

**DON PEDRO HYDROELECTRIC PROJECT
FERC NO. 2299**

FINAL LICENSE APPLICATION

**EXHIBIT B – DON PEDRO PROJECT OPERATIONS AND RESOURCE
UTILIZATION**

**APPENDIX B-1
CURRENT LICENSE ARTICLES**

This section describes the current FERC license terms most relevant to relicensing and a brief history of license additions, modifications, and compliance. The initial license order was issued by FERC on March 10, 1964 (FERC 1964); however, filings with FERC followed the original license order and, according to the license text, the license would not become active until accepted by the Districts (EES 2006; FPC 1964.) The Districts did not formally accept the license until May 1, 1966. The current license expires on April 30, 2016 (EES 2006).

The license is composed of two basic types of license articles: the Standard Form L-2 articles (Articles 1 through 33), and the Project-specific articles (Articles 34 through 58). Since issuance, several articles of the license have been deleted, modified, or added to the license. Articles 6 and 12 were Standard Form L-2 license articles deleted in the FPC March 10, 1964 issuing order. Article 7 was deleted slightly later on May 10, 1964 in the FPC order denying rehearing and Article 46 was deleted from the license on April 29, 1993. Articles 49 and 50 were added to the license in 1980; Articles 51 through 58 were added to the license in February of 1987 with the order approving the addition of a fourth unit to the Don Pedro powerhouse.

The current license has 54 active articles. Table 1 provides a table of the general subject matter of the active license articles for the Don Pedro Project. Some license articles are considered expired or out of date, often because the article was added to the license at a certain point in time and the activity specified within them has occurred or been completed.

The text of the license terms and conditions deemed most relevant to relicensing are provided below.

Article 10. The Licensee shall, for the conservation and development of fish and wildlife resources, construct, maintain and operate, or arrange for the construction, maintenance and operation of such facilities and comply with such reasonable modifications of the project structures and operation as may be ordered by the Commission upon its own motion or upon the recommendation of the Secretary of the Interior or the fish and wildlife agency or agencies of any State in which the project or a part thereof is located, after notice and opportunity for hearing and upon findings based on substantial evidence that such facilities and modifications are necessary and desirable, reasonably consistent with the primary purpose of the project and consistent with the provisions of the Act.

Article 11. Whenever the United States shall desire, in connection with the project, to construct fish and wildlife facilities or to improve the existing fish and wildlife facilities at its own expense, the Licensee shall permit the United States or its designated agency to use, free of cost, such of Licensee's lands and interests in lands, reservoirs, waterways and project works as may be reasonably required to complete such facilities or such improvements thereof. In addition, after notice and opportunity for hearing, the Licensee shall modify the project operation as may be prescribed by the Commission reasonably consistent with the primary purpose of the project, in order to permit the maintenance and operation of the fish and wildlife facilities constructed or improved by the United States under the provisions of this article. This article shall not be interpreted to place any obligation on the United States to construct or improve fish and wildlife facilities or to relieve the Licensee of any obligation under license.

Article 13. So far as consistent with proper operation of the project, the licensee shall allow the public free access to a reasonable extent, to project waters and adjacent project lands owned by the Licensee for the purpose of full public utilization of such lands and waters for navigation and recreational purposes, including fishing and hunting, and shall allow to a reasonable extent for such purposes the construction of access roads, wharves, landings, and other facilities on its lands the occupancy of which may in appropriate circumstances be subject to payment of rent to the Licensee in a reasonable amount; Provided that the Licensee may reserve from public access, such portions of the project water adjacent lands, and project facilities as may be necessary for the protection of life, health, and property, and Provided further that the Licensee's consent to the construction of access roads, wharves, landings and other facilities shall not, without its express agreement, place upon the Licensee any obligation to construct or maintain such facilities. These facilities are in addition to the facilities that the Licensee may construct and maintain as required by the Licensee.

Table 1. Subject matter of the active license articles for the Don Pedro Project.

Article #	Topic	Article # (con't.)	Topic
1	General	31	Abandonment of Project
2	FERC approval of changes to exhibits, maps, articles	32	Occupancy of lands of the United States after license expiration
3	FERC approval of changes to Project works	33	Applicability of Federal Power Act terms and conditions
4	FERC inspection and supervision	34	Commencement of construction
5	Operations related to storage and use of water	35	Project Boundary Maps and Land Ownership
6	<i>(deleted March 1964 - cost determination)</i>	36	Reservoir clearing
7	<i>(deleted May 1964 - rate of return)</i>	37	Fish flows (revised in 1996 and in 2009)
8	FERC instruction to install additional capacity	38	Flood control (revised in 1999)
9	Coordination with others if ordered by FERC	39	Fish studies
10	Construction of fish and wildlife protective devices by the Districts	40	FERC orders on operations changes related to water temperature
11	Construction of fish and wildlife protective devices by U.S.	41	Free passage of water through original Don Pedro Dam
12	<i>(deleted March 1964 - Recreation facilities)</i>	42	Gravel and sediment management
13	Public access to Project waters and permitting of roads, docks, piers, etc.	43	Flood control agreement.
14	Prevention of erosion and siltation	44	Transmission lines
15	Lease of Project lands	45	Recreation facilities plan
16	Filing of maps to show Project Boundary	46	<i>(deleted 1993 - Lands)</i>
17	Approval of facilities by U.S. land management agency	47	Annual charges and installed capacity (revised in 1987, 1989, and 1995)
18	Public safety related to location of transmission and telephone lines, etc.	48	Storage allocation agreement with CCSF
19	Avoidance of inductive interference	49	Cultural resources <i>(added 1980)</i>
20	Clearing of transmission line rights-of-way on U.S.-owned lands	50	Granting permission for use of Project lands <i>(added 1980)</i>
21	Clearing of reservoir margins	51	Construction erosion and dust control plan <i>(added 1987)</i>
22	Fire prevention	52	Woody debris removal plan <i>(added 1987)</i>

Article #	Topic	Article # (con't.)	Topic
23	Use of water for fire prevention, sanitary and domestic needs on U.S.-owned lands	53	Wards Ferry Bridge restroom facilities <i>(added 1987)</i>
24	Construction liability	54	Addition of fourth generating unit <i>(added 1987)</i>
25	Permits for use of U.S.-owned lands for transportation and communication	55	Filing of drawings for fourth generating unit <i>(added 1987)</i>
26	Takeover of Project roads	56	The Districts' approval and filing of cofferdam and excavation drawings <i>(added 1987)</i>
27	Ownership of Project property	57	Filing of revised Exhibit Drawings <i>(added 1987)</i>
28	Gaging and stream gaging	58	Chinook monitoring program <i>(added 1987, revised in 1996, 1999, and 2009)</i>
29	Surrender of license due to non-compliance		
30	Headwater benefits		

Article 28. For the purpose of determining the stage and flow of the stream or streams from which water is diverted for the operation of the project works, the amount of water held in and withdrawn from storage, and the effective head on the turbines, the Licensee shall install and thereafter maintain such gages and stream-gaging stations as the Commission may deem necessary and best adapted to the requirements; and shall provide for the required readings of such gages and for the adequate rating of such stations. The Licensee shall also install and maintain standard meters adequate for the determination of the amount of electric energy generated by said project works. The number, character, and location of gages, meters, or other measuring devices, and the method of operation thereof, shall at all times be satisfactory to the Commission and may be altered from time to time if necessary to secure adequate determinations, but such alteration shall not be made except with the approval of the Commission or upon the specific direction of the Commission. The installation of gages, the ratings of said stream or streams, and the determination of the flow thereof, shall be under the supervision of, or in cooperation with, the District Engineer of the United States Geological Survey having charge of stream-gaging operations in the region of said project, and the Licensee shall advance to the United States Geological Survey the amount of funds estimated to be necessary for such supervision or cooperation for such periods as may be mutually agreed upon. The Licensee shall keep accurate and sufficient record of the foregoing determinations to the satisfaction of the Commission, and shall make return of such records annually at such time and in such form as the Commission may prescribe.

Article 37. *Amended by 76 FERC 61,117,7/31/96*

The Licensees shall maintain minimum streamflows in the Tuolumne River at La Grange bridge (RM 50.5) for fish purposes in accordance with the table and schedules set forth below or with such schedules as may be agreed to among the Licensees, the CDFG and the USFWS. Any such schedules shall be available for public review at the licensee's offices. These flows may be temporarily modified if required by operating emergencies beyond the control of the Licensees.

Water Year Classification¹	Cumulative Occurrence	Freq.	60-20-20 Index (1906-1995)
Critical Water Year and below	<6.4	6.4	1500 TAF
Median Critical Water Yr.	6.4 - 14.4	8.0	1500
Inter. C-D Water Year	14.4 - <20.5	6.1	2000
Median Dry	20.5 - <31.3	10.8	2200
Intermediate D-BN	31.1 - <40.4	9.1	2400
Median Below Normal	40.4 - <50.7	10.3	2700
Intermediate BN-AN	50.7 - <66.2	15.5	3100
Median Above Normal	66.2 - <71.3	5.1	3100
Intermediate AN-W	71.3 - <86.7	15.4	3100
Median Wet/Maximum	86.7 - 100	13.2	3100

¹The fish flow year is defined as April 15 through April 14 of the following year. The water year is defined as October 1 through September 30.

The water year classification shall be determined using the California State Water Resources Control Board's San Joaquin Basin 60-20-20 Water Supply Index and the California Department of Water Resources' (Water Resources Department) April 1 San Joaquin Valley unimpaired runoff forecast. The 60-20-20 index numbers used each year shall be updated to incorporate subsequent water years pursuant to standard Water Resources Department procedures so as to maintain approximately the same frequency distribution of water-year types. The volume of annual flow shall be periodically readjusted upon agreement among the Licensees, CDFG, and USFWS after April 1 of each year as more current unimpaired flow information becomes available.

Between a Median Critical Water Year and an Intermediate Below Normal-Above Normal Water Year, the precise volume of flow to be released by the Licensees each fish flow year is to be determined using accepted methods of interpolation between index values given above.

Schedule Occurrence	Days	Critical & below 6.4%	Median Critical 8.0%	Interim CD 6.1%	Median Dry 10.8%	Interm D-BN 9.1%	Median Below Normal 10.3%	Interm BN-AN 15.5%	Median Above Normal 5.1%	Interm AN-W 15.4%	Median Wet-Max 13.3%
October 1-15	15	100 cfs 2,975 AF	100 cfs 2,975 AF	150 cfs 4,463 AF	150 cfs 4,463 AF	180 cfs 5,355 AF	200 cfs 5,950 AF	300 cfs 8,926 AF	300 cfs 8,926 AF	300cfs 8,926 AF	300 cfs 8,926 AF
Attraction Pulse	--	none	none	none	none	1,676 AF	1,736 AF	5,950 AF	5,950 AF	5,950 AF	5,950 AF
October 16-May 31	228	150 cfs 67,835 AF	150 cfs 67,835 AF	150 cfs 67,835 AF	150 cfs 67,835 AF	180 cfs 81,402 AF	175 cfs 79,140 AF	300 cfs 135,669 AF	300 cfs 135,669 AF	300 cfs 135,669 AF	300 cfs 135,669 AF
Out-migration Pulse Flow	--	11,091 AF	20,091 AF	32,619 AF	37,060 AF	35,920 AF	60,027 AF	89,882 AF	89,882 AF	89,882 AF	89,882 AF
June 1-Sept. 30	122	50 cfs 12,099 AF	50 cfs 12,099 AF	50 cfs 12,099 AF	75 cfs 18,149 AF	75 cfs 18,149 AF	75 cfs 18,149 AF	250 cfs 60,496 AF	250 cfs 60,496 AF	250 cfs 60,496 AF	250 cfs 60,496 AF
Volume (AF.)	365	94,000	103,000	117,016	127,507	142,502	165,002	300,923	300,923	300,923	300,923

If, as provided for under Article 37 as amended above, the Licensees, the CDFG, and the USFWS agree to a minimum flow release schedule differing from the schedule set forth in Article 37, the Licensees shall notify the Commission of the revised flow schedule within 30 days of the date of the agreement to change the flow schedule. If the project flow releases are temporarily modified as required by operating emergencies beyond the control of the Licensees, as provided under Article 37, the Licensees shall notify the Commission of the flow modifications within 30 days of the date of the temporary flow release change.

FERC further amended this article in 128 FERC 61,035 issued on July 16, 2009 as follows:

(G) Article 37 of the license for the Don Pedro Project, issued March 10, 1964, and amended July 31, 1996 (Ordering Paragraphs (D) and (E), Turlock and Modesto Irrigation District, 76 FERC 61,117) is amended to add the National Marine Fisheries Service as an agency to be consulted on any changes to the minimum flow release schedule for the project.

Article 38. *Amended by 89 FERC 62,247, 12/23/99: (Amended December 23, 1999)*

Flows below La Grange bridge may be altered by the licensees at any time in connection with the operation of the Project for flood control purposes or other emergencies provided that if such flood control operations are required, flows shall be made to meet the requirements of the U.S. Army Corps of Engineer's (Corps) approved Water Control Plan, Water (Flood) Control Diagram, and the Emergency Spillway Release Diagram or an approved deviation from these documents. The licensees shall take reasonable measures to ensure that releases from the project do not cause the flow in the Tuolumne River at the Modesto gage below Dry Creek to exceed 9,000 cubic ft per second unless otherwise agreed to by the Corps. After flood control criteria within the reservoir have been met, the licensees shall reduce the releases from the project as soon as it is reasonably practicable to do so.

Subject to the provisions of paragraph (a) so long as fluctuation do not result in reduction of flows below those in the applicable schedule prescribed in article 37, or such higher minimum daily flows as may be established in the 45-day period of November 5 to December 20 (or such other 45 day period between October 15 through December 31, as may be specified on two weeks prior notice by the California Department of Fish and Game, fluctuations may be made at any time); *Provided:*

- (1) Fluctuations shall be controlled as closely as possible during such 45-day period so as not to cause a daily increase of river height in excess of 10 inches; *Provided*, however, for a period of not to exceed two hours per day, the increase may exceed 10 inches but not more than a total of 18 inches.
- (2) From the end of such 45-day period until March 31 reduction in river height shall not exceed four inches below the average height established in the 45-day period, excluding heights reached as a consequence of the daily fluctuation in excess of 10 inches provided in paragraph (b)(1) and those resulting under paragraph (a).

- (B) In the report required by Article 58, the licensees shall describe any implemented flood control measures or other efforts to change the flood way or flood control operational guidelines for this project during the reporting period.

Article 39. *Order Modifying Opinion No,420 and Denying Applications for Rehearing, issued May 6, 1964. Substitute the following for original Article 39 language:*

The Licensees in cooperation with the California Department of Fish and Game and the Department of the Interior shall make necessary studies aimed at assuring continuation and maintenance of the fishery of the Tuolumne River in the most economical and feasible manner. Such studies shall be completed prior to the end of the 20-year period for which minimum stream flows have been provided in Article 28.

The Licensees shall develop in cooperation with the California Department of Fish and Game and the Department of the Interior a program for making such studies and for financing their cost. The program shall be submitted for Commission approval within one year from the effective date of this license.

Article 40. In the event water temperatures during the critical months of the spawning season are too high for successful salmon spawning, the Licensees and the California Department of Fish and Game shall confer to determine whether project operations may be adjusted to assist in correcting the situation. If no agreement can be reached, the Commission, upon request and after notice and opportunity for hearing, may order such adjustment as it finds to be necessary and desirable, reasonably consistent with the primary purpose of the project.

Article 43. The Licensees shall, prior to commencement of construction of the New Don Pedro project works, enter into an agreement with the Secretary of the Army or his designated representative providing for the operation of the project for flood control in accordance with rules and regulations prescribed by the Secretary of the Army. A conformed copy of the agreement shall be filed with the Commission for its information and records prior to commencement of construction of the project works.

Article 45. The Licensees shall construct, maintain and operate or shall arrange for the construction, maintenance and operation of such recreational facilities including modification thereto, such as access roads, wharves, launching ramps, beaches, picnic and camping areas, sanitary facilities and utilities, as may be prescribed thereafter by the Commission during the term of this license upon its own motion or upon the recommendation of the Secretary of the Interior or interested State agencies, after notice and opportunity for hearing and upon findings based upon substantial evidence that such facilities are necessary and desirable, and reasonably consistent with the primary purposes of the project. The Licensees shall within one year from the date of issuance of the license, file with the Commission for approval of their proposed recreational use plan for the project. The plan shall be prepared after consultation with appropriate Federal, State, and local agencies, and shall include recreational improvements which may be provided by others in addition to the improvements the Licensees plan to provide.

Article 46. *Deleted by Order Deleting Article 46, 4-29-93.*

Article 47. The licensees shall pay to the United States the following annual charges:

(Revised by errata notice dated 8/28/89 - Installed capacity changed to 222,800 hp.)

Amended to read: (a) For the purpose of reimbursing the United States for the cost of administration of Part I of the Act, a reasonable annual charge as determined by the Commission in accordance with the provisions of its regulations, in effect from time to time. The authorized installed capacity for that purpose is 222,800 horsepower. (b) For the purpose of recompensing the United States for the use and enjoyment of 4,801.86 ac of its lands, exclusive of transmission line right-of-way, a reasonable annual charge as determined by the Commission in accordance with the provisions of its regulations, in effect from time to time.

Revised September 20, 1995 -72 FERC 62,252 - Order amended Article 47.

Amended to read: (a) For the purpose of reimbursing the United States for the cost of administration of Part 1 of the Act, a reasonable annual charge as determined by the Commission in accordance with the provisions of its regulations, in effect from time to time. From July 1, 1989, the authorized installed capacity for that purpose is 168,015 kW.

Article 49. *Added by Order 11 FERC 62,147, 5-27-80.*

Prior to the commencement of any construction at the project, the Licensees shall consult and cooperate with the California State Historic Preservation Officer (SHPO) to determine the need for and extent of any archaeological or historical resource surveys and any mitigative measures that may be necessary. The Licensees shall, if needed, provide funds in a reasonable amount for such activities. If any previously unrecorded archaeological or historic sites are discovered during the course of construction, construction activity in the vicinity shall be halted, a qualified archaeologist shall be consulted to determine the significance of the sites, and the Licensees shall consult with the SHPO to develop a mitigation plan for the protection of significant archaeological or historical resources.

Article 50. *Added to the License with TID and MID acceptance September 24, 1980.*

Standard License Article allowing licensee to grant permission for certain types of use of project lands.

No later than January 31 of each year, the licensee shall file three copies of a report briefly describing for each conveyance made under this paragraph (c) during the prior calendar year, the type of interest conveyed, the location of the lands subject to the conveyance, and the nature of the use for which the interest was conveyed.

Article 51. *Order 38 FERC 61,097 issued 2/2/87.*

Licensees after consultation with ACOE, USFWS, CVRWQCB and CDFG, shall prepare and file with the Commission within one year of this order, a plan to control erosion and dust and to minimize the quantity of sediment or other potential water pollutants resulting from construction and operation of the project, including spoil disposal areas. Plan shall include functional design drawings and map locations of control measures, and implementation schedule monitoring and maintenance programs for project construction and operation and provisions for periodic review and revisions. Documentation of consultation shall be included in the filing. [May begin ground disturbing activities 90 days after filing the plan unless the Director says otherwise.]

Article 52. *Order 38 FERC 61,097 issued 2/2/87.*

Within 1 year, after consultation and coordination with the Sierra Club, the Tuolumne Preservation Trust, Friends of the River, Audubon, CalTrout, Stanislaus League of Voters; Tuolumne River Expeditions and other appropriate authority, establish a plan for removal of logs and debris from the reservoir. Include an implementation schedule, monitoring and notification procedures and evidence of consultation.

Article 54. *Order 38 FERC 61,097 issued 2/2/87.*

The licensees shall commence construction of the fourth generating unit of the project within two years from the issuance date of the license and shall complete its construction within five years from the issuance date of the license.

Article 58. *Order 38 FERC 61,097 issued 2/2/87.*

Revised by Order 76 FERC 61,117, Amending License issued July 31, 1996.

The Licensees after consultation with the CDFG and the USFWS shall implement a program to monitor Chinook salmon populations and habitat in the Tuolumne River. The monitoring program shall conform to the monitoring schedule set forth below and shall include: 1) Spawning escapement estimates; 2) Quality and Condition of Spawning Habitat; 3) Relative fry Density/Female Spawners; 4) Fry Distribution and Survival; 5) Juvenile Distribution and Temperature Relationships; and 6) Smolt Survival.

The monitoring frequencies and methods shall be agreeable among the Licensees and the consulted agencies. Any disagreements regarding the conduct of these studies not resolved among the licensees and consulted entities shall be filed with the Commission for determination.

The above monitoring information is to be documented in annual reports which will be filed with the Commission by April 1 of each year and be available for public review. The results of any fishery studies already completed and not yet filed with the Commission shall be filed by the Licensees by April 1, 2005.

The Licensees shall include in the annual reports filed with the Commission April 1 of each year pursuant to Article 58 a description of the non-flow mitigative measures implemented in the previous year and planned for implementation in the coming year.

The Licensees shall include in the results of fishery studies to be filed with the Commission by April 1, 2005, all results and a discussion of the results of all monitoring studies related to the effects of flow release fluctuations on the salmon resources in the lower Tuolumne River. The filing shall also identify all non-flow mitigative measures implemented to date, and the results of all monitoring studies related to the nonflow mitigative measures.

Based on the information provided in the Licensees' study results to be filed by April 1, 2005, the Commission will determine whether to require further monitoring studies and changes in project structures and operations to protect fishery resources in the Tuolumne River, after notice and opportunity for hearing.

FERC included additional information to be provided in the article 58 Report in the order amending Article 38 issued December 23, 1999 as follows:

In the report required by Article 58, the licensees shall describe any implemented flood control measures or other efforts to change the floodway or flood control operational guidelines for this project during the reporting period.

FERC further amended this article in 128 FERC 61,035 issued on July 16, 2009 as follows:

Article 58 of the license for the Don Pedro Project, issued March 10, 1964, and amended July 31, 1996 (Ordering Paragraphs (F) and (G), Turlock and Modesto Irrigation District, 76 FERC 61, 117) is amended to add the National Marine Fisheries Service as an agency to be consulted on monitoring Chinook salmon populations and habitat in the Tuolumne River.

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FINAL LICENSE APPLICATION

**EXHIBIT B – DON PEDRO PROJECT OPERATIONS AND RESOURCE
UTILIZATION**

**APPENDIX B-2
DEVELOPMENT OF UNIMPAIRED HYDROLOGY**

(Note: This report was provided as Attachment 2 to the Districts' April 9, 2013
"Response to Relicensing Participants Comments on the Initial Study Report."
The report acted as the March 27, 2013 Workshop Meeting Notes wherein a consensus
was reached on development of Operations Model hydrology.)

**Districts “Strawman” for Considering Further Development of Unimpaired Hydrology for the
Tuolumne River in Advance of Workshop On March 27, 2013**

1.0 Objective

Relicensing participants and the Districts are continuing to consider and discuss Tuolumne River hydrology for use in the Tuolumne River Operations Model (W&AR-02). This draft report is intended to be an initial “strawman” describing one possible approach to discuss further on March 27, 2013. The objective of this particular “strawman” is to develop a daily flow dataset that contains no negative values, results in more gradual changes in day-to-day flows, and conforms to the historical monthly volumes previously recorded by the Districts and CCSF. The period of record under consideration is Water Year 1971 – 2009. It is noted that the period of record may be extended to 2012 for use in the development of the river and reservoir temperature models.

2.0 Background

On September 10, 2012, the California Department of Fish & Wildlife (CDFW), provided comments to the State Water Resources Control Board (SWRCB) related to the unimpaired hydrology for the operations/water balance model being developed for the Don Pedro Project relicensing. In summary, CDFW is concerned “that the Districts’ proposed method of estimating unimpaired hydrology is not appropriate for the purpose of the state of California’s environmental review process required for a new license.”

The Districts subsequently undertook an investigation of CDFW’s suggested approach and submitted its report to SWRCB, CDFW and FERC on December 21, 2012. This report was also provided as Attachment A, Appendix A, of the W&AR-2 initial study report issued January 17, 2013. On February 14, 2013, representatives from CDFW, SWRCB, and CCSF met with the Districts to discuss the Districts’ report and the comparison of the two approaches. The Districts maintained that there was insufficient Tuolumne River gauge data to support the gauge proration approach for the period of record of the Operations Model. CDFW and SWRCB expressed interest in using all available gauge proration hydrology even if the period of record was not as complete as might be desired. CDFW and SWRCB suggested that alternatives be developed collaboratively in a workshop environment. CDFW and SWRCB agreed that the monthly mass balance from the existing gauge summation hydrology was sound and need not be adjusted. The Districts agreed to continue to discuss and consider alternative approaches, and agreed to provide a “strawman” for to advance and promote dialogue at a meeting to be held on March 27.

3.0 Methods

Hydrologic input to the Operations Model currently includes daily unimpaired hydrology estimates for three locations in the watershed: “La Grange” (at the USGS gage), “Hetch Hetchy Reservoir”, and Lake Lloyd Reservoir/Lake Eleanor combined “Cherry/Eleanor”. The Operations Model uses these inputs to calculate a fourth dataset of operational significance: the unimpaired flow from the unregulated portion

of the watershed above Don Pedro Reservoir (“Unregulated”). Details of these calculations are described in the ISR of W&AR-2, Attachment A.

3.1 Gauge Proration “Strawman”

To promote and advance discussions for the March 27 Workshop, the Districts, as agreed with SWRCB, CCSF and CDFW, have evaluated approaches to developing a hybrid flow record for the Tuolumne River using a combination of gauge proration conforming to the existing monthly mass balances underlying the Operations Model. This “strawman” is described below.

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

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

Areas at low elevations and high elevations in each of the application basins that are poorly represented or not represented at all by the reference gauges were “artificially added” into the elevation distributions of the most representative gauges in order to provide some amount of coverage for those elevation ranges. When artificial areas were added to the gauges, the amount of area added for each gauge was nominally established as one percent of the total application basin area for that elevation bin. For precipitation in artificially augmented elevation bands, a multiplier was applied to the application basin precipitation values equal to the multiplier for the nearest observed elevation band for that gauge.

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

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

Equation 3.1.1 Daily unimpaired flow where q is daily average flow, a is area, and p is average annual precipitation. Where g is each gauged basin, u is the application basin, and e is the lower limit of each 100-foot elevation band divided by 100.

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

The following three sections of the “strawman” contain specific data to each application basin. Figure 3.1.1 shows where all the gauges used provide elevation coverage in reference to the application basin. The first table in each subbasin description contains a list of gauges used for gauge proration hydrology in that subbasin. The final table in each subbasin description shows gauge data availability from USGS, where white is unavailable, light gray is available but not used, and dark gray means it is being used in the subbasin gauge proration calculation. Some gauged data went unused when better gauged data (closer, more similar in elevation range) were available.

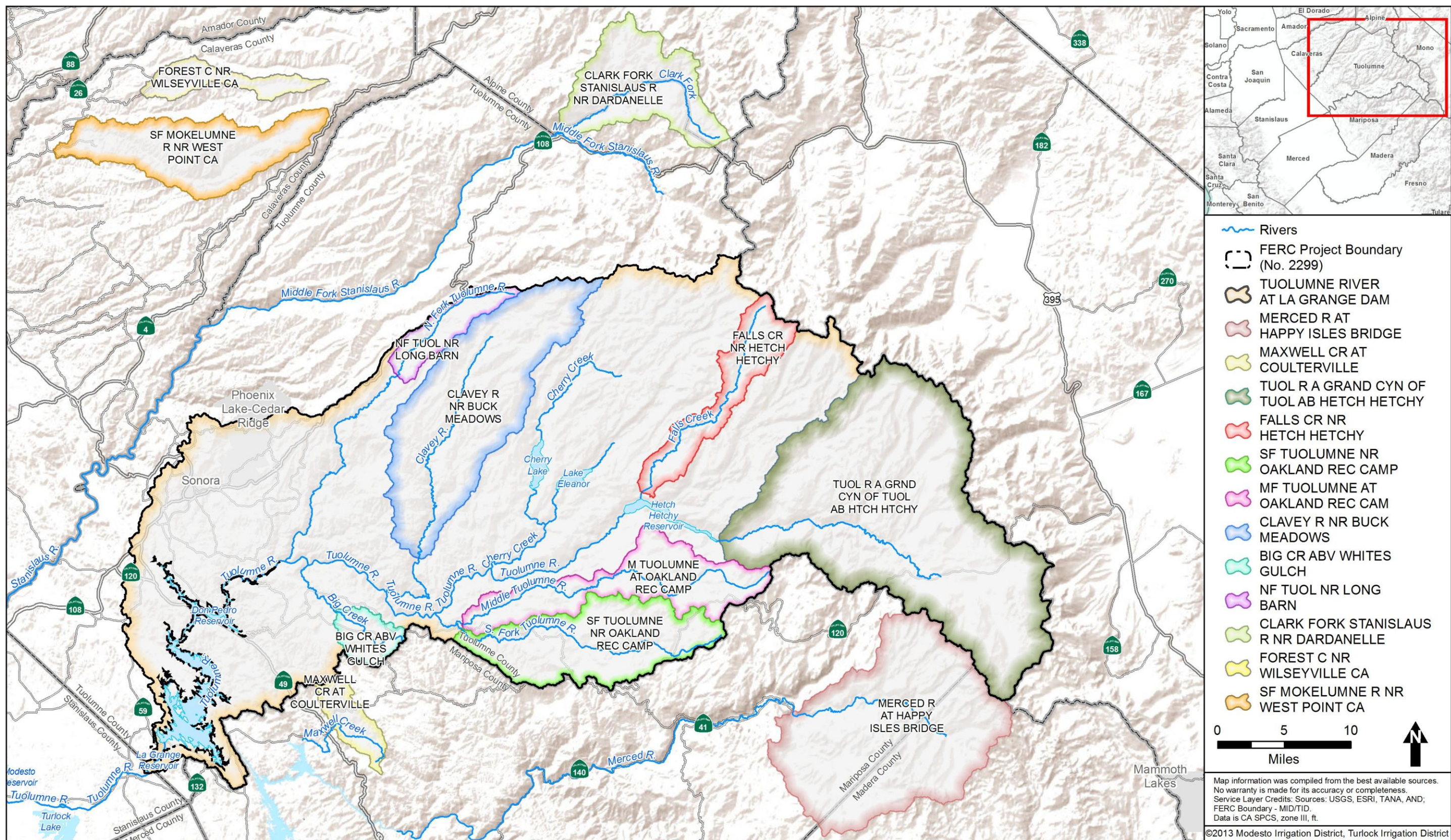


Figure 3.1.1 Map of gauges used in proration method for unimpaired hydrology

3.1.1 Hetchy Hetchy Subbasin

Table 3.1.1 Gauges used for gauge proration of Hetch Hetchy subbasin

11292500	CLARK FORK STANISLAUS R NR DARDANELLE CA
11274790	TUOLUMNE R A GRAND CYN OF TUOLUMNE AB HETCH HETCHY
11264500	MERCED R A HAPPY ISLES BRIDGE NR YOSEMITE CA
11275000	FALLS C NR HETCH HETCHY
11282000	M TUOLUMNE R A OAKLAND RECREATION CAMP CA

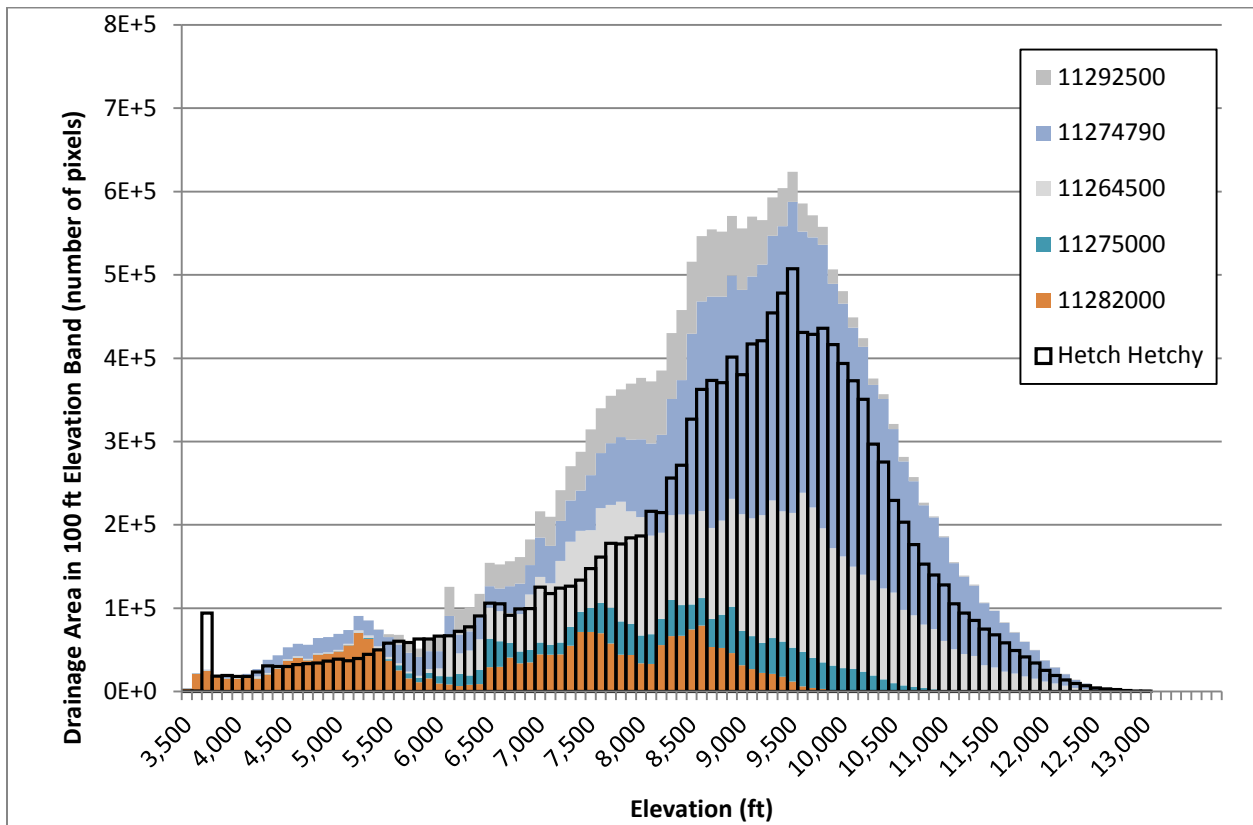


Figure 3.1.2 Elevation histograms for unimpaired gauges, compared to the Hetch Hetchy subbasin

Table 3.1.2 Gauge inventory for gauge proration of Cherry/Eleanor subbasin

WY	11292500	11274790	11264500	11275000	11282000
1971					
1972					
1973					
1974					
1975					
1976					
1977					
1978					

WY	11292500	11274790	11264500	11275000	11282000
1979					
1980					
1981					
1982					
1983					
1984					
1985					
1986					
1987					
1988					
1989					
1990					
1991					
1992					
1993					
1994					
1995					
1996					
1997					
1998					
1999					
2000					
2001					
2002					
2003					
2004					
2005					
2006					
2007					
2008					
2009					
2010					
2011					
2012					

3.1.2 Cherry/Eleanor Subbasin

Table 3.1.3 Gauges used for gauge proration of Cherry/Eleanor subbasin

11292500	CLARK FORK STANISLAUS R NR DARDANELLE CA
11274790	TUOLUMNE R A GRAND CYN OF TUOLUMNE AB HETCH HETCHY

11264500	MERCED R A HAPPY ISLES BRIDGE NR YOSEMITE CA
11283500	CLAVEY R NR BUCK MEADOWS CA
11275000	FALLS C NR HETCH HETCHY
11282000	M TUOLUMNE R A OAKLAND RECREATION CAMP CA
11284700	NF TUOLUMNE R NR LONG BARN CA
11281000	SF TUOLUMNE R NR OAKLAND RECREATION CAMP CA

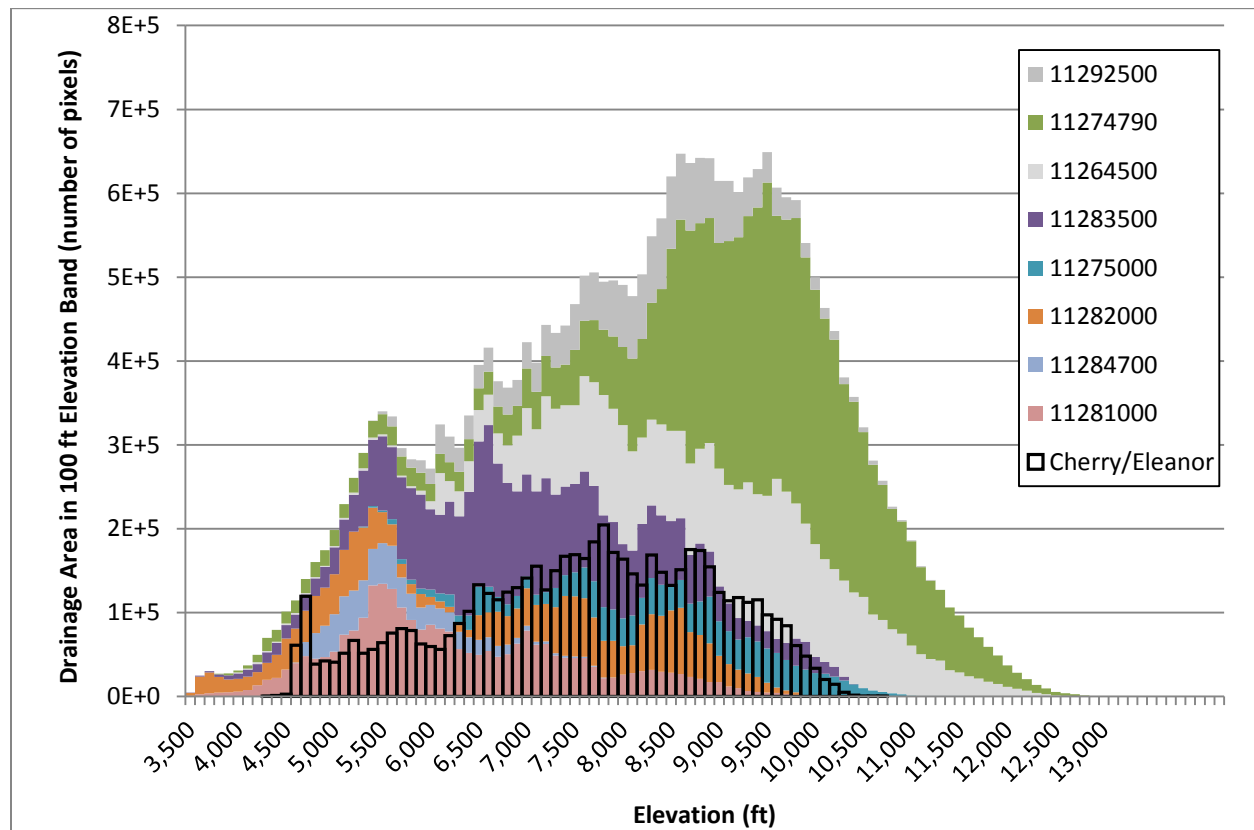


Figure 3.1.3 Elevation histograms for unimpaired gauges, compared to the Cherry/Eleanor subbasin

Table 3.1.4 Gauge inventory for gauge proration of Cherry/Eleanor subbasin

WY	11292500	11274790	11264500	11283500	11275000	11282000	11284700	11281000
1971								
1972								
1973								
1974								
1975								
1976								
1977								
1978								
1979								
1980								

WY	11292500	11274790	11264500	11283500	11275000	11282000	11284700	11281000
1981								
1982								
1983								
1984								
1985								
1986								
1987								
1988								
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								
2001								
2002								
2003								
2004								
2005								
2006								
2007								
2008								
2009								
2010								
2011								
2012								

3.1.3 Unregulated Subbasin

Table 3.1.5 Gauges used for gauge proration of Unregulated subbasin

11318500	SF MOKELUMNE R NR WEST POINT CA
11269300	MAXWELL C A COULTERVILLE CA
11316800	FOREST C NR WILSEYVILLE CA
11284400	BIG CR ABV WHITES GULCH

WY	3185	2693	3168	2844	2835	2645	2820	2847	2810
1982									
1983									
1984									
1985									
1986									
1987									
1988									
1989									
1990									
1991									
1992									
1993									
1994									
1995									
1996									
1997									
1998									
1999									
2000									
2001									
2002									
2003									
2004									
2005									
2006									
2007									
2008									
2009									
2010									
2011									
2012									

3.2 Monthly Volume

In order to scale the gauge proration hydrology to the observed historical monthly volumes, some adjustments had to be made to deal with months where the total monthly volume was calculated negative. Negative monthly volumes in the current Tuolumne record are an artifact of gauge summation calculations involving numerous flow and reservoir level gauges, each with small errors. These calculations are described in detail in Attachment A of the ISR of W&AR-2. Negative monthly volumes occur during certain low flow periods (August-January) of Cherry/Eleanor, Hetch Hetchy, and

unregulated inflow to Don Pedro. In total, adjustments were needed in 39 of the 504 months of the extended period of record (WY 1971 – WY 2012). This resulted in small changes to the annual volume from contributing subbasins for 22 of the 42 water years.

In order to eliminate negative monthly volumes without disturbing the gauge summation record, each of the upper subbasins (Cherry/Eleanor and Hetch Hetchy) were re-balanced with the Unregulated subbasin so that the monthly unimpaired volume at La Grange remains the same. Rather than transferring just enough volume to ‘zero’ out the negative month, an attempt was made to use the gauge proration record to find a reasonable value for the month being adjusted.

In the gauge proration hydrology record, typically the gauges being used don’t change during a water year due to the way USGS reports data. Monthly volumes were examined as a percentage of the total water year volume for both the gauge summation, and gauge proration data. The monthly percentage of the annual volume was used as a guide to form an ‘expected’ monthly volume.

When the Unregulated subbasin had a negative month, Cherry/Eleanor and/or Hetch Hetchy volumes for that month were examined for closeness to their ‘expected’ amount. In many cases, the Cherry/Eleanor subbasin was far wetter than ‘expected’ and an adjustment down fixed a large portion of the imbalance. In most cases, a blend of both Hetch Hetchy, and Cherry/Eleanor volumes were used to offset a negative volume in the Unregulated subbasin. The exact percentage from each subbasin varies depending on how the adjustment affected each subbasin.

When Cherry/Eleanor or Hetch Hetchy subbasins had a negative month, an ‘expected’ value was used as a guide for the offset volume. All of the re-balancing volume came from the Unregulated subbasin. In most cases, this volume had to be further adjusted manually in order to keep normal volumes in the Unregulated subbasin. Table 3.2.1 shows these adjustments.

The only “*new water*” adjustment comes in October 2002, where 2000 AF was added to the La Grange gauge. This was the minimum volume that could be used to produce a positive ‘expected normal’ month in the Unregulated subbasin (and Cherry/Eleanor subbasin). All of the adjustments made to the Unregulated subbasin balance to a net of 2000 acre feet. In other words, for the period of record, CCSF/Districts have the same amount of water flowing into the watersheds. The 2000 AF addition to La Grange goes exclusively to the Unregulated subbasin.

Table 3.2.1 Adjustments to unregulated inflow volume to Don Pedro, in AF. Red indicates water going from the Unregulated subbasin to Cherry/Eleanor, orange to Hetch Hetchy, and green indicates water going from a combination of Cherry/Eleanor and Hetch Hetchy to the Unregulated subbasin.

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1971	-1,633										-3,369	-2,260
1972	-4,146										-3,024	-1,515
1973											-3,271	-4,695
1974												-4,741
1975	-3,518											
1976				8,000								

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1977			-1,041								-1,359	7,287
1978	-1,545											
1981	-6,652											
1987				4,400								-400
1988												-800
1989										6,600	4,500	
1990										3,088	3,600	2,800
1991	1,700		-1,500									
1994				-7,923							-7,500	-981
1995	6,143											
1996	2,400	-200										
2000	-1,527											
2003	4,400											
2004	1,945	5,037										
2007												4,200
2012												-500

Monthly scaling factors were used to scale the gauge proration hydrology up or down to the adjusted historical monthly volume. The monthly scaling factor is defined as the adjusted historical monthly volume divided by the gauge proration monthly volume. A scaling factor of less than one means the gauge proration overestimated the historical flow. A scaling factor of greater than one means the gauge proration underestimated the historical flow. When multiplied by the scaling factor, the daily gauge proration flow values will result in adjusted historical monthly volumes. The following three sections show computed scaling factors used for each subbasin, with red to orange indicating a reduction in gauge proration flow, and yellow to green representing an increase in gauge proration flow.

3.2.1 Hetchy Hetchy Subbasin

Table 3.2.2 Hetch Hetchy monthly scaling factors for gauge proration. Bold indicates reduced volume and italics indicates increased volume.

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1971	0.11	1.08	1.15	1.00	0.84	0.87	0.82	0.91	0.95	0.79	0.60	0.57
1972	0.48	0.75	1.04	0.98	0.96	0.82	0.81	0.89	0.84	0.56	0.32	0.27
1973	0.54	0.73	0.90	1.00	1.06	1.01	0.80	0.84	0.88	0.64	0.41	0.02
1974	0.32	0.87	1.02	0.94	0.72	0.88	0.79	0.83	0.87	0.85	0.57	0.07
1975	0.12	0.11	0.96	0.93	1.21	1.23	1.00	0.81	0.86	0.84	0.49	0.36
1976	0.81	0.87	0.74	0.05	0.98	0.94	0.83	0.93	0.82	0.71	0.70	0.44
1977	0.81	0.68	0.57	0.52	0.69	0.96	0.89	1.01	1.10	1.12	1.04	<i>0.97</i>
1978	0.52	0.96	1.25	1.67	1.67	1.15	0.91	0.79	0.88	1.03	0.73	0.64
1979	0.57	0.73	0.84	1.04	1.19	1.09	0.86	0.89	0.86	0.76	0.45	0.09
1980	0.82	0.92	0.83	1.03	0.98	0.93	0.80	0.80	1.00	1.18	0.84	0.36

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1981	0.16	0.26	0.59	0.64	0.95	1.08	0.84	0.94	0.90	0.53	0.41	0.28
1982	0.91	1.09	1.03	1.09	0.94	0.78	0.74	0.81	0.89	0.87	0.86	0.91
1983	0.90	1.06	1.10	1.00	1.05	1.11	0.80	0.77	0.86	0.88	0.93	0.74
1984	0.95	1.80	1.45	0.96	1.06	1.17	1.22	1.58	1.76	1.24	0.79	0.60
1985	0.97	1.83	1.50	1.15	1.36	1.61	1.42	1.65	1.69	0.89	0.54	0.92
1986	1.55	1.63	2.13	1.90	1.57	1.19	1.27	1.45	1.62	1.56	1.01	0.57
1987	1.31	0.70	0.62	0.50	1.83	1.87	1.47	1.57	1.34	0.71	0.30	0.15
1988	0.56	1.10	1.77	2.03	1.43	1.40	1.55	1.59	1.40	0.80	0.55	0.57
1989	0.15	0.63	1.35	2.10	2.52	2.00	1.40	1.67	1.69	1.07	0.22	0.58
1990	1.34	1.41	1.50	2.03	2.14	1.81	1.58	1.61	1.50	0.76	0.39	0.12
1991	0.20	0.66	0.53	0.50	1.15	2.66	1.62	1.49	1.53	1.16	0.84	0.50
1992	1.18	1.39	1.35	1.44	2.02	1.70	1.39	1.37	1.00	1.02	0.74	0.61
1993	1.17	0.91	1.55	2.03	1.82	1.39	1.19	1.25	1.33	1.30	0.93	0.47
1994	0.88	0.56	1.28	0.62	1.84	2.08	1.64	1.70	1.64	0.62	2.06	0.61
1995	0.60	2.05	1.95	2.36	1.86	1.46	1.23	1.19	1.35	1.43	1.48	1.14
1996	0.39	0.95	1.91	1.74	1.78	1.34	1.30	1.47	1.84	1.70	1.05	1.01
1997	1.34	1.40	1.76	1.32	1.00	1.03	1.03	1.20	1.48	1.14	0.87	0.71
1998	1.03	1.17	1.96	2.49	1.72	1.58	1.19	1.23	1.34	1.35	0.87	0.77
1999	1.23	1.82	1.86	2.05	1.79	1.51	1.31	1.55	2.06	1.94	1.13	1.05
2000	1.54	1.61	1.26	2.42	1.98	1.54	1.45	1.49	1.50	1.17	1.11	0.92
2001	1.35	1.39	2.19	1.94	2.12	1.83	1.55	1.42	1.17	1.01	1.14	1.38
2002	2.46	1.71	2.09	1.81	1.67	1.51	1.40	1.57	1.61	1.13	1.22	2.06
2003	0.84	1.32	1.91	1.43	1.01	1.08	1.20	1.12	1.03	0.74	0.84	0.43
2004	1.27	1.26	1.90	0.89	0.95	1.20	1.22	1.40	1.33	0.88	0.96	1.55
2005	1.91	1.22	1.46	1.74	1.49	1.39	1.03	0.95	0.92	0.78	0.52	0.60
2006	0.88	1.09	2.14	1.23	1.24	1.14	1.06	0.99	1.10	0.88	0.56	0.27
2007	0.52	1.22	1.62	1.44	1.79	1.43	1.31	1.43	1.16	0.74	0.83	0.16
2008	1.28	1.32	1.90	1.52	1.58	1.36	1.26	1.36	1.32	0.83	0.48	0.77
2009	1.67	1.28	1.27	1.60	1.48	1.46	1.24	1.47	1.48	1.00	0.85	0.83
2010	1.31	1.03	1.52	1.56	1.57	1.52	1.49	1.36	1.31	1.06	0.75	1.06
2011	1.67	1.32	1.92	1.42	1.49	1.88	1.38	1.32	1.41	1.42	1.19	0.95
2012	1.02	0.92	0.58	1.38	1.18	1.30	1.32	1.28	1.07	0.69	0.58	0.61

3.2.2 Cherry/Eleanor Subbasin

Table 3.2.3 Cherry/Eleanor monthly scaling factors for gauge proration. Bold indicates reduced volume and italics indicates increased volume.

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1971	0.52	2.91	2.04	1.66	1.42	1.46	1.37	1.47	1.37	1.00	0.52	0.52
1972	0.53	2.46	1.63	1.44	1.47	1.64	1.54	1.52	1.41	0.17	0.53	0.52
1973	0.67	1.80	2.11	1.48	1.15	1.19	1.43	1.45	1.30	0.44	0.49	0.49
1974	0.83	2.76	1.62	1.44	1.07	1.36	1.29	1.43	1.28	1.09	0.14	0.52
1975	0.48	0.23	1.52	1.75	1.37	1.38	1.39	1.46	1.28	1.16	0.42	0.39
1976	2.52	1.61	1.28	0.09	1.83	1.89	1.90	1.62	0.81	0.24	2.14	1.63
1977	1.65	0.82	0.71	1.57	2.40	2.38	2.16	2.25	1.48	0.14	0.72	1.80
1978	0.54	2.54	3.55	2.05	1.32	1.40	1.25	1.49	1.39	1.30	0.78	2.27

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1979	0.05	1.27	1.78	2.10	1.62	1.41	1.51	1.44	1.28	0.99	1.15	1.62
1980	2.78	3.02	2.55	1.75	1.09	1.08	1.42	1.34	1.76	2.02	1.06	0.76
1981	0.62	0.44	1.61	1.65	2.28	1.85	1.98	1.66	1.36	1.27	3.38	2.36
1982	2.76	3.23	1.83	1.13	1.22	1.33	1.16	1.19	1.21	1.09	0.58	1.75
1983	2.39	1.52	1.03	0.96	0.91	0.84	0.99	1.27	1.27	1.32	1.21	1.07
1984	1.49	4.50	2.33	1.39	1.55	2.26	1.95	2.12	1.80	0.97	0.09	0.17
1985	2.47	5.03	3.28	2.01	2.66	3.12	2.95	2.43	1.91	0.81	0.92	1.16
1986	4.32	4.31	5.71	5.17	2.54	2.11	2.15	2.19	2.14	1.79	0.82	1.50
1987	1.38	0.71	0.98	0.67	3.76	3.25	3.89	2.65	1.66	0.36	0.76	0.63
1988	2.70	4.08	5.10	1.04	1.69	3.14	3.44	3.05	2.38	1.52	0.08	0.51
1989	1.27	4.80	4.05	4.02	3.73	3.25	2.30	2.36	2.02	0.52	0.09	3.64
1990	6.66	3.93	2.43	3.50	3.47	3.25	3.14	2.80	2.15	0.80	0.17	0.32
1991	0.47	0.67	0.92	1.02	2.53	5.29	3.43	3.01	2.68	2.25	0.84	0.24
1992	1.65	4.19	1.95	2.56	3.24	2.95	3.10	2.42	1.43	4.22	1.36	0.11
1993	3.35	3.58	3.09	2.44	1.74	2.08	2.02	2.11	2.20	2.36	1.09	0.40
1994	1.37	0.63	2.69	2.39	3.39	3.75	3.71	3.01	1.98	0.70	0.03	0.05
1995	1.79	11.40	4.67	1.83	2.07	1.28	1.80	1.96	2.01	1.64	1.38	0.35
1996	0.37	0.003	6.32	3.28	3.37	2.11	2.13	2.20	1.76	1.19	0.74	0.33
1997	2.40	3.24	5.53	2.56	1.70	2.05	1.69	1.14	1.06	0.52	0.24	1.27
1998	2.36	3.49	4.36	3.74	1.70	2.51	2.09	1.97	1.93	1.69	0.83	0.82
1999	1.13	5.78	3.78	3.34	2.36	2.49	2.28	2.25	2.27	1.52	0.30	0.04
2000	0.90	3.37	1.47	5.53	2.69	2.63	2.63	2.19	1.72	0.86	0.72	1.57
2001	3.18	4.09	5.20	5.25	5.16	4.28	2.84	1.78	0.92	1.02	3.35	3.66
2002	2.25	7.05	5.22	4.21	3.31	3.52	2.43	2.08	1.55	0.35	2.15	2.22
2003	1.43	4.70	6.20	4.35	2.99	3.03	2.24	1.42	0.99	0.63	1.18	2.60
2004	1.63	3.32	7.47	4.33	4.91	2.32	1.87	1.44	0.89	0.48	0.58	0.15
2005	7.77	4.56	5.68	4.44	3.54	2.79	1.99	1.64	1.21	0.85	0.27	0.84
2006	3.79	3.65	7.66	3.42	4.13	3.37	2.51	1.15	0.96	0.71	0.50	0.68
2007	2.07	5.46	7.26	6.35	6.84	3.92	2.59	1.74	1.11	1.68	4.46	2.06
2008	5.19	0.74	6.16	5.68	3.91	4.03	3.04	1.79	1.14	0.54	0.70	0.32
2009	2.78	4.80	3.51	5.02	4.01	3.55	2.93	2.61	2.19	1.08	1.02	1.47
2010	4.95	1.72	4.10	3.90	2.81	3.22	2.45	2.22	2.09	1.61	0.80	0.84
2011	4.61	4.01	3.06	2.60	2.86	2.26	2.46	2.51	1.78	1.66	1.71	1.71
2012	2.59	2.11	0.89	5.82	3.82	4.49	3.07	1.70	1.21	0.62	0.45	0.48

3.2.3 Unregulated Subbasin

Table 3.2.4 Unregulated subbasin scaling factors for gauge proration. Bold indicates reduced volume and italics indicates increased volume.

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1971	2.11	1.73	1.42	1.31	1.01	0.92	0.84	0.85	0.93	1.38	1.51	1.48
1972	0.59	1.24	1.20	1.66	1.19	0.87	0.83	0.88	1.15	2.63	3.78	2.21
1973	1.18	1.98	1.45	1.27	1.43	1.27	0.84	0.78	1.15	1.89	1.99	1.52
1974	1.98	1.00	1.23	1.04	0.94	0.92	0.92	0.86	1.14	1.55	2.03	2.77
1975	2.45	1.39	1.24	1.33	1.60	1.30	1.07	0.70	0.81	0.88	1.73	1.77
1976	1.22	1.45	1.47	0.81	1.18	1.13	1.01	0.94	1.35	3.25	3.13	2.87

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1977	1.47	1.62	0.39	1.45	1.14	0.95	0.86	0.96	1.03	0.40	2.77	1.02
1978	0.61	1.52	1.44	1.25	1.22	1.05	0.97	0.93	0.92	1.08	2.62	2.40
1979	1.22	2.85	1.45	1.46	1.50	1.17	0.83	0.79	0.96	1.60	1.52	1.79
1980	1.57	0.96	1.05	0.99	1.03	1.00	0.85	0.92	0.79	0.91	1.96	2.79
1981	1.48	0.90	1.56	1.76	0.93	1.40	0.83	0.89	1.40	2.88	8.09	3.69
1982	2.04	1.17	1.10	1.41	0.93	1.37	0.92	0.90	1.25	2.07	1.72	2.08
1983	1.09	1.16	1.01	1.22	1.13	1.05	0.97	0.79	0.75	0.90	0.92	1.12
1984	1.64	1.45	1.21	1.25	1.43	1.23	1.08	0.81	0.90	0.57	0.86	0.52
1985	1.22	1.49	1.15	1.06	1.40	1.62	1.07	0.81	0.73	1.25	3.49	2.36
1986	1.50	1.70	1.33	1.21	1.09	1.25	1.01	0.77	0.53	1.22	1.38	1.97
1987	1.19	0.65	0.77	0.37	1.12	1.30	0.73	0.81	1.64	1.87	3.59	0.66
1988	1.82	1.42	2.59	2.63	1.86	1.14	0.88	0.85	1.07	3.63	3.11	0.41
1989	0.56	2.05	1.65	1.45	1.16	0.94	0.78	0.77	0.94	0.71	0.86	0.64
1990	0.86	0.33	0.54	0.98	1.69	0.98	0.83	0.76	0.90	0.89	0.59	0.72
1991	0.14	3.34	0.86	1.39	1.18	1.59	0.98	0.94	1.00	3.28	6.76	5.02
1992	3.34	0.77	1.04	1.51	1.32	1.00	0.88	1.08	1.72	1.88	4.97	3.45
1993	2.13	0.40	1.49	1.50	1.31	0.94	0.76	0.76	0.89	1.54	2.77	2.74
1994	1.45	0.81	0.89	1.48	1.61	0.91	0.94	0.96	1.77	7.56	9.85	7.59
1995	0.40	1.06	1.77	1.28	0.96	1.10	0.95	0.89	0.92	0.94	0.85	0.70
1996	0.12	0.00	1.17	1.49	1.30	1.27	1.00	0.96	0.82	0.67	0.94	1.80
1997	0.90	1.44	1.44	1.22	1.04	1.41	1.07	0.74	0.25	0.77	1.77	1.18
1998	0.51	1.01	1.11	1.86	1.47	1.35	1.25	1.07	1.03	0.93	0.72	0.64
1999	0.39	1.00	1.13	1.31	1.17	1.09	1.11	0.97	1.02	1.25	1.65	2.27
2000	0.86	0.84	0.81	1.25	1.47	1.51	1.16	0.96	1.04	1.04	1.62	1.34
2001	1.23	0.54	0.85	1.22	1.46	1.33	1.11	0.86	0.85	1.51	2.39	2.60
2002	2.83	1.25	1.49	1.31	1.14	1.20	1.10	0.88	0.78	1.50	2.97	2.05
2003	0.16	1.16	1.51	0.94	0.93	1.19	0.92	0.76	0.56	0.66	1.75	1.75
2004	0.28	0.91	1.02	1.11	1.32	0.86	0.88	0.58	0.27	0.36	2.62	1.54
2005	2.52	0.52	1.14	1.61	1.43	1.25	1.10	1.09	0.99	0.84	1.36	2.22
2006	0.67	0.61	1.08	1.09	0.91	1.20	1.12	1.08	0.46	0.25	0.48	0.97
2007	0.92	0.57	0.68	0.18	1.19	0.79	0.82	0.47	0.42	0.68	0.75	0.55
2008	0.92	0.33	1.52	1.86	1.62	1.18	0.85	0.74	0.37	0.52	3.70	2.44
2009	0.24	0.88	0.81	1.74	1.20	0.99	0.83	0.80	0.55	1.00	2.01	1.73
2010	0.99	0.07	1.23	1.39	1.35	1.19	0.79	0.69	0.67	0.42	0.38	1.13
2011	1.01	1.28	1.32	1.25	1.20	1.27	1.03	0.76	0.82	0.69	0.96	1.00
2012	0.64	0.65	0.26	0.84	0.79	1.31	0.94	0.59	0.92	1.65	2.01	2.14

3.3 Smoothing Between Scaling Factors

It can be seen in the record of scaling factors that most of the period of record contains gradually changing scaling factors each month. In several cases there are some abrupt changes, which have the potential to artificially shape the gauge proration. This is particularly the case during snowmelt recession, when a large factor in June might drop to a very small factor in July. This would make the

hydrograph appear to drop quite rapidly to the baseflow rate, instead of the expected gradual recessional limb of a hydrograph.

In order to alleviate this problem, caused by the boundaries between monthly scaling factors, a smoothing technique was used to gradually shift between scaling factors over the course of two weeks (one week in each month). Any monthly volumetric changes resulting from this smoothing were applied as a multiplier adjustment to the middle two weeks of the month. In most months, where scaling factors do not change significantly, these adjustments do not change the hydrograph in any noticeable way.

The function used to smooth between scaling factors was a cumulative normal distribution with a standard deviation of 1.80. In several cases, in order to maintain the monthly volume, the standard deviation had to be decreased in order to provide a more abrupt transition. An example of typical daily scaling factors can be seen in Figure 3.3.1.

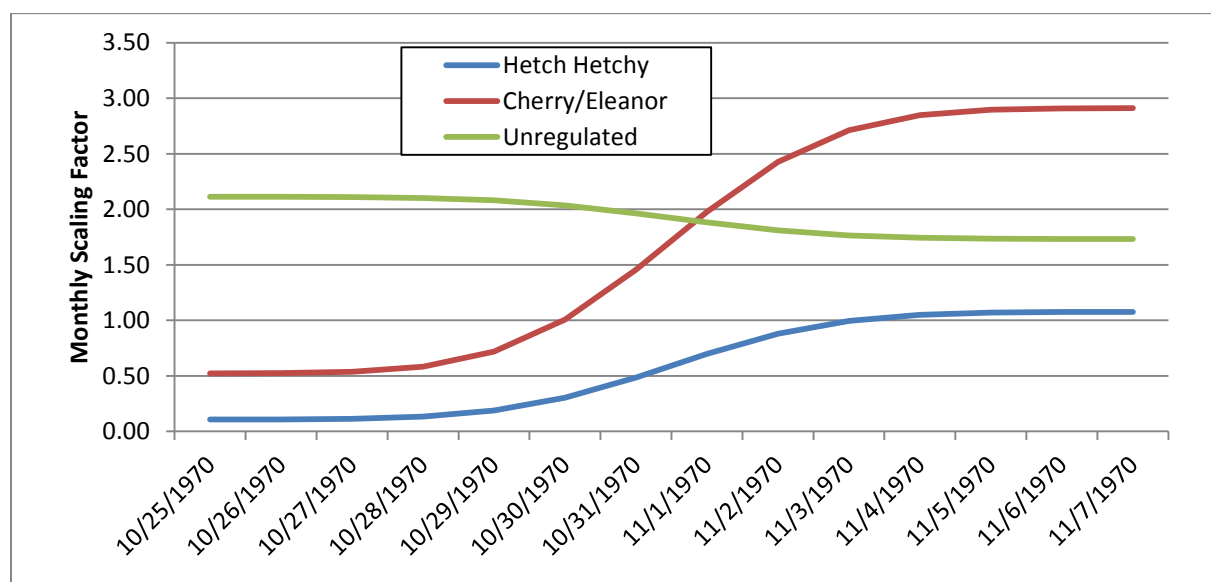


Figure 3.3.1 Typical daily scaling factor smoothing

4.0 Results

The resulting “strawman” can be seen in the attached HEC-DSS database.

5.0 Discussion

In water year 1997, and water years 2003-2008 there are only four unimpaired gauges representing the Unregulated subbasin. Two of those gauges are in the Mokelumne River basin, one in the Merced River basin, and the smallest one is in the Tuolumne River basin. Together, these four gauges provide a poor representation of the Unregulated subbasin, and combined have a drainage area equal to less than 27% of the Unregulated subbasin (Figure 5.1). This period is the poorest representation of any of the application areas for the period of record. Despite the poor match in drainage size, elevation range, and

even overall geography, the gauge proration provides a reasonable looking daily hydrograph when scaled to the historical monthly volumes (Figure 5.2).

In the Operations Model, the function of the model is to allow comparisons to be made of different scenarios. Absolute accuracy is not the goal. Relative differences between modeling scenarios is a powerful decision making tool. While statistically accurate daily values may not be achieved using the gauge proration methods described herein, they do create a dataset that:

- Describes general hydrograph shape, variability, and magnitude of peak flows
- Maintains the historical monthly volumes
- Provides a reasonable depiction of daily flow conditions over the period of record

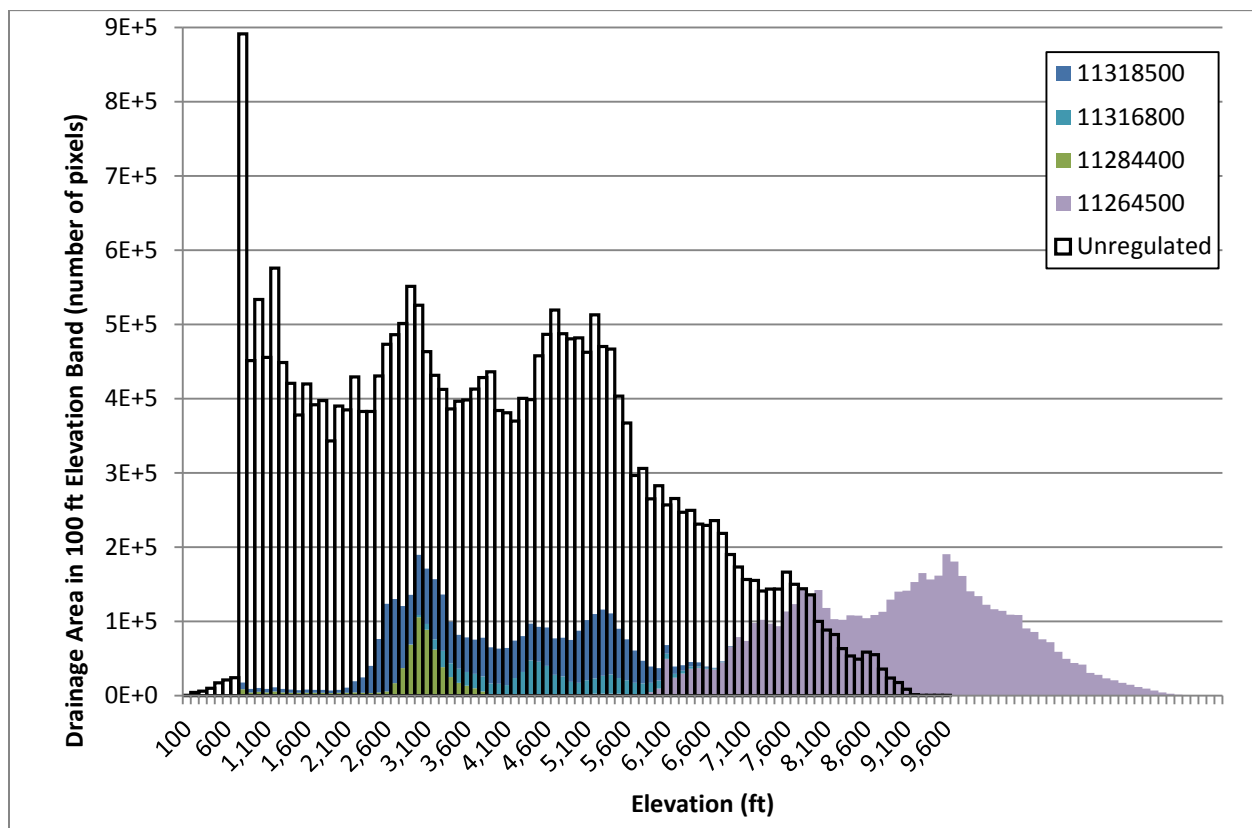


Figure 5.1 Elevation histogram for Unregulated subbasin gauge proration (WY 97, 02-08)

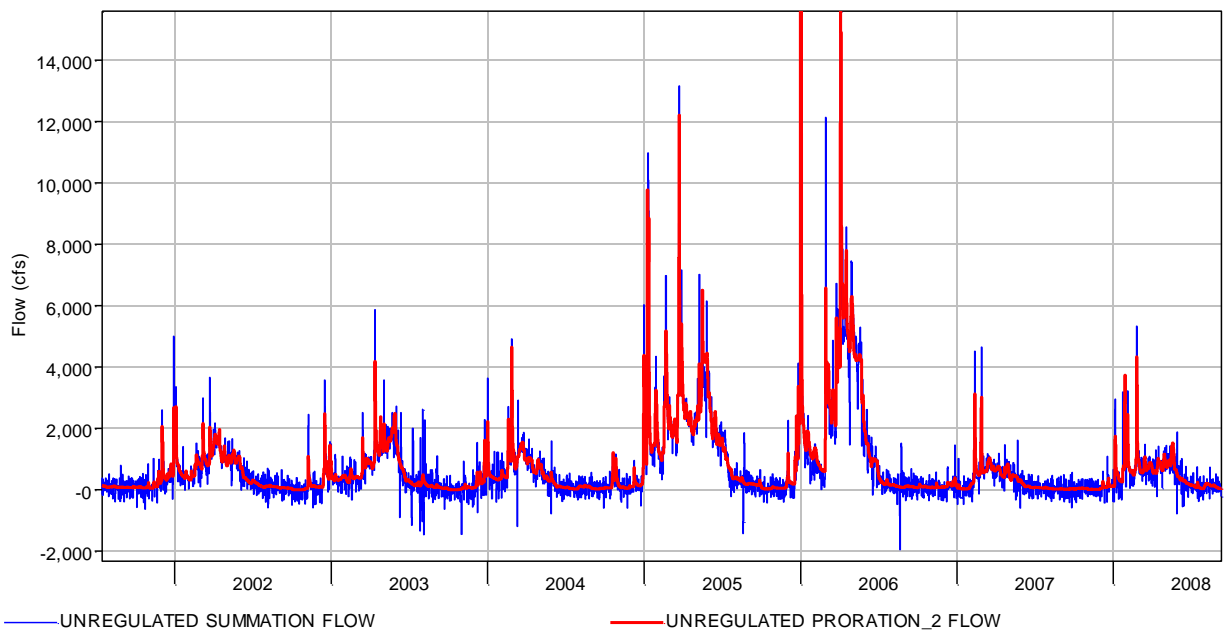


Figure 5.2 Hydrograph comparison gauge summation (W&AR-02) and gauge proration

References

- Study Report W&AR-02. Project Operations/Water Balance Model. Attachment A. Tuolumne River Daily Operations Model
- PRISM Climate Group, 2006, *United States Average Monthly or Annual Precipitation 1971 – 2000*, <<http://prism.oregonstate.edu>>, Oregon State University, Created 12 Jun 2006.
- United States Geologic Survey (USGS), 2009, *1/3 Arc Second National Elevation Dataset*, <<http://seamless.usgs.gov>>, USGS Earth Resources Observation & Science (EROS) Center, Sioux Falls, SD, Created 23 March 2009.

**DON PEDRO HYDROELECTRIC PROJECT
FERC NO. 2299**

FINAL LICENSE APPLICATION

**EXHIBIT B - DON PEDRO PROJECT OPERATIONS AND RESOURCE
UTILIZATION**

**APPENDIX B-3
1997 TO 2012 HISTORICAL AND BASE CASE
ANNUAL AND MONTHLY FLOW DURATION CURVES**

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Figure B-2.	Flow duration at USGS La Grange gage for historical and base case operations -- January.	1
Figure B-3.	Flow duration at USGS La Grange gage for historical and base case operations -- February.	2
Figure B-4.	Flow duration at USGS La Grange gage for historical and base case operations -- March.	2
Figure B-5.	Flow duration at USGS La Grange gage for historical and base case operations -- April.	3
Figure B-6.	Flow duration at USGS La Grange gage for historical and base case operations -- May.	3
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Figure B-12.	Flow duration at USGS La Grange gage for historical and base case operations -- November.	6
Figure B-13.	Flow duration at USGS La Grange gage for historical and base case operations -- December.	7

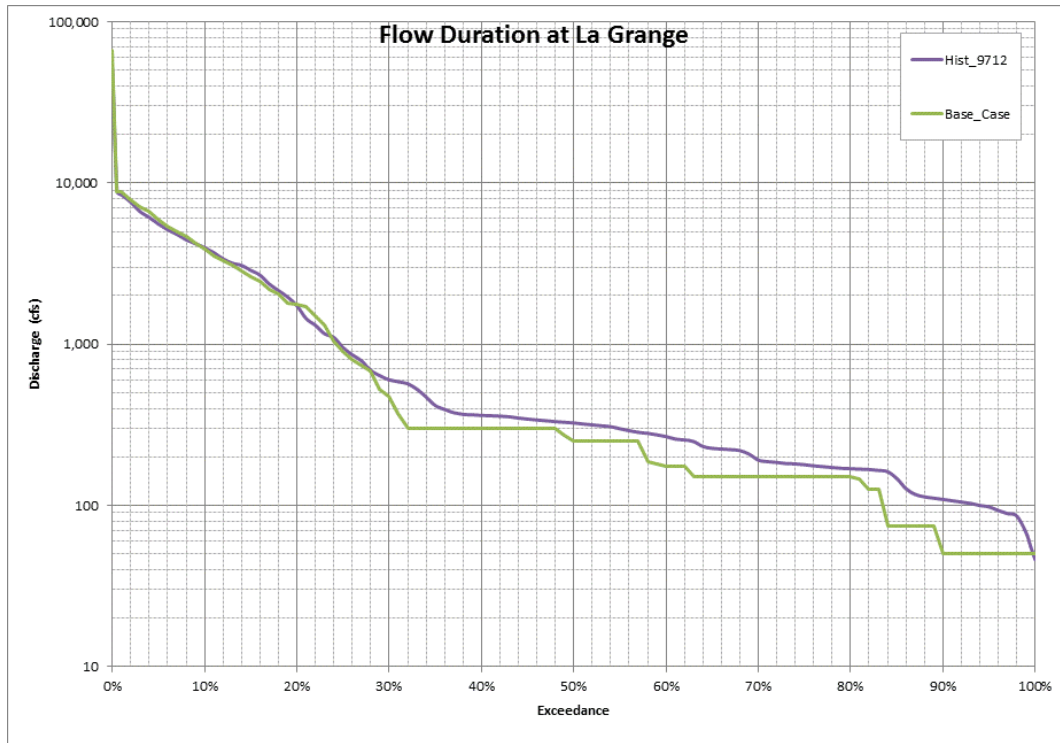


Figure B-1. Annual flow duration at USGS La Grange gage for historical and base case operations.

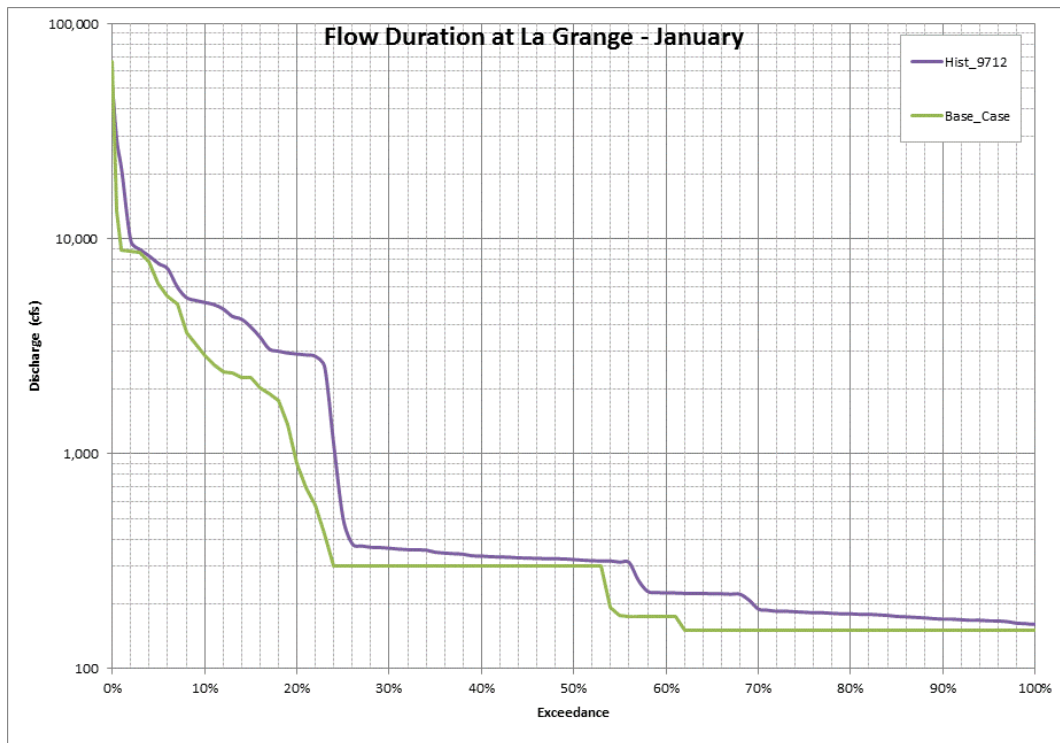


Figure B-2. Flow duration at USGS La Grange gage for historical and base case operations -- January.

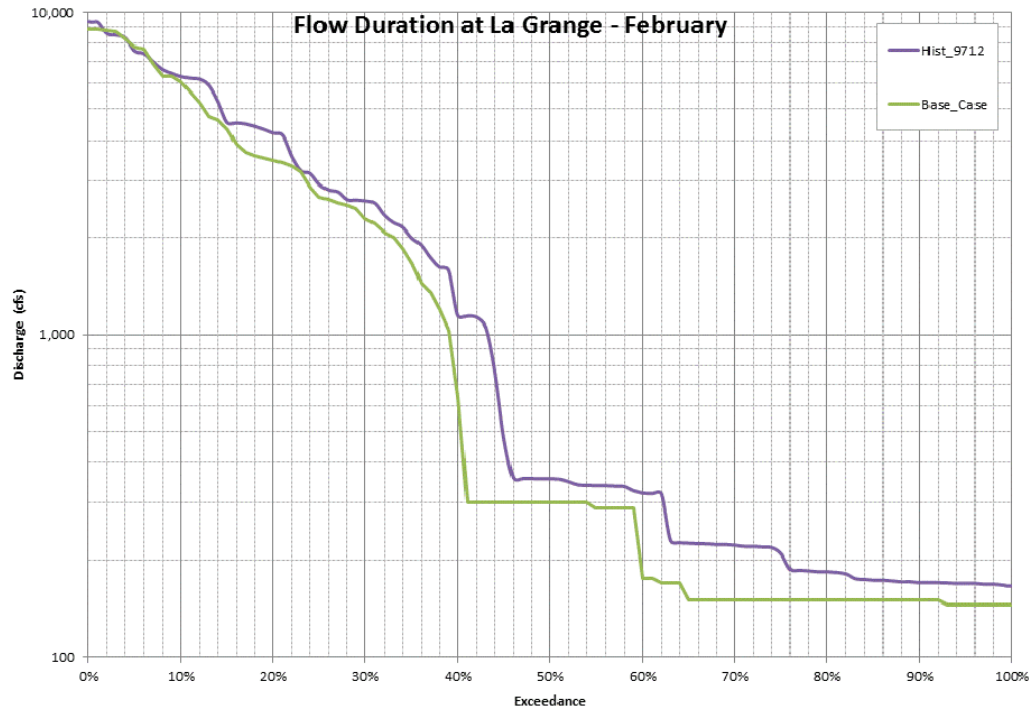


Figure B-3. Flow duration at USGS La Grange gage for historical and base case operations -- February.

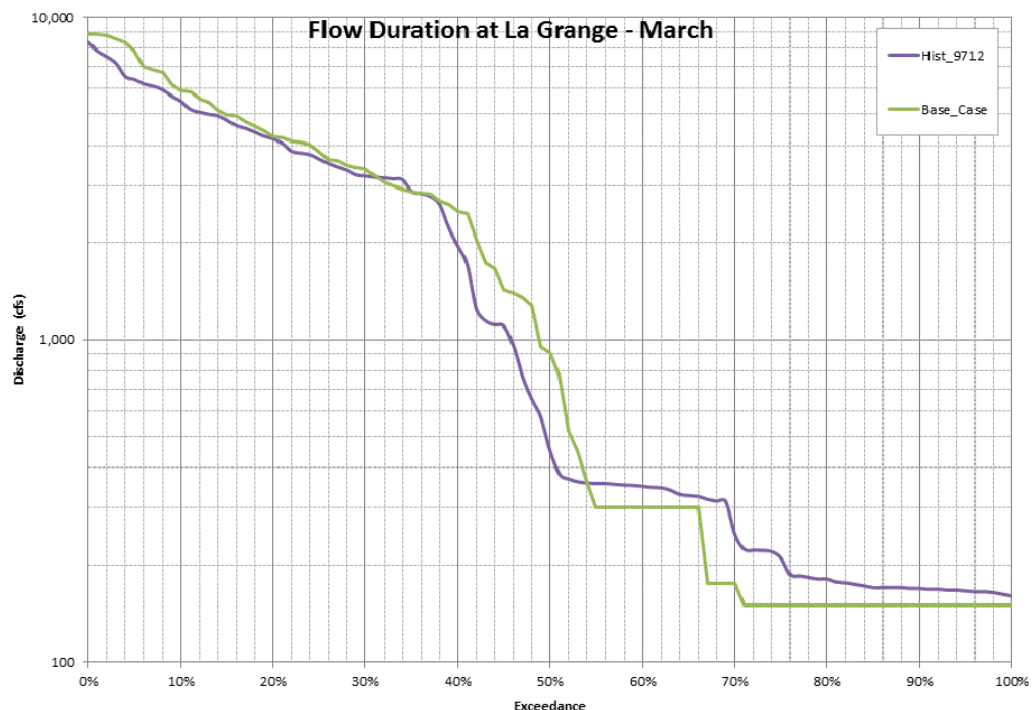


Figure B-4. Flow duration at USGS La Grange gage for historical and base case operations -- March.

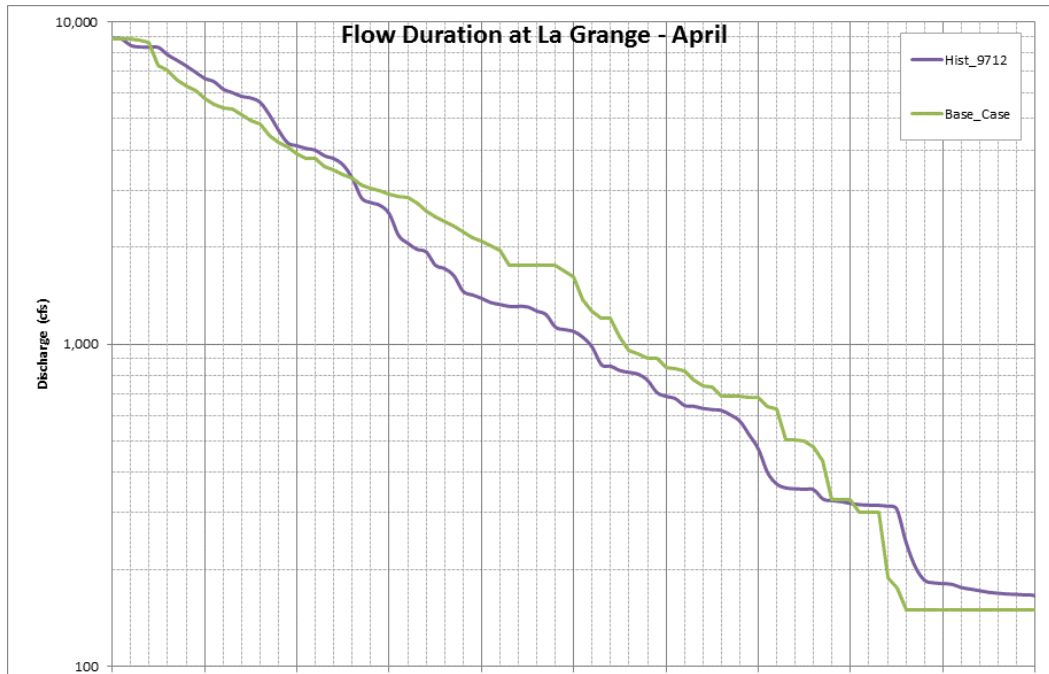


Figure B-5. Flow duration at USGS La Grange gage for historical and base case operations -- April.

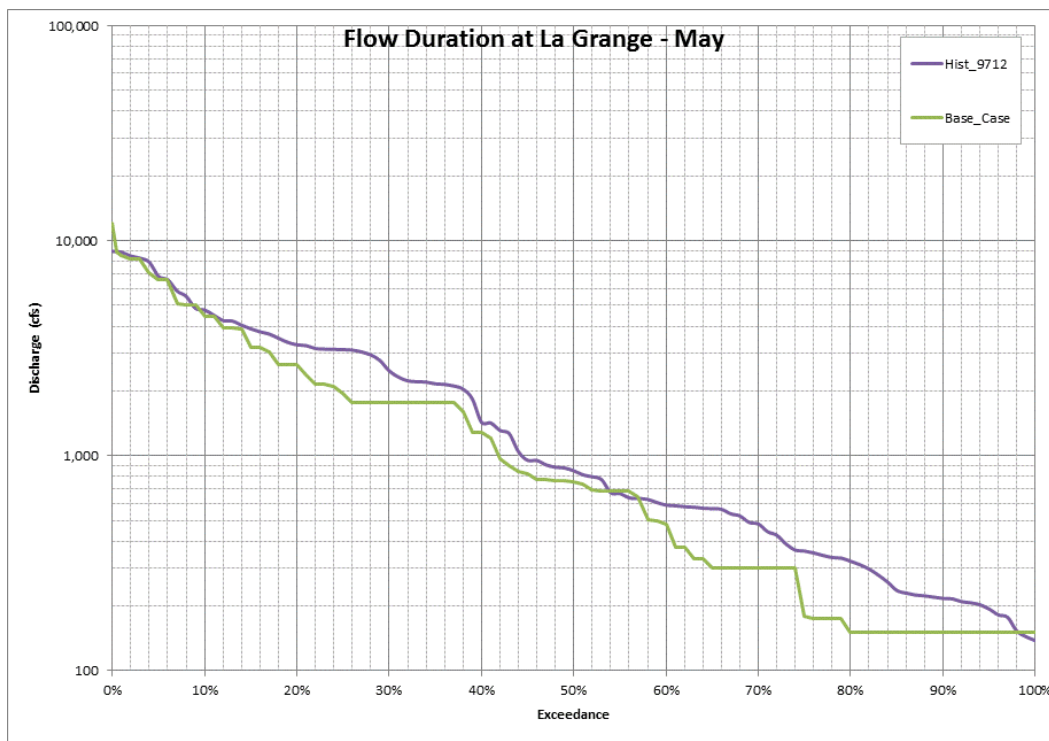


Figure B-6. Flow duration at USGS La Grange gage for historical and base case operations -- May.

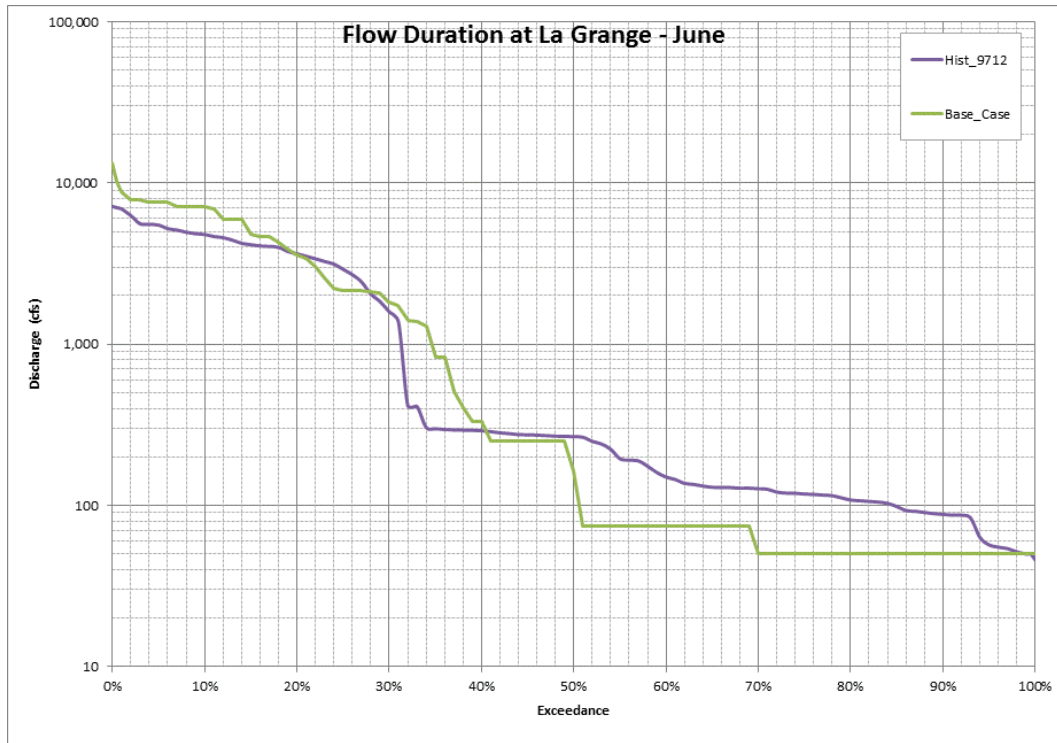


Figure B-7. Flow duration at USGS La Grange gage for historical and base case operations -- June.

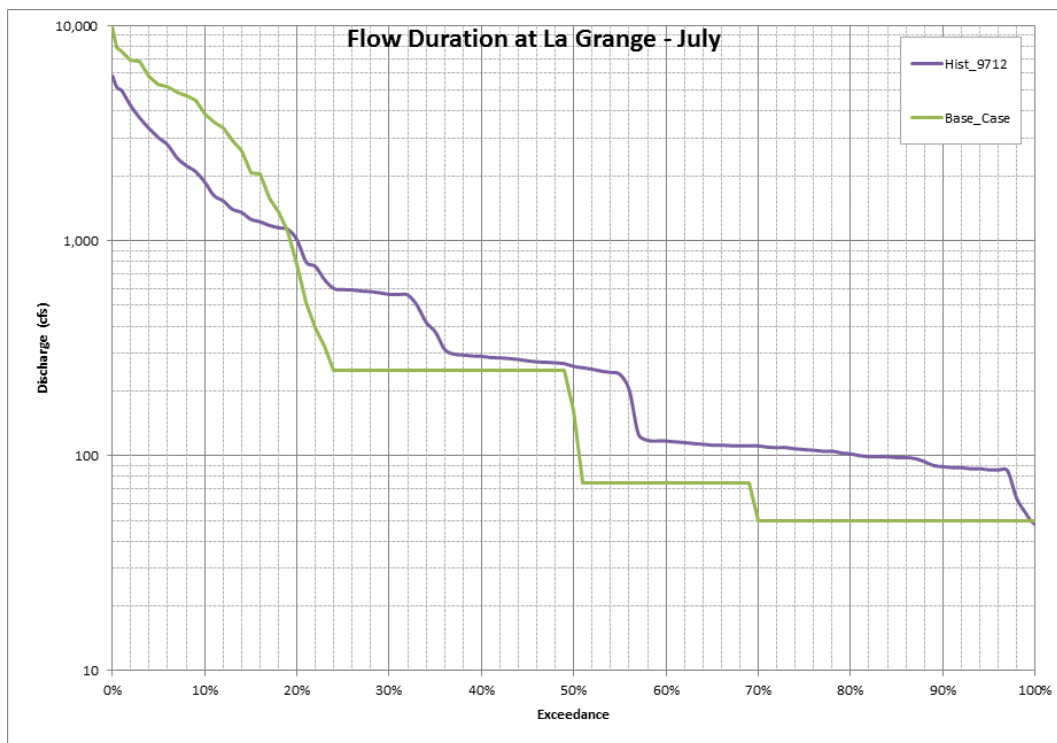


Figure B-8. Flow duration at USGS La Grange gage for historical and base case operations -- July.

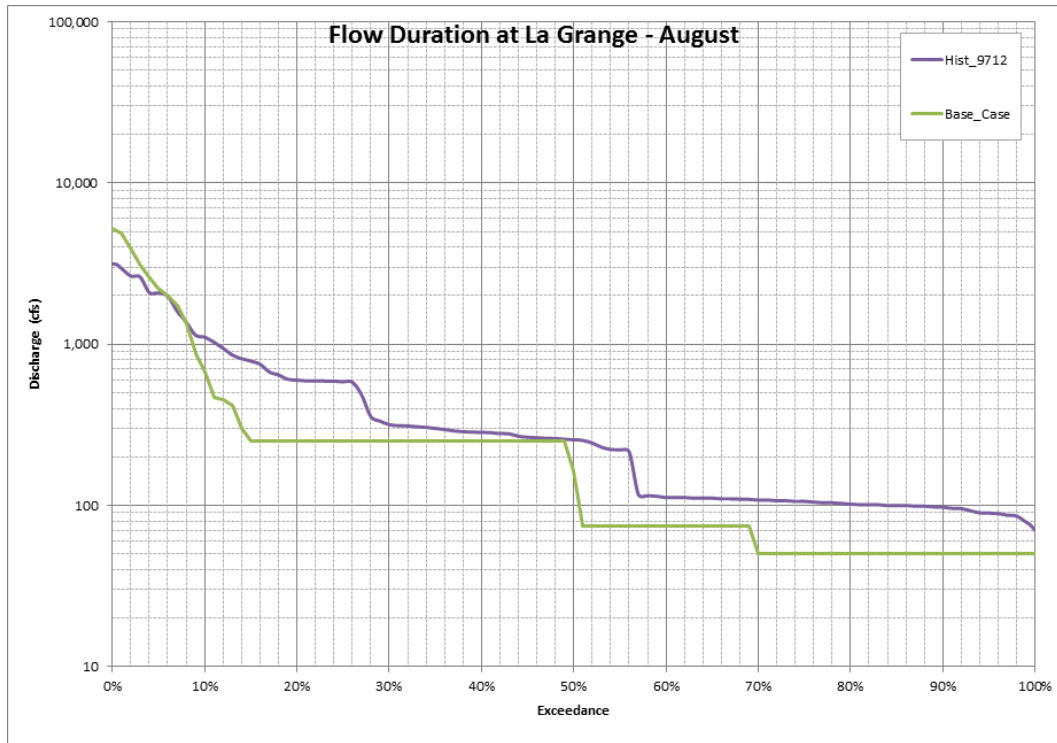


Figure B-9. Flow duration at USGS La Grange gage for historical and base case operations -- August.

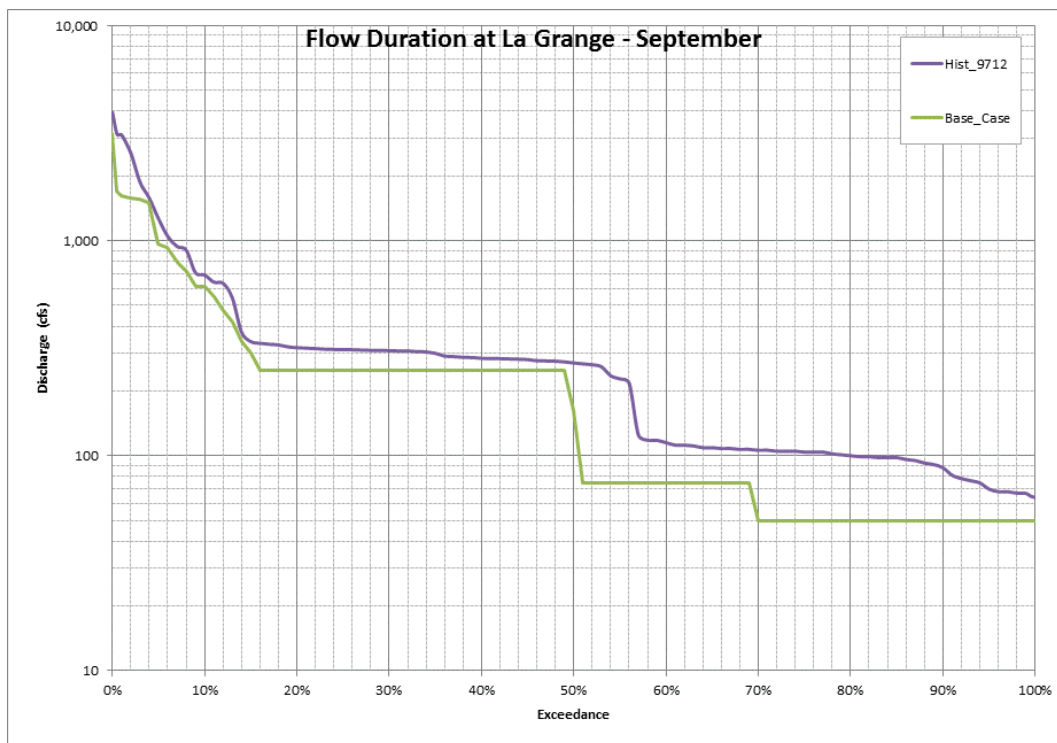


Figure B-10. Flow duration at USGS La Grange gage for historical and base case operations -- September.

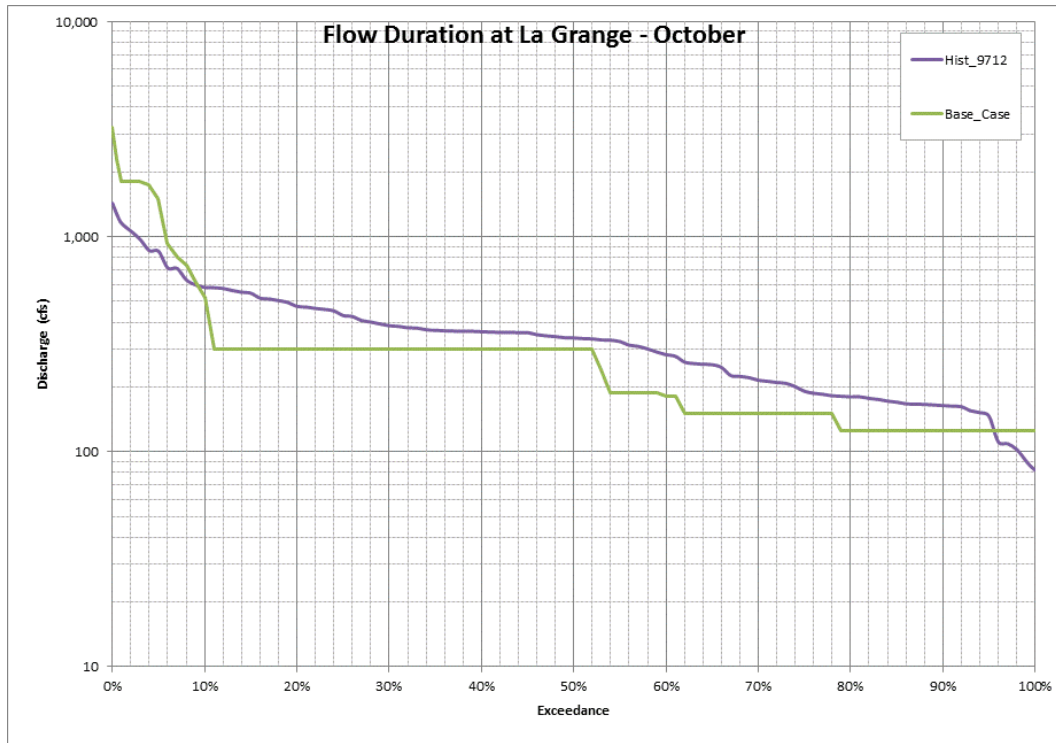


Figure B-11. Flow duration at USGS La Grange gage for historical and base case operations -- October.

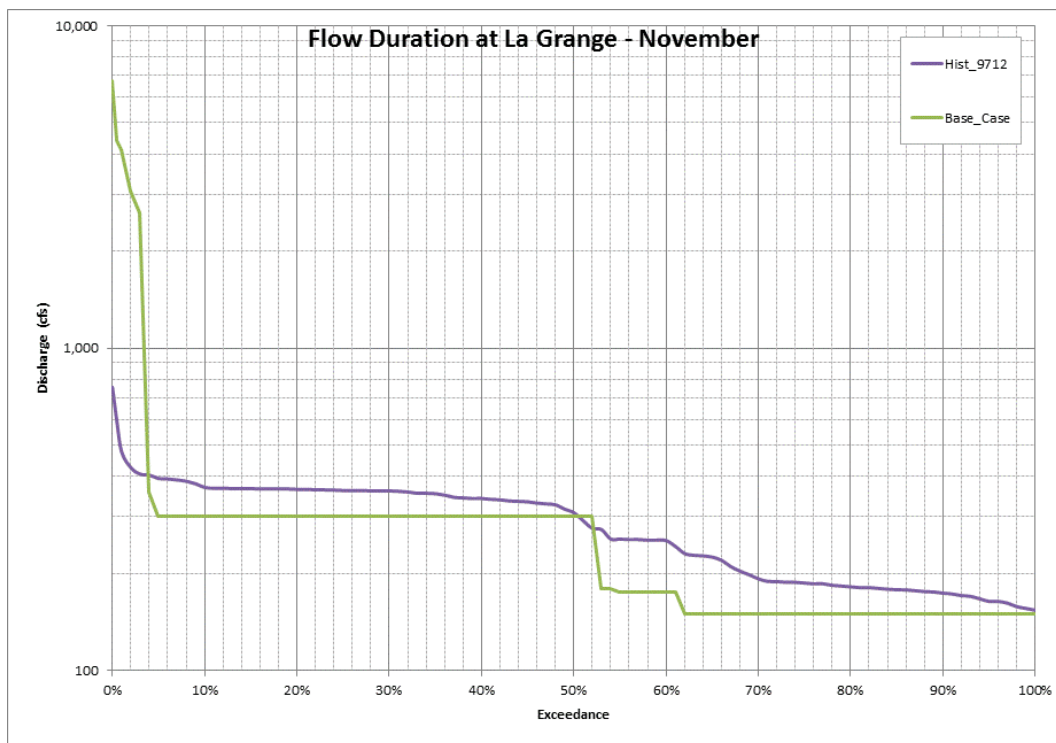


Figure B-12. Flow duration at USGS La Grange gage for historical and base case operations -- November.

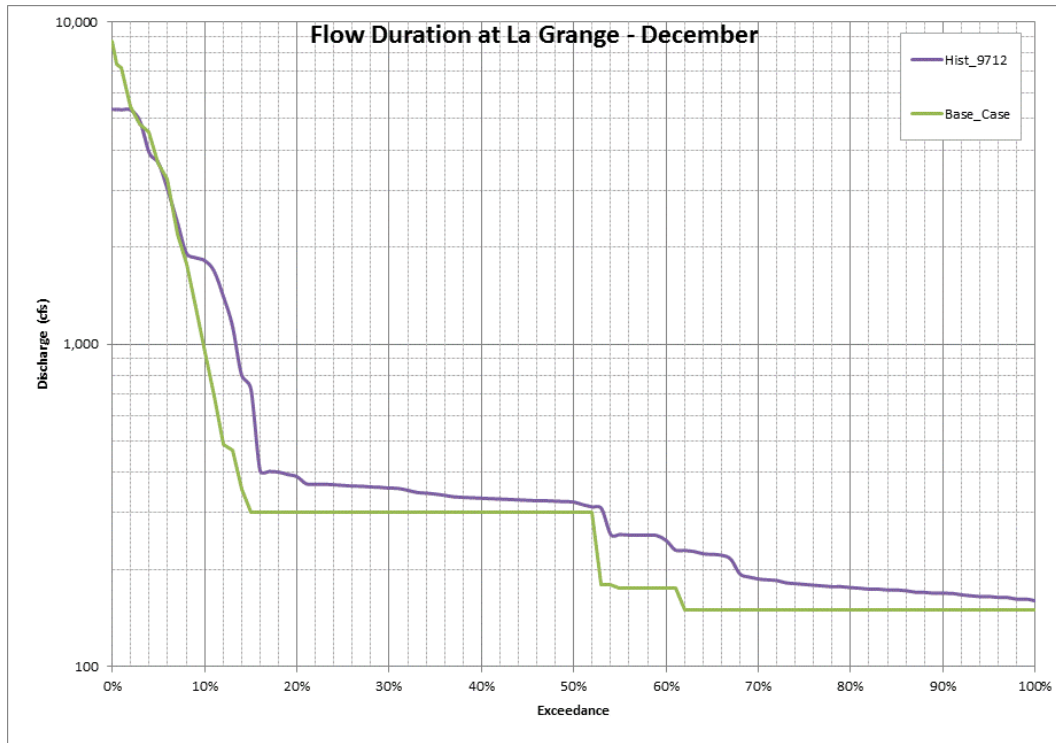


Figure B-13. Flow duration at USGS La Grange gage for historical and base case operations -- December.