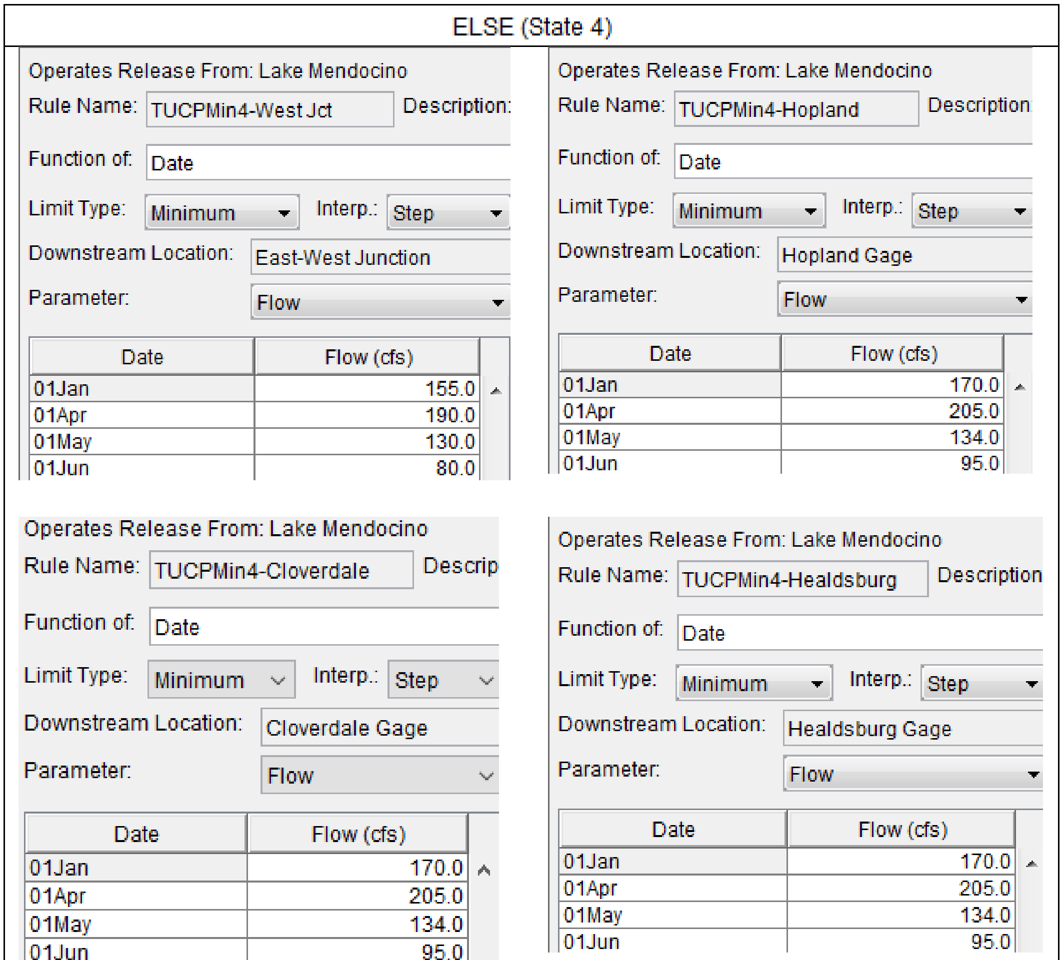


Figure 29 WSC I-1610 Q-TUCP Rule - (State 4)

ELSE IF (Dry)

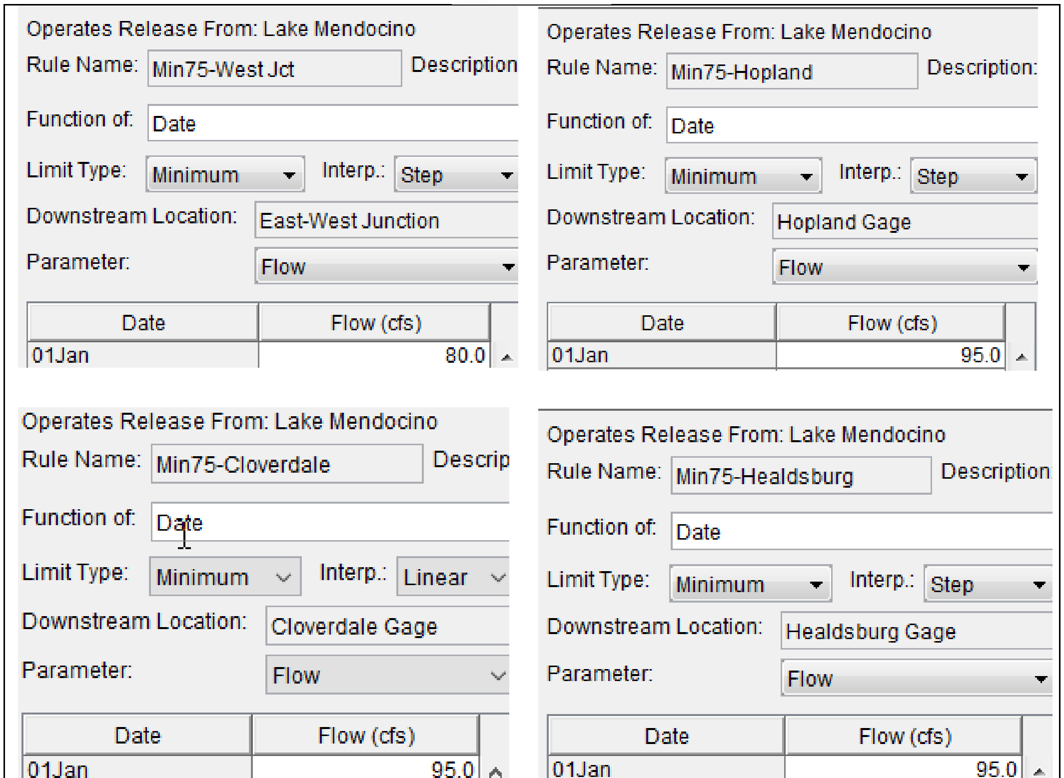


Figure 30 WSC I-1610 Q-TUCP Rule - (Dry)

ELSE (Critical)

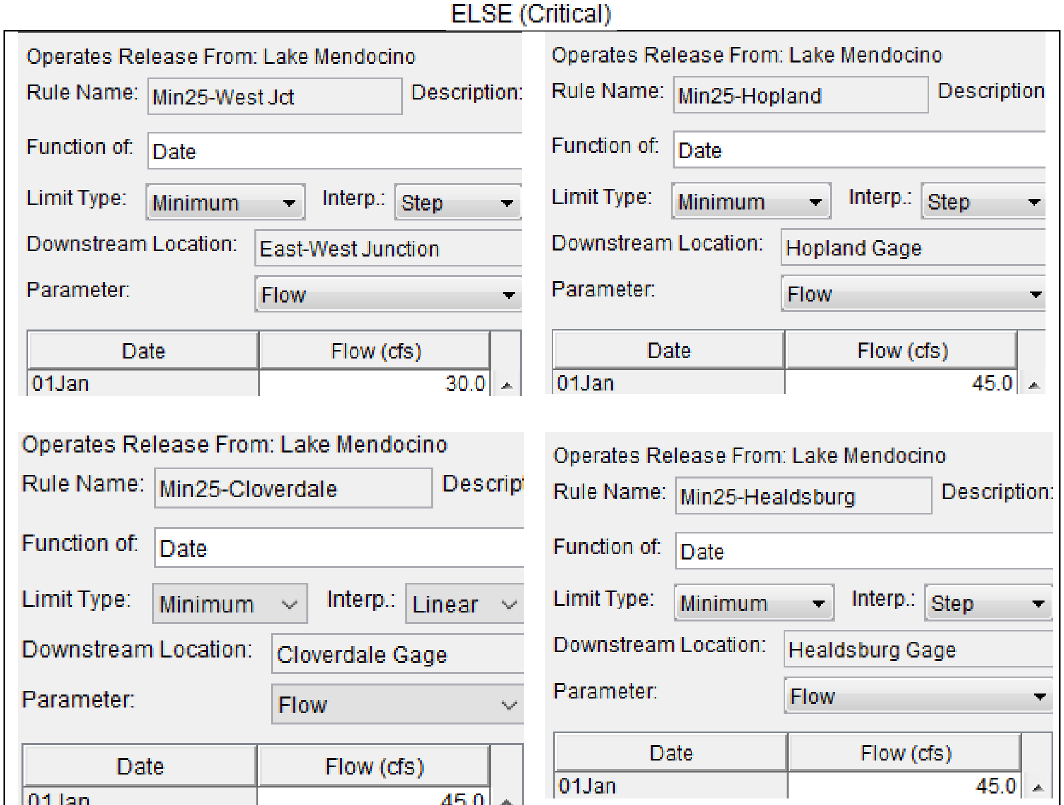


Figure 31 WSC I-1610 Q-TUCP Rule- (Critical)

7. IF_Block: DROC_April2016

The Decreasing Rate of Change (DROC) IF_Block, *DROC_April2016* (Figure 32 to Figure 34), reflects an agreement between USACE-San Francisco District and NMFS in April 2016, primarily intended to minimize fish stranding. The requirement updates the previous rules established under the 2008 Russian River BIOP, limiting the "ramp-down" of Coyote Valley Dam releases based on the magnitude of the discharge and time of year. Outflows greater than 4,000 cfs may be reduced by 1,000 cfs/hour, but only by 250 cfs/hour when between 4,000 cfs and 2,500 cfs, and only by 100 cfs/hour for flows less than 2,500 cfs. Releases less than 250 cfs must ramp down no faster than 25 cfs/hour for most of the year. Between 15 March and 15 May, releases below 250 cfs may also decline by no more than 50 cfs/day, which was implemented as 2.083 cfs/hr in the HEC-ResSim model.

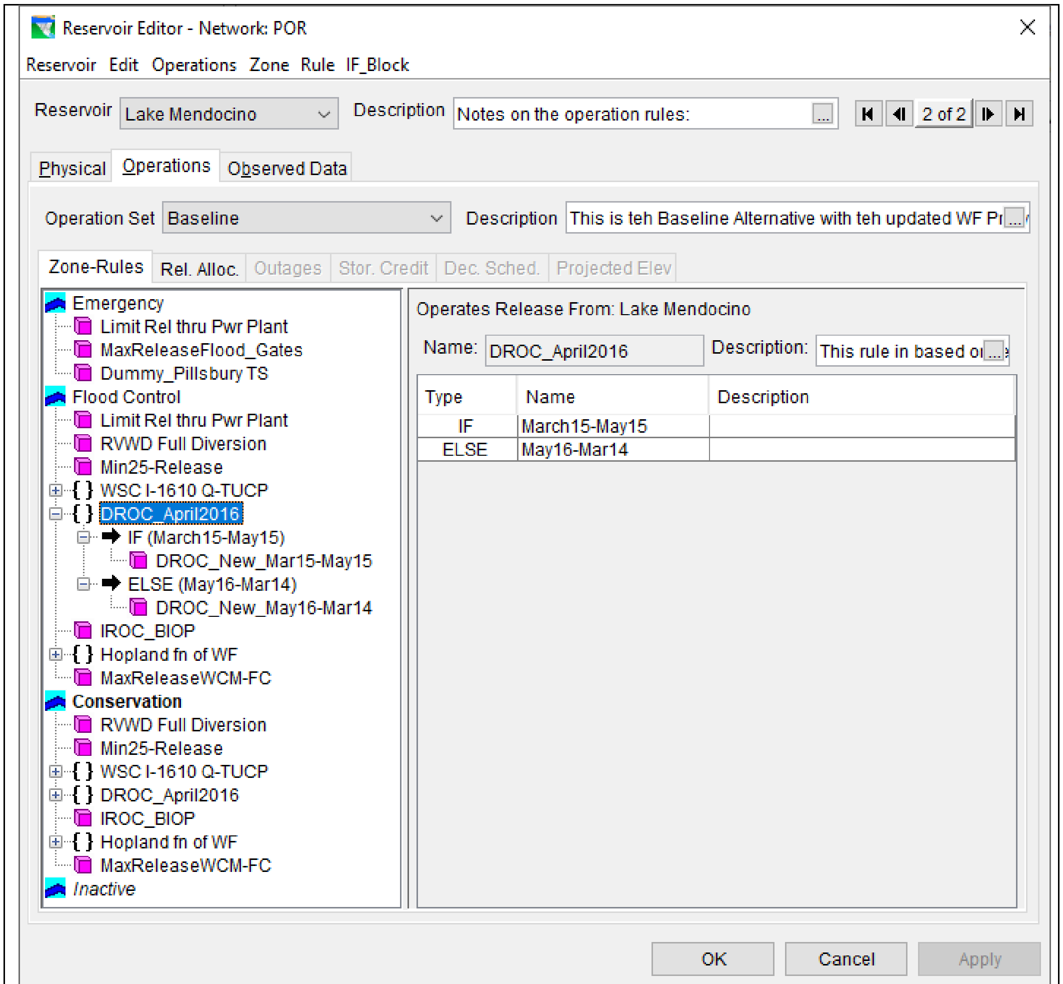


Figure 32 Decreasing Rate Of Change (DROC_April2016) Rule

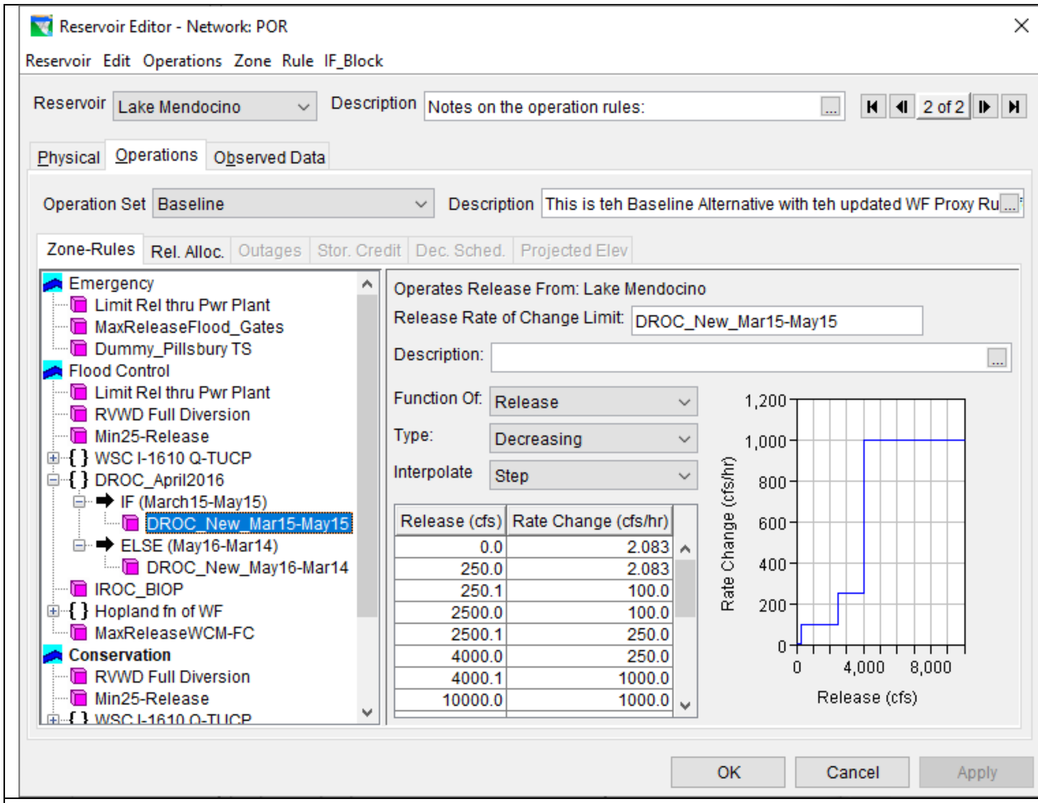


Figure 33 March15-May 15 - DROC_April2016 Rule

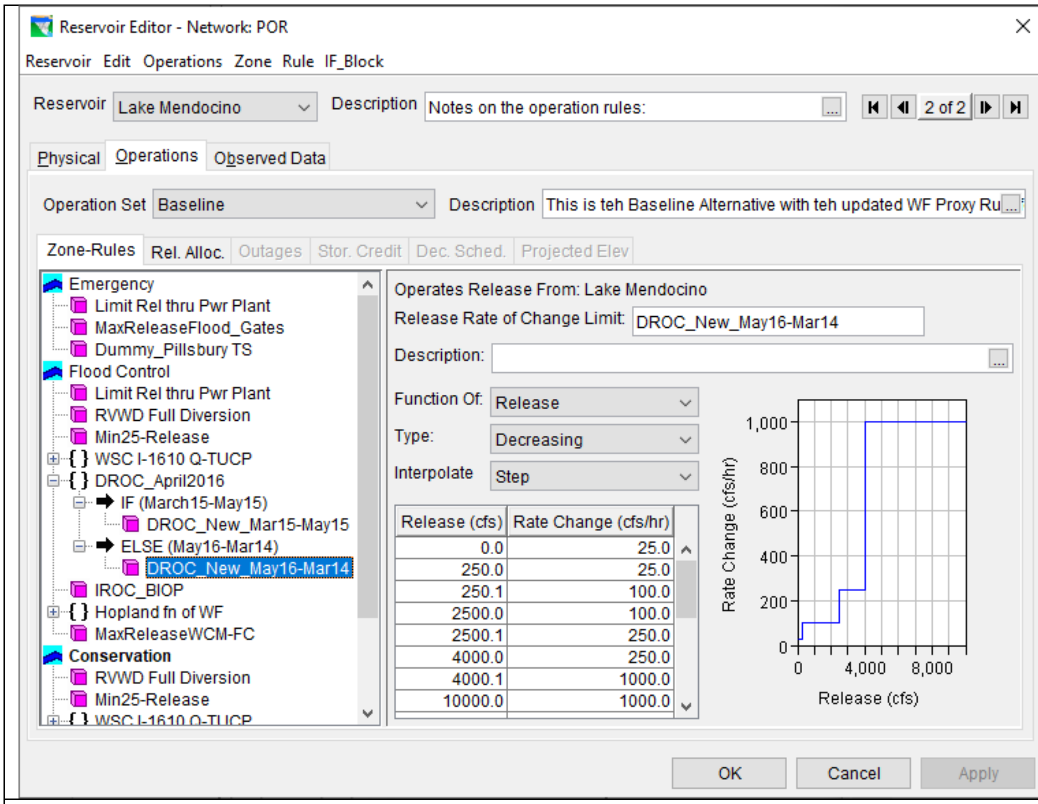


Figure 34 May 16-March 14 - DROC_April2016 Rule

8. Rule: IROC_BIOP

The rule *IROC_BIOP* (Figure 35) represents increasing rate of change operational requirements from the biological opinion (BIOP). Releases below 1,000 cfs may increase by only 1,000 cfs/hour, while higher outflows may ramp-up by 2,000 cfs/hour.

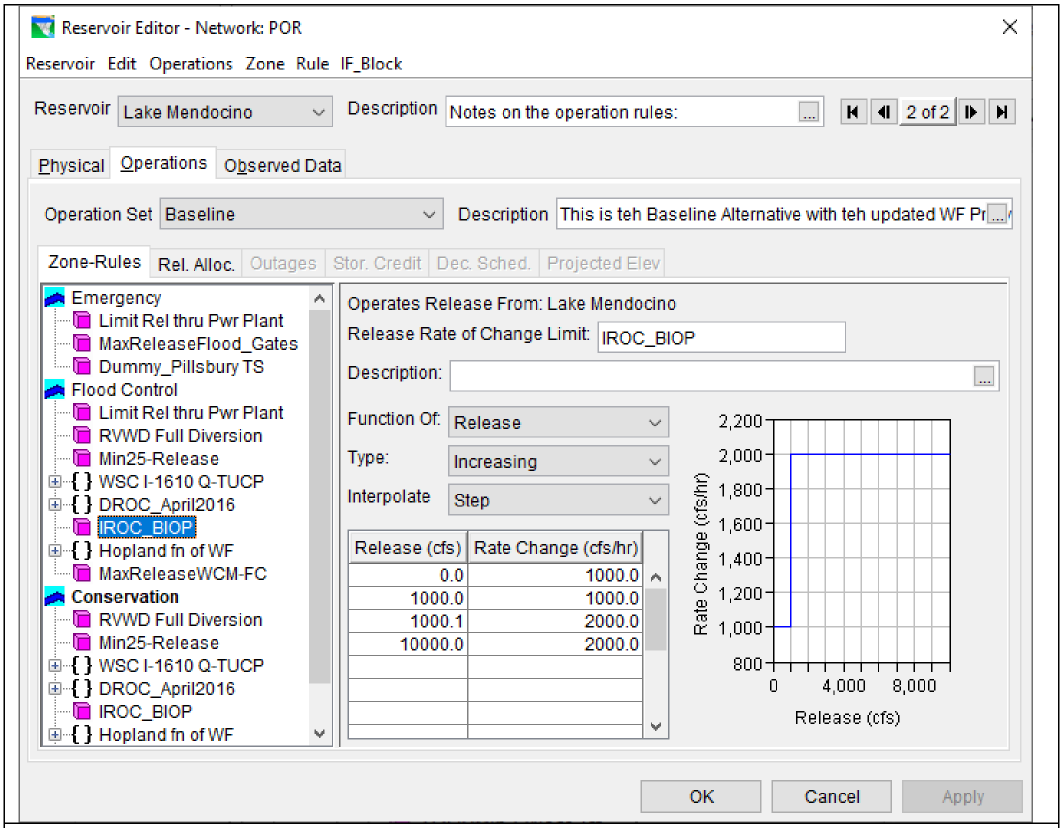


Figure 35 Increasing Rate Of Change (IROC_BIOP) Rule

9. IF_Block: Hopland fn of WF

The IF_Block *Hopland fn of WF* (Figure 36 to Figure 40) represents a special approach developed for the Russian River HEC-ResSim model to replace two existing rules specified in the Coyote Valley Dam Water Control Manual:

- 8,000 cfs maximum allowable flow at Hopland USGS gage (USGS 11462500)
- 25 cfs maximum allowable release when the Russian River at Ukiah USGS gage (USGS 11461000), located on the West Fork of the Russian River, is above 2,500 cfs

The *Hopland fn of WF* IF_Block contains rules regarding the goal of limiting flow at Hopland to 8,000 cfs. The standard HEC-ResSim rule for maintaining maximum releases at a downstream location computes the outflow by performing an approximate routing from the reservoir to the control point, and incorporates intervening local flows in future time steps. Such assumed knowledge of the near future conditions downstream may be appropriate when simulating release decisions, where experienced operators might consider a variety of information such as flows at the control point forecasted by the NWS. However, for this study to explore the impact on release decisions of actual forecast information for the downstream local flows, the modeling team attempted a more limited representation of the actual decision logic typically employed by the operator for Lake Mendocino in the baseline condition.

In practice, the operator does not determine flood operation outflows by routing candidate releases from Coyote Valley Dam to Hopland, and does not know the local flow hydrographs. The operator makes judgments based on experience and awareness of basin conditions, primarily considering the level of Lake Mendocino and the flow observed at the nearby gage on the West Fork Russian River.

Flow at Hopland has three components: Lake Mendocino release, West Fork (WF) flow and local downstream flows above Hopland. For this study, a release decision referred to as a proxy rule was defined by using the WF flow as a surrogate for the local downstream flows above Hopland. Mass balance provides the following relationship, simplified to use just WF flow and rearranged for simplicity:

Release = 8000 – WF-Flow – local-downstream
Release = 8000 – WF-Flow – WF-flow * ratio
Release = 8000 – WF-Flow * ratio+1

The relationship between WF flow and downstream local flow was estimated from historical data, as is reflected in a multiplier. The value of the multiplier (ratio+1) varied in different conditions to reflect the amount of uncertainty around the assumed relationship and the need to hedge against that uncertainty. A larger multiplier lowers the release, providing greater hedging.

The *Hopland fn of WF* IF_Block models the decision process according to two conditions that define three situations, using a different value of ratio+1 in each situation. The two conditions are (1) whether flows on West Fork are rising or falling, and (2) if falling, whether reservoir elevation is greater or less than 755 feet.

When WF flow is rising, downstream flows are also assumed to be rising, and might vary greatly from the relationship estimated between WF flow and Hopland local flow. Thus a high multiplier (ratio+1) of 10 is employed. When WF flow is falling but elevation is below 755 feet, a less conservative release is made by using a lower multiplier (ratio+1) of 3. When elevation is greater than 755 feet, more concern rests with lowering the pool level, and release is least conservative with the lowest multiplier (ratio+1) of 2.3.

The basic statement of (Release = 8000 – WF-Flow * ratio+1) is often negative. So, it's actually MAX (0, Release = 8000 – WF-Flow * ratio+1).

Within the HEC-ResSim model, the proxy release relationship was captured in rules that define release as a function of WF flow. A rule exists for each of the 3 values of ratio+1, to be used in each of the three situations described above and listed below.

(1) Flow rising on the West Fork gage (Figure 37). This situation is the first condition (*Hopland fn of WF* IF_Block) and determines how to reduce releases in order to protect downstream locations.

(2) Flow declining on the West Fork gage (Figure 38) and the reservoir stage is above 755 feet (Figure 39). This situation is the second condition (*Hopland fn of WF* IF_Block), where the reservoir stage is above 755 feet and governs the emptying of the flood pool when the reservoir is high, and operators are more concerned with the reservoir level than the possibility of exceeding 8,000 cfs at Hopland.

(3) Flow declining on the West Fork gage and the reservoir stage is below 755 feet (Figure 40). This situation is the third condition (*Hopland fn of WF* IF_Block), where the reservoir stage is below 755 feet and governs the emptying of the flood pool when the reservoir is not high, and greater consideration is given to the Hopland flow.

Outflows in the rules were determined according to relationships using the West Fork Russian River flow described above, developed by Sonoma Water. Review with operators confirmed that these rules acceptably captured the actual operations for the rising and falling limbs of Russian River flows, without using forecast information.

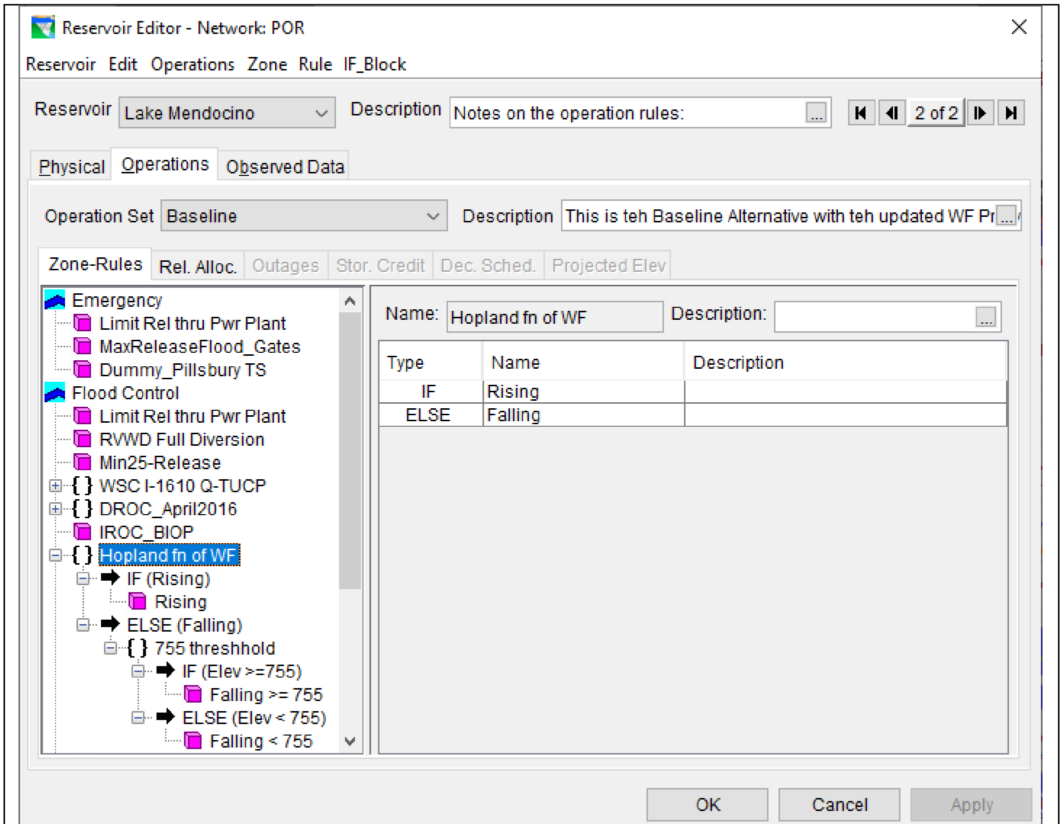


Figure 36 Hopland fn of WF Rule

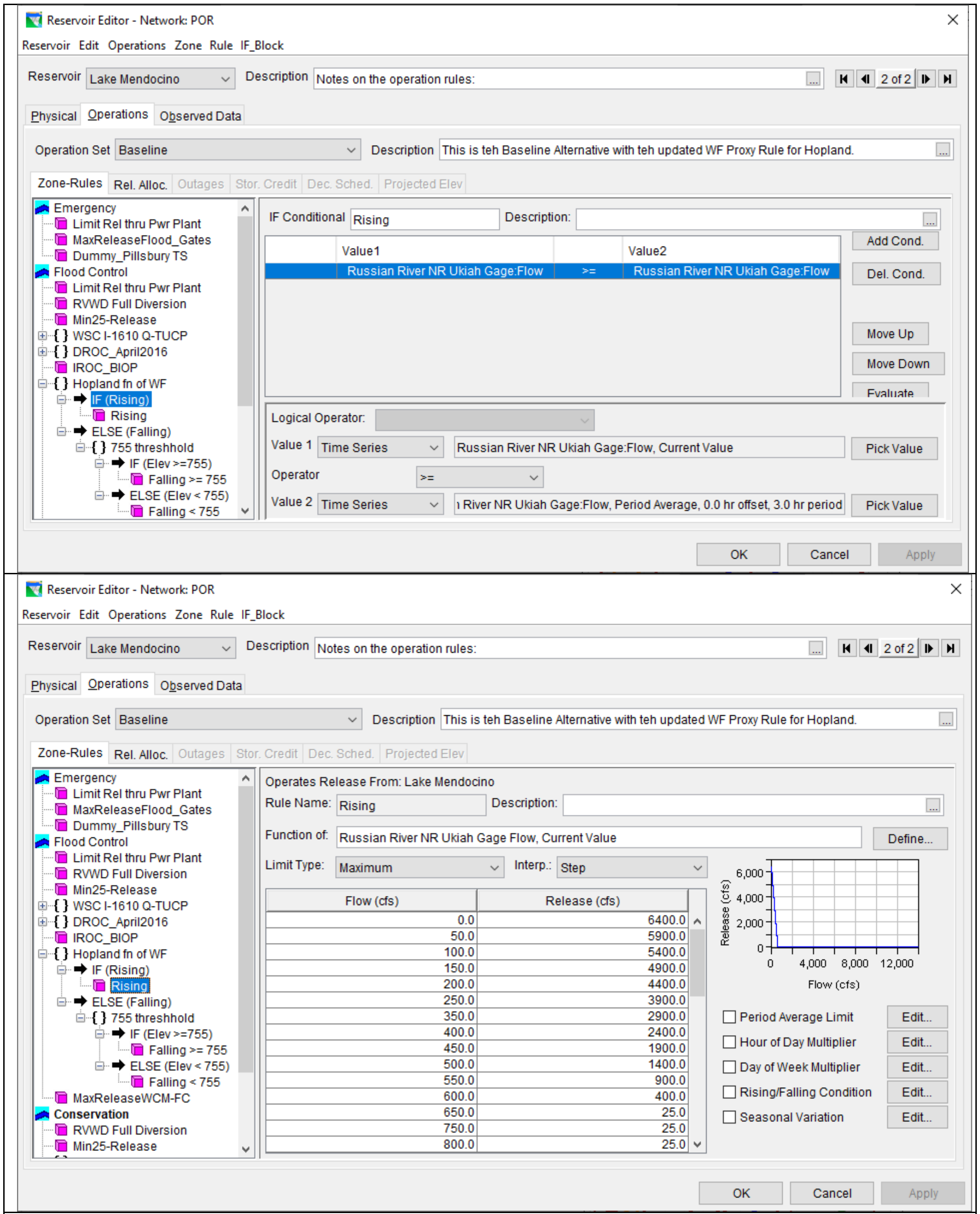


Figure 37 Hopland fn of WF _State is Rising

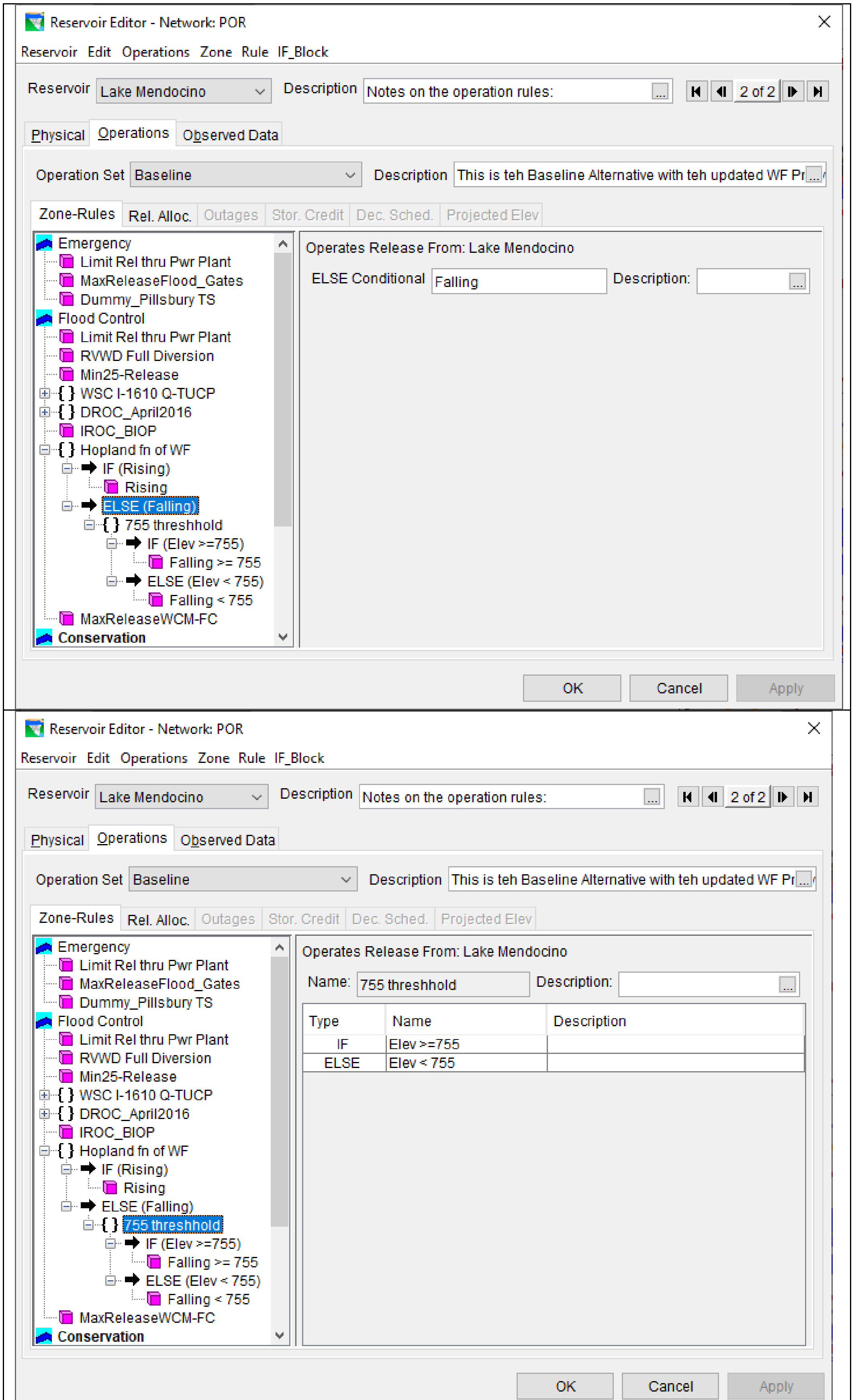


Figure 38 Hopland fn of WF _State is Falling

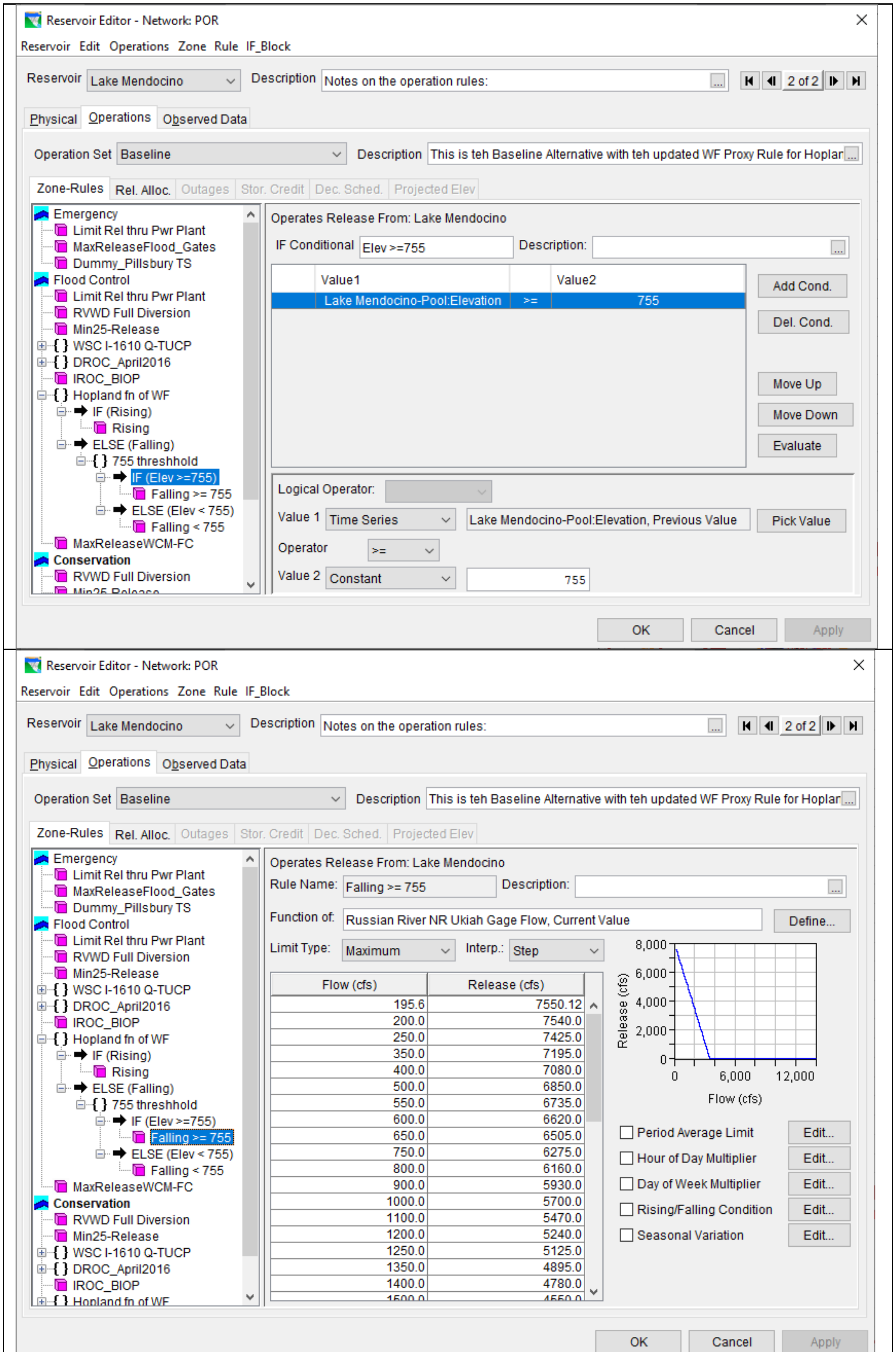


Figure 39 Hopland fn of WF_State is Falling_pool Elev>=755

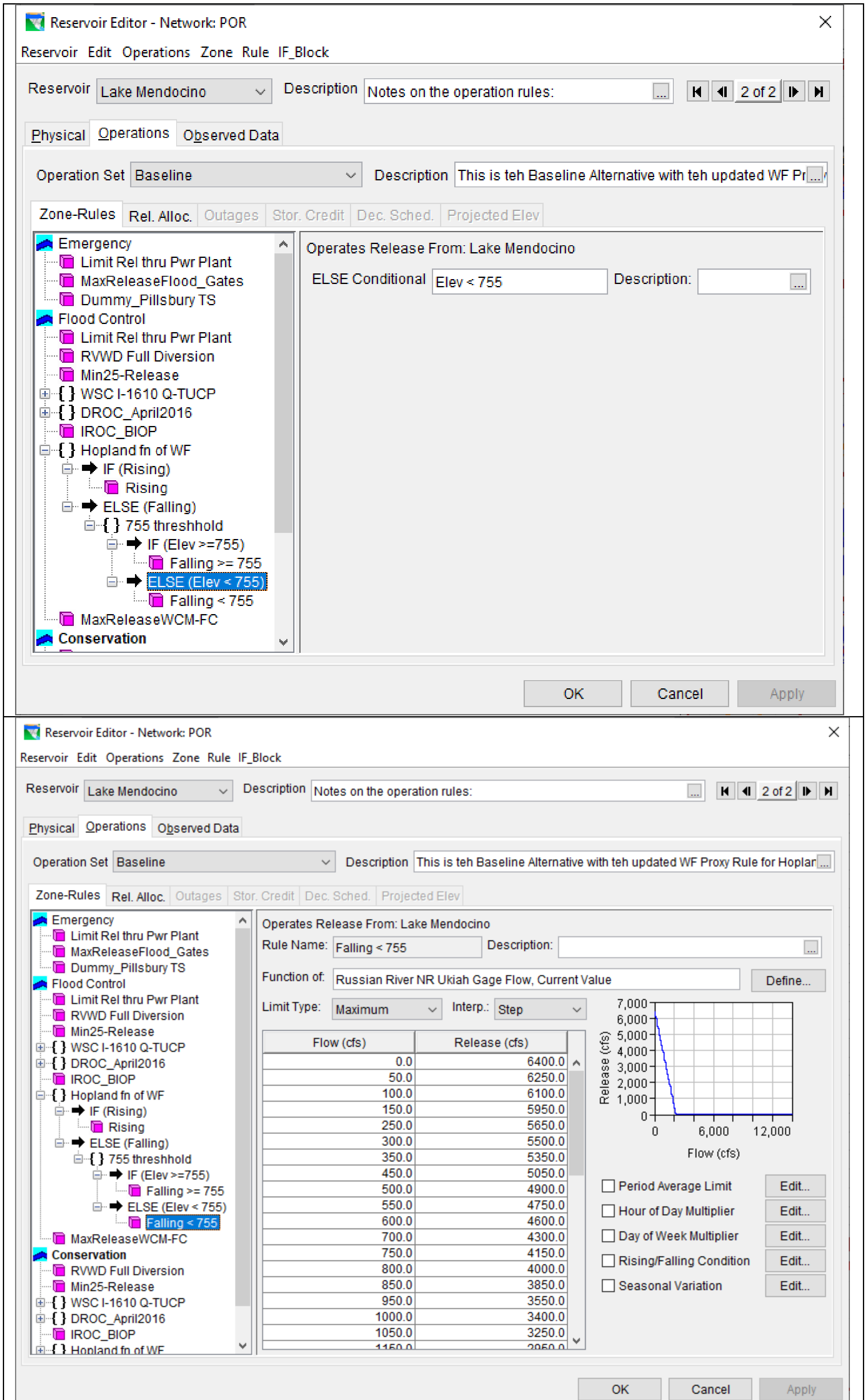


Figure 40 Hopland fn of WF_State is Falling_Pool elev <755

10. Rule: MaxReleaseWCM-FC

The rule *MaxReleaseWCM-FC* (Figure 41) sets maximum flows at 4,000 cfs or 6,400 cfs, based on elevation, according to typical operational practices. The 4,000 cfs thresholds represented limits in the Water Control Diagram (Appendix A) for *Flood Control Schedule 1 and 2* and 6,400 cfs thresholds represented limits for *Flood Control Schedule 3*.

The hydraulics of weir flow over the 200-foot uncontrolled spillway quickly increases the outflow as the lake rises, so that the spillway provides all of the specified *Flood Control Schedule 3* (Appendix A) release and the gate stays closed. In situations with spillway flow, the outflow from Coyote Valley Dam could become largely outside the control of operators, with Lake Mendocino no longer providing as much flood protection to downstream locations. Lake Mendocino has never reached the *Emergency Release Schedule* (Appendix A).

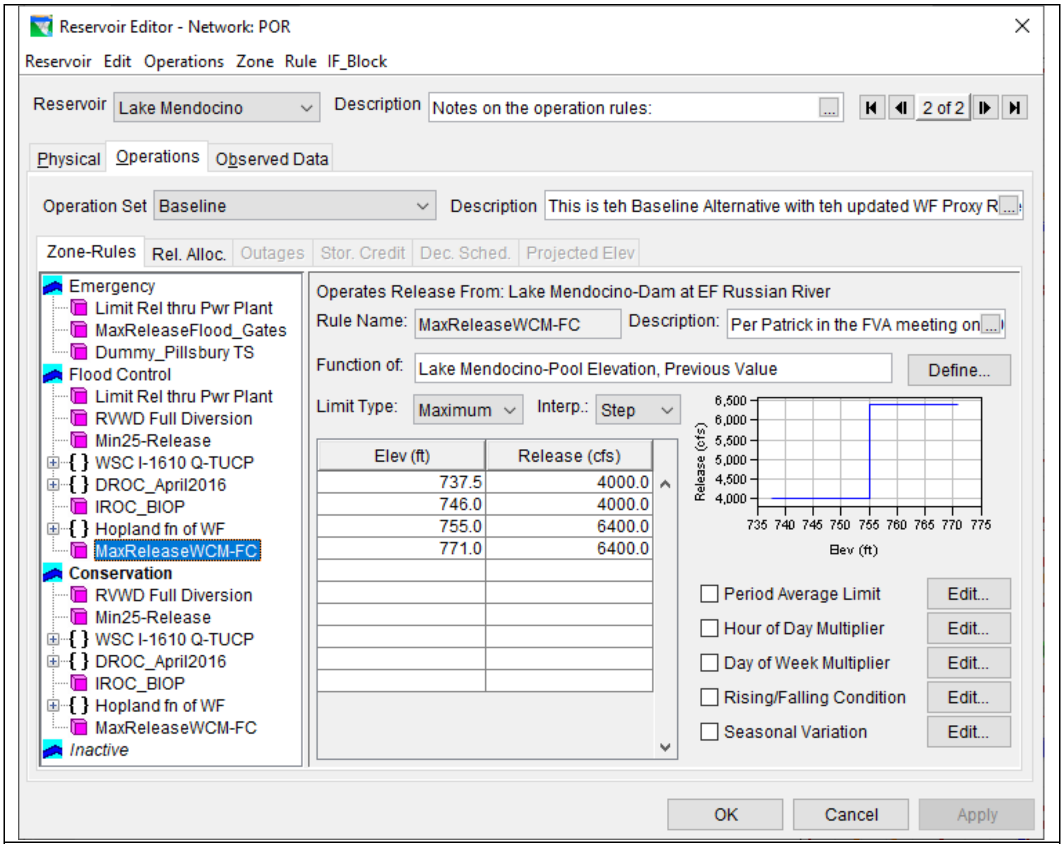


Figure 41 MaxReleaseWCM-FC Rule

V. Warm Springs Dam (Lake Sonoma)

Warm Springs Dam was completed in 1983 on Dry Creek, creating Lake Sonoma. Warm Springs Dam was authorized by the Flood Control Act of 1962 for the purposes of flood control, water supply, environmental stewardship, and recreation. Congressional authorization in the mid-1970's added mitigation for fish identified in the Endangered Species Act to the mission set for both federal dams on the Russian River. Warm Springs Dam is compacted earth fill with an impervious core, with a maximum height above the streambed of 319 feet and a crest length of

3,000 feet. Elevation of the dam crest is 519 feet. The adjacent uncontrolled spillway has a 100-foot long crest at elevation 495 feet.

The drainage area above Warm Springs Dam totals approximately 131 square miles, or about 25 percent more area than above Coyote Valley Dam. However, Warm Springs Dam offers 136,000 AF of flood control reservation between the guide curve and spillway crest, which is 1.8 times the flood control reservation at Lake Mendocino. The outlet works consist of low flow water quality outlet with three five-foot diameter intake tunnels (at elevations of 431, 391, and 352 feet). The flood control outlets at Warm Springs Dam consist of two 5' x 8' service gates and two 5' x 8' slide gates. These outlets restrict flows at the Yoakum Bridge near Geyserville (7,000 cfs), and at Guerneville, where flows cannot exceed 35,000 cfs.

Similar to Coyote Valley Dam, flood control operations at Warm Springs Dam typically require outflows to be minimized during storms. Lake Sonoma offers much more storage than Lake Mendocino, so reservoir operators have greater flexibility regarding when to release storage accumulated during storms. Storm storage retained in Lake Sonoma substantially reduces flood peaks on Dry Creek and its confluence near Healdsburg, but has a limited effect on flood peaks along the lower Russian River.

Similar to Coyote Valley Dam, Warm Springs Dam supports instream flows at locations on Dry Creek and the lower Russian River. Warm Springs Dam also maintains flow to a fish hatchery immediately below the dam. Coyote Valley Dam and Warm Springs Dam perform no explicit system operations. However, Warm Springs Dam releases needed to provide minimum flows on the Russian River do take prior releases from Coyote Valley Dam into consideration, representing an implicit system operation.

Figure 42 shows the location of Warm Springs Dam and its pool (Lake Sonoma) as it is represented in the HEC-ResSim model.

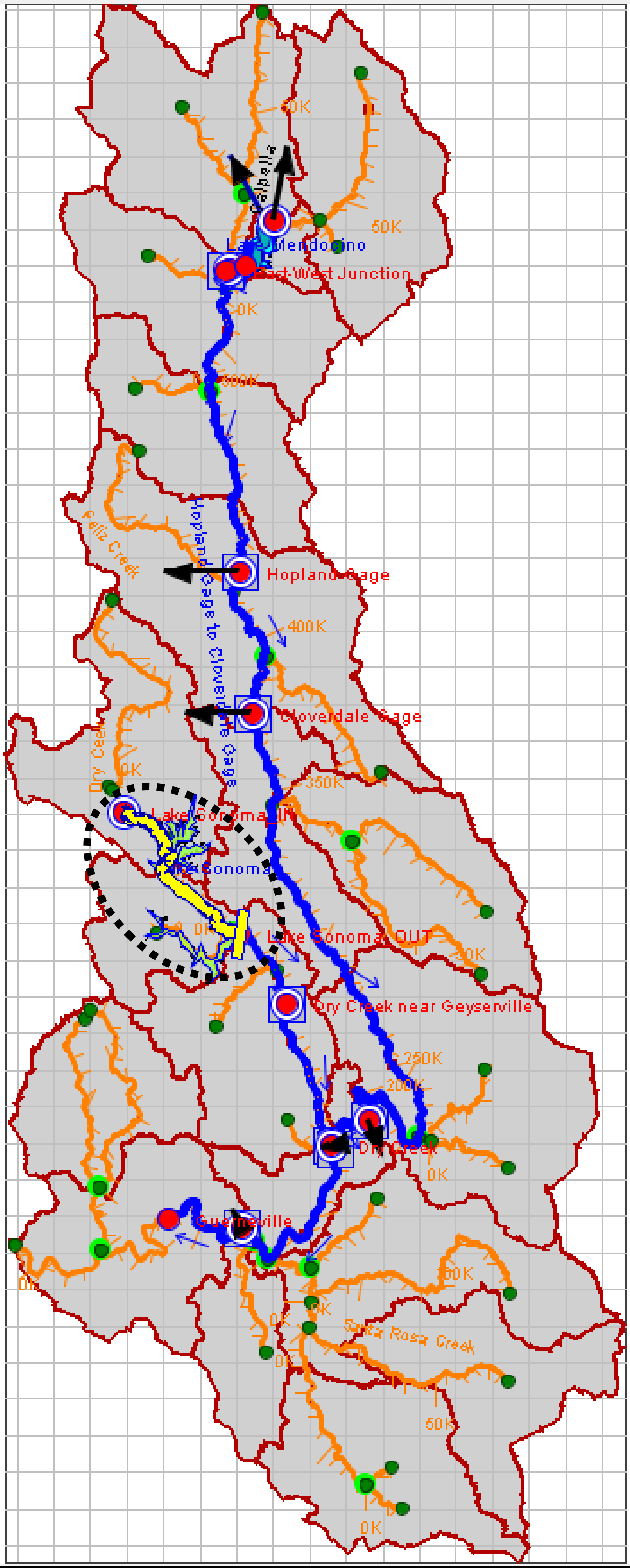


Figure 42 HEC-ResSim Map Display Showing Location of Warm Springs Dam

1. Physical Characteristics

Warm Springs Dam is compacted earth fill with an impervious core, with a maximum height above the streambed of 319 feet and a crest length of 3,000 feet. Elevation of the dam crest is 519 feet. The approximately 381,000 AF capacity (at spillway invert) of Lake Sonoma is used for flood control and flood conservation in the Russian River basin. The outlet works consist of a low flow water quality outlet with three five-foot diameter intake tunnels (at elevations 431, 391, and 352 feet). The flood control outlets consist of two 5' x 8' service gates and two 5' x 8' slide gates. Outlets are operated to restrict flows to 7,000 cfs at the Yokum Bridge near Geyserville and to not exceed 35,000 cfs on the Russian River at Guerneville.

The physical characteristics of the reservoir are separated between the *Pool* and the *Dam* in the HEC-ResSim model.

A. Pool

The E*levation-Storage-Area* defines the pool as shown in Figure 43. The Lake Sonoma elevation-storage-area relationship was taken from the Warm Springs Dam Water Control Manual, Exhibit A.

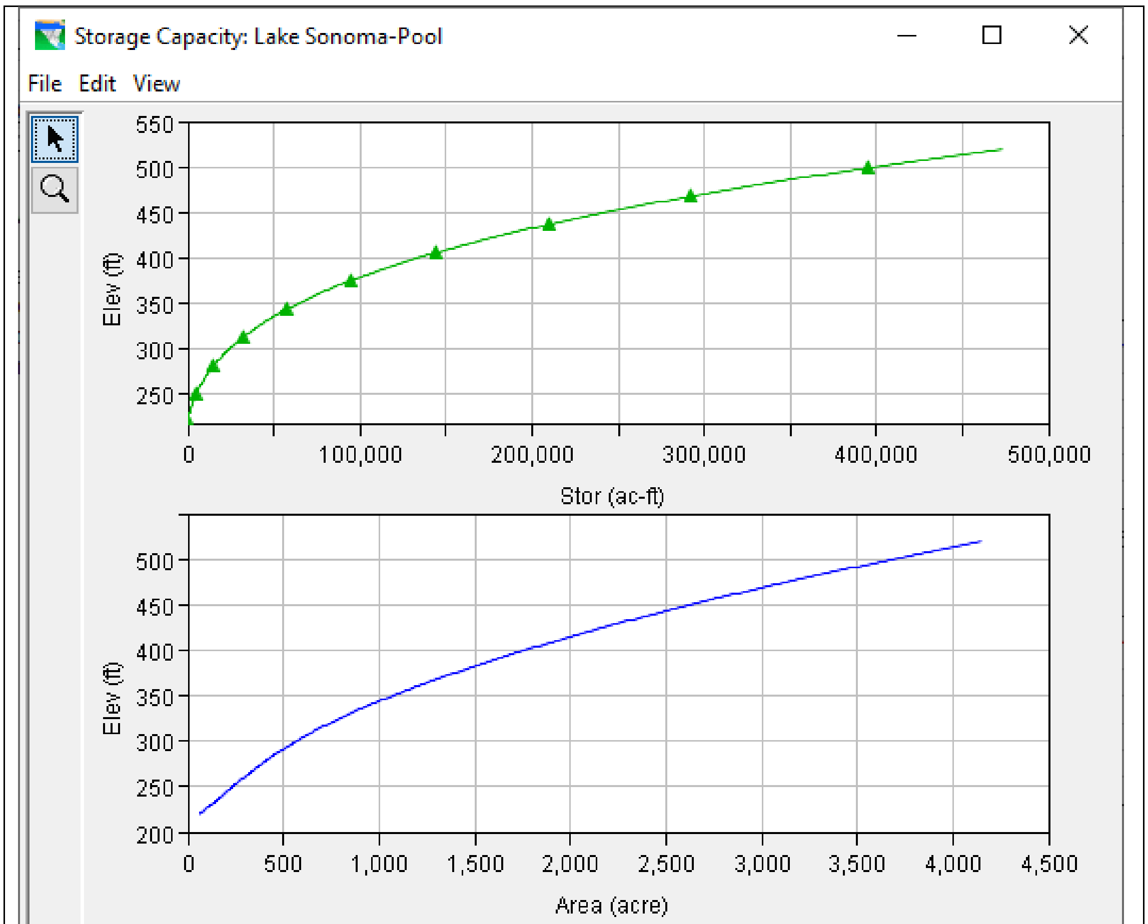


Figure 43 Reservoir Editor - Physical Tab - Lake Sonoma Pool

B. Evaporation

Monthly evaporation losses from Lake Sonoma are contained in Figure 44. The evaporation values were provided by Sonoma Water.

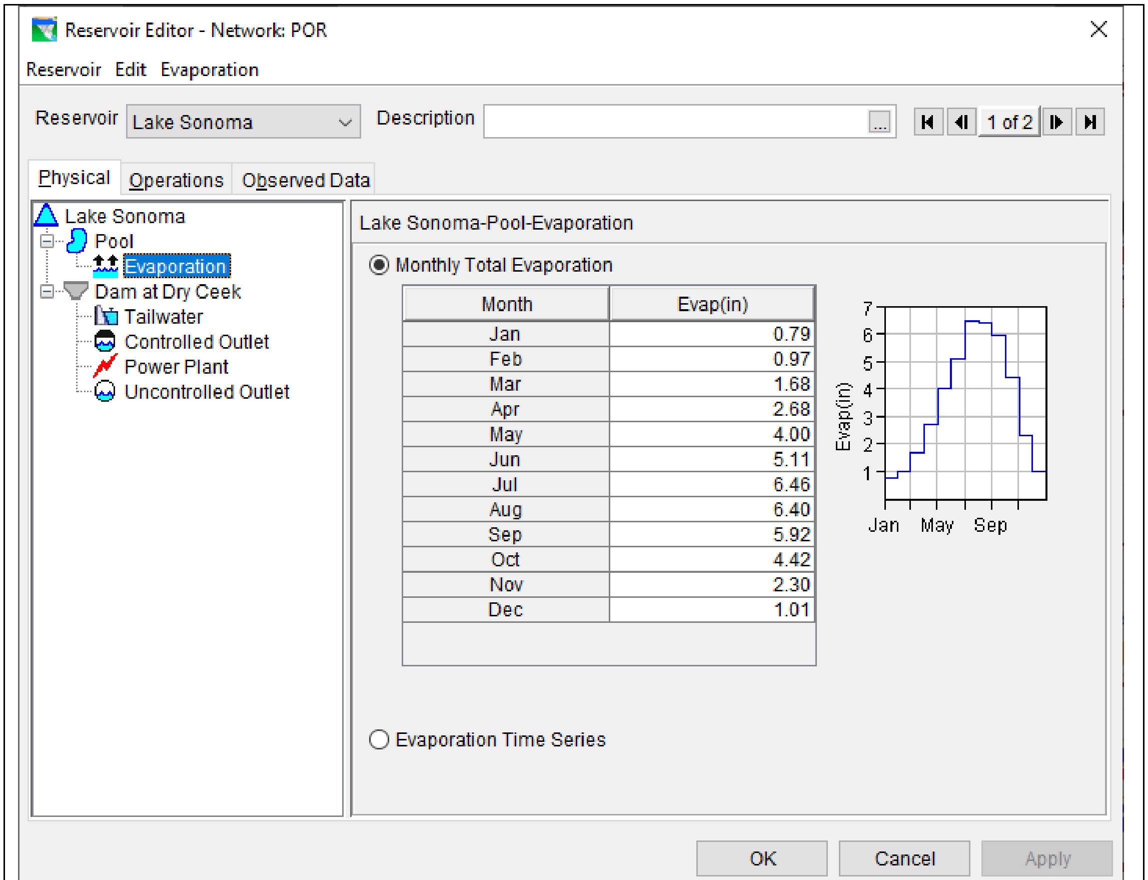
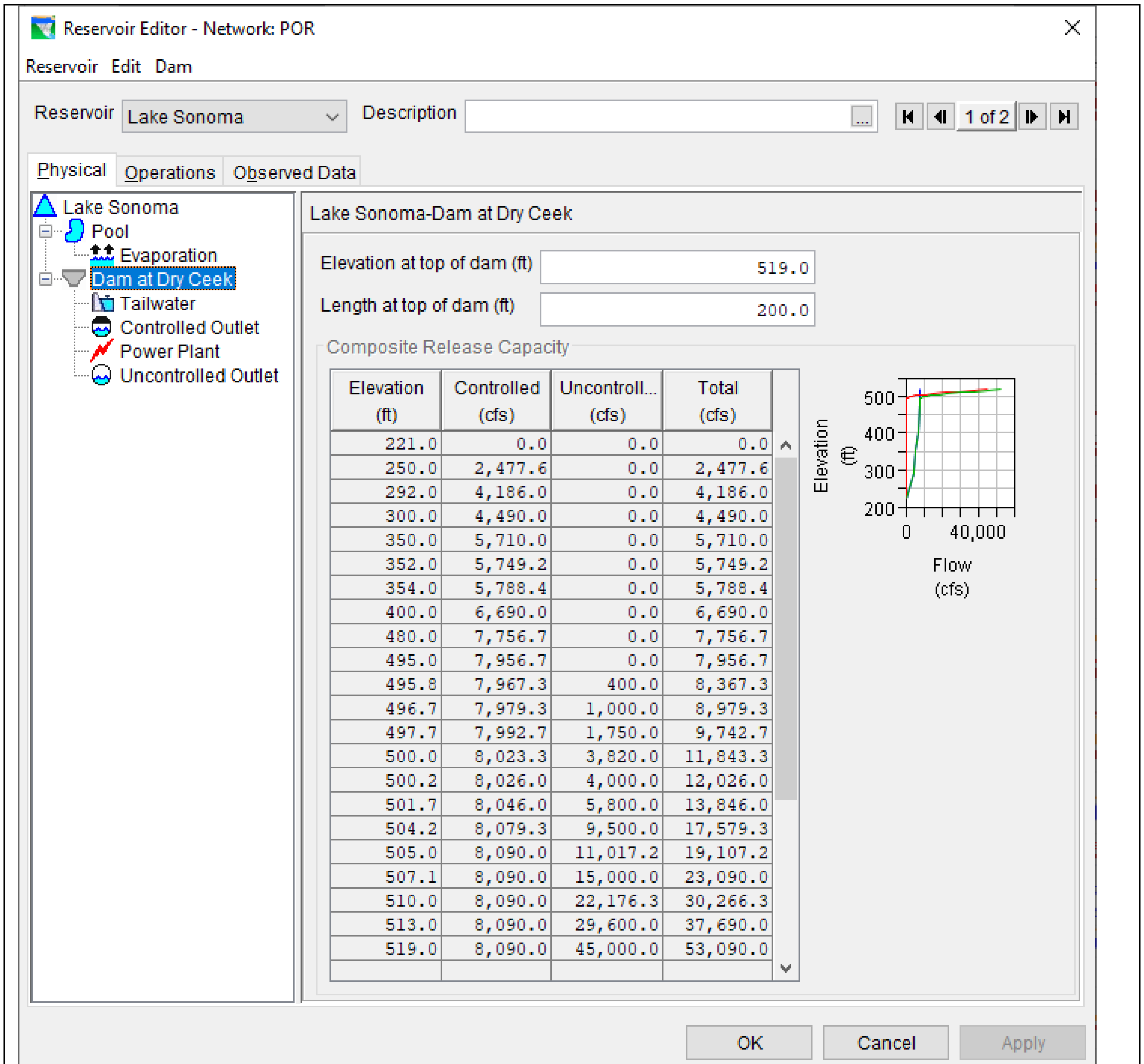


Figure 44 Reservoir Editor - Physical Tab - Lake Sonoma Evaporation

C. Dam

The dam consists of three types of outlets: (1) a controlled, (2) a power plant, and (3) an uncontrolled outlet (spillway). Each of these outlets is defined in the model as shown in Figure 45, and the Dam release table reflects the composite release capacity of all of the outlets. The power plant and gates may be operated concurrently. There are no diversions from the pool, but a hatchery operates immediately below the dam.



Elevation (ft)	Controlled (cfs)	Uncontroll... (cfs)	Total (cfs)
221.0	0.0	0.0	0.0
250.0	2,477.6	0.0	2,477.6
292.0	4,186.0	0.0	4,186.0
300.0	4,490.0	0.0	4,490.0
350.0	5,710.0	0.0	5,710.0
352.0	5,749.2	0.0	5,749.2
354.0	5,788.4	0.0	5,788.4
400.0	6,690.0	0.0	6,690.0
480.0	7,756.7	0.0	7,756.7
495.0	7,956.7	0.0	7,956.7
495.8	7,967.3	400.0	8,367.3
496.7	7,979.3	1,000.0	8,979.3
497.7	7,992.7	1,750.0	9,742.7
500.0	8,023.3	3,820.0	11,843.3
500.2	8,026.0	4,000.0	12,026.0
501.7	8,046.0	5,800.0	13,846.0
504.2	8,079.3	9,500.0	17,579.3
505.0	8,090.0	11,017.2	19,107.2
507.1	8,090.0	15,000.0	23,090.0
510.0	8,090.0	22,176.3	30,266.3
513.0	8,090.0	29,600.0	37,690.0
519.0	8,090.0	45,000.0	53,090.0

Figure 45 Reservoir Editor - Physical Tab - Lake Sonoma Dam

2. Operation Sets

Operation of Lake Sonoma is described in the updated Water Control Manual (2004) and includes operations for both flood control and water supply.

A. Baseline Operation Set

Lake Sonoma operates according to a guide curve, similar to Lake Mendocino, with rules defined for Emergency, Flood Control, and Conservation storage zones. The operation set supports instream flow requirements similar to the ones applicable to Lake Mendocino. Warm Springs Dam flood operations also resemble those of Coyote Valley Dam, in that the operation set reduces outflows to protect downstream locations until the river recedes.

The HEC-ResSim representation of Lake Sonoma operations was simpler than for Lake Mendocino, which in turn made the operations at Warm Springs Dam simpler. In addition, Lake

Sonoma has a greater ability to store floodwater, which lessens the urgency to clear the flood storage by "backfilling" receding flows downstream. The water supply operations of Lake Sonoma also face less stress in comparison to Lake Mendocino. Operations at Warm Springs Dam were modeled in the same manner as for each of the water management alternatives evaluated at Coyote Valley Dam. An operations set was defined for the Warm Springs Dam representing the Existing Conditions alternative, and was named Baseline.

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 46 shows the definition of Lake Sonoma's "Baseline" operational zones, which consist of zones of Emergency, Flood Control, Conservation, and Inactive zone. These zones each contain a set of operational rules for reservoir operation.

The guide curve for Lake Sonoma remains constant at 451.1 feet throughout the year.

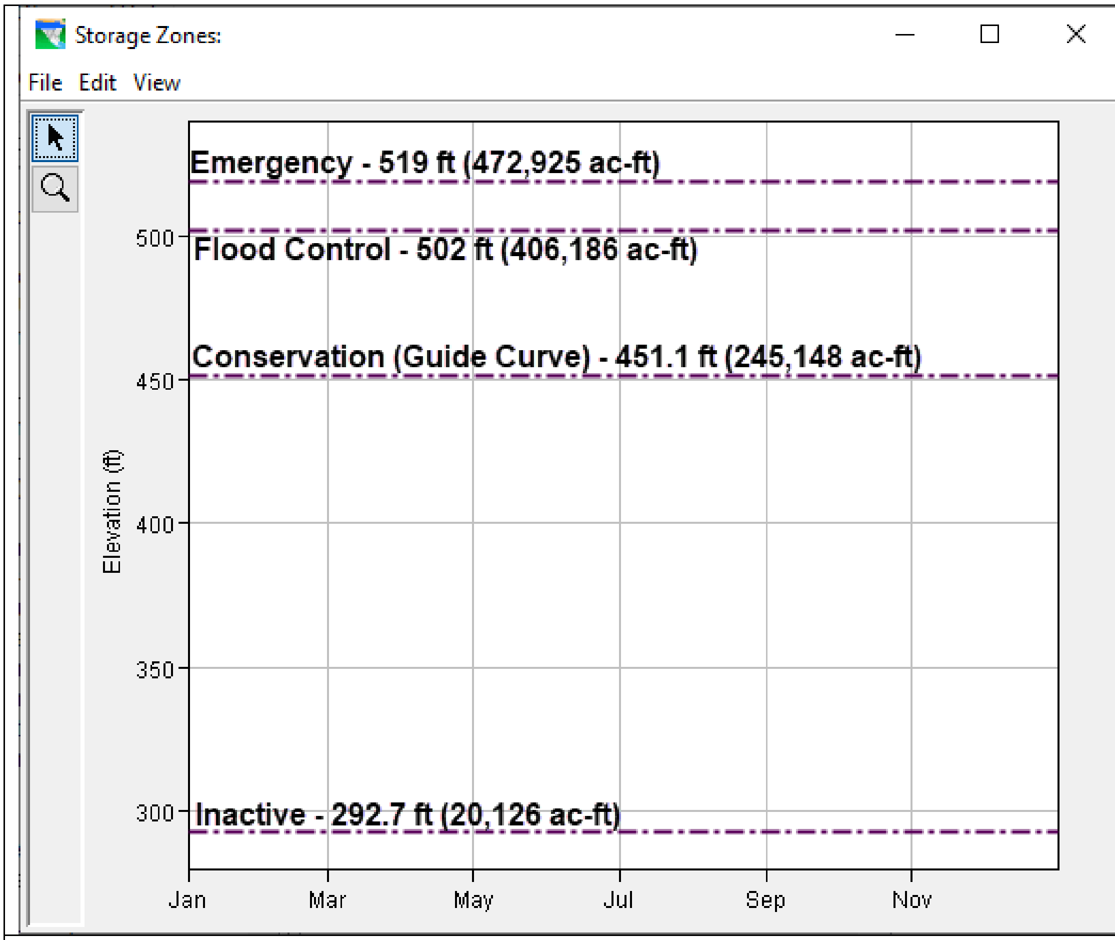


Figure 46 Zone Elevations for Baseline Operation Set - Lake Sonoma

The available outlets are given an order of priority for release. Figure 47 shows a sequential release allocation approach specified for available outlets along Warm Springs Dam. The power plant gets the release first until it reaches release capacity. After the capacity through the powerhouse is reached, the remainder of the release goes through the controlled outlet.

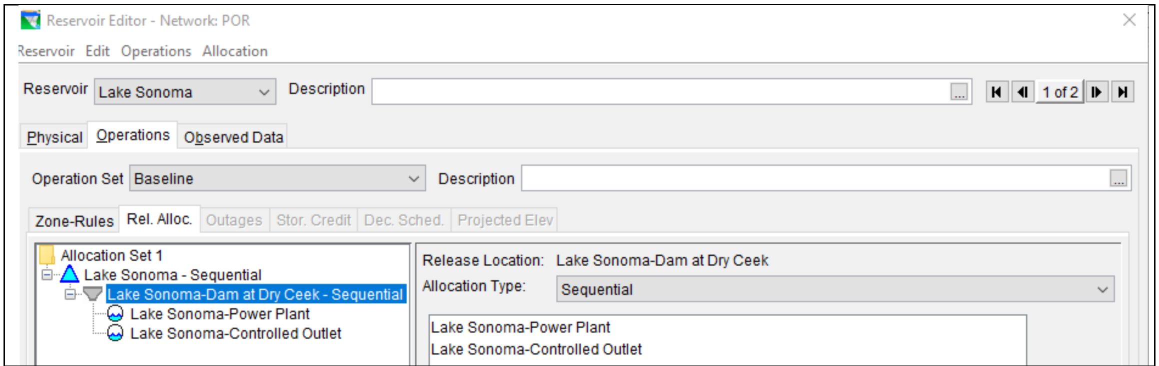


Figure 47 Release Allocation - Lake Sonoma

B. Rule Descriptions

Figure 48 shows a set of operational rules specified for each zone that reflects the operation set named *Baseline*.

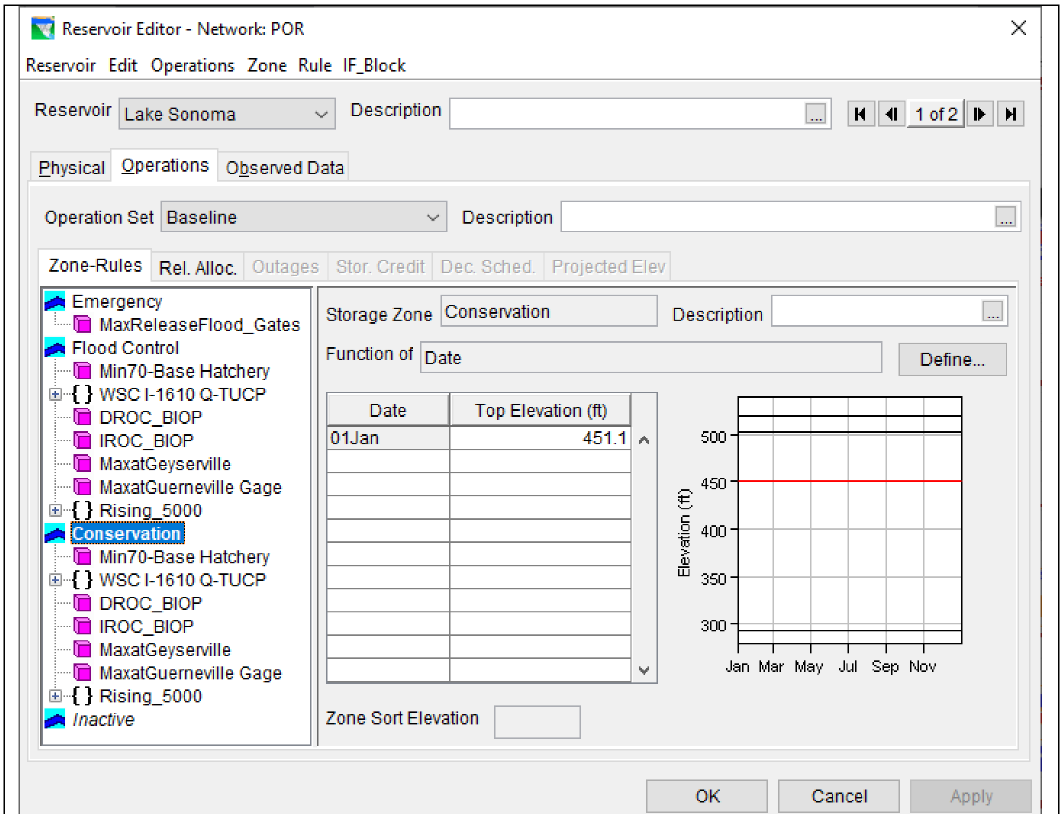


Figure 48 Zones and Rules - Lake Sonoma

1. Rule: MaxReleaseFlood_Gates

The rule *MaxReleaseFlood_Gates* (Figure 49) is the only rule in the emergency zone. It describes the emergency release schedule, which specifies how to operate the gates in conjunction with flow over the spillway. The rule sets a maximum release from Lake Sonoma through controlled outlet to less than 7,900 cfs until the pool is below 505 feet, per the emergency release schedule in Water Control Diagram (2004).

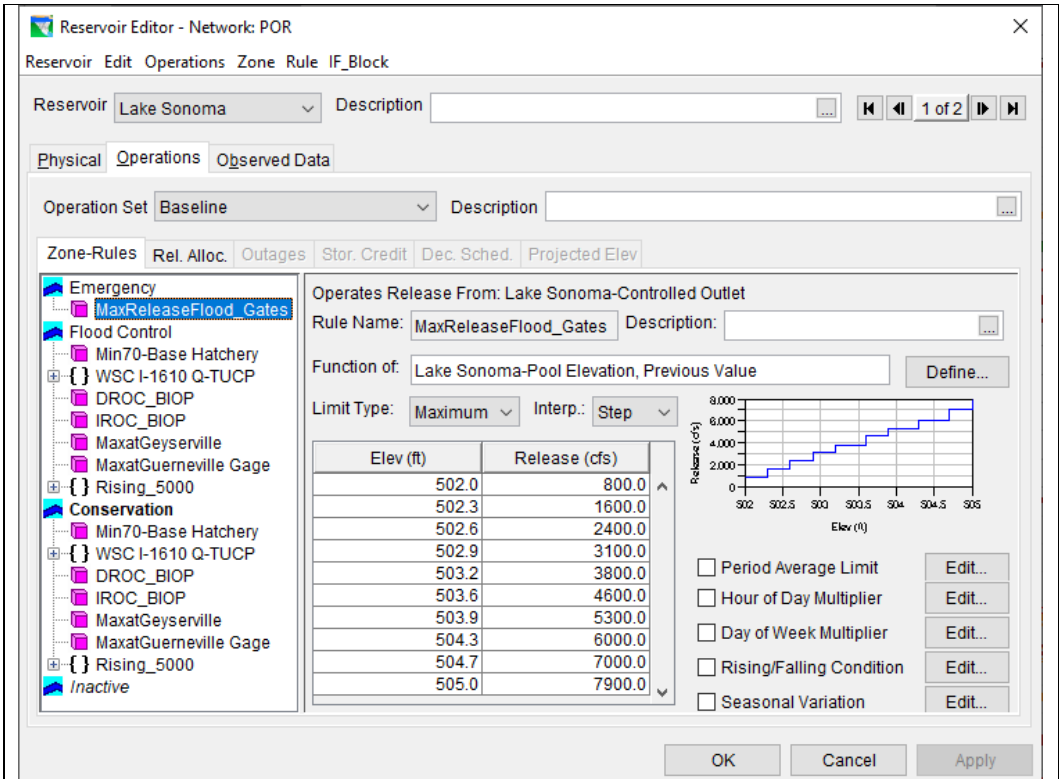


Figure 49 MaxReleaseFlood_Gates Rule

2. Rule: Min70-Base Hatchery

The rule *Min70-Base Hatchery* (Figure 50) is the highest priority rule in the Conservation and Flood Control zones required for the fish hatchery. The rule sets the minimum release to 70 cfs for all simulation time-steps for hatchery purposes, per Sonoma Water personal communication.

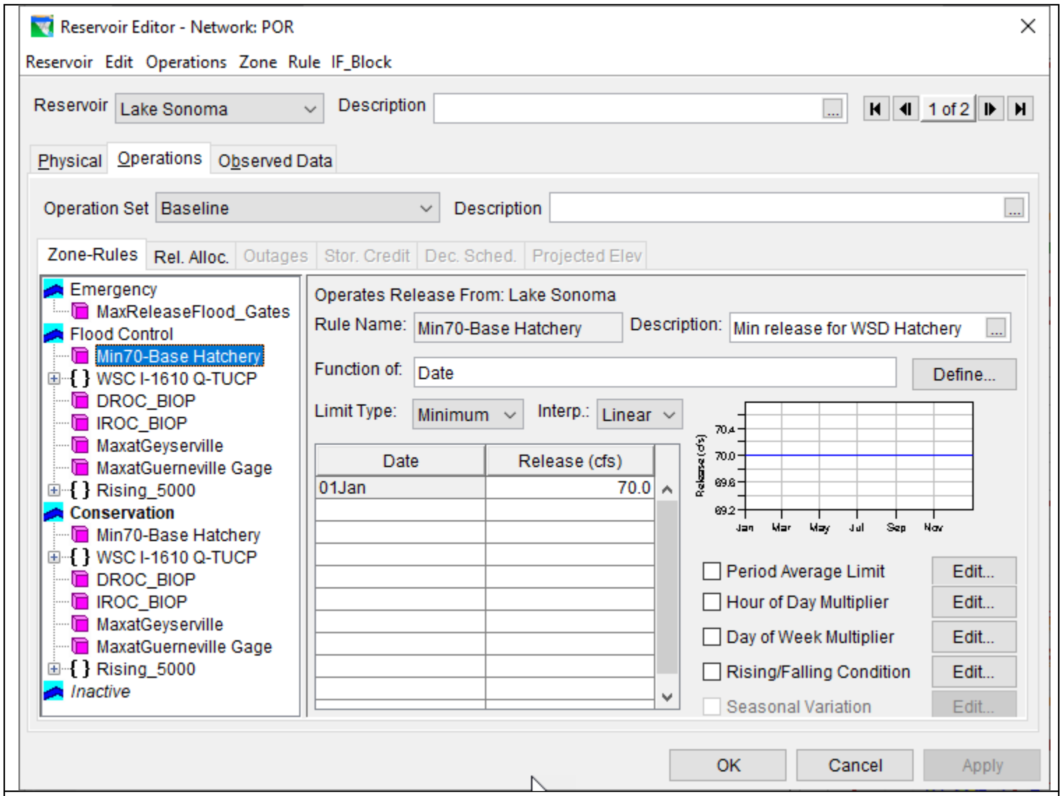


Figure 50 Min70-Base Hatchery Rule

3. IF_Block: WSC I-1610 Q-TUCP

Similar to Lake Mendocino, the minimum flows required at different downstream locations per SWRCB Decision 1610 were specified according to the annual hydrologic index. The requirements were expressed for three locations (the Dry Creek, Dry Creek conf, Guerneville Gage). HEC-ResSim resolves the different flow requirements at the locations by releasing the maximum of the minimums from Lake Sonoma.

Per a recommendation from Sonoma Water, these flow targets were further padded by varying amounts to reflect "safety buffer" increments used in operations to overcome potential losses along the river. The details of this rule are shown in Figure 51 to Figure 54.

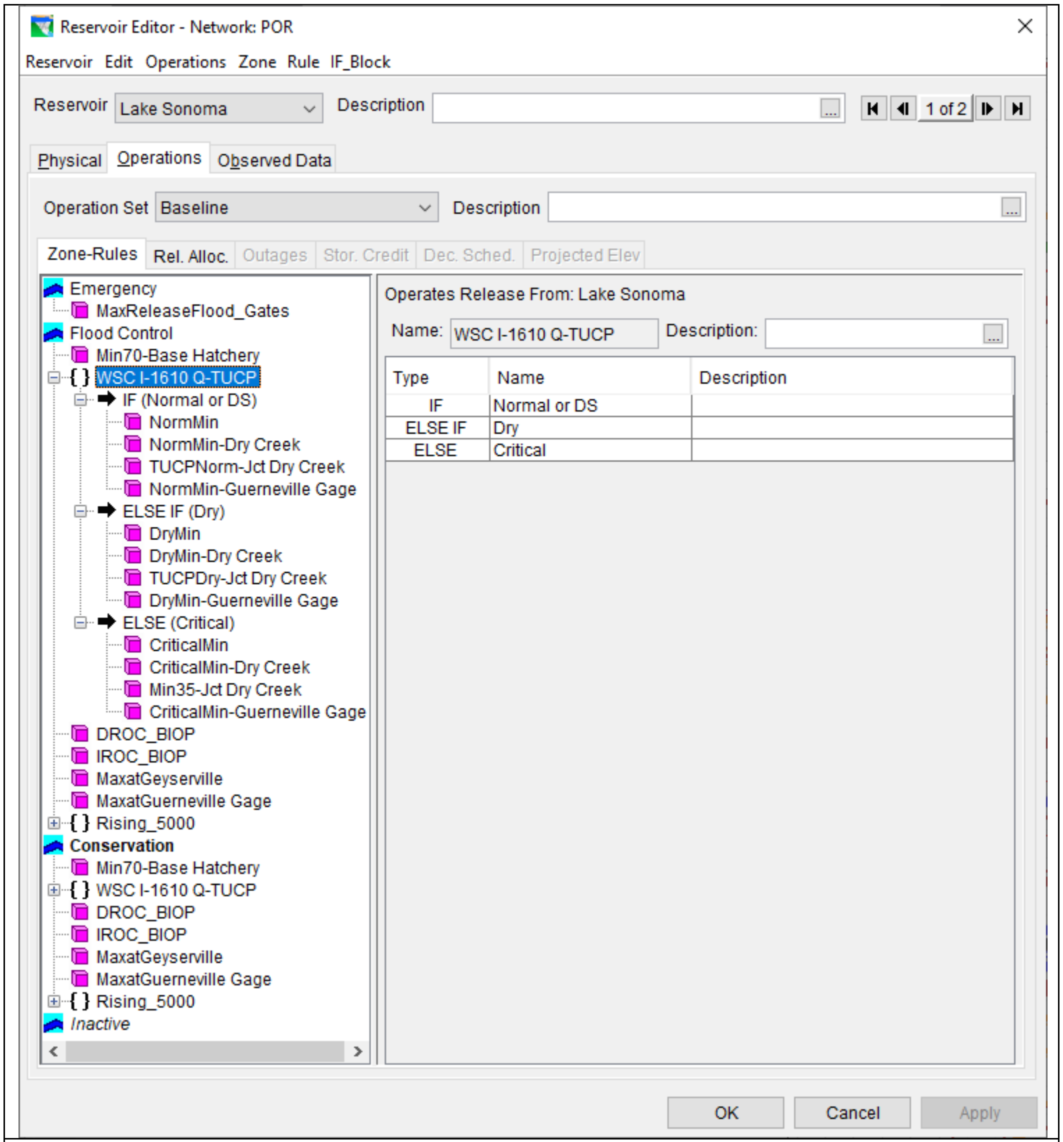


Figure 51 WSC I-1610 Q-TUCP Rule

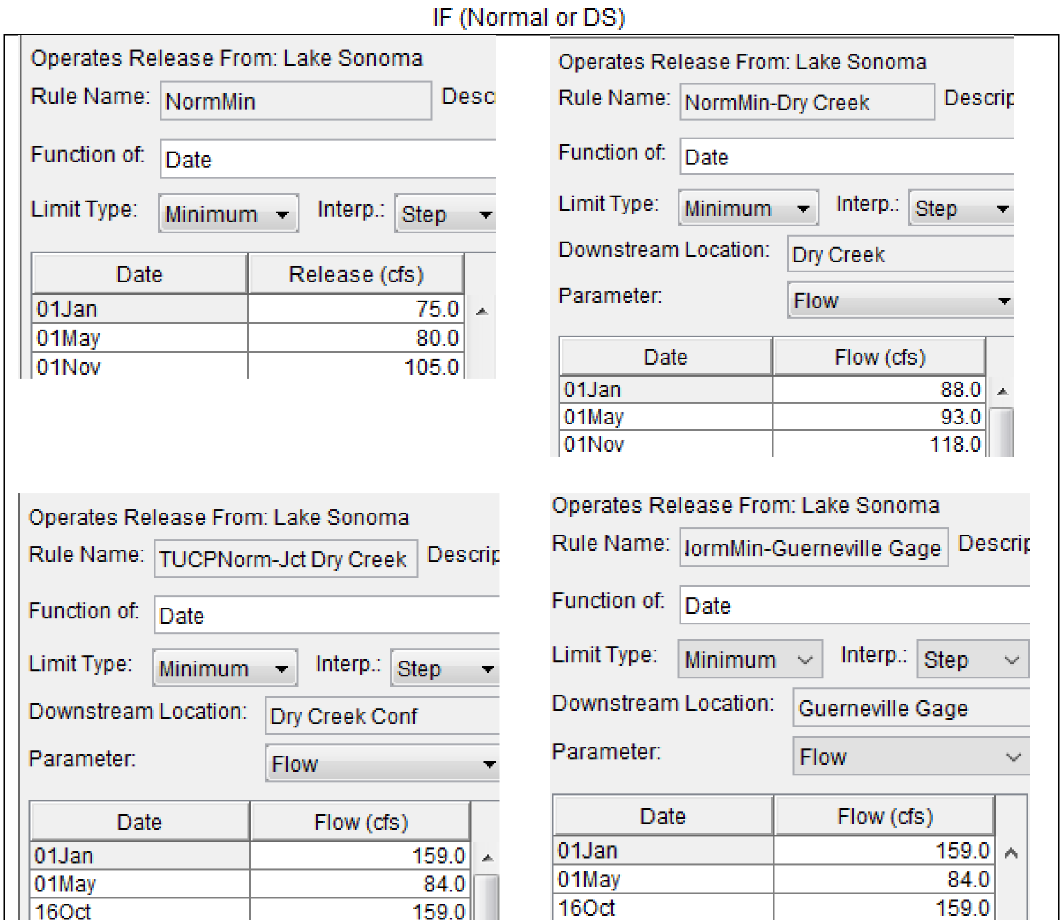


Figure 52 WSC I-1610 Q-TUCP Rule - (Normal)

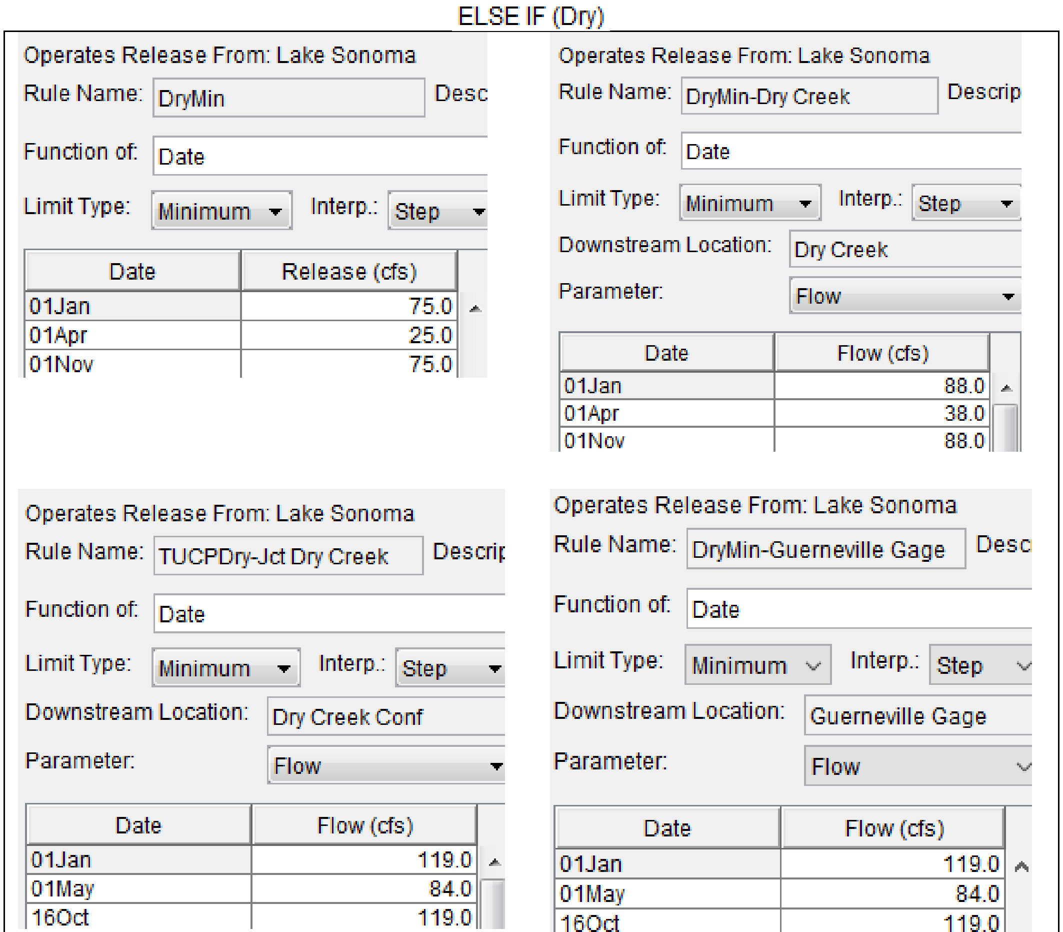


Figure 53 WSC I-1610 Q-TUCP Rule - (Dry)

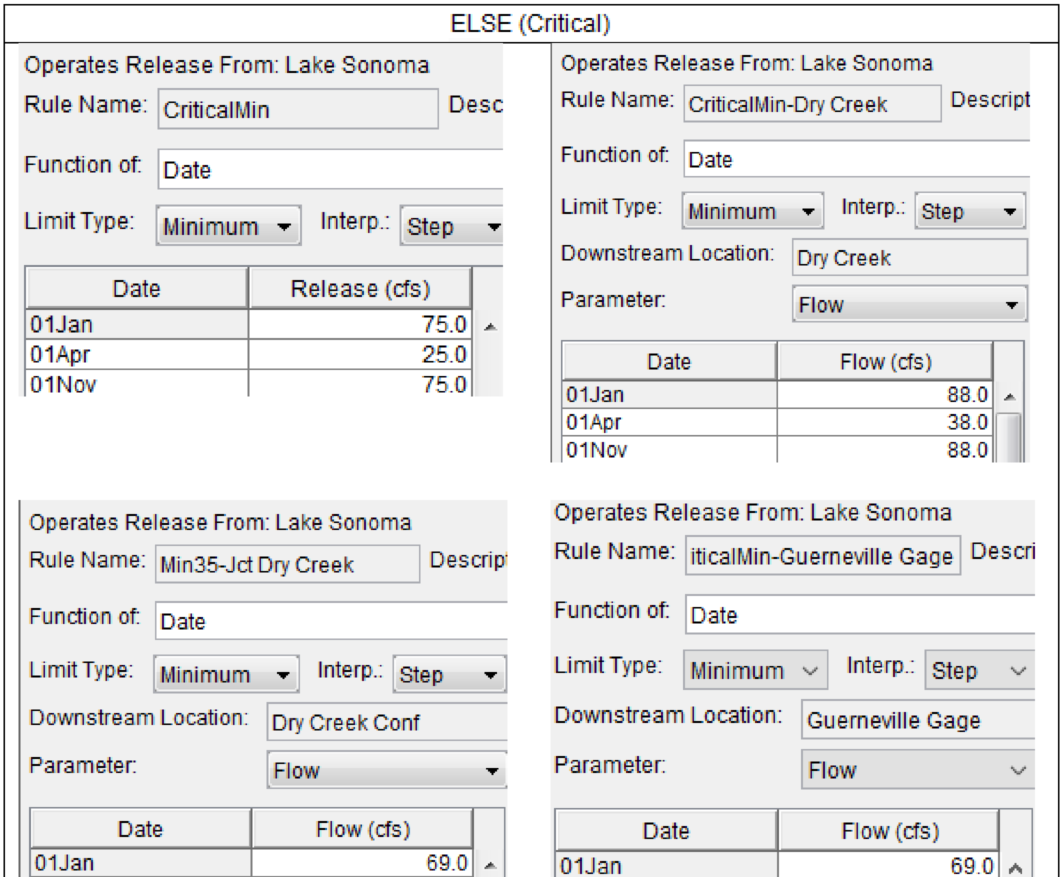


Figure 54 WSC I-1610 Q-TUCP Rule - (Critical)

4. Rule: DROC_BIOP

The rule *DROC_BIOP* (Figure 55) sets the allowable decreasing rate of change. The 2008 Biological Opinion report (BiOp) allows releases to be ramped down of 25 cfs/hr when outflows from the reservoir are less than 250 cfs, 250 cfs/hr when outflows from the reservoir are between 250 cfs and 1,000 cfs, and 1,000 cfs/hr when outflows from the reservoir are above 1,000 cfs.

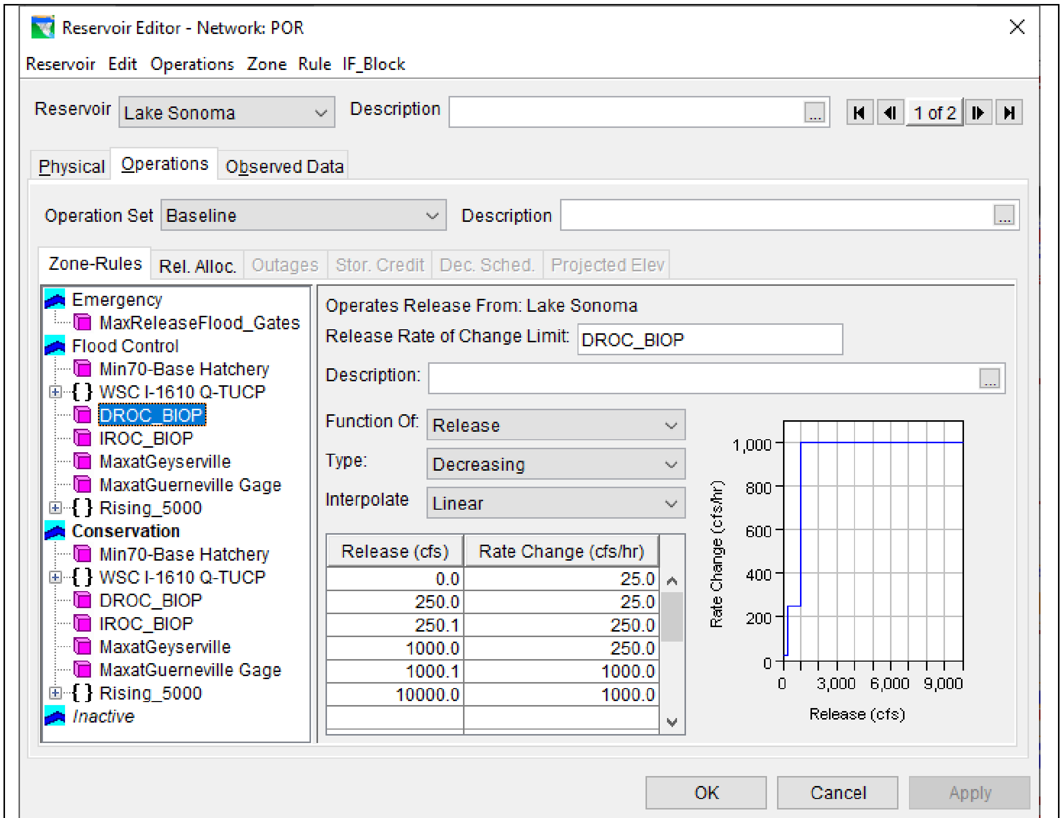


Figure 55 DROC_BIOP Rule

5. Rule: IROC_BIOP

The rule *IROC_BIOP* (Figure 56) sets the allowable increasing rate of change. The 2008 Biological Opinion report allow releases to be increased up to 1,000 cfs/hr when outflows from the reservoir are less than 1,000 cfs, and up to 2,000 cfs/hr when outflows from the reservoir exceeds 1000 cfs.

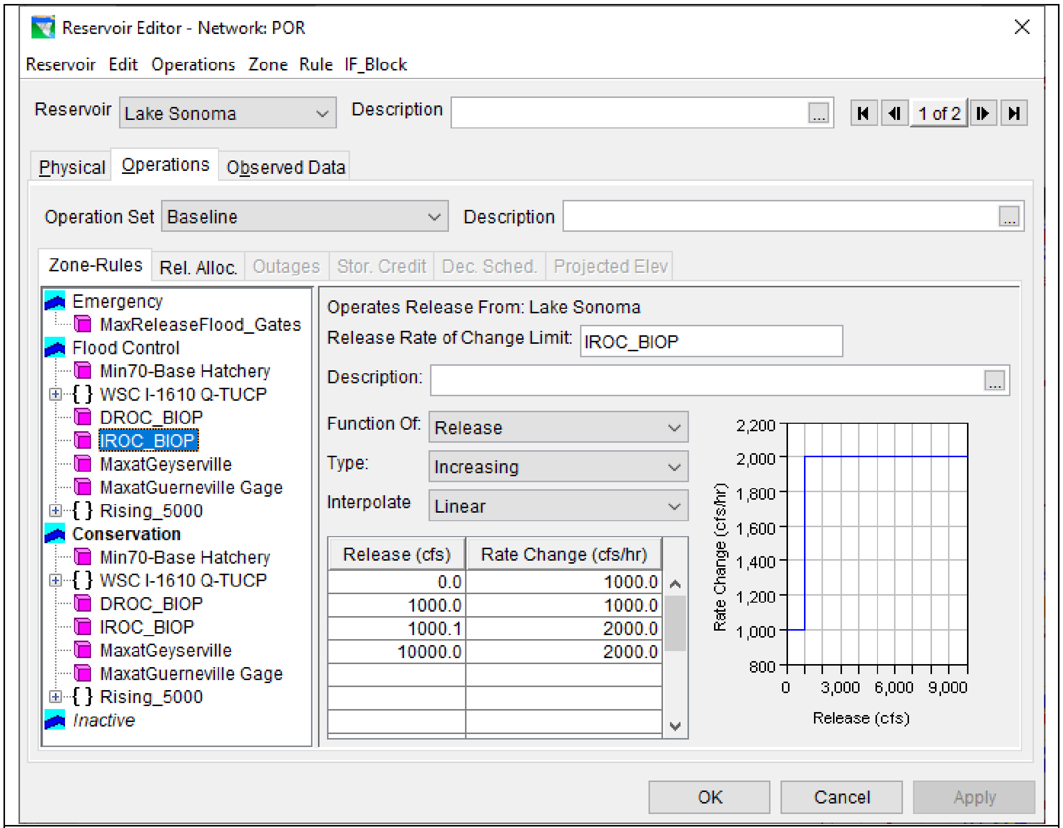


Figure 56 IROC_BIOP Rule

6. Rule: MaxatGeyserville

The rule *MaxatGeyserville* (Figure 57) ensures that Dry Creek near Geyserville does not exceed 7,000 cfs per limitation 3 in the Lake Sonoma Water Control Manual (2004). This rule is a downstream control rule that makes use of internal routing of future downstream flows to set the release.

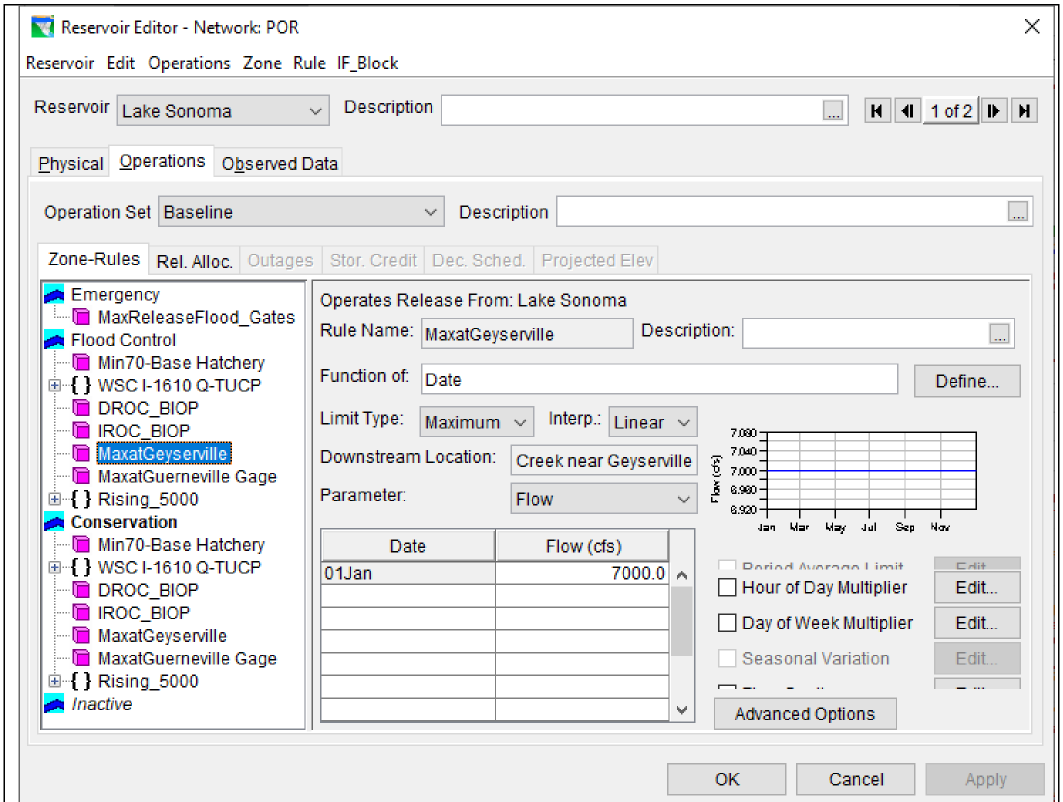


Figure 57 MaxatGeyserville Rule

7. Rule: MaxatGuerneville Gage

The rule *MaxatGuerneville Gage* (Figure 58) requires releases to avoid contributing to flows at the Guerneville Gage above 35,000 cfs per limitation 3 in the Lake Sonoma Water Control Manual (2004). This rule is a downstream control rule that makes use of internal routing of future downstream flows to set the release.

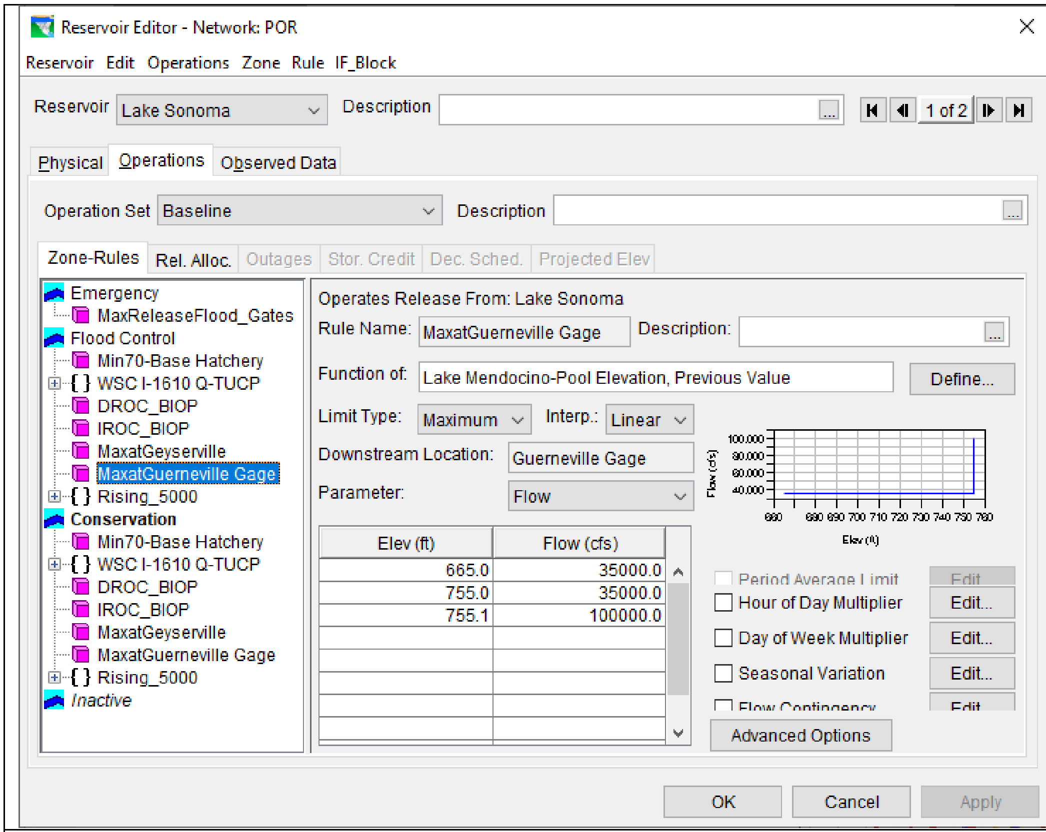
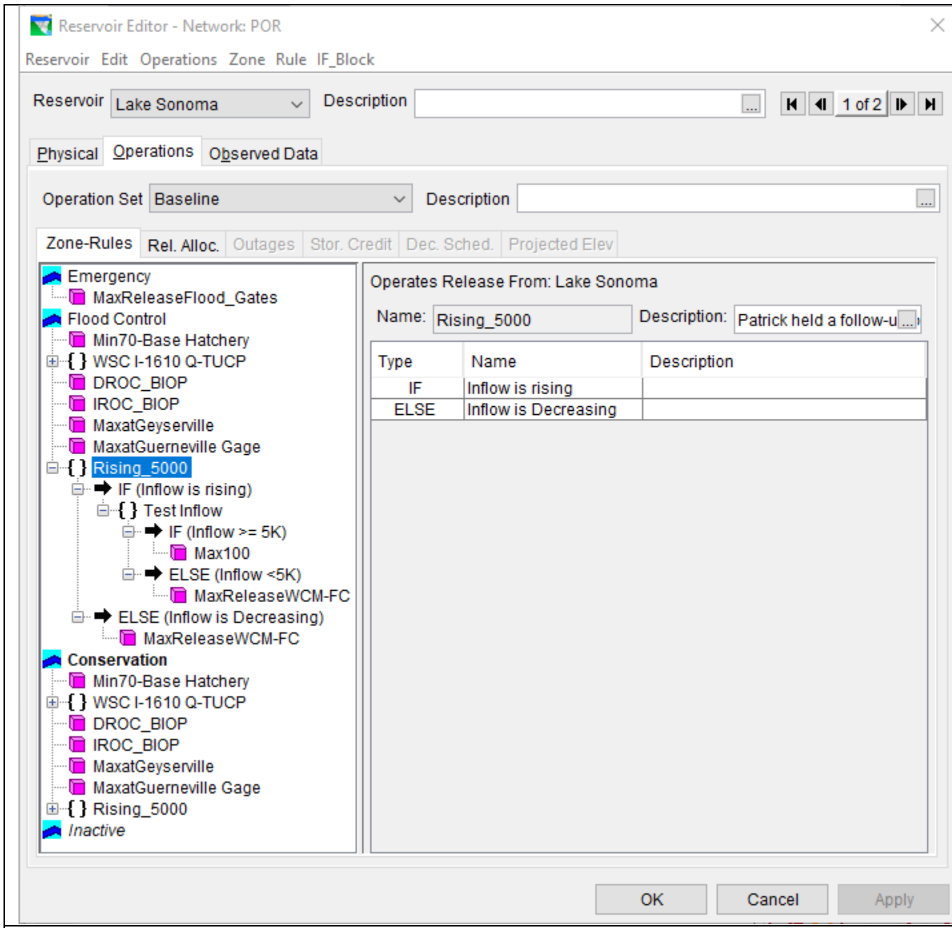


Figure 58 MaxatGuerneville Gage Rule

8. IF_Block: Rising_5000

The IF_Block *Rising_5000* (Figure 59) contains the logic governing the releases to be made in accordance with *Flood Control Schedules 1* through *3* of the Water Control Diagram (Appendix A). *Rising_5000* sets maximum outflows based on the reservoir level, unless the reservoir inflows are over 5,000 cfs and rising. In this case, the outflows were limited to 100 cfs in order to reduce the hazard to an emergency water supply line.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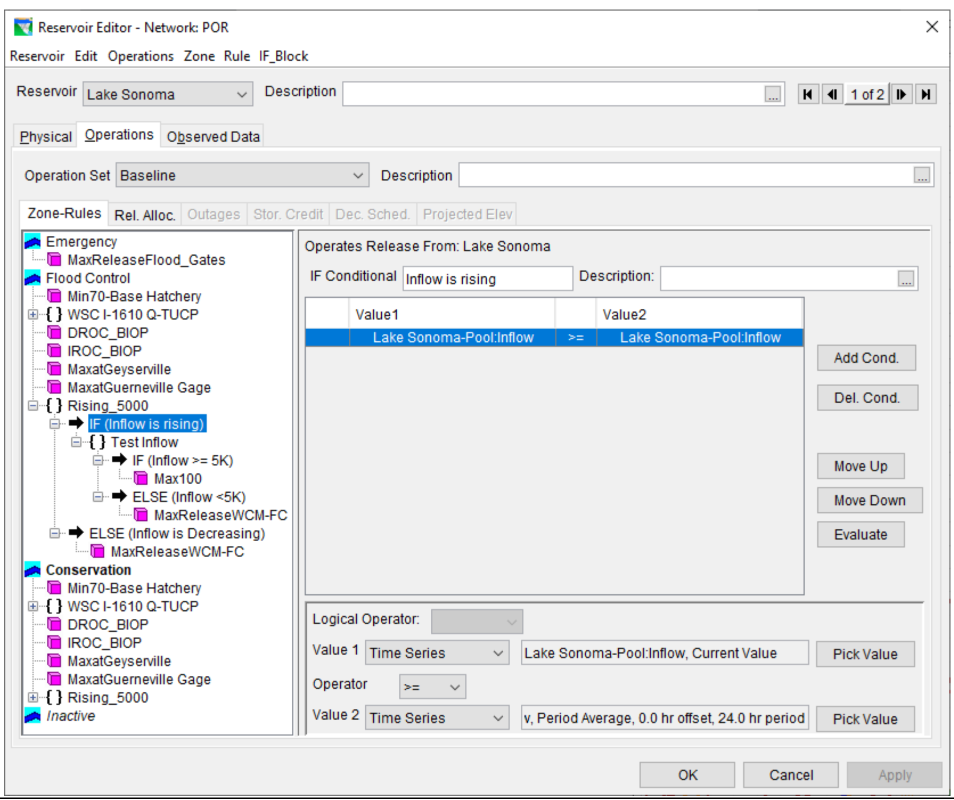
Reservoir
Lake Sonoma
Description
1 of 2
Physical
Operations
Observed Data
Operation Set
Baseline
Description
Zone-Rules
Rel. Alloc.
Outages
Stor. Credit
Dec. Sched.
Projected Elev
Emergency
MaxReleaseFlood_Gates
Flood Control
Min70-Base Hatchery
WSC I-1610 Q-TUCP
DROC_BIOP
IROC_BIOP
MaxatGeyserville
MaxatGuerneville Gage
Rising_5000
IF (Inflow is rising)
Test Inflow
IF (Inflow >= 5K)
Max100
ELSE (Inflow <5K)
MaxReleaseWCM-FC
ELSE (Inflow is Decreasing)
MaxReleaseWCM-FC
Conservation
Min70-Base Hatchery
WSC I-1610 Q-TUCP
DROC_BIOP
IROC_BIOP
MaxatGeyserville
MaxatGuerneville Gage
Rising_5000
Inactive
Operates Release From: Lake Sonoma
Name:
Rising_5000
Description:
Patrick held a follow-u
Type
Name
Description
IF
Inflow is rising
ELSE
Inflow is Decreasing
OK
Cancel
Apply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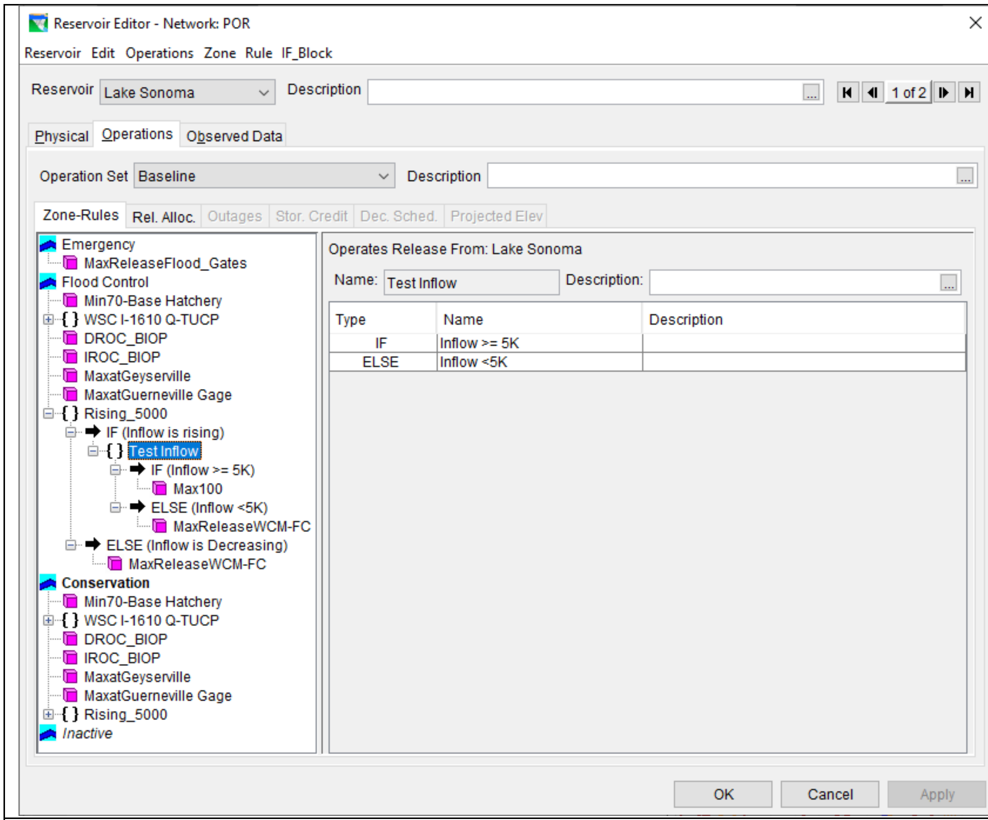
Reservoir
Lake Sonoma
Description
1 of 2
Physical
Operations
Observed Data
Operation Set
Baseline
Description
Zone-Rules
Rel. Alloc.
Outages
Stor. Credit
Dec. Sched.
Projected Elev
Emergency
MaxReleaseFlood_Gates
Flood Control
Min70-Base Hatchery
WSC I-1610 Q-TUCP
DROC_BIOP
IROC_BIOP
MaxatGeyserville
MaxatGuerneville Gage
Rising_5000
IF (Inflow is rising)
Test Inflow
IF (Inflow >= 5K)
Max100
ELSE (Inflow <5K)
MaxReleaseWCM-FC
ELSE (Inflow is Decreasing)
MaxReleaseWCM-FC
Conservation
Min70-Base Hatchery
WSC I-1610 Q-TUCP
DROC_BIOP
IROC_BIOP
MaxatGeyserville
MaxatGuerneville Gage
Rising_5000
Inactive
Operates Release From: Lake Sonoma
IF Conditional
Inflow is rising
Description:
Value1
Value2
Lake Sonoma-Pool:Inflow
>=
Lake Sonoma-Pool:Inflow
Add Cond.
Del. Cond.
Move Up
Move Down
Evaluate
Logical Operator:
Value 1
Time Series
Lake Sonoma-Pool:Inflow, Current Value
Pick Value
Operator
>=
Value 2
Time Series
v, Period Average, 0.0 hr offset, 24.0 hr period
Pick Value
OK
Cancel
Apply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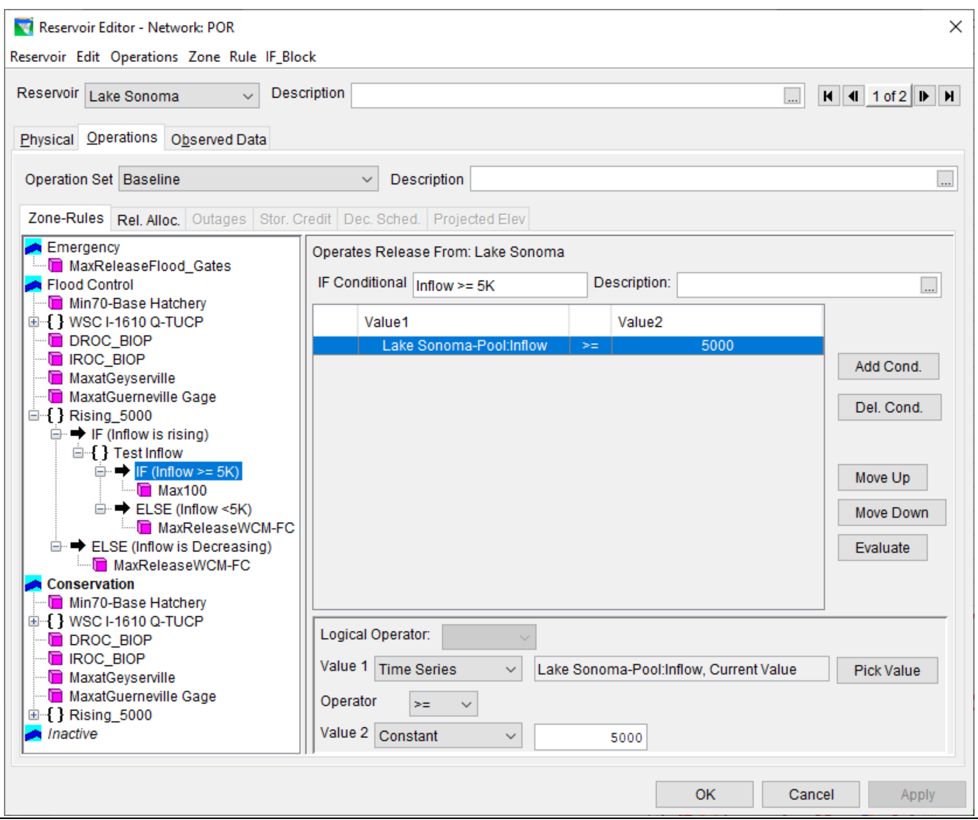
1 of 2
Physical Operations Observed Data
Operation Set Baseline Description
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev
Emergency
MaxReleaseFlood_Gates
Flood Control
Min70-Base Hatchery
WSC I-1610 Q-TUCP
DROC_BIOP
IROC_BIOP
MaxatGeyserville
MaxatGuerneville Gage
Rising_5000
IF (Inflow is rising)
Test Inflow
IF (Inflow >= 5K)
Max100
ELSE (Inflow <5K)
MaxReleaseWCM-FC
ELSE (Inflow is Decreasing)
MaxReleaseWCM-FC
Conservation
Min70-Base Hatchery
WSC I-1610 Q-TUCP
DROC_BIOP
IROC_BIOP
MaxatGeyserville
MaxatGuerneville Gage
Rising_5000
Inactive
Operates Release From: Lake Sonoma
Name: Test Inflow Description:
Type Name Description
IF Inflow >= 5K
ELSE Inflow <5K
OK Cancel Apply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Reservoir Lake Sonoma Description
1 of 2
Physical Operations Observed Data
Operation Set Baseline Description
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev
Emergency
MaxReleaseFlood_Gates
Flood Control
Min70-Base Hatchery
WSC I-1610 Q-TUCP
DROC_BIOP
IROC_BIOP
MaxatGeyserville
MaxatGuerneville Gage
Rising_5000
IF (Inflow is rising)
Test Inflow
IF (Inflow >= 5K)
Max100
ELSE (Inflow <5K)
MaxReleaseWCM-FC
ELSE (Inflow is Decreasing)
MaxReleaseWCM-FC
Conservation
Min70-Base Hatchery
WSC I-1610 Q-TUCP
DROC_BIOP
IROC_BIOP
MaxatGeyserville
MaxatGuerneville Gage
Rising_5000
Inactive
Operates Release From: Lake Sonoma
IF Conditional Inflow >= 5K Description:
Value1 Value2
Lake Sonoma-Pool:Inflow >= 5000
Add Cond.
Del. Cond.
Move Up
Move Down
Evaluate
Logical Operator:
Value 1 Time Series Lake Sonoma-Pool:Inflow, Current Value Pick Value
Operator >=
Value 2 Constant 5000
OK Cancel Apply

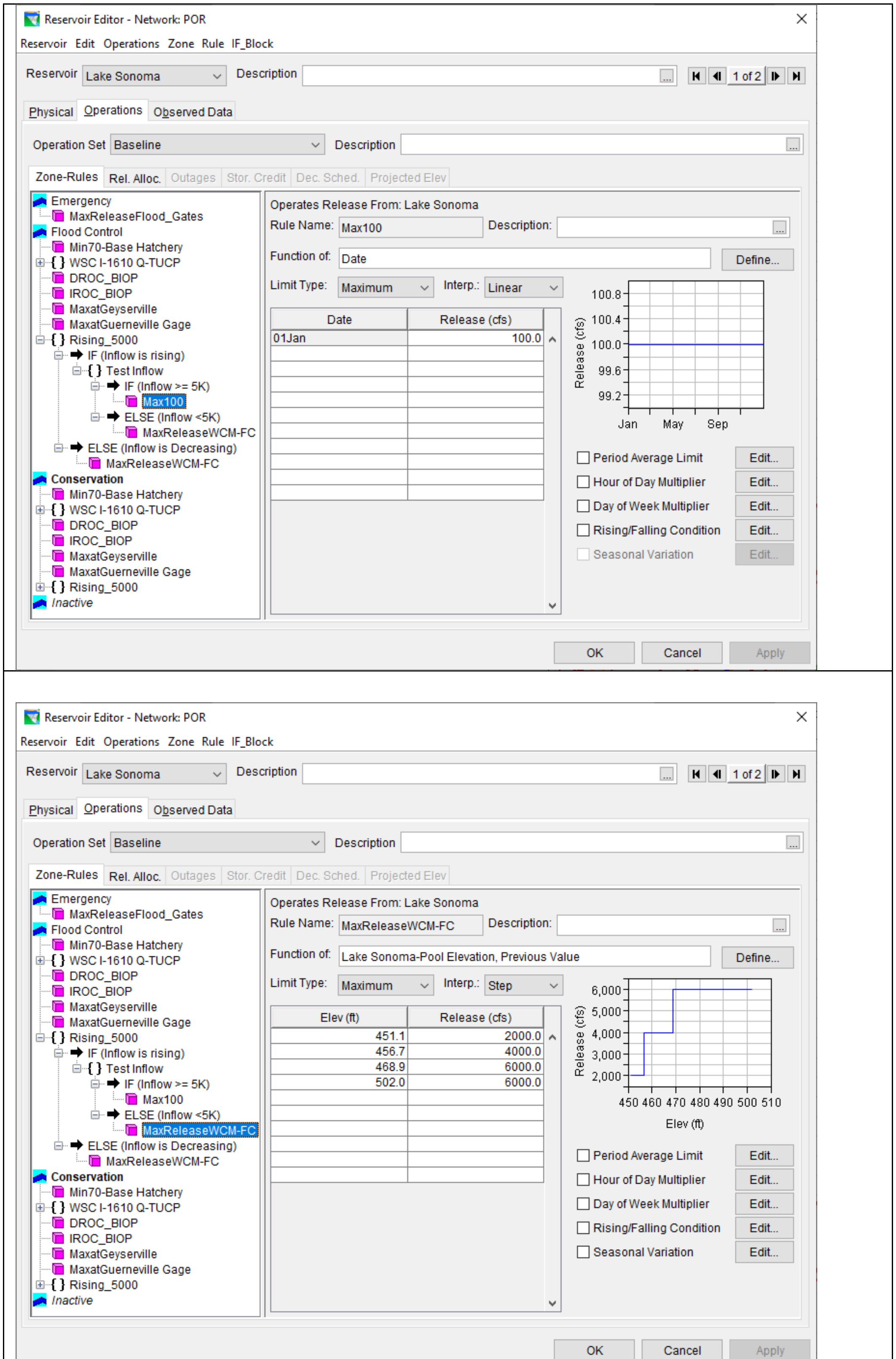

Figure 59 Rising_5000 Rule

VI. Routing

The HEC-ResSim software provides a set of hydrologic routing methods to be used by the modeler to represent the lag and attenuation effects on flow in a natural river system. The Modified Puls routing method was selected for use in this study because well-calibrated coefficients were available from an HEC-RAS model of the Russian River basin provided by Sonoma Water. HEC-ResSim's downstream operation logic attempts to account for the routing effects when one or more reservoirs are set to operate for a downstream requirement.

There are 11 reaches in the Russian River watershed. All of them use the Modified Puls routing method. The storage and outflow relationship for all routing reaches are shown in Figure 60.

	ResSim Reaches										
	Russian River NR Ukiah to East-West Junction	Lake Mendocino _Out to East-West Junction	East-West Junction to Hopland Gage	Hopland Gage to Cloverdale Gage	Cloverdale Gage to Healdsburg Gage	Healdsburg Gage to Dry Creek Conf	Lake Sonoma_OUT to Dry Creek near Geyserville	Dry Creek near Geyserville to Dry Creek	Dry Creek to Dry Creek Conf	Dry Creek Conf to Guerneville Gage	Guerneville Gage to Guerneville
Q cfs	Volume (ac-ft)	Volume (ac-ft)	Volume (ac-ft)	Volume (ac-ft)	Volume (ac-ft)	Volume (ac-ft)	Volume (ac-ft)	Volume (ac-ft)	Volume (ac-ft)	Volume (ac-ft)	Volume (ac-ft)
100.00	3.42	10.57	187.92	181.48	425.27	49.67	28.91	100.32	3.98	201.40	182.43
200.00	5.31	15.61	275.33	271.11	633.07	70.72	44.05	153.53	5.53	292.35	256.23
300.00	7.51	19.75	347.01	343.43	810.21	88.84	57.53	199.45	6.82	369.04	320.38
400.00	9.25	23.43	410.26	406.81	971.34	106.50	70.02	241.56	8.06	437.89	380.39
500.00	10.95	26.86	467.78	465.68	1125.33	123.62	82.56	281.59	9.03	500.73	435.03
600.00	12.43	30.07	521.28	520.80	1274.28	139.10	93.80	319.62	9.93	560.24	485.04
700.00	13.80	33.22	571.72	573.71	1418.08	153.06	105.40	358.03	10.78	613.26	533.25
800.00	14.95	36.16	620.49	624.53	1562.09	166.49	117.15	394.90	11.60	663.19	579.49
900.00	16.02	38.90	667.29	673.76	1699.18	179.84	128.48	430.43	12.46	710.95	622.71
1,000.00	17.05	42.01	713.41	726.60	1828.46	192.91	139.88	464.47	13.37	757.34	664.51
2,000.00	25.50	66.25	1129.09	1217.18	3032.61	313.70	234.46	797.92	22.79	1194.72	1017.91
3,000.00	32.42	87.23	1507.63	1638.36	4072.13	422.22	313.69	1123.45	29.94	1570.68	1313.23
4,000.00	39.59	107.01	1884.83	2007.61	5046.71	508.17	385.52	1393.10	34.52	1915.42	1581.28
5,000.00	46.88	125.78	2267.44	2374.33	5967.23	595.93	452.77	1635.32	40.31	2257.01	1843.86
6,000.00	54.75	144.64	2637.83	2704.90	6854.45	673.09	519.02	1855.42	47.40	2598.23	2081.6
7,000.00	60.38	161.52	3006.15	3022.89	7742.76	744.81	581.36	2091.84	54.37	2928.06	2309.85
8,000.00	65.73	176.73	3378.94	3333.86	8587.32	813.86	643.86	2292.50	60.66	3348.85	2533.06
9,000.00	70.51	191.52	3785.07	3655.40	9444.80	878.98	712.73	2496.19	66.17	3696.60	2767.4
10,000.00	75.01	205.70	4232.04	3974.66	10247.49	949.61	776.50	2686.60	71.75	4022.74	2990.08
11,000.00	79.17	219.53	4724.29	4292.55	11007.76	1016.26	847.05	2875.04	77.57	4351.68	3222.99
12,000.00	83.26	233.42	5255.88	4665.11	11787.44	1077.95	919.98	3063.50	84.21	4669.60	3444.99
13,000.00	87.03	246.39	5805.69	5157.88	12529.36	1140.91	996.19	3252.60	90.46	4990.86	3663
14,000.00	90.62	259.02	6367.13	5630.55	13230.31	1201.84	1072.87	3444.13	96.96	5316.44	3863.04
15,000.00	94.21	272.43	6929.30	6142.11	13928.74	1258.42	1154.64	3643.38	102.49	5640.05	4054.74
16,000.00	97.77	289.04	7496.29	6981.42	14672.34	1311.01	1236.27	3848.37	108.19	5942.71	4246.49
17,000.00	101.04	314.60	8100.89	7433.77	15185.00	1363.29	1319.17	4062.71	113.91	6250.11	4436.37
18,000.00	104.26	332.75	8770.65	8060.01	15907.71	1415.38	1401.61	4277.26	119.36	6557.50	4622.46
19,000.00	107.42	358.16	9357.60	8373.21	16633.79	1465.20	1487.21	4499.52	124.99	6860.57	4814.24
20,000.00	110.52	380.40	9944.65	9110.91	17274.23	1515.09	1561.50	4722.09	130.84	7174.38	5002.5
21,000.00	113.73	402.02	10509.85	9644.91	17912.25	1563.65	1635.53	4945.13	136.27	7470.82	5193.88
25,000.00	126.36	480.04	12695.12	11175.28	20416.06	1755.54	1934.98	5854.55	156.27	8824.64	5987.46
30,000.00	148.39	581.07	15204.18	13641.52	23481.30	2013.50	2269.37	7066.88	184.68	10464.66	7016.4
35,000.00	178.30	674.84	17661.58	16174.36	26470.95	2240.24	2609.13	8373.85	208.23	12252.56	8027.64
40,000.00	221.32	766.15	19709.55	18353.83	29806.65	2455.98	2960.43	9706.47	229.63	14101.01	9030.33
45,000.00	267.13	854.53	21742.88	20307.38	32840.53	2703.68	3306.78	11264.17	250.72	16104.12	9977.6
50,000.00	318.31	948.52	23682.38	21945.45	36677.30	2921.24	3601.92	12620.03	271.72	18190.32	10958.83
55,000.00	374.58	1033.09	25639.31	23833.07	39315.97	3147.53	3885.63	14193.32	292.52	20228.89	11936.34
60,000.00	425.90	1127.98	27561.94	25951.45	42727.12	3375.00	4117.95	15763.64	312.75	22180.25	12918.13
65,000.00	477.01	1209.96	29446.30	27925.12	46601.97	3634.86	4345.05	16997.13	332.67	24306.46	13938.01
70,000.00	496.50	1289.07	31285.32	30019.98	49470.64	3900.82	4564.07	18109.77	352.14	26660.10	14956.9
75,000.00	527.72	1369.37	33102.90	32148.15	53580.46	4159.74	4781.66	19540.93	356.89	27296.02	15959.22
80,000.00	557.63	1446.71	34874.04	34160.27	59223.04	4490.16	4991.28	20957.48	378.97	32219.00	16942.61
90,000.00	614.84	1601.11	38419.20	38115.16	70207.76	5389.79	5404.88	22599.00	462.29	38816.62	18872.01
100,000.00	668.39	1768.64	41805.30	41627.67	79721.70	6322.20	5782.57	23785.05	603.26	44703.45	20757.26
110,000.00	719.04	1939.42	45169.10	45611.12	89312.92	7147.90	6026.35	25528.83	633.63	53070.50	22535.63
120,000.00	766.68	2102.81	48513.50	49559.00	97315.91	7854.98	6337.52	27255.39	663.99	58730.03	24225.96
130,000.00	812.33	2267.67	51796.70	53647.30	105193.15	8636.99	6651.65	28902.64	758.25	64029.68	25880.59
140,000.00	857.63	2433.26	55088.40	57591.10	117443.55	9518.38	6969.11	30500.44	839.08	72080.55	27474.76
150,000.00	899.38	2601.31	58437.90	61482.90	125888.15	10489.27	7262.82	32158.18	887.12	79359.88	29040.34
200,000.00	1091.38	3418.48	74865.10	80611.80	169715.46	14205.85	8725.76	39472.31	1469.86	113963.64	36415.96
300,000.00	1409.17	4949.06	108160.10	117753.00	250629.68	24091.06	11387.27	54268.68	3322.89	164510.60	49352.68
400,000.00	1700.94	6436.36	142123.50	153949.50	336691.99	33972.93	13871.76	70613.42	5291.68	214669.80	60840.09
500,000.00	1901.52	7317.72	177023.40	189472.90	420682.36	42454.11	16039.87	88605.61	7513.02	260098.00	71574.25

Figure 60 Modified Puls Routing

VII. Diversions

A. Potter Valley Project

Water has been diverted from the Eel River to the upper reach of the East Fork of the Russian River for power generation purposes at the Potter Valley Project (PVP) since the early 1900s. Diversions from the Eel River through the PVP have historically averaged over 150,000 AF annually. Since 2006, operation of the PVP under the terms of Biological Opinion and the amended licenses has significantly reduced PVP diversions compared to historical levels. These reduced PVP flows have significantly reduced inflows into Lake Mendocino and impacted its water supply reliability. Also, the timing of the PVP diversion reductions has impacts on Lake Mendocino water supply reliability. Springtime diversions from the PVP have been greatly reduced since 2006. (SCWA, 2015).

The PVP flow is modeled as a local flow at “Lake Mendocino_IN” junction.

B. Consumptive Withdrawals

Water withdrawals occur in the Russian River basin for various purposes. Sonoma Water developed estimates for the distributed losses throughout the Russian River watershed. These losses include Sonoma Water’s diversions and all other depletions from the watershed, including evapotranspiration by riparian vegetation, aquifer recharge, agricultural diversions, and non-Sonoma Water municipal and industrial (M&I) diversions. Sonoma Water serves as the best source of data on this topic.

For the HEC-ResSim modeling, the simulation relies on some constructed data for the diversions, implemented as repeating annual patterns. The years are classified as wet or dry, with separate annual patterns developed for both conditions. Figure 61 shows the diversions in the watershed. Table 1 shows the list of diversions and their locations.

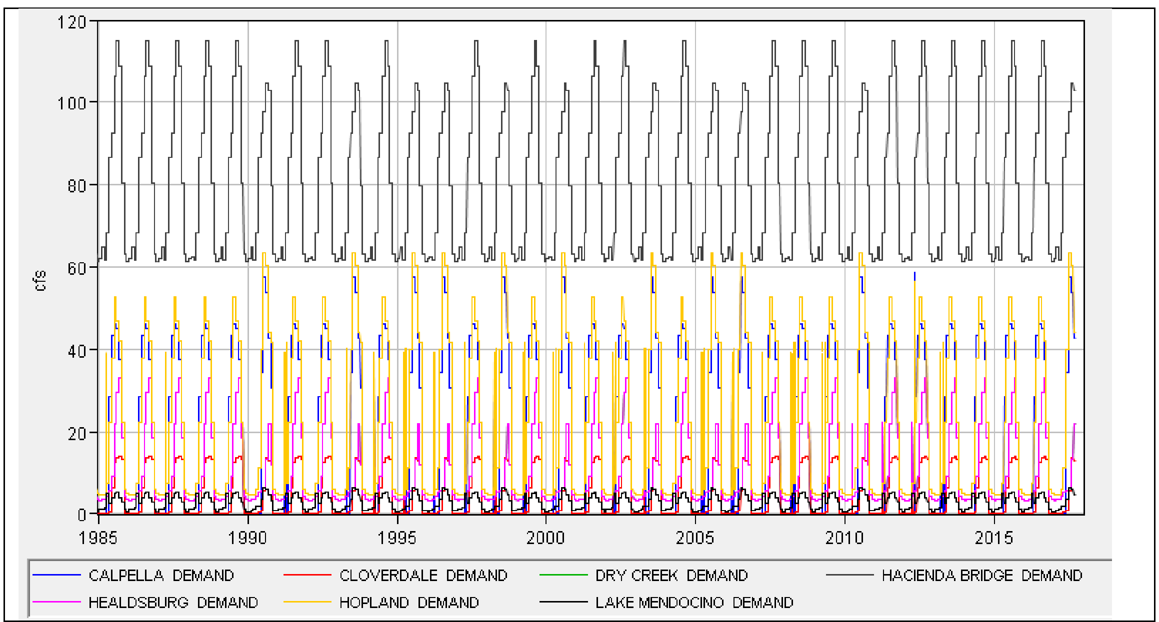

Figure 61 Diversions

Figure 62 shows the "Calpella Div" diversion from "Lake Mendocino_IN" junction and "Redwood Valley Div" diversion from the diverted outlet at Lake Mendocino.

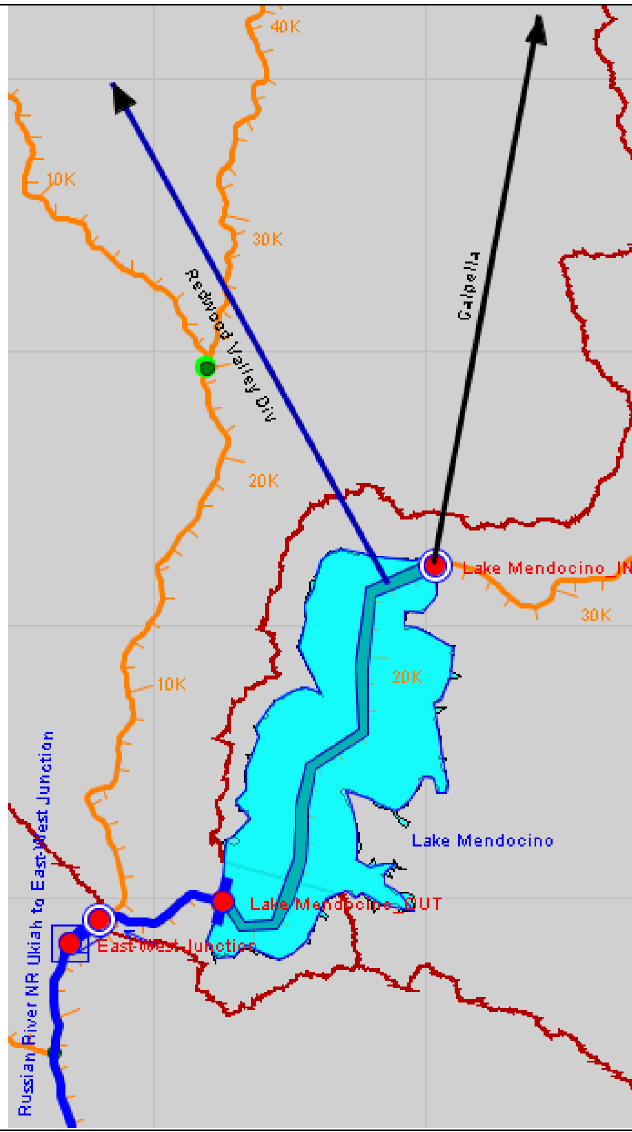

Figure 62 "Calpella Div" and "Redwood Valley Div" Diversions

Figure 63 shows the "Hopland Div" diversion from "Hopland Gage" junction and "Cloverdale Div" diversion from "Cloverdale Gage" junction.

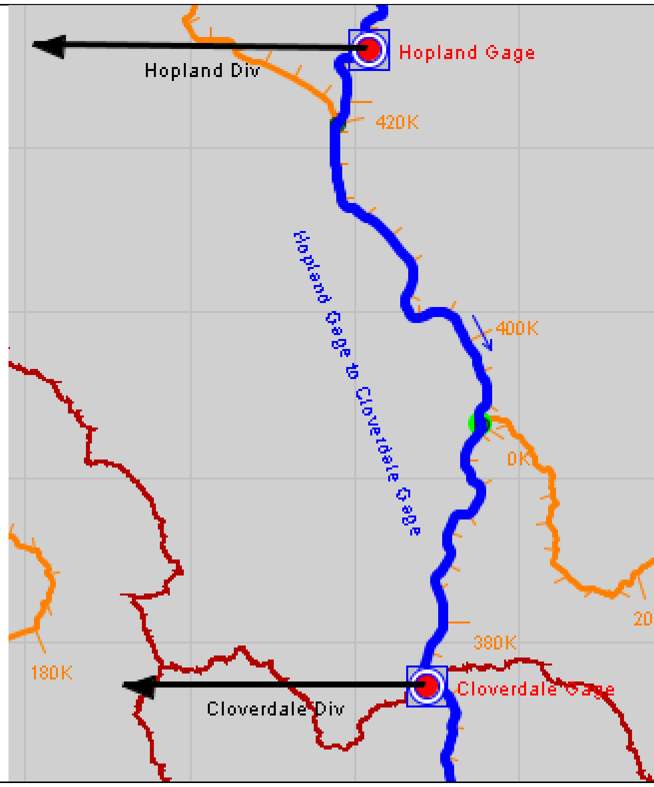

Figure 63 "Hopland Div" and "Cloverdale Div" Diversions

Figure 64 shows the "Healdsburg Div" diversion from "Healdsburg Gage" junction and "Dry Creek Div" diversion from "Dry Creek" junction.

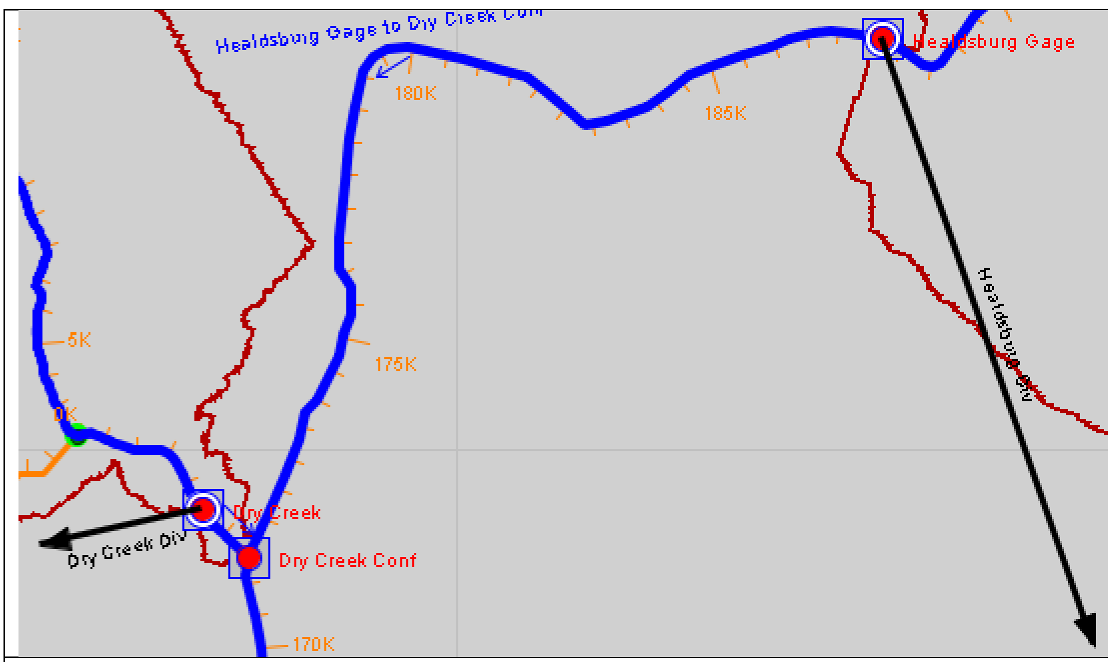

Figure 64 "Healdsburg Div" and "Dry Creek Div" Diversions

Figure 65 shows the "Hacienda Div" diversion from "Guerneville Gage" junction.

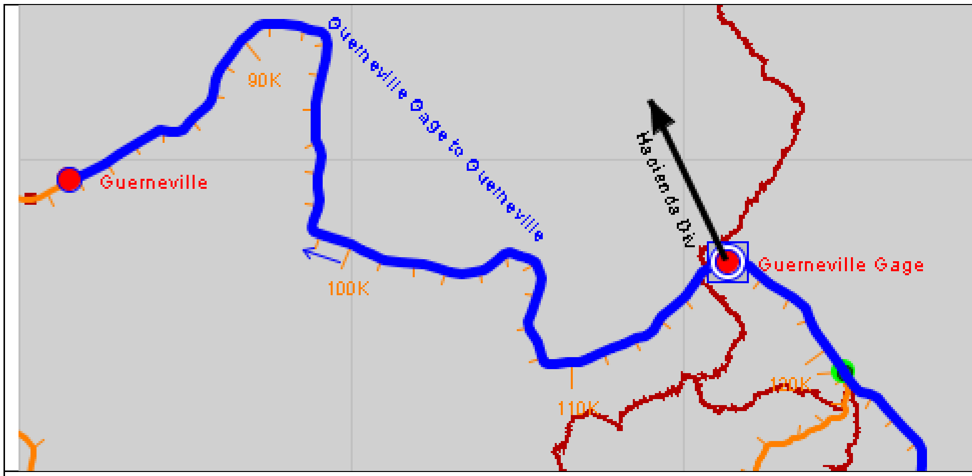

Figure 65 "Hacienda Div" Diversion

VIII. Baseline Validation Results

Reservoir model validation compares results against historical data to determine whether the model reacts as desired under the same circumstances. Validation results were only evaluated at Lake Mendocino, and were not assessed for Lake Sonoma. Operation of Lake Mendocino is not affected by Lake Sonoma outflows.

The historical observed outflows and pool levels for Coyote Valley Dam represent different regulation practices and diversion flows, so the model results reflecting the Existing Condition are unlikely to match the historical observations. The primary differences from historical operations, especially during the early years of Lake Mendocino, involve:

1) The *Baseline* alternative assumes the existence of current Potter Valley Project flows. The current flows diverted from the Eel River are greatly diminished from historical amounts. The *Baseline* results in the FIRO analysis reflect a drier system than what occurred in the observed record.

2) The *Baseline* alternative reflects higher agriculture and municipal demands than historically occurred, as well as newer requirements for instream environmental flows. The *Baseline* reservoir storage depletions often exceed historical amounts.

3) Reservoir operating practices of the past differ from the *Baseline* simulation rules. Some standard practices have evolved, such as earlier reservoir filling dates in recent years. In other situations, the historical operations differ from the expected plans for unknown reasons. The *Baseline* simulation does not have access to all the information available to the human operators of the past, and does not attempt to represent the judgment calls that occur throughout the historical record.

Because the goal of this study was to assess flood risk for FIRO alternatives, it was important to validate flood operation for the largest events in the available Period of Record (1986, 1995, 1997, and 2006).

Figure 66 to Figure 71 show the *Baseline* results validation for 1986, 1995, 1997, and 2006 events at Lake Mendocino, showing short windows from the Period of Record computation. Inflows shown in the figures represent modeled *Baseline* reservoir inflows.

1. 1986 Event

Figure 66 displays the baseline validation results for the 1986 event. When the 1986 event started, the historical operation and modeled reservoir were almost at the same pool elevation. The modeled reservoir gets to the higher flood pool due to different release decisions. Both the historical operation and modeled reservoir try to get back to guide curve as soon as possible. This takes a longer time for the modeled reservoir since it has a higher flood pool.

For the 1986 event, the maximum modeled flood pool elevation is 765.52 feet and the historical operation flood pool elevation is 761.57 feet. This means that the modeled reservoir flood pool elevation is 3.95 feet higher than the historical reservoir flood pool elevation.

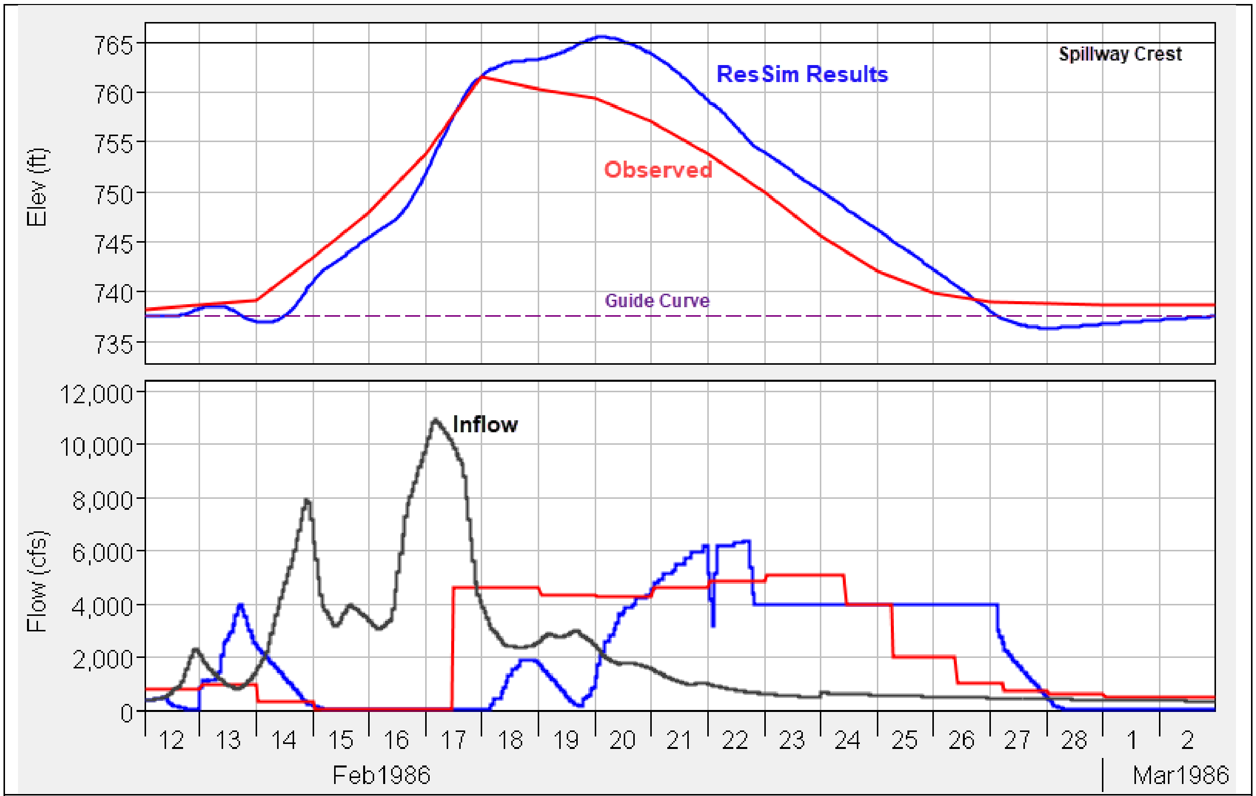

Figure 66 Baseline Validation Results _1986 Event

2. 1995 Event

Figure 67 displays the baseline validation results for two 1995 events in January and March. The modeled reservoir level enters the January event lower than the historical level and keeps a lower peak flood pool. The historical operation and modeled reservoir enter the second event in March

1995 at the same pool level and get to almost the same maximum flood pool. However, the modeled reservoir gets back to guide curve more aggressively and stays on the guide curve. This is because the current guide curve was not applied until 2009. The historical operation stays at a pool level around 748 feet, which was the applied guide curve in 1995.

For the January 1995 event, the maximum historical operation flood pool elevation is 759.26 feet, and the maximum modeled reservoir flood pool elevation is 755.06 feet. This means that for the January 1995 event, the historical reservoir flood pool elevation is 4.2 feet higher than the modeled operation flood pool elevation.

For the March 1995 event, the maximum historical operation flood pool elevation is 758.09 feet, and the maximum modeled reservoir flood pool elevation is 754.77 feet. This means that for the March 1995 event, the historical operation flood pool elevation is 3.32 feet higher than the modeled reservoir flood pool elevation.

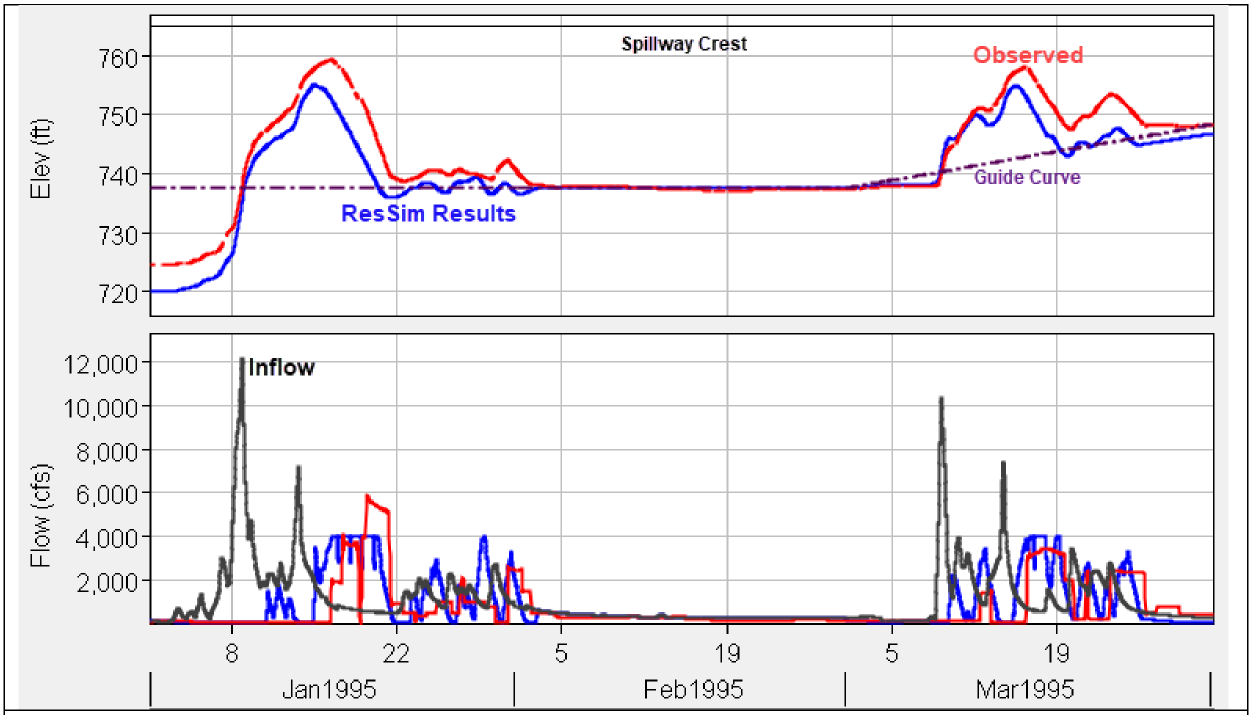

Figure 67 Baseline Validation Results _1995 Event

3. 1997 Event

Figure 68 displays the *Baseline* validation results for the January 1997 event. When the 1997 event started, the historical operation and modeled reservoir were at almost the same pool elevations. The historical operation gets to the higher flood pool due to different release decisions at the end of December, perhaps because of downstream flooding concerns. Both the historical operation and modeled reservoir try to get back to guide curve as soon as possible. This takes a longer time for the historical reservoir since it has a higher flood pool.

At the beginning of the January 1997 event, the historical operation flood pool elevation was 756.82 feet and the modeled reservoir flood pool elevation is 753.76 feet. This means for the first peak of the January 1997 event, the historical operation flood pool elevation is 3.06 feet higher than the modeled reservoir flood pool elevation.

During the second peak of the January 1997 event, the historical operation flood pool elevation was 747.62 feet, and the modeled reservoir flood pool elevation is 744.51 feet. This means that for the second peak of the January 1997 event, the historical operation flood pool elevation is 3.11 feet higher than the modeled reservoir flood pool elevation.

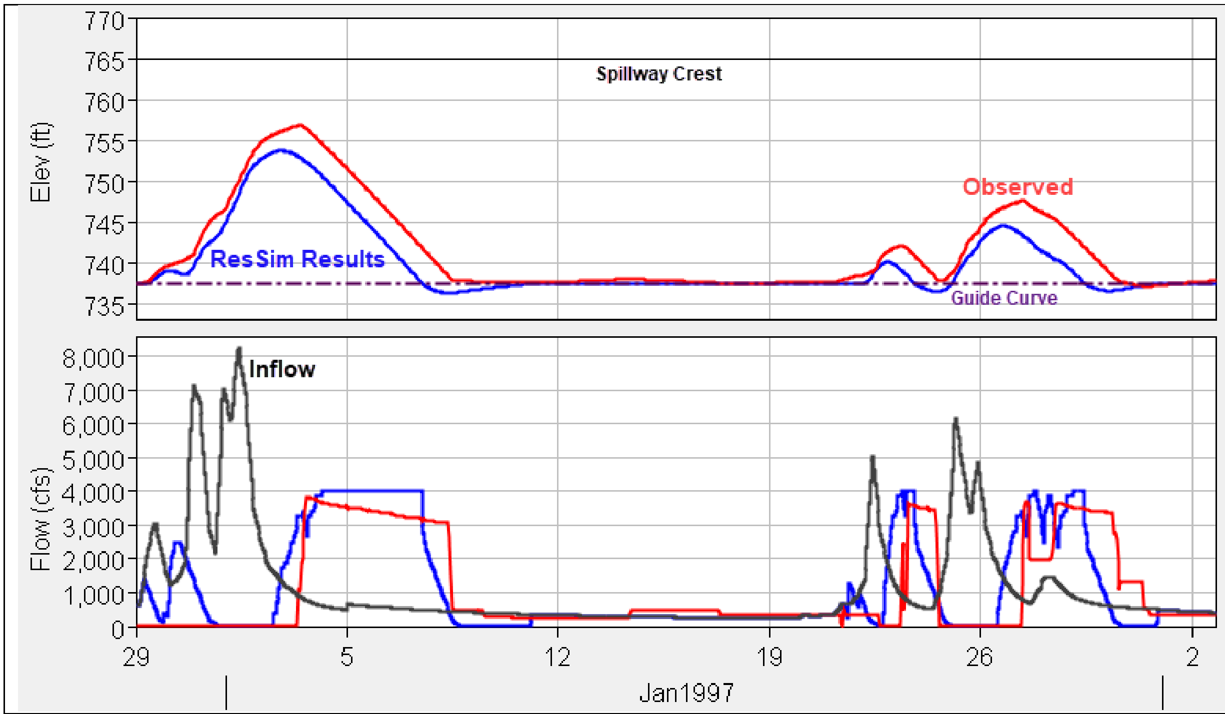

Figure 68 Baseline Validation Results _1997 Event

4. 2006 Event

Figure 69 displays the *Baseline* validation results for the 2006 event. The modeled reservoir level enters the prior small events starting on 19 Dec 2005 at an elevation 7 feet higher than the historical level. The guide curve used in the model allows for storage up to 761.8 ft for all simulated years, while the historical operation only allowed storage up to 748 ft before 2007. As a result, the modeled storage in 2005 was higher than the observed, which carried over to December.

Both the historical operation and modeled reservoir get to the maximum flood pool at almost the same elevation because at the end of December the observed flood release is twice as high as modeled release.

The maximum historical operation flood pool elevation was 760.63 feet, and the modeled reservoir flood pool elevation is 759.42 feet. This means that for the 2006 event, the historical operation flood pool elevation is 1.21 feet higher than the modeled reservoir flood pool elevation.

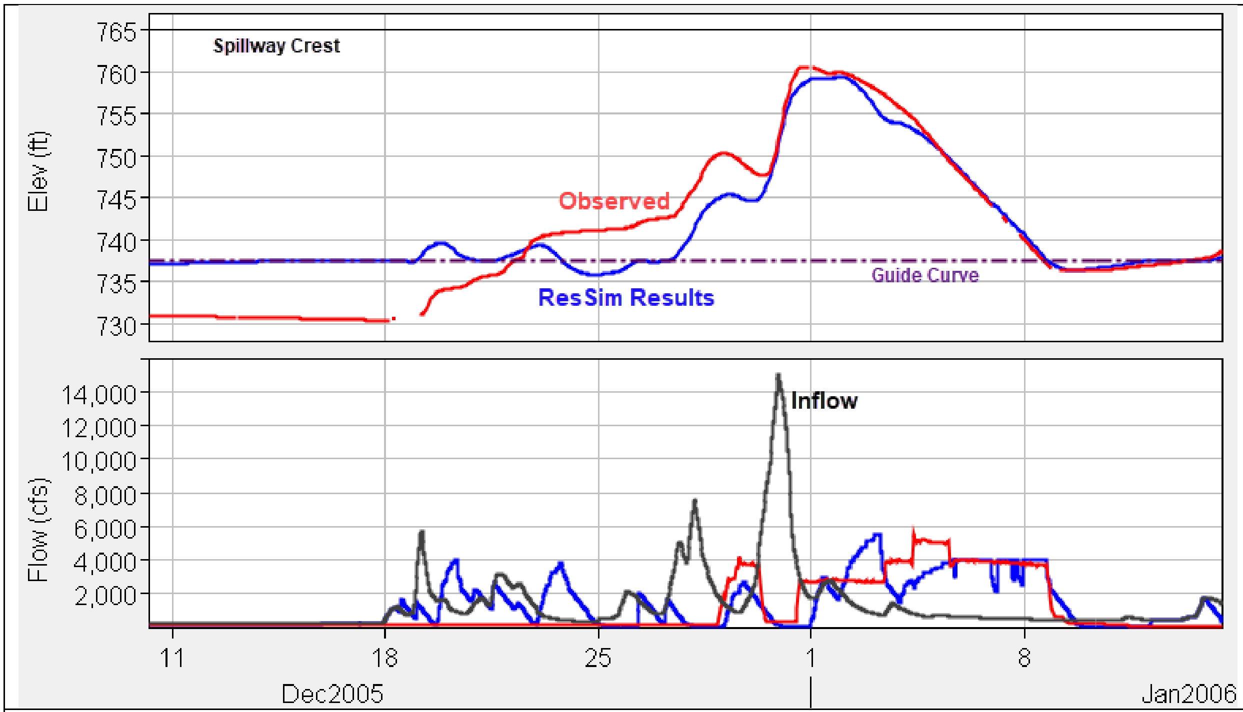

Figure 69 Baseline Validation Results _2006 Event

Figure 70 displays the *Baseline* validation results for the years 2000 through 2017. The current guide curve with the summer pool at 761.8 feet came into use during 2009. Note that the reservoir typically failed to re-fill the pool in spring due to diminished inflow from the Potter Valley Project. Also note that observed level prior to 2009 reflects operations using a different guide curve with the summer pool at 748 feet, while the simulated reservoir operations always used a guide curve elevation of 761.8 feet.

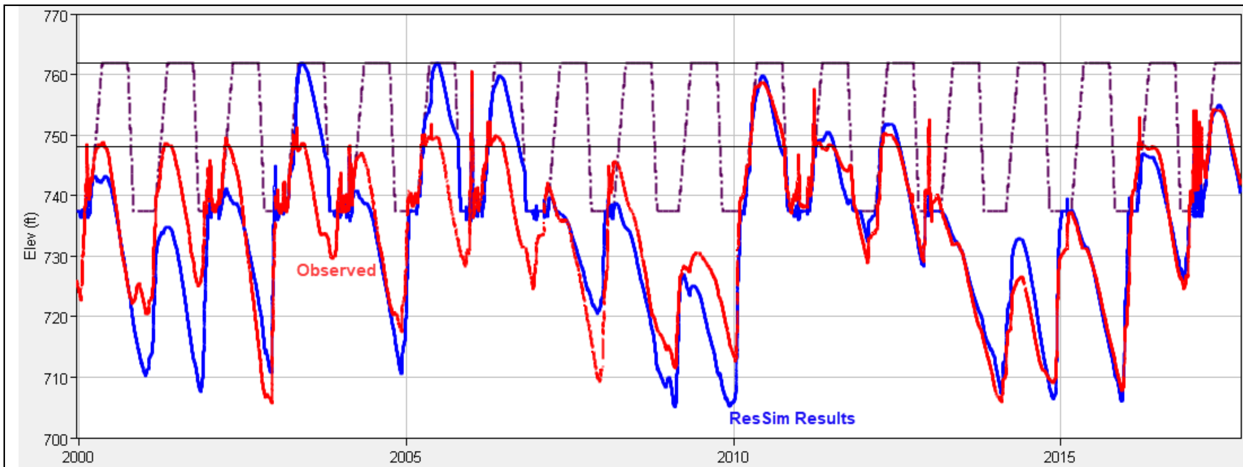

Figure 70 Baseline Validation Results _2000-2017

IX. Representation of Baseline Operation

A typical flood operation and conservation operation simulated at Coyote Valley Dam for the *Baseline* alternative is provided in this section.

A. Coyote Valley Dam

1. Flood operations

A typical flood operation simulated at Coyote Valley Dam for the *Baseline* alternative is provided in Figure 71. Prior to 9 January, the pool was below the guide curve and the reservoir was releasing only the minimum 25 cfs.

Inflows from the first storm drove the pool above guide curve on 9 January. Early on 9 January, the West Fork gage was falling and the pool remained below 755 feet, so the Coyote Valley Dam release was based on West Fork flows, according to the relationship specified in the *Hopland fn of WF* IF_Block. According to that relationship, outflows remain limited to 25 cfs flow while the West Fork flows exceed 2,150 cfs. The *Hopland fn of WF* IF_Block (*Section IV.2.9*) displays the detail of this relationship. Based on this rule, when the West Fork gage was rising, outflows remained limited to 25 cfs flow while the West Fork flows exceeded 650 cfs.

The reservoir continued to follow the *Hopland fn of WF* IF_Block conditions and released appropriate flows, based on both the West Fork flow values and the rising or falling condition with a pool elevation below 755 feet. The outflow is constrained by the maximum limit of 4000 cfs applied by the *MaxReleaseWCM-FC* rule starting on 16 January.

The pool rose above 755 feet only in the first two time steps of 15 January. The *IROC_BIOP* rule constrained the release to 1025.6 cfs and 3025.6 cfs in these time steps. The pool followed the relationship defined in the ‘falling >=755’ condition of the *Hopland fn of WF* IF_Block at 15 January 1995, 03:00.

The reservoir attempted to limit outflows to 25 cfs according to the rule for rising flows at Ukiah at the beginning of 11, 12, and 13 January, but the DROC requirement limited the release change to a maximum of 100 cfs/hour, taking several hours to reach 25 cfs each time.

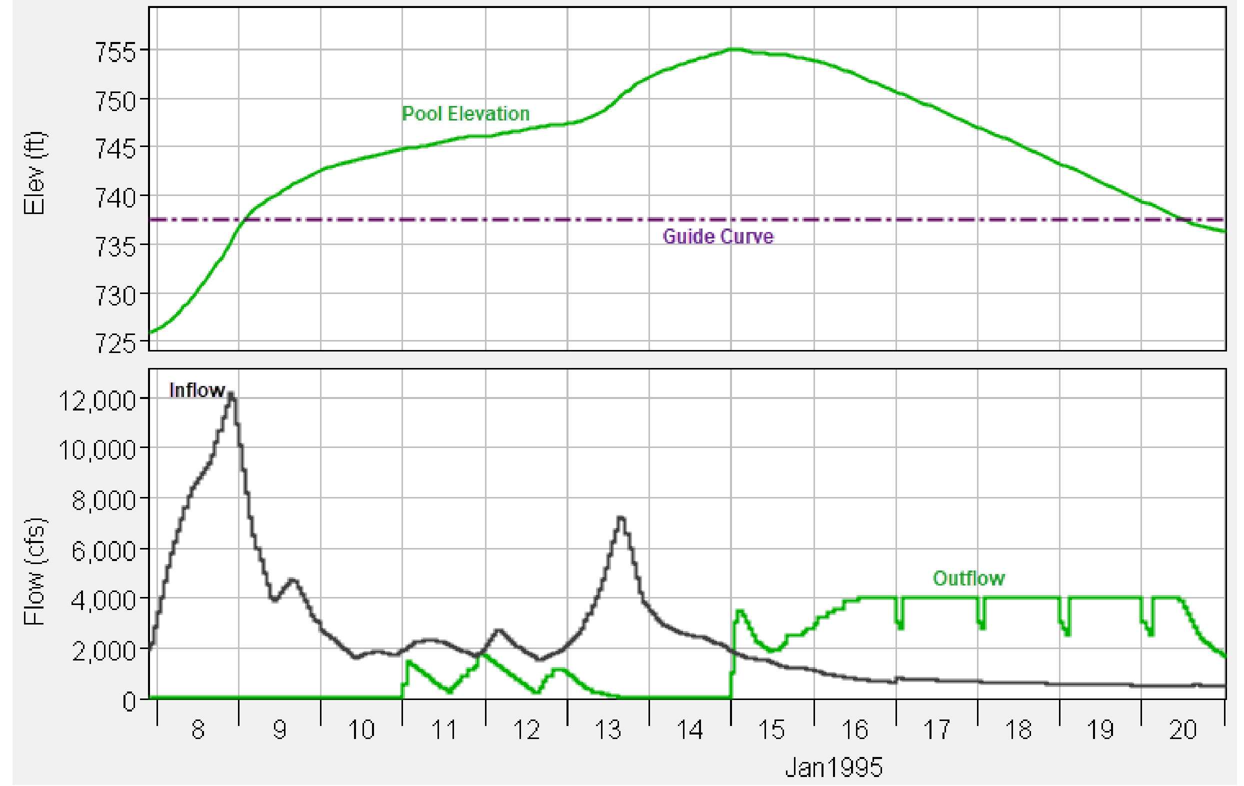

Figure 71 Simulated Flood Operations – POR Baseline _Lake Mendocino

2. Conservation Operation

Conservation releases were generally determined according to the highest of the minimum flow rules. HEC-ResSim iteratively performed linear routing of candidate releases to evaluate which of the downstream minimum locations controlled. The calculations included local flows from downstream tributaries and diversions out of the river. A typical series of release decisions for a period of time when the reservoir was in the conservation pool (i.e., below guide curve) and the watershed had a hydrologic index of "Normal" is displayed in Figure 72.

SWRCB Decision 1610 requires that the Coyote Valley Dam releases ensure 125 cfs throughout the Upper Russian River during the month of May, and the model rules included an additional 5 cfs buffer for East-West junction and a 9 cfs buffer for locations from Hopland through Healdsburg, making the effective minimum 130 for East-West junction and 134 cfs for locations from Hopland through Healdsburg.

Until 22 May 2006, 13:00 the reservoir released around 86 cfs to maintain the desired flow at East-West junction. Starting at the next time step, the Hopland Gage junction controlled the minimum release until 25 May 2006, 02:00. This shift in controlling rules occur due to a change in local flows.

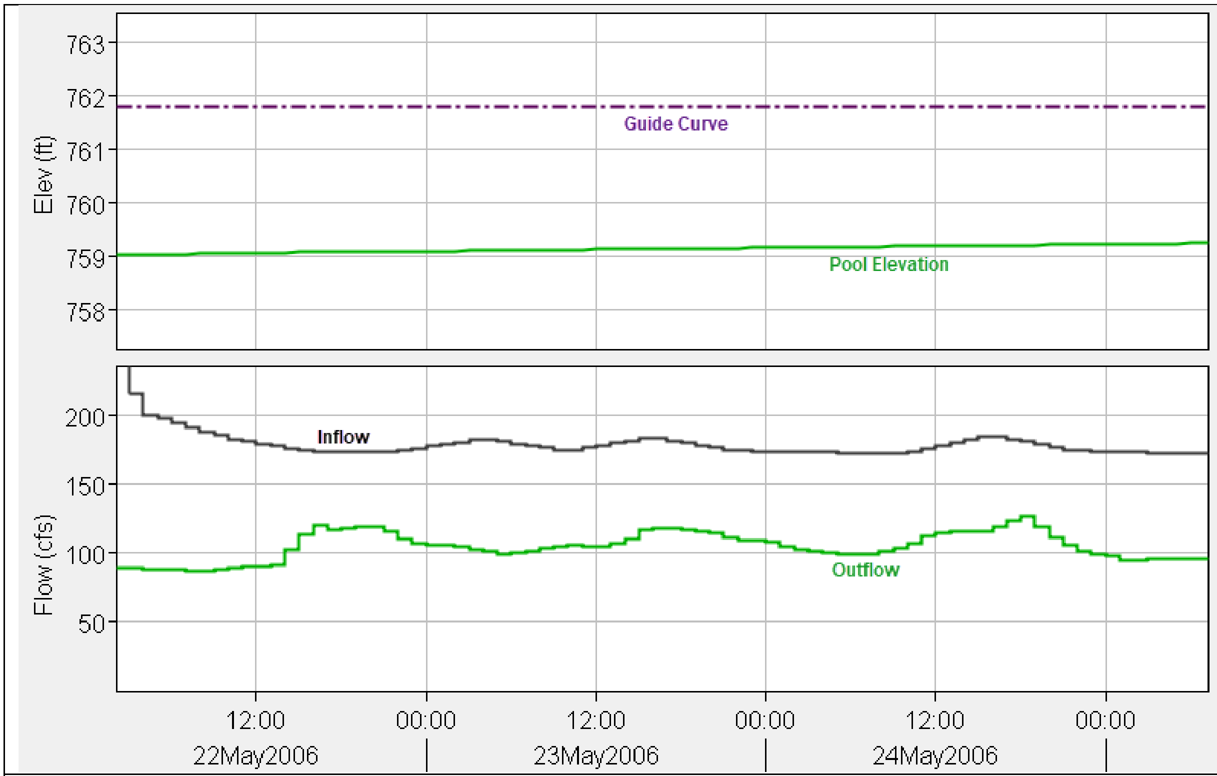

Figure 72 Simulated Conservation Operations – POR Baseline _Lake Mendocino

X. Description of State Variables

A. StorageState

The "StorageState" state variable code (script) computes the Lake Mendocino storage index. This script is evaluated by HEC-ResSim each time-step during the model simulation. Output from the script is the index used when setting minimum flows from Lake Mendocino in *WSC I-1610 Q-TUCP* IF_Block logic.

The script checks the date of the time step. At the beginning of June, the script reads in the storages from Lakes Mendocino and Pillsbury and defines the combined storage. The *Slave_CombineStorageid_May31* state variable stores the combined storage value. That value is maintained through the rest of the year (unless other criteria are met in the fall).

```
#####
##### STATE VARIABLE SCRIPT INITIALIZATION SECTION
#####


from hec.script import Constants
from hec.hecmath import TimeSeriesMath, DSS, DSSFile
from hec.script import  ClientAppWrapper

# This script is evaluated by HEC-ResSim each time-step during the model simulation. Output from the script is
# the hydrologic index used when setting minimum flows from Lake Mendocino in WSC I-1610 Q-TUCP If logic.
# Script checks the date of the time step. At the beginning of June, the script reads in the storages from lake
# Mendocino and Pillsbury and defines the combined storage (Slave_CombineStorageid_May31 state variable stores
# the combined storage value). That value is maintained through the rest of the year (unless other criteria met
```

```
# in the fall).

def initStateVariable(currentVariable, network):

        tw=network.getRssRun().getCurrentComputeBlockRunTimeWindow()
        tws = tw.getTimeWindowString()

        currentVariable.localTimeSeriesNew("step")
        currentVariable.localTimeSeriesNew("curmonth")
        currentVariable.localTimeSeriesNew("curday")
        currentVariable.localTimeSeriesNew("curhour")
        currentVariable.localTimeSeriesNew("combStorMay31")
        currentVariable.localTimeSeriesNew("mendfractionMay31")

        return Constants.TRUE


#####
##### STATE VARIABLE SCRIPT COMPUTATION SECTION
#####

from hec.heclib.util import HecTime
from hec.script import  ClientAppWrapper
from hec.hecmath import  DSS

curmonth=currentRuntimestep.month()
curday=currentRuntimestep.getHecTime().day()
curhour=currentRuntimestep.getHecTime().hour()
step = currentRuntimestep.getStep()

step_TS=currentVariable.localTimeSeriesGet("step")
step_TS.setCurrentValue(currentRuntimestep, step)

curmonth_TS=currentVariable.localTimeSeriesGet("curmonth")
curmonth_TS.setCurrentValue(currentRuntimestep, curmonth)

curday_TS=currentVariable.localTimeSeriesGet("curday")
curday_TS.setCurrentValue(currentRuntimestep, curday)

curhour_TS=currentVariable.localTimeSeriesGet("curhour")
curhour_TS.setCurrentValue(currentRuntimestep, curhour)

combStorCap = 160370   #Combinded LM and LP storage capacity

#Get StorageState value from previous time step
stateid = currentVariable.getPreviousValue(currentRuntimestep)
mendStateid = currentVariable.getPreviousValue(currentRuntimestep)
combineStorageid_May31SV = network.getStateVariable("Slave_CombineStorageid_May31")

# If time step is prior to dry spring then set id to 1
if curmonth<=5:
  stateid = 1
  mendStateid = 0

if curmonth>=6:
        mendStateid = 0
        if curmonth == 6 and curday == 1 and curhour==6:

                mendStorTS = network.getTimeSeries("Reservoir","Lake Mendocino", "Pool", "Stor")
                pillStorTS = network.getTimeSeries("Reservoir","Lake Mendocino", "Pillsbury Storage", "",1)
                #pillStorTS = currentVariable.localTimeSeriesGet("pillStorTS")

                mendStorMay31 = mendStorTS.getValue(step-1)
                pillStorMay31 = pillStorTS.getValue(step-1)
                combStorMay31 = mendStorMay31+pillStorMay31
                mendfractionMay31 = combStorMay31/combStorCap

                combStorMay31_TS=currentVariable.localTimeSeriesGet("combStorMay31")
                combStorMay31_TS.setCurrentValue(currentRuntimestep, combStorMay31)

                mendfractionMay31_TS=currentVariable.localTimeSeriesGet("mendfractionMay31")
                mendfractionMay31_TS.setCurrentValue(currentRuntimestep, mendfractionMay31)
```

```
                    if combStorMay31 >= 150000 or mendfractionMay31 > 0.9:
                        combineStorageid_May31 = 1
                    elif combStorMay31 >= 130000 or mendfractionMay31 > 0.8:
                        combineStorageid_May31 = 2
                    else:
                        combineStorageid_May31 = 4
                    combineStorageid_May31SV.setValue(currentRuntimestep, combineStorageid_May31)
            else:
                    combineStorageid_May31 = combineStorageid_May31SV.getPreviousValue(currentRuntimestep)
                    combineStorageid_May31SV.setValue(currentRuntimestep, combineStorageid_May31)
else:
  combineStorageid_May31SV.setValue(currentRuntimestep, 1)

if curmonth>=10:
        mendStor = network.getTimeSeries("Reservoir","Lake Mendocino", "Pool",
"Stor").getCurrentValue(currentRuntimestep)
        if mendStor < 30000:
                mendStateid = 3
        else:
                mendStateid = 0

if mendStateid == 3:
        stateid = 3
else:
        stateid = combineStorageid_May31SV.getValue(currentRuntimestep)

currentVariable.setValue(currentRuntimestep, stateid)


#####
##### STATE VARIABLE SCRIPT CLEANUP SECTION
#####

from hec.script import Constants

currentVariable.localTimeSeriesWriteAll()
```

B. Slave_CombineStorageid_May31

“Slave_CombineStorageid_May31” is a slave state variable that stores the combined storage of Lakes Mendocino and Pillsbury and is used in *StorageState* state variable.

XI. Reference

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