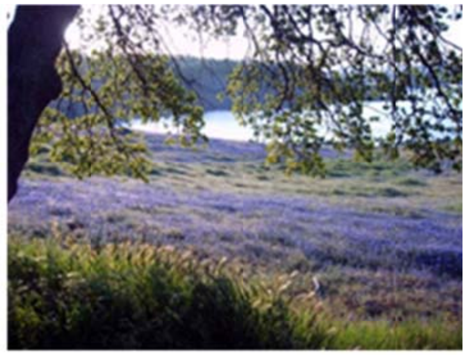
DON PEDRO HYDROELECTRIC PROJECT
FERC NO. 2299

AMENDMENT OF APPLICATION

EXHIBIT B – DON PEDRO PROJECT OPERATIONS AND RESOURCE UTILIZATION





TID WATER & POWER
Serving Central California since 1887

MID
Modesto Irrigation District

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September 2017

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List of Acronyms

ac	acres
ACOE	U.S. Army Corps of Engineers
AF	acre-feet
AFLA	Amendment of the Final License Application
Bay Area	San Francisco Bay Area
CCSF	City and County of San Francisco
CDFW	California Department of Fish and Wildlife
CDWR	California Department of Water Resources
CEC	California Energy Commission
cfs	cubic feet per second
CUAW	consumptive use of applied water
CY	calendar year
Districts	Turlock Irrigation District and Modesto Irrigation District
Don Pedro Project	Don Pedro Hydroelectric Project
DPRA	Don Pedro Recreation Agency
EIS	Environmental Impact Statement
°F	Fahrenheit
FERC	Federal Energy Regulatory Commission
FLA	Final License Application
FPA	Federal Power Act
FPC	Federal Power Commission
ft	feet
GW	groundwater
hp	horsepower
IG	infiltration galleries
kWh	kilowatt-hours
M&I	Municipal and Industrial
mi^2	square miles
MID	Modesto Irrigation District
MW	megawatt
MWh	megawatt hour

NGVD29....................National Geodetic Vertical Datum of 1929
NEPA..........................National Environmental Policy Act
NGOs..........................Non-Governmental Organizations
PDAW........................Project Demand of Applied Water
PM&E........................Protection, Mitigation and Enhancement
PMF............................Probable Maximum Flood
RM.............................River Mile
SD2............................Scoping Document 2
SFPUC.......................San Francisco Public Utilities Commission
SRP............................Special Run Pools
SWRCB......................State Water Resources Control Board
TAC............................Technical Advisory Committee
TAF............................thousand acre-feet
TID.............................Turlock Irrigation District
USFWS......................U.S. Department of the Interior, Fish and Wildlife Service
USGS.........................U.S. Department of the Interior, Geological Survey
WY.............................water year

EXHIBIT B - PROJECT OPERATIONS AND RESOURCE UTILIZATION

Exhibit B is a statement of project operation and resource utilization. If the project includes more than one dam with associated facilities, the information must be provided separately for each such discrete development. The exhibit must contain:

(1) A statement whether operation of the powerplant will be manual or automatic, an estimate of the annual plant factor, and a statement of how the project will be operated during adverse, mean, and high water years;

(2) An estimate of the dependable capacity and average annual energy production in kilowatt-hours (or a mechanical equivalent), supported by the following data:

  (i) The minimum, mean, and maximum recorded flows in cubic feet per second of the stream or other body of water at the powerplant intake or point of diversion, with a specification of any adjustments made for evaporation, leakage, minimum flow releases (including duration of releases), or other reductions in available flow; monthly flow duration curves indicating the period of record and the gauging stations used in deriving the curves; and a specification of the period of critical streamflow used to determine the dependable capacity;

  (ii) An area-capacity curve showing the gross storage capacity and usable storage capacity of the impoundment, with a rule curve showing the proposed operation of the impoundment and how the usable storage capacity is to be utilized;

  (iii) The estimated hydraulic capacity of the powerplant (minimum and maximum flow through the powerplant) in cubic feet per second;

  (iv) A tailwater rating curve; and

  (v) A curve showing powerplant capability versus head and specifying maximum, normal, and minimum heads;

(3) A statement, with load curves and tabular data, if necessary, of the manner in which the power generated at the project is to be utilized, including the amount of power to be used on-site, if any, the amount of power to be sold, and the identity of any proposed purchasers; and

(4) A statement of the applicant's plans, if any, for future development of the project or of any other existing or proposed water power project on the stream or other body of water, indicating the approximate location and estimated installed capacity of the proposed developments.

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PREFACE

On April 28, 2014, the co-licensees of the Don Pedro Hydroelectric Project, Turlock Irrigation District (TID) and Modesto Irrigation District (MID) (collectively, the Districts), timely filed with the Federal Energy Regulatory Commission (Commission or FERC) the Final License Application (FLA) for the Don Pedro Hydroelectric Project, FERC No. 2299. As noted in the filing and acknowledged by FERC at the time, several studies were ongoing which were likely to inform the development of additional protection, mitigation, and enhancement (PM&E) measures. The Districts have now completed these studies and herein submit this Amendment of Application (Amendment to the Final License Application or AFLA). For ease of review and reference, this AFLA replaces the Districts' April 2014 filing in its entirety.

The Don Pedro Project provides water storage for irrigation and municipal and industrial (M&I) use, flood control, hydroelectric generation, recreation, and natural resource protection (hereinafter, the "Don Pedro Project"). The environmental analysis contained in this AFLA considers all the components, facilities, operations, and maintenance that make up the Don Pedro Project and certain facilities proposed to be included under the new license. The Don Pedro Project is operated to fulfill the following primary purposes and needs: (1) to provide water supply for the Districts for irrigation of over 200,000 acres of Central Valley farmland and M&I use, (2) to provide flood control benefits along the Tuolumne and San Joaquin rivers, and (3) to provide a water banking arrangement for the benefit of the City and County of San Francisco (CCSF) and the 2.6 million people CCSF supplies in the Bay Area. The original license was issued in 1966. In 1995, the Districts entered into an agreement with a number of parties, which resulted in greater flows to the lower Tuolumne River for the protection of aquatic resources.

Hydroelectric generation is a secondary purpose of the Don Pedro Project. Hereinafter, the hydroelectric generation facilities, recreational facilities, and related operations will be referred to as the "Don Pedro Hydroelectric Project," or the "Project". With this AFLA to FERC, the Districts are seeking a new license to continue generating hydroelectric power and implement the Districts' proposed PM&E measures. Based on the information contained in this AFLA, and other sources of information on the record, FERC will consider whether, and under what conditions, to issue a new license for the continued generation of hydropower at the Districts' Don Pedro Project. The Districts are providing a complete description of the facilities and operation of the Don Pedro Project so the effects of the operation and maintenance of the hydroelectric facilities can be distinguished from the effects of the operation and maintenance activities of the overall Don Pedro Project's flood control and water supply/consumptive use purposes.

Being able to differentiate the effects of the hydropower operations from the effects of the flood control and consumptive use purposes and needs of the Don Pedro Project will aid in defining the scope and substance of reasonable PM&E alternatives. As FERC states in Scoping Document 2 in a discussion related to alternative project operation scenarios: "…alternatives that address the consumptive use of water in the Tuolumne River through construction of new structures or methods designed to alter or reduce consumptive use of water are…alternative mitigation strategies that could not replace the Don Pedro *hydroelectric* [emphasis added] project. As such, these recommended alternatives do not satisfy the National Environmental

Policy Act (NEPA) purpose and need for the proposed action and are not reasonable alternatives for the NEPA analysis."

1.0 BACKGROUND AND PURPOSE OF THE DON PEDRO PROJECT

Construction of the new Don Pedro Project was completed in 1971. The Don Pedro Project consists of the 580-foot-high Don Pedro Dam, which creates the 2,030,000 acre-foot (AF) Don Pedro Reservoir, covering approximately 13,000 ac in southwest Tuolumne County. A powerhouse with a Federal Energy Regulatory Commission (FERC) authorized capacity of 168 megawatts (MW) sits at the toe of the dam. The new dam and reservoir inundated the original, smaller old Don Pedro dam, located about 1.5 miles (mi) upstream of the new Don Pedro Dam. While the renewable hydropower generation is an important benefit to the Districts and the region, it is secondary to the primary purposes of the new Don Pedro Project which are to (1) provide water storage to meet demand for irrigation and certain municipal and industrial (M&I) water supplies in Stanislaus County and adjacent areas, (2) provide flood control benefits along the Tuolumne and San Joaquin river corridors, and (3) provide water supply benefits to 2.6 million people served by CCSF in the greater San Francisco Bay area (Bay Area). The water supply and flood control benefits of the Don Pedro Project contribute significantly to the welfare of the people and communities of the Central Valley region and the San Francisco Bay Area.

1.1 TID and MID – Joint Don Pedro Project Owners

Both TID and MID were organized in 1887 under the laws of the State of California to deliver Tuolumne River irrigation water to their respective service areas. The Districts agreed to co-develop and share the waters of the Tuolumne River based on the acreages in their service areas. As a result, TID owns 68.46 percent and MID owns 31.54 percent of the Don Pedro Project. The Districts are authorized under California law to provide both water supply and retail electric service. Over 200,000 ac of highly productive, prime[1] farmland are dependent upon the irrigation water provided by the Districts. The Districts also provide electric service to over 200,000 customers and treated drinking water to over 200,000 people, essential utility services which depend heavily on the operations of the Don Pedro Project.

1.2 Overview of Don Pedro Project Benefits

Combined, the Districts provide water supply and/or retail electric services to customers covering portions of four counties in the Central Valley region of California. The Don Pedro Project is the primary asset of the Districts for providing these services. The reliable water supply provided by the Don Pedro Project is a critical component of the economy of the region served by the Districts.[2]

CCSF contributed financially to the construction of the Don Pedro Project to meet its flood control obligations and to obtain water banking privileges in the new Don Pedro Reservoir. This

[1] "Prime farmland" is a formal designation assigned by U.S. Department of Agriculture defining land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and is also available for these land uses.

[2] In fact, the the City of Modesto's official motto, "Water Wealth Contentment Health," is featured on the downtown Modesto Arch.

innovative water banking arrangement allows CCSF to pre-release flows from its upstream facilities into the Don Pedro Reservoir where the flows are credited against CCSF's obligation to meet the Districts' water entitlements so that at other times CCSF can divert water that otherwise would have to be released to satisfy the Districts' senior water rights. Both the transfer of flood management and the creation of the water bank provided CCSF and its wholesale customers in the Bay Area with improved reliability of water supply and greater flexibility with its water and power operations. Under certain circumstances, the Districts and CCSF share responsibility for meeting FERC license requirements related to the reach of the lower Tuolumne River downstream of the Don Pedro Project (see Article 8 in Section 2.1). Therefore, changes in downstream flow requirements may affect both the Districts' and CCSF's ability to meet the water supply needs of their customers in the Central Valley and the Bay Area, respectively.

The U.S. Army Corps of Engineers (ACOE) also contributed financially to the construction of the new Don Pedro Project. By doing so, the ACOE contractually acquired 340,000 AF of seasonal flood storage space in the new reservoir. This storage space is maintained seasonally through the Districts' implementation of the ACOE's Flood Control Manual.

Other current benefits of the Don Pedro Project as presented and described in this license application include hydropower generation, natural resource protection, cultural resource protection, protection of the traditional interests of Native tribes, and recreation at and on Don Pedro Reservoir.

1.3 Overview of the Don Pedro Project Setting

The Tuolumne River watershed covers approximately 1,960 square miles (mi^2) upstream of its confluence with the San Joaquin River in the Central Valley of California and approximately 1,533 mi^2 above the Don Pedro Dam. The Tuolumne River is the largest of three rivers – Stanislaus, Tuolumne, and Merced – that drain the western slopes of the Sierra Nevada and enter the San Joaquin River from the east prior to the San Joaquin entering California's Bay-Delta water bodies. The upper Tuolumne watershed is sparsely populated and is dominated by Yosemite National Park and the lands of the Stanislaus National Forest. The precipitation patterns of the watershed vary considerably, with the uppermost reaches receiving in excess of 60 inches annually in the form of snow and rain whereas the lowermost reaches receive less than 12 inches of rain. The irrigated lands of the lower Tuolumne River receive a *total* summertime precipitation (May through September) in an average year of less than 1 inch. During the summers, daily high temperatures along the lower Tuolumne River can exceed 100°F.

The Don Pedro Reservoir is located in the Sierra foothills region of California. At a water surface elevation of 830 feet (ft) it contains a gross water storage volume of approximately 2,030,000 AF, approximately 1,721,000 AF of which is active storage above the minimum pool level under the current FERC license. The long-term mean annual unimpaired flow of the Tuolumne River at Don Pedro Dam is approximately 1.84 million AF.[3] The estimated historical mean annual inflow to the Don Pedro Reservoir (based on the period 1971 to 2012) is

[3] "Estimates of Natural and Unimpaired Flows for the Central Valley of California: Water Years 1922-2014", DWR, March 2016 (DRAFT).

approximately 1.7 million AF, with the bulk of the difference being the out-of-basin diversions made by CCSF to serve its water supply customers in the Bay Area.

The annual runoff of the Tuolumne River is subject to considerable variability. During this same 42-year time period (1971-2012), the annual unimpaired runoff of the Tuolumne River has varied by a factor of 12, from 382,000 AF in 1977 to 4.6 million AF in 1983.[4]

1.4 Primary Purposes of the Don Pedro Project

The Don Pedro Reservoir provides 2,030,000 AF of total water storage at a normal maximum water surface elevation of 830 ft. The Don Pedro Project is used to satisfy the following primary purposes and needs:

- Provide water storage for the beneficial use of irrigation of over 200,000 ac of prime farmland in California's Central Valley served by the Districts. Combined, the Districts supply, on average, approximately 850,000 AF of irrigation water per year to their customers.
- Provide water storage for the beneficial use of municipal and industrial customers. MID provides a portion of the treated water supply of the City of Modesto (population: 210,000), and TID and MID jointly provide treated water to the community of La Grange. The Districts provide up to a maximum of 67,500 AF of water per year for M&I use.
- Consistent with agreements between the Districts and CCSF, the Don Pedro Project provides a water bank of 570,000 AF of storage (when Don Pedro Reservoir is below elevation 801.9 ft, and up to 740,000 AF when Don Pedro is at 830 ft) that CCSF uses to help manage the water supply of its Hetch Hetchy water system while meeting the senior water rights of the Districts. CCSF's water bank within Don Pedro Reservoir is a critical component of CCSF's water supply system serving 2.6 million customers in the Bay Area.
- Provide storage for flood management on the Tuolumne and San Joaquin rivers. In cooperation with the ACOE, the Don Pedro Project provides up to 340,000 AF of storage for the purpose of flood flow management.

These four uses are critical functions of the Don Pedro Project. The water storage capability of the Don Pedro Project substantially improves the reliability of irrigation water supply and thereby the value of the productive farmland served by the Districts. Don Pedro also directly supports the water needs of over 2.8 million people and numerous commercial, manufacturing, and industrial interests, all of which provide a foundation for the economy of the Central Valley and the San Francisco Bay Area. Other important benefits provided by the Don Pedro Project are protection of aquatic resources, including anadromous and resident fish in the lower Tuolumne River, lake recreation, and renewable hydropower generation.

[4] At an estimated runoff of 4.8 million AF, WY 2017 may be the wettest year on record based on preliminary streamflow records.

1.5 Overview of Current Don Pedro Project Operations

In general, the Don Pedro Project operates on an annual cycle consistent with managing and providing a reliable water supply for consumptive use purposes, providing flood flow management, and ensuring delivery of downstream flows to protect aquatic resources. For purposes of using the water year as the starting point, on October 1 of each year, minimum flows provided to the lower Tuolumne River, as measured at the U.S. Department of the Interior, Geological Survey (USGS) gage at La Grange, are adjusted in accordance with FERC license requirements to benefit upmigrating adult fall-run Chinook salmon. This includes in certain years providing a pulse flow, the amount of which varies depending on the water year type. By October 6 of each year, the Don Pedro Reservoir must be lowered to at least elevation 801.9 ft to provide the 340,000 AF of flood control benefits acquired by the ACOE through its financial contribution to construction.

In accordance with FERC license requirements, minimum flows to the lower Tuolumne River are adjusted again on October 16, the rate of flow dependent on water year type, and these flows are maintained through May 31 of the following year to protect egg incubation, emergence, fry and juvenile development, and smolt outmigration of fall-run Chinook salmon. A spring pulse flow is provided each year to aid smolt outmigration, the amount depending upon water year type. Irrigation deliveries normally begin in early March, but can begin as early as February to provide water for early growing season soil moisture in dry winters. Irrigation deliveries increase considerably by April and normally reach their peak in July and August. Water deliveries from the Don Pedro Reservoir for M&I purposes occur year-round.

Throughout the winter months, Don Pedro Project operators maintain a constant assessment of snow conditions in the upper Tuolumne River watershed and, during years with heavy snow accumulation, may reduce reservoir levels to balance forecasted inflows, outflows, and reservoir storage. The goal of operations is to fill the reservoir by early June; however, greater snowpack volumes can extend this filling into early July if needed for maintenance of the required ACOE flood control space. ACOE flood control guidelines also provide for maintenance of downstream flows in the lower Tuolumne River of less than 9,000 cfs as measured at the USGS gage at Modesto (RM 16), located downstream of Dry Creek almost 40 miles below the Don Pedro Project.

Minimum flows released to the lower Tuolumne River are adjusted again on June 1 and these then extend through September 30. Irrigation and M&I deliveries normally continue through October, but may extend into November depending on soil moisture conditions.

The current total demand for Tuolumne River water during normal water years is roughly 1.5 million AF, divided among the Districts' needs for irrigation and M&I water (approximately 900,000 AF), CCSF's needs for M&I water (approximately 250,000 AF), and flows to protect anadromous fish in the lower Tuolumne River (approximately 300,000 AF). The storage available in Don Pedro Reservoir provides protection for water dependent uses and natural resources during water shortages in individual and successive dry years, such as those that occurred during the drought periods of 1976–1977, 1987–1992, 2001–2004, and the recent drought years of 2013, 2014 and 2015.

Delivery of Don Pedro Project benefits—irrigation water, M&I water, water for the protection of aquatic life, recreation, hydropower generation, and flood protection—requires careful and skillful management of water. The operation of the Don Pedro Project involves the continuous assessment of known and unknown variables, assessment of current and forecasted hydrology, coordination with other water systems, and the balancing of water demands and other Don Pedro Project requirements. The forecasting of future hydrologic conditions, even relatively near term conditions, involves considerable uncertainty. The timing and degree of droughts and floods remain largely unpredictable. To manage these highly variable conditions and meet the purposes and needs of the Don Pedro Project, the Districts have adopted a "water first" operations philosophy. Under this approach, the Districts plan and operate the Don Pedro Project to meet the needs for water supply and consumptive use purposes as a first priority, consistent with satisfying all downstream flow requirements for resource protection. Water is released from the Don Pedro Project for three purposes: (1) to meet the irrigation and M&I demand of its customers, (2) to meet the guidelines of the ACOE Flood Control Manual, including pre-releasing flows during wet years in anticipation of high runoff, and (3) to fulfill the license requirements for flows in the lower Tuolumne River as measured at the USGS La Grange gage. Don Pedro hydroelectric generation is a consequence of providing flows for these purposes.

Later sections of this Exhibit B provide a detailed description of the water management practices in place at the Don Pedro Project. As part of the relicensing studies, these water management practices have been incorporated into a Tuolumne River Operations Model, described in detail further below, to depict the current demands, regulatory requirements, and operational policies of both the Districts' and CCSF's Hetch Hetchy water storage and delivery systems, as well as the current flow requirements to protect the aquatic resources of the lower Tuolumne River. This river-specific Operations Model presents the Base Case, "no-action" alternative for future Tuolumne River water system operations and provides a means for evaluating the impacts of alternative future operating scenarios.

1.6 Proposed Action

FERC is the federal agency authorized to issue licenses for the construction, operation, and maintenance of the nation's non-federal hydroelectric facilities. In accordance with the Federal Power Act (FPA), FERC is able to issue such licenses for a period not less than 30 years, but no more than 50 years. Upon expiration of an existing license, FERC must decide whether, and under what terms, to issue a new license. Under the FPA, FERC must issue licenses which are best adapted to a comprehensive plan for improving or developing a waterway, and, in so doing, must consider a suite of beneficial public uses including, among others, water supply, flood control, irrigation, and fish and wildlife. As the federal "action agency," FERC complies with the requirements of the National Environmental Policy Act (NEPA). Under NEPA, FERC must clearly define the specific proposed action it is considering, and define the purpose and need for the proposed action.

In the case of the Don Pedro Hydroelectric Project, the Proposed Action under review by FERC is the issuance of a new license to the Districts to authorize the continued generation of hydroelectric power at Don Pedro Dam. As such, and as generally described in FERC's Scoping

Document 2 (SD2) issued on July 25, 2011, any alternatives to address the Project's effects ("mitigation strategies") must be reasonably related to the purpose and need for the Proposed Action, which in this case is whether, and under what terms, to authorize the continuation of hydropower generation at Don Pedro.

Operations for purposes of hydropower generation are secondary to the primary purposes of the Don Pedro Project as discussed previously, and therefore hydropower needs, except possibly for short-term electric system emergencies, do not drive the Districts' decisions related to overall water management at the Don Pedro Project. The Districts refer to this type of water management as a "water first" operation, versus water management driven by hydropower production.

1.7 Purpose and Need for the Proposed Action

Clean, renewable hydropower generation is one of the benefits of the Don Pedro Project. The average annual electrical generation of the Project from 1997 to 2012 was 622,440,000 kilowatt-hours (kWh) of electricity. Issuing a new license will allow the Districts to continue generating emissions-free hydropower at Don Pedro Dam for the term of the new license, producing low-cost electric power from a non-polluting, renewable resource. The electricity generated by the Project is important to the State of California. In January 2016, the California Energy Commission issued the California Energy Demand 2016–2026, Revised Electricity Forecast. The updated forecast presents low, mid, and high forecasts for the state: average annual growth rates for electricity consumption for 2014–2026 are 0.54 percent, 0.97 percent, and 1.27 percent, respectively (Kavalec et al. 2016).

Generation from the Don Pedro Hydroelectric Project is the lowest-cost source of electricity for both Districts. The combination of a reliable water supply and low cost electricity provides the primary competitive advantage of the communities and businesses served by the two Districts. The Districts' customers, including growers, food processors, and manufacturing concerns, operate in a highly competitive global agricultural market where small changes in the cost of production can materially affect the business decisions made by consumers, buyers, and employers. Maintaining competitive electricity rates is an important element of the Districts' responsibilities as retail electric service providers. The availability and reliability of water supply is also a significant factor for the many municipal and industrial water users in the Bay Area, all of which can be affected by the allocation of water from the Don Pedro Project.

2.0 CURRENT AND PROPOSED OPERATION OF THE DON PEDRO PROJECT

2.1 Historical Perspective of Tuolumne River Water Uses

The waters of the Tuolumne River have been the source of competing needs, uses, and claims dating back to the late 1800s. Because the history of these competing interests continues to be relevant to Don Pedro Project operations today, a historical perspective of the water use issues is valuable.

In 1887, the California legislature authorized a new form of popularly-elected local government, the irrigation district, based on the idea that since irrigation would be a community benefit, its finance and governance should be community-based rather than be controlled by individual landowners or irrigators. In June of that year, TID became the first to organize under the new law, followed in July by MID. Three years later, in August 1890, the two pioneer districts signed an agreement to build a joint diversion dam, La Grange Diversion Dam (located about two miles below the present Don Pedro Dam), and to divide such flow as the Districts had rights to in proportion to the total acreage in each district. The agreement also provided an option to share future projects upstream from La Grange Diversion Dam on the same acreage formula, putting in place a partnership for the development of the river that has lasted for 120 years. La Grange Diversion Dam, however, was not the first dam to be built on the Tuolumne River. The first major dam built on the Tuolumne River was Wheaton Dam constructed in 1871, before the Districts were formed, by a small private company, the Tuolumne Water Co., near the present location of La Grange Diversion Dam (RM 52.2).

La Grange Diversion Dam was built of boulders set in concrete and faced with roughly dressed stones quarried nearby. Its sole purpose was to raise the elevation of the river behind it to the level necessary to divert water into the Districts' irrigation canals, and any water not diverted into the canals simply passed safely over the top of the dam. At 127 feet high and 90 feet thick at the base, it was the highest dam of its kind when it was completed in 1893.

The Districts' position as the only users of the Tuolumne River was challenged in 1901 when the City of San Francisco announced plans to construct dams at Hetch Hetchy Valley and on Eleanor Creek to create a new municipal water supply. At first San Francisco's applications for rights-of-way over federal park and forest lands were rejected, but in 1908, Secretary of the Interior James Garfield granted a permit. The Garfield Permit recognized specific senior water rights of the Districts. The permit also required San Francisco to sell surplus water to the Districts at cost and to sell electricity to the Districts for irrigation and drainage pumping at cost.

Between 1908 and 1912, San Francisco engineers developed plans for diverting water for municipal supply and generating hydroelectric power from the Tuolumne watershed — including an additional dam in Cherry Valley — that would be capable of supplying up to 400 million gallons per day to San Francisco and other cities around the bay. In 1910, Garfield's successors reopened the controversy when they threatened to revoke San Francisco's right to use Hetch Hetchy Valley. In 1913, Secretary of Interior Fisher concluded he could not allow San Francisco to build the Hetch Hetchy Project without clearer authorization from Congress. As a bill authorizing San Francisco's plan worked its way through Congress, the Districts negotiated terms with San Francisco. The Raker Act passed by Congress in 1913 recognized and protected the senior priority water diversions by TID and MID named in the previous Garfield Permit—a total of 2,350 cfs or natural flow, whichever is less, year-round and 4,000 cfs for 60 days each spring.

While the Hetch Hetchy project was being debated, the Districts were moving forward with plans for storage reservoirs because the natural flow and absence of storage at La Grange Diversion Dam made it impossible to irrigate any substantial acreage after the snow-melt ended in early summer. Both Districts first built small foothill reservoirs along their main canals—Modesto Reservoir in 1911 and Turlock Lake in 1914—and in 1915, they agreed to cooperate on a larger dam upstream of the La Grange Diversion Dam.

The construction agreement for the original Don Pedro Project signed in April 1919 allocated costs and benefits according to acreage, fixing TID's share of the Don Pedro Project, and subsequent water supply facilities on the river, at 68.46 percent and MID's share at 31.54 percent. When the original Don Pedro Dam was finished in 1923, the 284-foot-high arched dam was the highest in the world and had a maximum storage of 289,000 AF, which expanded the Districts' irrigation season beyond just the spring runoff season.

The original Don Pedro Project also put the Districts in the power business. Because in the 1920s electric lines rarely extended into rural areas, there had long been an interest in having the Districts distribute the power produced at Don Pedro. TID built its own transmission line and began retail distribution in 1923, with a branch to supply MID until it could build its own line from the dam. Growth was rapid, and in 1928, the generation capacity of Don Pedro was doubled to 30 MW. Private utilities found it impossible to compete with the Districts' low rates and expanding network of distribution lines; TID took full control of electric service within its boundaries in 1931, and MID did so in 1940. The Districts' hydroelectric power development kept them solvent during the Depression while also helping to lower property tax rates to help cash-strapped residents.

To maintain a minimum power pool at Don Pedro and increase irrigation storage, the Districts added gates to the spillway. The nine-foot increase in reservoir elevation flooded federal land above the 1916 reservation of public lands, resulting in the issuance of a Federal Power Commission (FPC) minor part license for the original Don Pedro Project in 1930.

San Francisco and the Districts continued to discuss their respective needs and rights to the Tuolumne River. In 1933, the Districts filed suit as San Francisco neared completion of the Hetch Hetchy Aqueduct, arguing that their rights under state law exceeded the flow San Francisco was required to release to the Districts under the Raker Act. Negotiations soon developed on a cooperative solution. The result was what became known as the First Agreement, a brief document that suspended litigation and committed San Francisco and the Districts to continued cooperation that would "recognize the provisions of the Raker Act as applying to the Districts and to the City without waiving any of their rights."

To satisfy the needs of those depending on the Districts and San Francisco to provide water, the Districts and San Francisco began a cooperative program, which included discussions of building additional storage on the Tuolumne River. However, planning was complicated by the efforts of the ACOE to construct a flood control reservoir at Jacksonville, just upstream of old Don Pedro. That prompted the Second Agreement in 1943, which proclaimed that a dam on Cherry Creek in the upper watershed and a larger Don Pedro dam were part of a coordinated and comprehensive watershed plan for developing the river. The next year the Districts and San Francisco took their case to Congress, and succeeded in stopping the federal dam and substituting a federal financial contribution to their projects to provide flood control.

In 1949, the Third Agreement between the Districts and San Francisco spelled out the terms of the comprehensive plan. New Don Pedro would be built with a financial contribution by San Francisco providing it with use of storage in the new reservoir. San Francisco's junior rights on the Tuolumne River would entitle it to relatively little or no water in dry years, which meant that it needed significant year-to-year carry-over storage to turn those junior rights into a reliable water supply.

Rather than building a number of additional small, uneconomical reservoirs in the upper watershed, new Don Pedro allowed San Francisco to acquire storage on terms that were more favorable. New Don Pedro would be owned and operated exclusively by the Districts, so the Third Agreement introduced the concept of a "water bank"; San Francisco would receive credit for inflow in excess of the Districts' priorities as listed in the Raker Act, and could use those credits to offset the subsequent upstream diversion of water that would otherwise have had to flow to the Districts. In essence, the agreement allows San Francisco to pre-release water from its upstream facilities into a water bank in the Don Pedro Reservoir so at other times it can hold back an equivalent amount of water that otherwise would have had to be released to satisfy the Districts' senior water rights. Once the water enters the Don Pedro Reservoir, it belongs to the Districts and the Districts have unrestricted entitlement to its use.

To pay for its water bank space, and to relieve its reservoirs of any federal flood control obligations, San Francisco agreed to pay for a portion of the construction of a new dam capable of storing a total of 1.2 million AF, including 290,000 AF to replace the original Don Pedro Project, 340,000 AF of flood control storage requested by ACOE, and 570,000 AF for water bank storage. ACOE flood control space would be kept empty during the rainy season to absorb storm inflows. When not obligated for ACOE flood control space, San Francisco could obtain water bank credits for up to 50 percent of the flood control storage space. All water in the reservoir belongs to the Districts, and San Francisco agreed to not construct or install facilities to divert water from the reservoir. The Districts would provide the land for the Don Pedro Project and pay for the new, and much larger, power plant. They also had the right to create additional storage for themselves by paying the marginal cost of a higher dam.

The Districts opted to increase new Don Pedro to its current maximum capacity of 2,030,000 AF. As part of the FERC licensing process, the California Department of Fish and Wildlife (CDFW) asked the FPC, predecessor agency to FERC, to require a set of scheduled minimum flows below La Grange Diversion Dam to protect fall-run Chinook Salmon that spawned in the Tuolumne River. There was a general recognition that new Don Pedro was a necessary prerequisite for protection of the Tuolumne fall-run Chinook Salmon since the existing dam had no downstream release requirement. FPC also recognized that fishery releases, when combined with rising San Francisco diversions, could ultimately undermine the economic feasibility of the Don Pedro Project. To balance those factors, FPC's 1964 (FPC 1964) decision set normal year releases of 123,000 AF and dry year releases at 64,000 AF for the first 20 years, and required the Districts to conduct studies that could be used to develop future fishery requirements.

The overall allocation of costs and benefits—the basic New Don Pedro bargain—had been defined by the Third Agreement but implementation still had details to be finalized. San Francisco and the Districts negotiated such further details in the Fourth Agreement, which was executed by the parties in 1966. Key provisions of the Fourth Agreement include the following:

- The Water Bank Account is to be maintained on a daily basis based upon the computed daily natural flow at La Grange Diversion Dam. "Daily natural flow" is defined as that flow which would have occurred at La Grange Diversion Dam had no facilities been constructed by any party in the Tuolumne River watershed. San Francisco receives a credit of advance releases whenever the inflow to the reservoir from all sources exceeds 2,416 cfs or natural flow, whichever is smaller, year-round, and 4,066 cfs or natural flow, whichever is smaller, for 60 days following and inclusive of April 15. The additional 66 cfs was for an 1871 mining ditch right acquired during the construction of the original Don Pedro Dam. A major portion of the mining ditch right served the Waterford Irrigation District which was later annexed by MID.
- Except with the prior consent of the Districts, San Francisco is not entitled to have a debit balance in the Water Bank Account.
- The parties agree to share in certain costs based on a ratio of 51.7121 percent to San Francisco and 48.2875 percent to the Districts. These costs included (1) continuing costs for deficit operation of recreation facilities required under a FERC license and (2) the costs of (a) fishery studies required by FERC, (b) any resulting proceedings, and (c) any facilities or programs instituted as a consequence of such fishery studies or proceedings.
- Future responsibility for fishery releases in Article 8, which provides:

  The Districts and City recognize that Districts, as licensees under the [FERC] license for the New Don Pedro project, have certain responsibilities regarding the water release conditions contained in said license, and that such responsibilities may be changed pursuant to further proceedings before the [FERC]. As to these responsibilities, as they exist under the terms of the proposed license or as they may be changed pursuant to further proceedings before the [FERC], Districts and City agree:

  (a) That any burdens or changes in conditions imposed on account of benefits accruing to City shall be borne by City.

  (b) That at any time Districts demonstrate that their water entitlements, as they are presently recognized by the parties, are being adversely affected by making water releases that are made to comply with [FERC] license requirements, and that the [FERC] has not relieved them of such burdens, City and Districts agree that there will be a

re-allocation of storage credits so as to apportion such burdens on the following basis: 51.7121% to City and 48.2879% to Districts.

In the event City and Districts cannot agree that there has been such an adverse effect and the extent thereof, these issues shall be determined by arbitration as provided in [this Agreement].

(c) That in the event of such adverse effects on Districts' water entitlements, and the consequent necessity for distribution of burden therefor as provided in subparagraph b, Districts shall forthwith seek modifications by the [FERC] of the water release conditions of said license.

Article 37 of the Project license established minimum flow releases for the first 20 years of operation (1971 to 1991) and reserved FPC's authority to revise the minimum flow requirements after 20 years. Article 39 of the license required the Districts, in cooperation with CDFW, to study the Tuolumne River fishery and how it could feasibly be sustained (see Appendix B-1 of this Exhibit for current license articles). The Districts subsequently commenced 18 years of fishery studies.

In 1985, the Districts applied to FERC to amend their license to add a fourth generating unit. While the amendment proceeding was underway, the Districts, CDFW, and the U.S. Department of the Interior, Fish and Wildlife Service (USFWS) entered into an agreement to amend the approved fish study plan provided for in Article 39 of the license. Among other things, the agreement contemplated extending the existing study and maintaining the existing flows until 1998. In 1987, FERC granted the license amendment and included the revised study plan in the license. FERC added Article 58 to the license, making the Districts' amended fish study plan a condition of the license and requiring the Districts to file a report on the results, with recommendations for changes in the existing flow releases and ramping rates for the Project. In doing so, however, FERC found that it was beyond the scope of the amendment request to extend the ongoing study or minimum flows beyond the initial 20-year period provided for in the existing license. As a result, the requirement to revisit the Project's minimum flows after 20 years, and to provide the results of the ongoing fish study, remained intact.

In 1995, the Districts entered into a FERC-mediated settlement agreement (1995 Settlement Agreement) with CDFW, USFWS, CCSF, California Sportfishing Protection Alliance, Friends of the Tuolumne, Tuolumne River Expeditions, and the Tuolumne River Preservation Trust. Pursuant to this agreement, in 1996, FERC amended Articles 37 and 58 of the license to implement new minimum flows and fishery monitoring studies. Before approving the license amendment, FERC completed formal consultation with the USFWS pursuant to Section 7 of the federal Endangered Species Act on two listed fish species, the Delta Smelt and Sacramento Splittail. FERC also prepared an Environmental Impact Statement (EIS) that examined the effects of various alternative flow regimes. As amended in 1996, Article 37 required a modified minimum flow regime to protect fishery resources in the Tuolumne River. This flow regime remains in effect today.

2.2 Water Rights Owned by TID and MID

The Districts have a number of individual water rights on the Tuolumne River including certain appropriative water rights acquired in 1855, riparian water rights, additional pre-1914 appropriative water rights, and post-1914 appropriative water right licenses issued by the State of California (License Numbers 11057 and 11058).

Section 2.1 above provides a description of the Raker Act and the Fourth Agreement between the Districts and CCSF. The Fourth Agreement defines the allocation of the waters of the river between CCSF and the Districts, the primary holders of water rights on the Tuolumne River. The Districts also have storage water rights in the original and existing Don Pedro Reservoir licensed by the State Water Resources Control Board (SWRCB). The water rights recognized under License Numbers 11057 and 11058 permit the use of water for irrigation, power generation, and recreation. The licenses also allow the storage, withdrawal from storage, diversion, and re-diversion of Tuolumne River water. Specifically, License Numbers 11057 and 11058 permits the Districts to store 1,046,800 AF of water per year to be collected from November 1 to July 31 of the succeeding year, to divert and re-divert a maximum of 1,371,800 AF per year, and withdraw 951,100 AF of water per year.

2.3 Statutes and Agreements Affecting Future Project Operations

The Raker Act, passed by Congress in 1913, authorized CCSF to build certain water and power facilities on federal lands and addressed the allocation of the waters of the Tuolumne River between the Districts and CCSF. Following passage of the Raker Act the Districts and CCSF entered into a series of agreements, culminating with the Fourth Agreement, which governs the allocation of costs and responsibilities associated with the construction and other aspects of the new Don Pedro Project, as well as the associated water bank accounting. In early 1996, TID and MID approved a further agreement (the “Side Agreement”) with CCSF that established the manner by which the minimum flow schedules contained in the 1995 Settlement Agreement would be allocated between the Districts and CCSF. By the terms of the Side Agreement, the Districts would provide the required instream flows and CCSF would compensate the Districts in amounts spelled out in the agreement. While by its terms the Side Agreement expires with the issuance of a new FERC license, the involved parties have expressed mutual satisfaction with the Side Agreement. Subject to what the final instream flow conditions associated with a new license may be, it is reasonable to assume the terms of the Side Agreement, up to the limits of the current instream flow requirements, will continue under the new license.

2.4 Detailed Description of Current Don Pedro Project Operations

The operation of the Don Pedro Project is subject to a number of interacting and seasonally overlapping considerations, predominantly consisting of the following elements:

- flood flow management consistent with ACOE guidelines,
- ensuring the reliability and delivery of irrigation and M&I water to the Districts’ customers, including consideration of annual carry-over storage,

- water bank accounting, and
- release of flows for the protection of anadromous fish and aquatic resources in accordance with FERC license terms.

The factors involved in each of these elements are discussed in the sections below, as are the flow releases and reservoir water levels that result from balancing these considerations in real-time. Before discussing each of these areas, an overview of the hydrology of the Tuolumne River is presented below.

2.4.1 Hydrology of the Tuolumne River Basin

The climate and hydrology of the 1,960 mi^2 Tuolumne River basin varies considerably over the river's 150-mile length. As an illustration of this variation, annual precipitation in the higher elevations of the watershed, above 10,000 ft, exceeds 60 inches per year, occurring mostly as snow, while less than 100 miles away in the lower lying San Joaquin Valley area, the annual precipitation is less than 12 inches. In addition to the geographic variation in precipitation, the seasonal and annual variations are also extreme. In the lower lying reaches of the Tuolumne River, the precipitation on average for the entire May through September period, inclusive, is less than one inch. Year-to-year variation in total runoff is also dramatic. In the period of 1971 to 2012, the lowest unimpaired flow of 351,000 AF occurred in water year (WY) 1977 and the highest unimpaired flow of 4.6 million AF occurred in WY 1983.[5] This represents a hydrology with a natural annual range that varies by a factor of 12. Another characteristic of the basin's hydrology is that dry and wet years often come in multi-year, back-to-back periods. The third driest year in the WY 1971 to 2012 period was WY 1976 (670,000 AF), the year before the driest year, and the third wettest year was WY 1982 (3.8 million AF), the year before the wettest year.

Water resource planners design systems to provide adequate water supply through periods of extended droughts. This is especially true where the consequences of drought on human welfare and economic health are significant. This is the case with the Tuolumne River, the Bay Area, and the Don Pedro Project. The irrigated lands of Stanislaus County served by the Districts are highly productive farmlands, and support high value nut and fruit orchards and animal and dairy operations. However, without a reliable year-to-year supply of irrigation water, tree crops are not sustainable and animal herds are vulnerable. Likewise, the Bay Area communities' 2.6 million people supplied by CCSF's Hetch Hetchy system, which accounts for 85 percent of CCSF's water supply, are adversely impacted when water supplies are reduced. Therefore, having adequate water supplies during extended drought periods is a "design condition" for the Don Pedro and Hetch Hetchy systems.

For the Don Pedro Project, the "design drought" in the WY 1971 to WY 2012 period is the drought of 1987 to 1992. During this six year period, the mean annual unimpaired flow at La Grange gage was 0.9 million AF, and not any single year in this period had an annual runoff that exceeded 70 percent of the long term average unimpaired flow of 1.95 million AF. Don Pedro

[5] Preliminary figures for WY 2017 indicate total unimpaired flow was 4.8 million AF.

Reservoir fell to elevation 690 ft in November 1992. It is important to recognize that this period also preceded the adoption of increased minimum flows and pulse flows under the 1995 Settlement Agreement. The two-year drought of WY 1976 through 1977 was drier with an average annual unimpaired flow of only 0.53 million AF (27 percent of mean runoff). The reservoir fell to its lowest level ever of 598 ft in October 1977. The period of 2001 through 2004 was another dry period, with unimpaired flow estimated to be only 69 percent of the long-term mean, and no single year in that four year period exceeding 82 percent. The recent 2012 through 2015 drought witnessed two of the five driest years on record since 1922[6] and all of the years had less than 60 percent of the mean annual runoff. Water supply to the Districts' customers was cut back to up to 50 percent in 2015 and the reservoir level dropped to elevation 671.2 ft in October 2015. Though groundwater use rose sharply, this source of supplemental water supply is unlikely to be as available under the recently enacted Sustainable Groundwater Management Act in California.

The estimated monthly and annual unimpaired runoff of the Tuolumne River at La Grange gage (drainage area 1,533 mi^2) is provided in Table 2.4-1. The occurrence of such large variations in seasonal and annual hydrology, as demonstrated in the table, represents the design conditions and highlights the year-over-year hydrologic variability that the Districts and CCSF must incorporate into their water supply planning to ensure the welfare of the communities and businesses they serve.

2.4.2 Flood Flow Management

The ACOE participated financially in the building of the Don Pedro Dam in exchange for the Districts setting aside 340,000 AF of flood control storage space. This space occurs between elevations 801.9 and 830.0 ft and is kept vacant from October 7 through April 27 of the next year. The maximum reservoir level experienced to date at Don Pedro is 831.4 ft, which occurred on January 2, 1997. On February 20, 2017, the reservoir level reached 830 feet and the Don Pedro Project spilled for just the second time, with the maximum release being 19,100 cfs.

Reservoir flood management at Don Pedro allows for winter and spring capture of both rain and snowmelt floods, and is part of the ACOE system for flood control operations along the San Joaquin River, which includes other "rim reservoirs" surrounding the eastern rim of California's Central Valley. Don Pedro Reservoir's flood control storage requirements increase from zero on September 8 to the maximum reservation of 340,000 AF by October 7. The flood control storage is maintained at 340,000 AF through April 27 after which, unless additional reserved space is indicated by snowmelt parameters, it can decrease uniformly to zero by June 3. Figure 2.4-1 depicts the flood control rule curve for the Don Pedro Project.

In addition to flood control space needs within the reservoir, downstream flow restrictions also affect operations related to flood management. The primary downstream flow guideline cited in the 1972 ACOE Flood Control Manual (ACOE 1972) is that flow in the Tuolumne River at

[6] "Estimates of Natural and Unimpaired Flows for the Central Valley of California: Water Years 1922-2014", DWR, March 2016 (DRAFT).

Modesto (as measured at the 9th Street Bridge) should not exceed 9,000 cfs. Flows in excess of 9,000 cfs have the potential to cause significant damage to property in the urbanized area of the Tuolumne River and Dry Creek, a tributary of the Tuolumne River. Between La Grange Diversion Dam (RM 52.2) and the 9th Street Bridge in Modesto (RM 16.1), the single largest contributor of local flow to the Tuolumne River is Dry Creek. The Dry Creek watershed has its headwaters in the foothills just northeast of Don Pedro Dam. It is a flashy watershed; once the soil is saturated, any rainfall results in a rapid response in runoff. Significant flows, on the order of 6,000 cfs or higher, can occur when there is significant rainfall between Modesto and the upper end of the Dry Creek watershed. Flows from Dry Creek enter the Tuolumne River above the USGS streamflow gage located at Modesto. Therefore, Dry Creek flows must be taken into account when making releases from Don Pedro so that when combined with Don Pedro flows, total flow at Modesto is less than 9,000 cfs.

Although flood management operations and flood control space in Don Pedro Reservoir can be generally described in this simplified manner, management of the reserved storage space is accomplished on a real-time basis. Inflow forecasts are constantly updated. Don Pedro Project operations and management for flood control purposes requires the development of a long-term forecast of the potential inflow into Don Pedro under various potential runoff scenarios. Flood flow management may require the early release of water from Don Pedro Reservoir (termed "pre-releases") to maintain the reserved storage space and flows at Modesto below the 9,000 cfs level. In short, if there is a large volume of water expected to be intercepted by Don Pedro either in the short or longer term that could result in higher releases than 9,000 cfs, then pre-flood releases may be made to reduce the risk of having to release higher flows at a later time. The decision to make pre-releases at the Don Pedro Project involves flow forecasting based on long-term weather predictions and risk-based hydrologic analyses. To perform this task, the Districts review, on a continuous basis, the current status and future forecasts of Tuolumne River runoff. The Districts continuously update their canal flow requirements (long and short term) and communicate with CCSF and federal and state agencies that operate reservoirs within the San Joaquin River system. The Districts are in contact with the California Department of Water Resources (CDWR) and the federal National Weather Service regarding weather forecasts and forecasted rainfall and/or runoff. The Districts are in frequent contact with the ACOE. The Districts use a number of computer models for the calculation of potential inflows to Don Pedro and future release requirements. These models range in time step from annual, monthly, weekly, daily, and finally, hourly or real-time. These models develop statistical probability curves for runoff forecasts and combine these forecasts with simulations of potential Don Pedro Project operations to develop the operations plans.

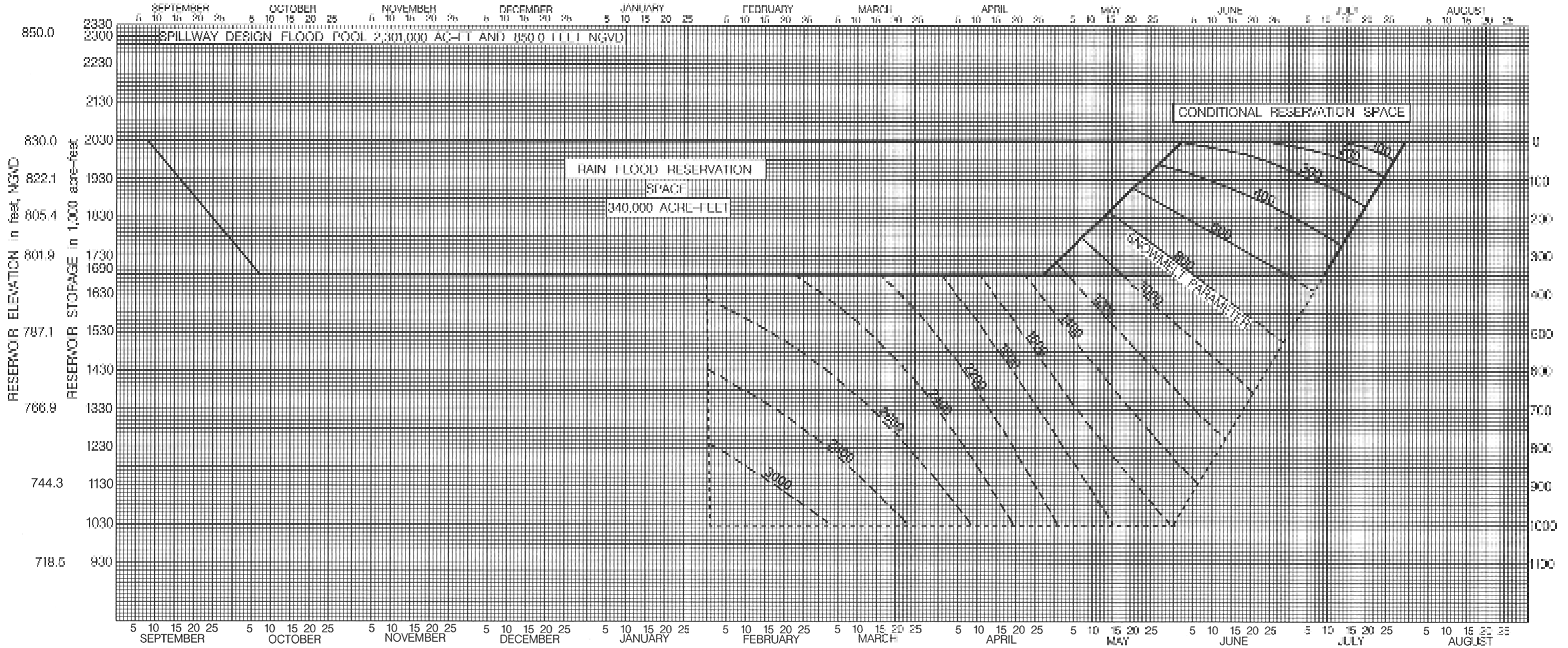
While the guideline of 9,000 cfs at Modesto must be reasonably adhered to, it is recognized that flood flows of substantially greater magnitude can occur on the Tuolumne River. While the mean annual unimpaired river flow at La Grange gage is approximately 2,700 cfs, the highest flow event experienced at the new Don Pedro Project since the beginning of commercial operation occurred on January 1, 1997. The peak inflow to the reservoir was estimated to be 120,935 cfs, and the peak outflow 59,462 cfs. The flood of record on the Tuolumne River is estimated to have occurred in January 1862 and is believed to have been approximately 130,000 cfs. A flood flow of 61,000 cfs occurred in December 1950, prior to the construction of the new Don Pedro Dam. The design flood for the Don Pedro Project is the Probable Maximum Flood

(PMF) event. The PMF has an estimated reservoir inflow of 706,900 cfs and an estimated outflow of 525,600 cfs. During the PMF event, reservoir water levels would rise to a peak elevation of 852 ft, three feet below the top of dam. The Project Boundary extends to water surface elevation of 845 ft in the Tuolumne River at the upstream end of the Project Boundary.

Table 2.4-1. Estimated unimpaired flow at La Grange gage from 1971 through 2012 (AF).

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1971	10,403	86,522	123,255	116,137	94,103	146,315	194,252	348,968	418,322	110,651	19,624	9,842	1,678,393
1972	6,172	34,879	76,534	61,383	78,026	181,275	155,725	344,141	219,556	28,316	11,508	11,038	1,208,554
1973	11,439	36,103	86,245	139,554	186,056	173,428	259,410	655,199	400,297	57,344	19,697	5,901	2,030,673
1974	17,289	171,389	136,439	179,855	68,704	228,524	273,855	560,602	441,592	122,520	28,527	9,507	2,238,803
1975	14,699	12,106	35,333	53,844	144,298	224,185	176,272	582,041	596,317	149,543	27,588	14,613	2,030,839
1976	70,107	55,744	31,605	7,900	37,718	70,665	99,528	208,988	39,704	14,409	20,658	14,771	671,798
1977	12,091	8,452	3,231	10,687	16,711	24,991	78,646	105,316	104,440	10,835	3,632	2,800	381,833
1978	1,655	11,798	96,334	189,971	195,781	331,031	354,170	603,288	661,374	309,832	60,386	83,972	2,899,594
1979	10,607	29,477	33,062	153,911	151,774	238,936	260,209	626,232	314,829	66,623	17,076	9,636	1,912,372
1980	29,332	42,198	49,346	528,791	394,144	221,188	304,081	497,410	538,734	346,613	58,809	22,254	3,032,900
1981	11,243	8,339	25,745	48,152	63,400	125,896	243,173	328,482	151,211	21,812	19,147	8,770	1,055,370
1982	29,077	173,741	220,232	227,881	388,417	339,727	660,444	693,111	566,799	322,574	79,977	102,945	3,804,926
1983	152,854	176,418	244,790	261,263	325,705	554,459	291,756	695,534	1,024,537	638,665	205,640	60,567	4,632,189
1984	51,524	313,439	405,707	177,008	152,734	203,760	225,150	563,743	342,461	93,243	19,919	7,576	2,556,263
1985	26,611	86,072	48,301	40,203	69,518	127,565	302,634	341,384	135,004	22,769	15,297	17,853	1,233,211
1986	33,399	49,228	94,056	126,876	637,574	490,248	322,503	539,965	500,911	146,703	30,159	18,815	2,990,437
1987	18,330	7,189	8,644	6,170	43,156	89,931	191,647	205,993	66,200	10,978	5,881	1,736	655,855
1988	10,099	27,213	48,866	70,214	58,513	105,214	158,208	211,691	99,220	23,677	5,289	2,142	820,346
1989	1,847	22,370	26,900	36,981	62,227	286,012	307,438	319,033	208,219	24,567	2,575	13,732	1,311,900
1990	49,807	25,385	20,532	35,561	54,889	133,067	221,040	179,627	101,596	19,804	2,449	1,217	844,974
1991	982	8,779	4,180	5,950	8,851	168,572	179,992	334,911	299,086	66,836	18,852	7,012	1,104,004
1992	15,913	26,032	17,284	25,086	95,292	113,080	231,981	187,793	46,522	56,032	13,076	4,110	832,201
1993	11,096	13,008	45,527	278,924	165,923	319,513	321,485	628,266	505,510	211,719	41,624	13,090	2,555,685
1994	13,216	6,949	17,731	20,248	50,640	103,289	185,954	274,460	115,037	23,356	14,060	7,323	832,264
1995	6,615	62,444	59,634	345,179	147,243	580,033	409,409	658,216	792,024	640,448	149,917	26,786	3,877,947
1996	2,928	1,893	70,462	124,072	350,198	293,830	333,468	577,821	386,230	126,871	25,107	12,406	2,305,286
1997	10,649	111,176	395,920	993,122	164,045	229,020	286,771	527,209	319,150	89,353	31,042	12,881	3,170,339
1998	8,055	17,287	36,321	215,888	367,838	348,714	351,185	469,946	849,275	540,481	70,185	32,748	3,307,924
1999	15,093	51,486	68,248	142,259	257,917	169,912	254,689	567,235	424,883	100,289	25,242	16,656	2,093,910
2000	8,280	17,956	11,370	131,610	278,379	249,790	327,021	529,862	307,687	52,214	21,282	13,384	1,948,836
2001	16,451	15,946	22,001	30,634	63,300	189,870	235,844	416,612	62,364	23,427	11,565	8,052	1,096,067
2002	7,721	38,946	104,487	98,040	79,528	143,210	303,256	385,292	220,546	30,533	11,458	6,580	1,429,597
2003	-588	69,475	70,469	89,021	64,992	130,238	217,015	522,924	373,580	55,918	28,039	11,199	1,632,280
2004	2,626	10,762	82,640	70,234	108,719	257,309	267,607	315,850	145,681	27,310	11,694	3,922	1,304,353
2005	51,651	52,995	72,504	258,454	186,669	315,456	304,589	839,252	584,291	255,278	35,507	16,145	2,972,792
2006	11,313	16,146	253,634	236,755	157,300	292,801	622,598	834,124	644,165	199,162	26,017	9,791	3,303,806

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
2007	9,687	16,463	30,830	27,556	94,441	150,141	181,930	246,298	62,309	16,240	10,214	4,089	850,199
2008	7,346	2,877	17,262	76,578	102,747	128,423	192,092	360,565	207,420	35,284	11,766	3,632	1,145,991
2009	4,580	60,476	25,630	107,965	115,404	231,165	261,458	564,833	224,025	59,140	15,673	6,388	1,676,737
2010	56,344	10,585	40,469	90,140	105,834	159,640	247,578	384,423	623,115	140,842	13,441	8,755	1,881,167
2011	103,237	83,675	331,215	174,482	140,926	413,651	430,289	516,744	774,892	450,460	88,097	28,086	3,535,754
2012	36,596	17,767	5,564	48,811	32,290	108,325	289,328	254,087	63,489	17,117	10,898	6,247	890,517
Average	23,057	49,790	85,680	144,365	151,474	223,629	274,183	452,559	356,252	137,138	31,871	16,166	1,946,164



NOTES:

1. Don Pedro Lake shall be operated for flood control in accordance with this water control diagram and the accompanying emergency spillway release diagram. Reservoir releases shall be made in accordance with the diagram requiring greater release.

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

3. Snowmelt parameter value is the forecasted natural runoff in thousand acre–feet of Tuolumne River inflow to Don Pedro Lake between the given date and 31 July. Dash line parameter extentions below rain flood reservation line are used for computation purposes to define gross reservation requirement (before reduction for empty space in upstream reservoirs.)

4. The flood control reservation in Don Pedro Lake determined from snowmelt parameters may be decreased by 80 percent of the available empty space in each of Hetch Hetchy Reservoir and Lake Lloyd. No reduction will be permitted below 50,000 acre–feet or into the rain flood reservation value. No more than 70% of the creditable portion of the requirement may be allowed for empty space in Hetch Hetchy Reservoir nor more than 30% for empty space in Lake Lloyd.

5. When space available for flood control is less than that indicated by the diagram (after allowing credit for empty space in upstream reservoirs), water shall be released as rapidly as possible without causing flows in Tuolumne River below Dry Creek to exceed 9,000 c.f.s. or non–damaging channel capacity.

6. Releases shall not be increased more than 2,000 c.f.s. or decreased more than 1,000 c.f.s. in any 2–hour period except as required by the Emergency Spillway Release Diagram.

DON PEDRO LAKE
TUOLUMNE RIVER, CALIFORNIA

WATER CONTROL DIAGRAM

Prepared Pursuant to Flood Control Regulations for Don Pedro Dam and Lake in accordance with the Code of Federal Regulations Title 33 Part 208.11

APPROVED: [signature] Colonel, USA, Division Engineer, South Pacific Division

APPROVED: [signature] Chief, Administrative Officer, Modesto Irrigation District

APPROVED: [signature] Manager, Turlock Irrigation District

Effective Date: 27 JUL 1978 File No. [illegible]

Figure 2.4-1. **ACOE flood management guide curve for the Don Pedro Project.**

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For weekly and daily operations, the Districts develop a total release schedule for the Don Pedro Project and the allocation of these releases to the TID and MID canals and the lower Tuolumne River. Flows to the Districts are for the beneficial use of irrigation and M&I requirements either currently or in the future. Hydroelectric operations occur as a consequence of this flow release schedule. At certain times of the year, the Districts may shape the daily flow schedule to release somewhat higher flows from Don Pedro during on-peak hours and lower flows during off-peak hours to increase the value of the water scheduled to be released. However, this flow shaping must be done within other limits placed on hydropower generation by irrigation canal operational and physical constraints. These are discussed further below.

2.4.3 Agricultural and Municipal Water Supply

The primary function of the Don Pedro Project is to provide water storage and release to benefit irrigation, municipal, and industrial water supply. Both TID and MID have obligations to supply both water and retail electric service to their respective service areas. The Don Pedro Project also provides water storage (in the form of water bank credits) for CCSF so it can reliably meet the water needs of its 2.6 million customers in the Bay Area.

The Districts' irrigation system consists of the Don Pedro Dam and Reservoir for the storage and delivery of Tuolumne River water to the Districts' service territory, La Grange Diversion Dam where releases from Don Pedro are diverted from the river into the TID (south side of the river) and MID (north side of the river) canal systems, and a complex system of canals, laterals, intermediate storage, and control structures. The TID irrigation system consists of approximately 250 miles of canals and laterals. TID also owns and operates an intermediate storage reservoir, Turlock Lake. MID owns and maintains approximately 200 miles of canals, laterals, and pipelines. MID also owns and operates an intermediate storage reservoir, Modesto Reservoir.

The TID irrigation service area encompasses 307 mi^2 of the Central Valley. TID provides full-service irrigation water to over 150,000 acres of farmland. MID's irrigation service area is 156 mi^2 with over 60,000 acres of irrigated land. The historical reliability of the Districts' water supply has allowed farm owners to make the long-term investments necessary to develop and maintain nut and fruit orchards. The Districts' service territory also supports a large dairy infrastructure. The approximate crop distributions can change slightly from year to year, but representative percentages are as follows:

- nut orchards: 32 percent,
- corn (including corn silage): 26 percent,
- hay: 23 percent,
- vegetables: 8 percent,
- field and other: 5 percent,
- fruit: 3 percent,
- grape: 2 percent, and
- grain: 1 percent.

The farmland served by the Districts is characterized by rich soils with long growing seasons; however, irrigation water is required due to natural summer precipitation levels totaling less than one inch. Water delivery from Don Pedro Reservoir to serve the Districts' irrigation systems and irrigation customers occurs primarily from March through October. However, irrigation-related water releases may occur from Don Pedro year-round, depending on winter moisture conditions, storage needs in Turlock Lake and/or Modesto Reservoir, and early-or-late season temperatures. MID also provides a portion of the treated water supply of the City of Modesto. Water deliveries to the city for M&I purposes occur year-round, but vary from year to year. MID's potable water treatment facilities are designed to deliver up to a maximum of 67,200 AF per year. The Districts also provide a small amount of domestic water to the community of La Grange.

From 1997 to 2012, inclusive, the average annual water releases from the Don Pedro Project to meet the Districts' consumptive needs were 900,000 AF. The year 1997 was the first full calendar year after the implementation of the 1995 Settlement Agreement. MID, TID, and total canal deliveries for that period are provided in Figures 2.4-2, 2.4-3, and 2.4-4, respectively. Total canal deliveries include water to meet crop evapotranspiration needs; M&I needs; canal, lateral, and reservoir evaporation and seepage losses; and operational losses at the ends of laterals and canals.

2.4.4 Water Bank Operations

The CCSF water system on the Tuolumne River includes the three physical reservoirs (Hetch Hetchy Reservoir, Lake Lloyd, and Lake Eleanor), diversions to the Bay Area through the San Joaquin Pipeline, and an accounting for the Don Pedro water bank account. As described previously in this exhibit, CCSF participated financially in the construction of the new Don Pedro Dam and Reservoir. For this participation, CCSF acquired water banking privileges amounting to 570,000 AF of available credits that allow CCSF to ensure the reliability of its water supply to its 2.6 million Bay Area customers. Using the water bank, CCSF can pre-release flows from its upstream facilities into the Don Pedro water bank where the flows are credited against CCSF's obligation to meet future District entitlements so that later (in dry periods), CCSF can divert and use Tuolumne River water which it otherwise would have to bypass to meet the Districts' senior water rights. CCSF's water bank credits substantially improve the reliability of its water system by crediting the water bank in wet years so that it can debit the account in dry years. Approximately 85 percent of CCSF's water supply to the Bay Area comes from the Tuolumne River.

The water bank account volume is monitored by both the Districts and CCSF. A running account of the water bank account balance is computed daily, in accordance with the Fourth Agreement and other implementing agreements. The water bank accounting is periodically updated and reconciled with finalized USGS reservoir storage and streamflow gage data. In accordance with the Fourth Agreement, CCSF is not allowed to have a negative balance in the water bank without the prior consent of the Districts.

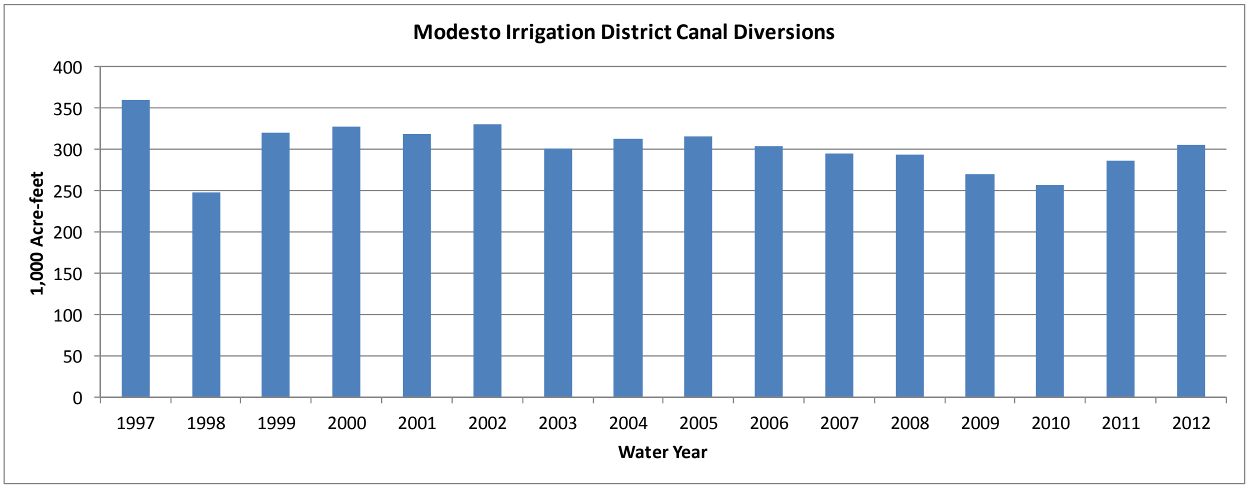

Figure 2.4-2. Total canal deliveries from 1997 to 2012 to Modesto Irrigation District.

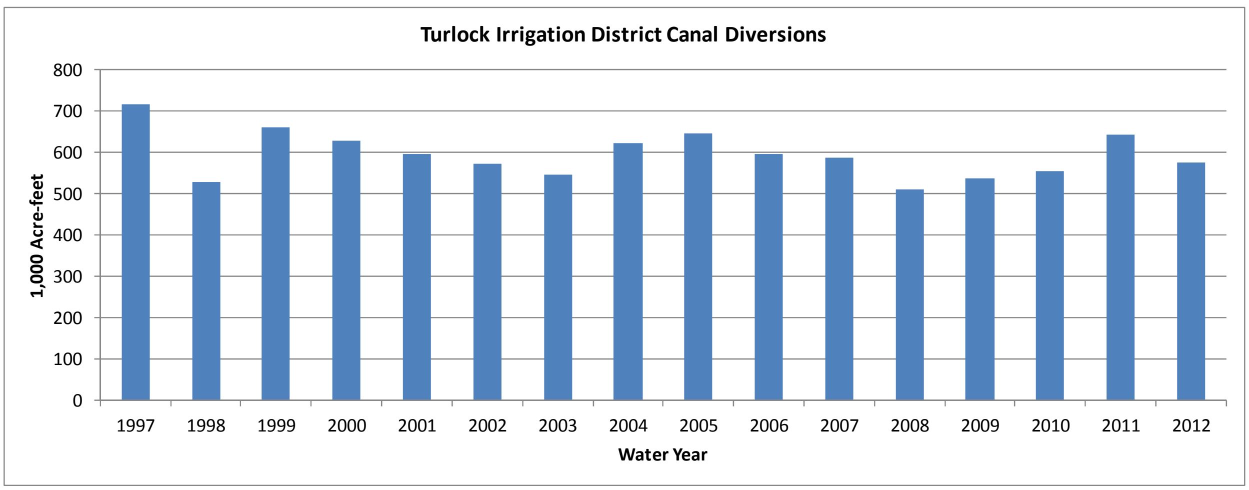

Figure 2.4-3. Total canal deliveries from 1997 to 2012 to Turlock Irrigation District.

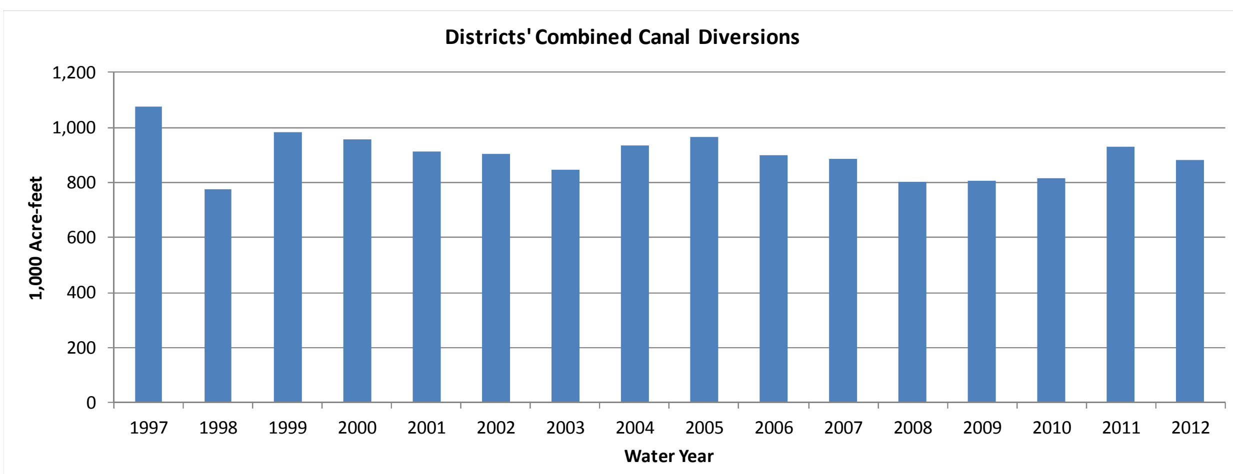

Figure 2.4-4. Districts' combined total canal deliveries from 1997 to 2012.

2.4.5 Reservoir Releases to Benefit Lower Tuolumne River Fisheries

The Districts have actively participated in the study, monitoring, protection, and enhancement of the fall-run Chinook Salmon in the lower Tuolumne River. Since the issuance of the original license, operations have been modified to improve conditions for fall-run Chinook Salmon. In 1995, the Districts entered into a settlement agreement with CDFW, USFWS, CCSF, and four non-governmental organizations (NGOs) that provided greater releases from the Don Pedro Project to the lower Tuolumne River to improve conditions for fall-run Chinook Salmon. FERC issued an order on July 31, 1996 amending the Don Pedro license to incorporate the lower Tuolumne River minimum flow provisions contained in the settlement agreement. The revised summertime minimum flows were to vary from 50 cfs to 250 cfs, a substantial increase over the prior summertime minimum flow of 3 cfs, and fall through winter minimum flows would vary from 150 cfs to 300 cfs depending on water year type. There are 10 water year types. The water year classifications are re-calculated each year to maintain approximately the same frequency distribution of water year types. The settlement agreement and license order also provided for the release of pulse flows, the volume of which also varies with water year type. The flow schedule provided for by the Settlement Agreement and subsequent FERC Order is shown in Table 2.4-2.

Under current procedures and protocols, the preliminary determination of the appropriate water year type is completed by April 14 of each year based on a "water first" protocol, which applies an assumption of 90 percent confidence level to the remaining runoff in the current water year. This determination is reviewed by resource agencies and sets the stage for definition of the spring outmigration pulse flow volume and timing. The proposed pulse flow schedule to aid outmigration is provided to resource agencies for comment, and then forwarded to FERC for compliance purposes. The final determination of the actual amount of runoff is made in July. If the final estimate of runoff is greater than the estimate of April 14, then additional flows may be released to the lower Tuolumne River equal to the amount flows were underestimated. If the final estimate of runoff is less than the estimate of April 14, the Districts do not get to recover these flows by reducing future instream flows. Any additional flows to be provided to the river are scheduled by resource agencies as to the timing and rate of release of these additional flows.

The potential effects of the Don Pedro Project operations on the environment of the lower Tuolumne River have undergone continuous evaluation, monitoring, and study since the new Don Pedro Project began commercial operation in 1971. The Districts have worked closely with all parties interested in protecting and enhancing the fisheries in the lower Tuolumne River, especially in regard to the fall-run Chinook Salmon population. Between 1972 and 1992, the Districts, in consultation with resource agencies, conducted numerous studies of the lower Tuolumne fisheries. In 1992, the Districts provided FERC and interested parties a compilation of these studies in an eight-volume filing consisting of 28 individual environmental reports (TID/MID 1992). These studies led to the development of a FERC-mediated 1995 Settlement Agreement with CCSF, resource agencies, environmental groups, and other interested parties whereby the Districts agreed to provide, among other things, increased flows to the lower Tuolumne River for the purpose of enhancing and protecting the fall-run Chinook Salmon population.

In accordance with the 1995 Settlement Agreement, the Districts continued to monitor the fall-run Chinook Salmon population and provided annual reports to all parties. The Tuolumne River Technical Advisory Committee (TAC), consisting of the Districts, CCSF, environmental groups, CDFW, and USFWS, was designated under the terms of the 1995 Settlement Agreement to be responsible for coordinating portions of the Agreement, reviewing annual studies on the fall-run Chinook Salmon and *Oncorhynchus mykiss* fisheries, and advising the Districts on adjustments to fisheries studies. The TAC meetings are open to the public, allowing any interested party to participate. Numerous additional aquatic resource monitoring and evaluation studies have been undertaken from 1996 to the present time. In March 2005, the Districts prepared and filed a Ten Year Summary Report covering the environmental studies conducted from 1995 to 2004 (TID/MID 2005). Annual studies and reports have been filed each year since that time.

In total, the Districts have performed and completed more than 150 studies of the lower Tuolumne River since 1992 (TID/MID 2010). The Districts continue to work with the Tuolumne River TAC to monitor the fisheries of the lower Tuolumne River. The most recent monitoring results conducted in 2016 were filed with FERC in March 2017.

2.4.6 Hydropower Generation

The Don Pedro powerhouse sits immediately below Don Pedro Dam and contains four turbine-generator units with a total hydraulic capacity of 5,500 cfs and a maximum generation capability of approximately 200 MW at maximum head. Flows to the powerhouse are delivered via the power tunnel, which has an inlet centerline elevation of 534.3 ft. Flow releases through the powerhouse from the Don Pedro Reservoir are scheduled based upon requirements for (1) flood flow management, including pre-releases in advance of anticipated high flows during wet years, (2) Districts' irrigation and M&I demands, including flows to maintain water storage in Turlock Lake and Modesto Reservoir, and (3) protection of aquatic resources in the lower Tuolumne River in accordance with the terms of the FERC license. Once the weekly and daily flow schedules are established based on these water demands, then outflows from the Don Pedro powerhouse are scheduled to deliver these flows. During periods of greater electrical demand, hourly outflows may be shaped to generate more electricity during on-peak periods and less during off-peak periods, subject to meeting the requirements of the pre-established water demand flow schedule. In accordance with the Districts' water first policy, flow releases are scheduled to satisfy the three requirements listed above, then delivered via the generation units up to their capacity and availability. Hydropower generation at Don Pedro is a secondary consideration with respect to flow scheduling. Monthly and annual generation for the period 1997 to 2012 is provided in Table 2.4-3. During this period, the annual generation averaged 622,440 MWh, ranging from a low of 339,500 MWh in 2008 to a high of 1,055,300 MWh in 1998.

Table 2.4-2. Schedule of flow releases to the lower Tuolumne River by water year type contained in FERC's 1996 order.

Schedule	Units	# of Days	Critical and Below	Median Critical[1]	Interm. CD[1]	Median Dry	Interm. D-BN	Median Below Normal	Interm. BN-AN[2]	Median Above Normal	Interm. AN-W	Median Wet/Max
Occurrence	%	--	6.4%	8.0%	6.1%	10.8%	9.1%	10.3%	15.5%	5.1%	15.4%	13.3%
October 1–15	cfs	15	100	100	150	150	180	200	300	300	300	300
	AF	--	2,975	2,975	4,463	4,463	5,355	5,950	8,926	8,926	8,926	8,926
Attraction Pulse	AF	--	none	none	none	none	1,676	1,736	5,950	5,950	5,950	5,950
October 16–May 31	cfs	228	150	150	150	150	180	175	300	300	300	300
	AF	--	67,835	67,835	67,835	67,835	81,402	79,140	135,669	135,669	135,669	135,669
Outmigration Pulse Flow	AF	--	11,091	20,091	32,619	37,060	35,920	60,027	89,882	89,882	89,882	89,882
June 1–September 30	cfs	122	50	50	50	75	75	75	250	250	250	250
	AF	--	12,099	12,099	12,099	18,149	18,149	18,149	60,496	60,496	60,496	60,496
Volume (total)	AF	365	94,000	103,000	117,016	127,507	142,502	165,003	300,923	300,923	300,923	300,923

Source: FERC 1996.

[1] Critically dry.

[2] 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 Districts each fish flow year is to be determined using accepted methods of interpolation between index values.

The hydropower generation is shared by the two Districts in the same proportion as their ownership in the Don Pedro Project – 68.46 percent TID and 31.54 percent MID. Both TID and MID are summer-peak utilities, meaning their highest electrical demands occur during the summer months. TID's peak demand approaches 450 MW and MID's 600 MW. The Districts operate the Don Pedro Project as a "water first" project, meaning water releases are managed for purposes of water supply first and not hydropower generation. The peak electrical demand months of July and August also correspond to the greatest flow needs for consumptive use purposes; therefore, the hydropower production is also greater during these months.

Some hourly flow shaping of the daily volumes released to satisfy consumptive use purposes occurs during on-peak periods. As an example of the flow shaping that sometimes occurs once water supply needs are determined, Table 2.4-4 provides a summary of Don Pedro hydropower operations during the summer peak demand periods for 2009, 2010, and 2011. Both TID and MID experience their greatest on-peak demands during the summer months. As can be seen in the table, the change in Don Pedro generation from off-peak to on-peak periods is relatively small on average, and off-peak generation is never zero. This change in generation from on-peak to off-peak periods reflects the minor degree of hourly shaping of daily flows that occurs.

The amount of daily shaping that can be achieved is not only limited by the water supply scheduling for the purposes mentioned above, but also other physical and operational constraints. First, the volume of usable storage in La Grange headpond is not sufficient to allow it to act as a re-regulating reservoir and flows released through the Don Pedro hydropower units simply pass through the La Grange headpond virtually unchanged. Second, while the TID main canal, the larger of the two main canals, has a design hydraulic capacity of 3,400 cfs, flow may be restricted to a maximum of approximately 2,500 cfs for safety reasons and ramping rates in the main canal are constrained to about 300 cfs per hour, or 10 MW/hr, hardly conducive to a peaking or load-following operation.

Also, the operation of the Districts' irrigation water storage reservoirs – Turlock Lake and Modesto Reservoir – have limited storage capacities, the use of which are driven by irrigation purposes and needs. Winter hydropower generation at Don Pedro is very limited because of the Don Pedro Project's "water first" operation. Except for minimum flows to the lower Tuolumne River, water is either being stored for water supply purposes, released for filling of the irrigation storage reservoirs, or released for flood management purposes without regard to on-peak/off-peak releases. Figures 2.4-5 through 2.4-16 show total load for each District and the typical hydropower generation that occurs during the summer peak season.

2.4.7 Total Don Pedro Project Outflows

Once the overall flow release schedule is established, outflows from the Don Pedro Project are generally released first through the turbine-generator units (up to 5,500 cfs), then the hollow jet valve up to a capacity of either 800 cfs or 3,000 cfs, depending on whether Unit 4 is operating, then through the low level outlet works up to their capacity of 7,500 cfs, and then through the spillways as water levels approach elevation 830 ft. Total outflows are recorded for each point of delivery, as follows:

- flows in the lower Tuolumne River are measured at the USGS gage *Tuolumne River at La Grange* located approximately 0.5 mi below the Districts' La Grange Diversion Dam,
- flows in the TID canal are measured at the entrance to the TID Main Canal, and
- flows to the MID canal are measured at the entrance to the MID Main Canal.

Total Don Pedro Project outflows are the sum of these three measurements. For the WY 1971 to 2012 period, the total outflows are shown in Table 2.4-5.

2.4.8 Don Pedro Reservoir Levels

The Don Pedro Project was constructed for the purposes of providing water storage for water supply and flood flow management. The Don Pedro Project is operated to provide water storage sufficient to satisfy annual flow requirements while considering the need for carry-over storage that may be necessary to satisfy water demands over successive dry years. Achieving these primary purposes results in substantial annual and multi-year changes in Don Pedro Reservoir water levels. The historical headwater duration curve of the Don Pedro Project, once initial filling was complete, is provided in Figure 2.4-17. Table 2.4-6 provides the end of month and end of year reservoir storage levels for each year of the 1972 to 2012 period. This table shows that on average water storage level changes over the water year can exceed 1 million AF, although they are normally less than about 700,000 AF from the normal low level, which occurs in the October/November time frame to the normal high, which occurs in the May/June time frame.

The effect of hydropower operations on reservoir water levels is limited to the daily shaping of flows discussed previously. Using the data provided in Table 2.4-4, the greatest on-peak/off-peak change in generation was roughly 40 MW. If it is assumed that the on-peak period lasts for 16 hours during the summer, this equates to a flow of roughly 1,200 cfs more during on-peak periods than during the off-peak period. Over a 16-hour period, this amounts to a volume of 1,600 acre-feet. At the median reservoir level of 780 ft, this represents a change in reservoir level of 0.15 ft, or 1.8 inches occurring over a 16-hour period, when compared to the off-peak flow occurring all day. This change in reservoir level also assumes that there was zero inflow to the reservoir during the time.

Table 2.4-3. Monthly and annual generation for the period 1997 to 2012 in megawatt-hours (MWh).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Calendar Year Total
1997	125,807	112,176	79,403	79,955	91,751	62,960	84,199	64,326	36,628	31,271	9,585	9,543	787,610
1998	56,357	123,068	135,338	125,292	117,338	120,149	120,217	100,448	75,210	40,680	7,151	34,072	1,055,327
1999	44,765	81,324	96,268	41,266	68,889	64,896	76,417	75,500	40,689	31,869	11,881	14,937	648,706
2000	11,795	55,976	110,295	83,714	81,391	71,623	86,957	86,278	48,789	29,422	8,090	12,897	687,232
2001	10,538	30,737	33,242	53,223	72,264	58,898	65,789	54,452	30,734	21,270	4,137	4,900	440,188
2002	5,078	4,258	38,044	61,818	54,412	54,340	66,447	52,811	28,789	18,759	6,073	7,004	397,839
2003	5,394	11,275	25,075	39,599	51,963	65,441	75,800	61,666	32,692	33,134	8,342	6,261	416,648
2004	7,508	12,122	62,984	72,157	58,301	58,788	68,904	54,145	25,451	23,118	4,564	4,401	452,449
2005	12,339	48,759	98,232	137,057	143,776	137,290	122,689	84,792	43,861	22,202	9,831	33,044	893,877
2006	111,668	72,155	125,740	110,498	131,216	124,759	97,386	80,643	46,356	26,151	11,631	8,204	946,413
2007	12,597	15,207	45,087	48,189	54,255	57,215	64,530	53,546	22,956	15,460	7,032	3,779	399,858
2008	3,183	5,562	37,289	43,157	58,311	45,852	54,811	46,689	22,416	11,466	4,646	6,113	339,501
2009	4,911	5,325	21,733	41,083	55,266	56,221	67,625	53,082	28,387	18,050	7,780	5,495	364,964
2010	6,865	7,736	27,539	58,257	119,843	119,846	92,165	70,799	43,904	28,570	19,302	120,918	715,749
2011	114,959	82,977	112,795	109,858	120,545	114,007	105,415	138,488	70,250	29,961	6,913	7,188	1,013,360
2012	32,928	13,185	26,369	27,095	69,323	54,121	66,022	54,510	31,515	17,446	3,900	2,892	399,312
Average	35,418	42,615	67,215	70,764	84,303	79,150	82,211	70,761	39,289	24,927	8,179	17,603	622,440

Table 2.4-4. Total Project weekly summer off-peak and on-peak generation (May through September); 2009 through 2011 (MWs).

Average Don Pedro Generation in MW/h Total (Monday = 1, Sunday = 7),(On Peak=HE7 to HE22 or 6:00:01 to 22:00:00 for Monday through Saturday)

Average of TOTAL		DayofWeek	On_Off											
		1		2		3		4		5		6		7
Year	Month	off	On	off	On	off	On	off	On	off	On	off	On	off
2009														
	5	53	84	52	84	47	90	53	91	57	86	53	78	73
	6	59	86	61	90	59	85	58	88	65	87	60	81	79
	7	79	94	75	86	79	98	77	98	81	104	83	95	91
	8	47	75	55	77	59	80	59	75	60	86	64	82	68
	9	21	38	24	46	25	48	33	59	30	54	25	35	35
2010														
	5	149	157	170	171	171	170	167	166	167	166	157	155	148
	6	175	167	156	154	156	159	167	164	169	168	175	177	176
	7	97	120	95	112	97	124	118	137	124	141	119	139	128
	8	74	104	78	113	81	106	83	109	87	112	76	86	86
	9	38	72	42	75	46	73	52	64	55	80	49	60	48
2011														
	5	160	164	158	157	161	161	162	165	166	163	164	164	162
	6	164	162	152	152	143	147	155	154	157	154	162	174	172
	7	141	134	139	147	153	157	151	150	138	136	132	138	136
	8	177	185	181	180	192	188	188	187	187	189	186	188	188
	9	86	96	89	108	82	103	96	112	90	105	96	101	84

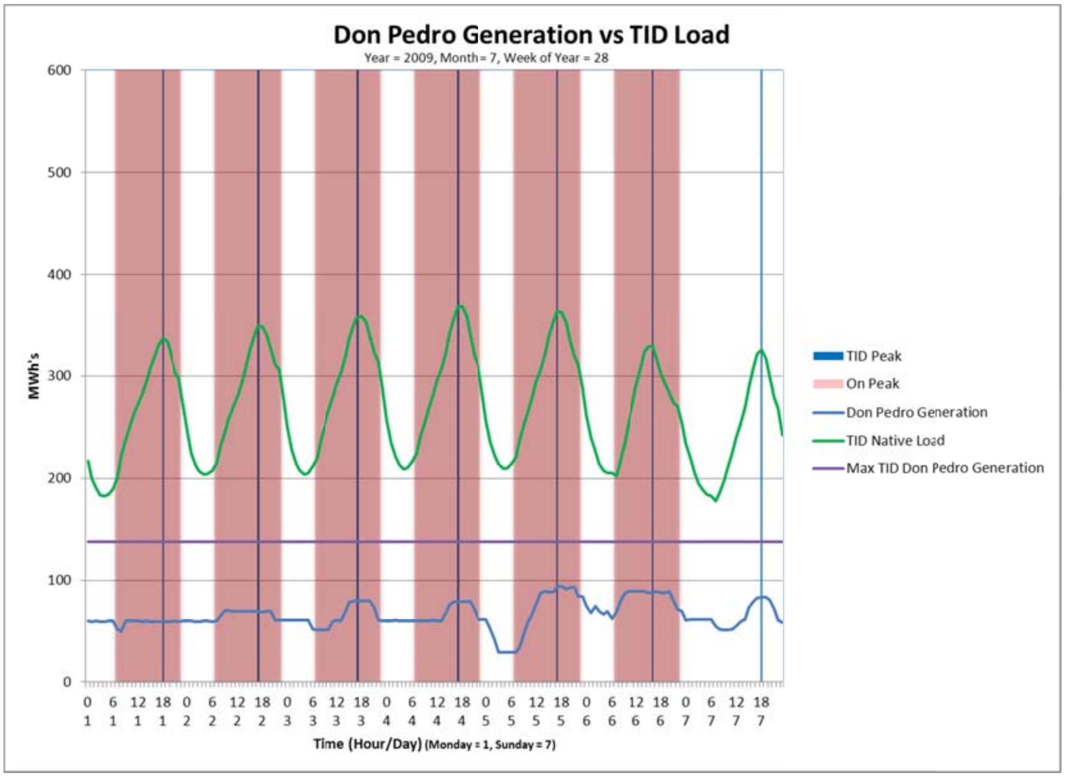

Figure 2.4-5. TID's portion of Project generation versus TID load; July 2009.

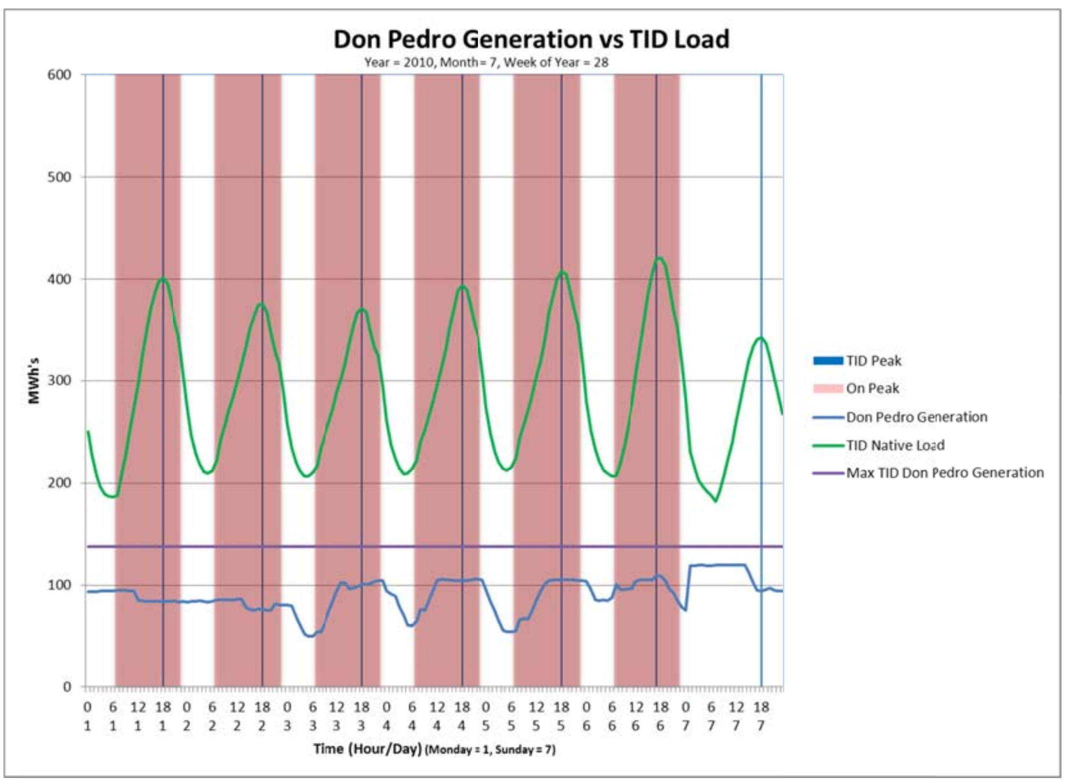

Figure 2.4-6. TID's portion of Project generation versus TID load; July 2010.

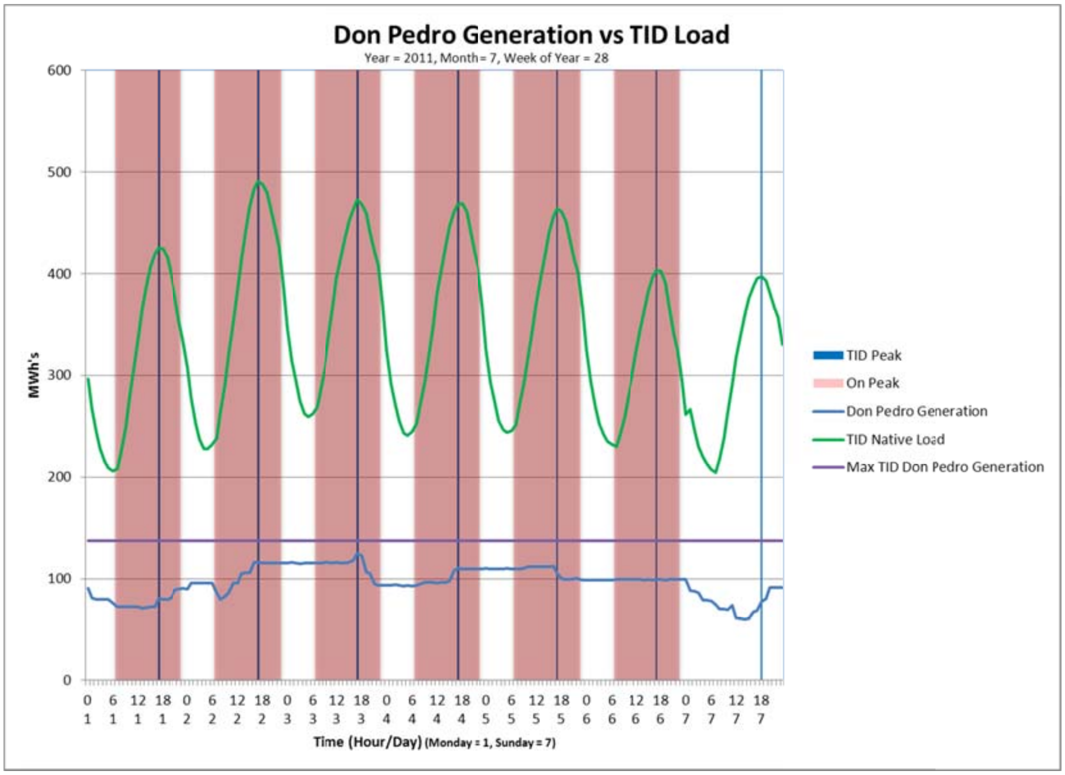

Figure 2.4-7. TID's portion of Project generation versus TID load; July 2011.

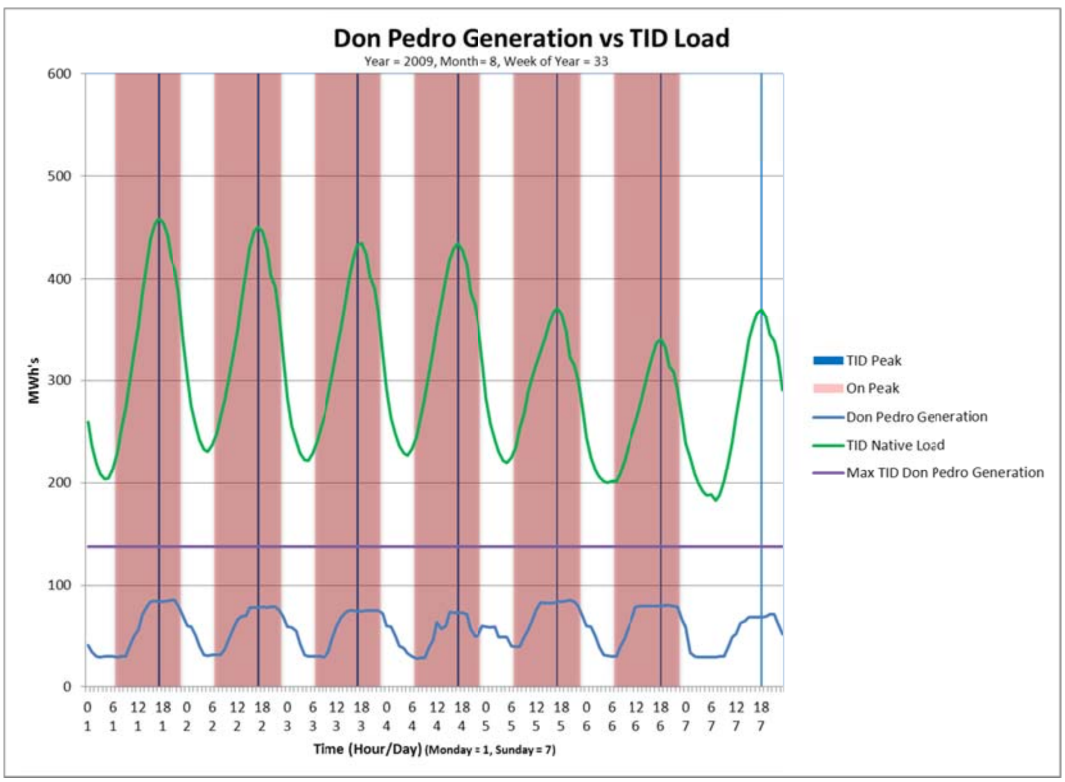

Figure 2.4-8. TID's portion of Project generation versus TID load; August 2009.

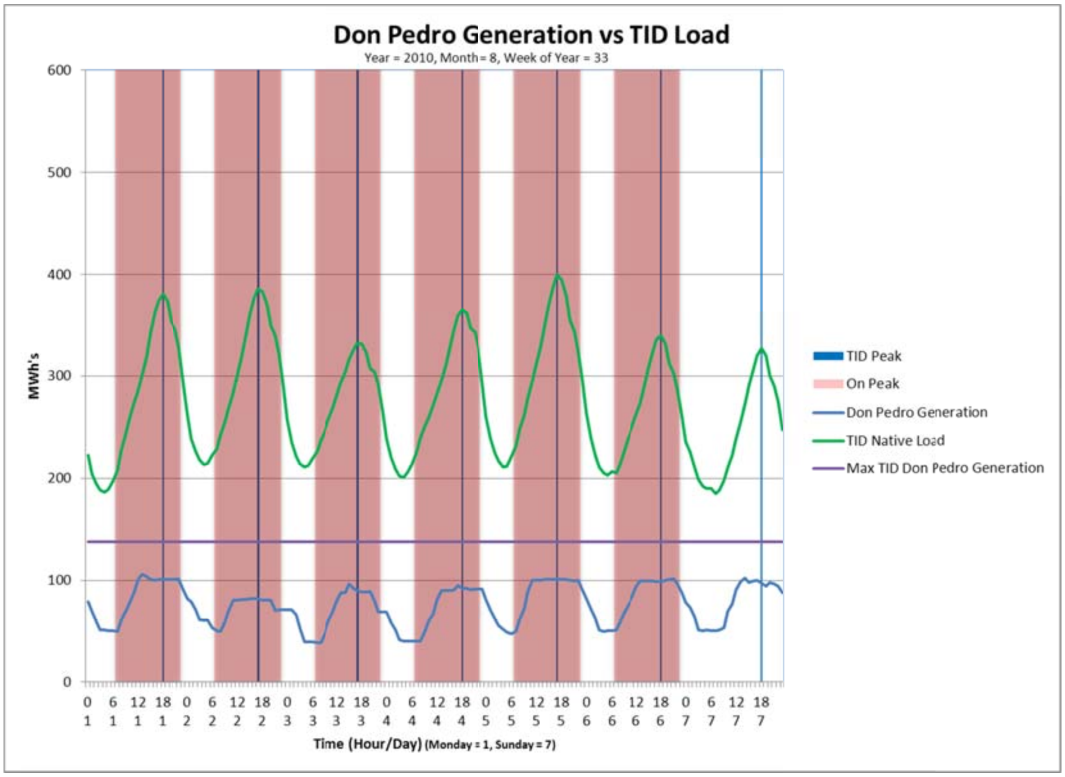

Figure 2.4-9. **TID's portion of Project generation versus TID load; August 2010.**

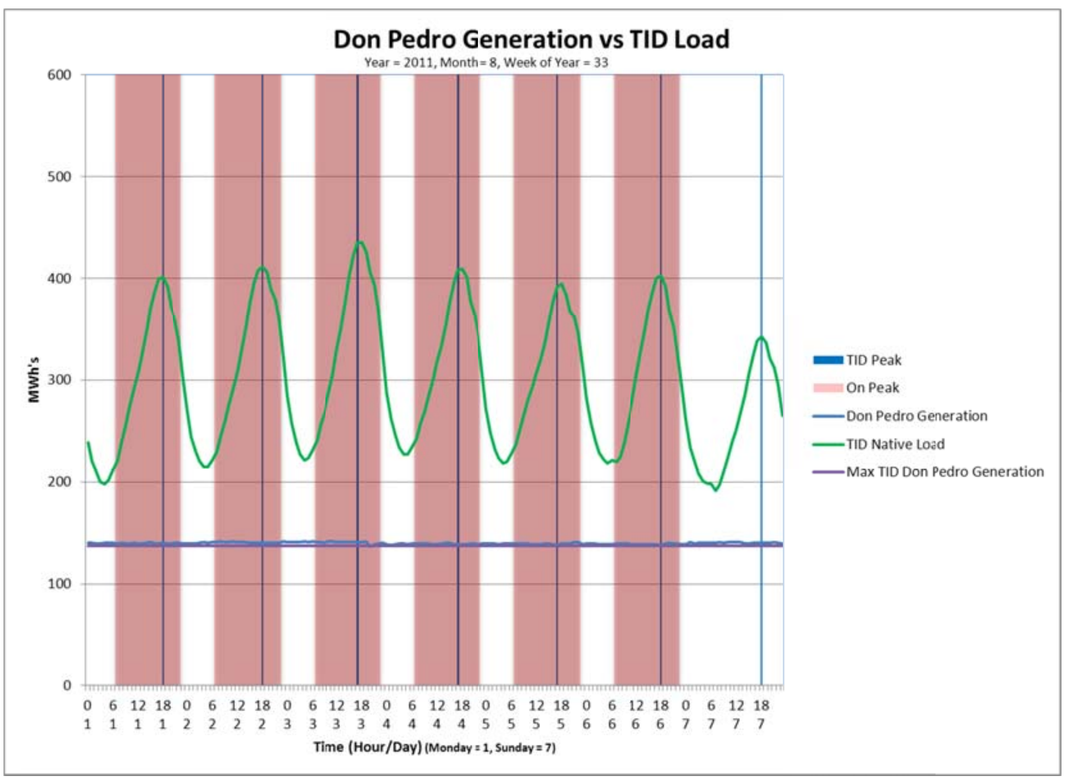

Figure 2.4-10. **TID's portion of Project generation versus TID load; August 2011.**

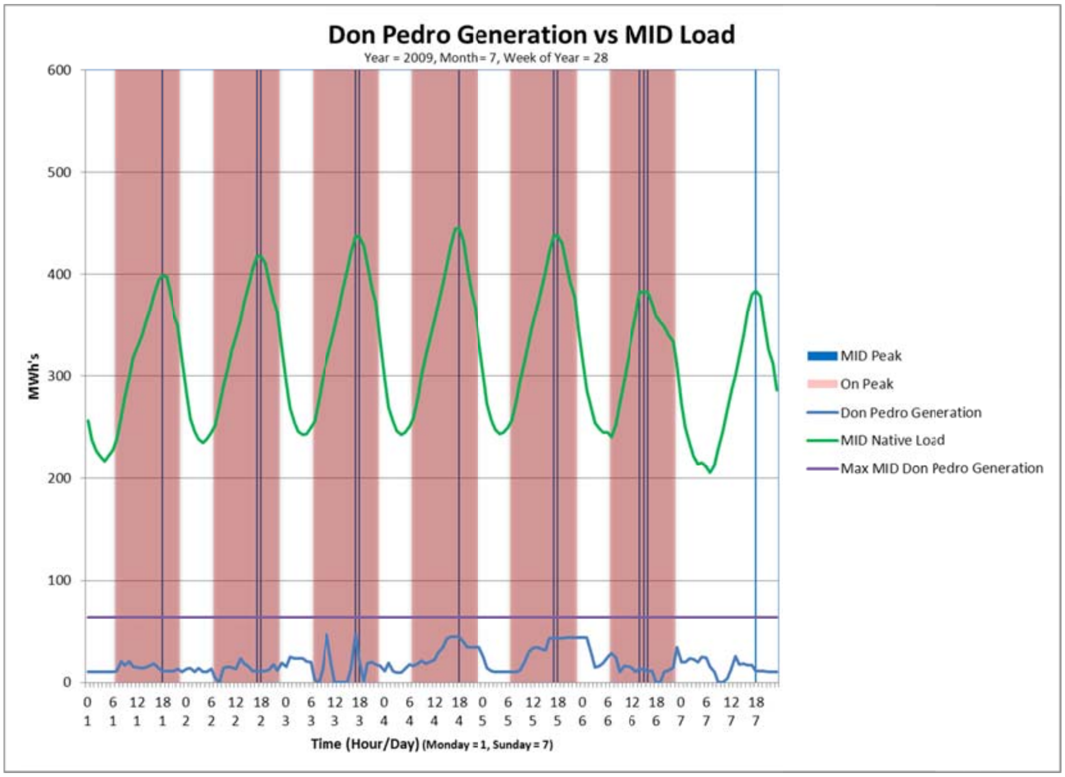

Figure 2.4-11. MID's portion of Project generation versus MID load; July 2009.

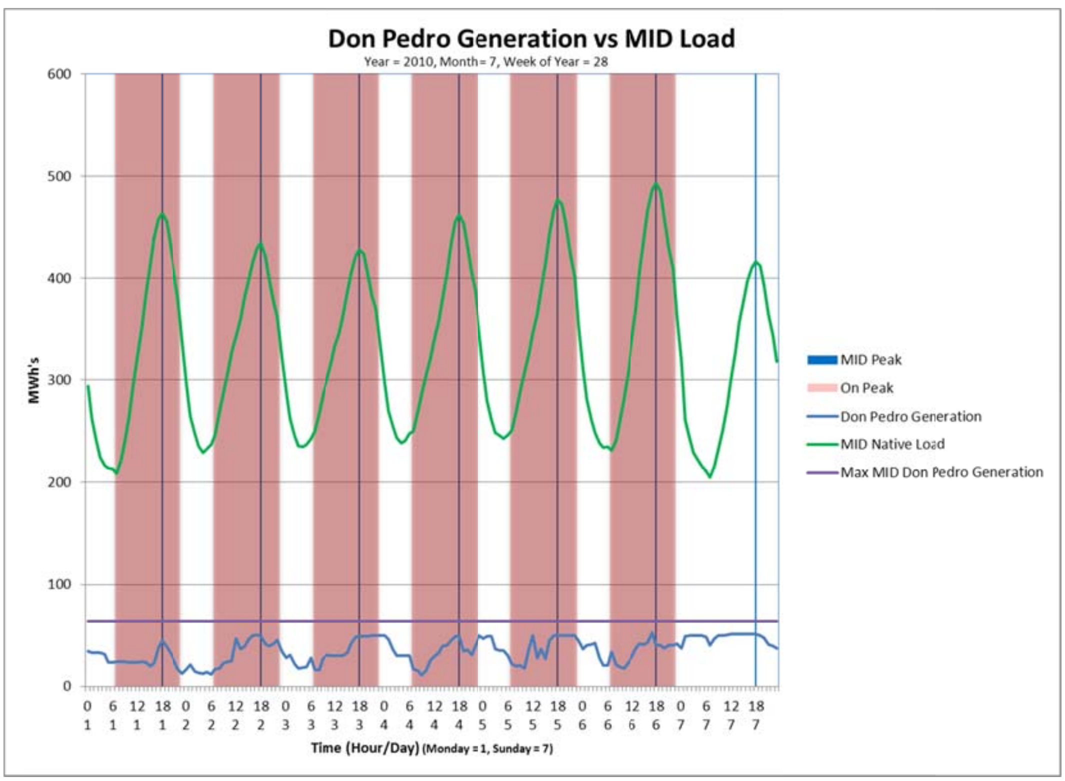

Figure 2.4-12. MID's portion of Project generation versus MID load; July 2010.

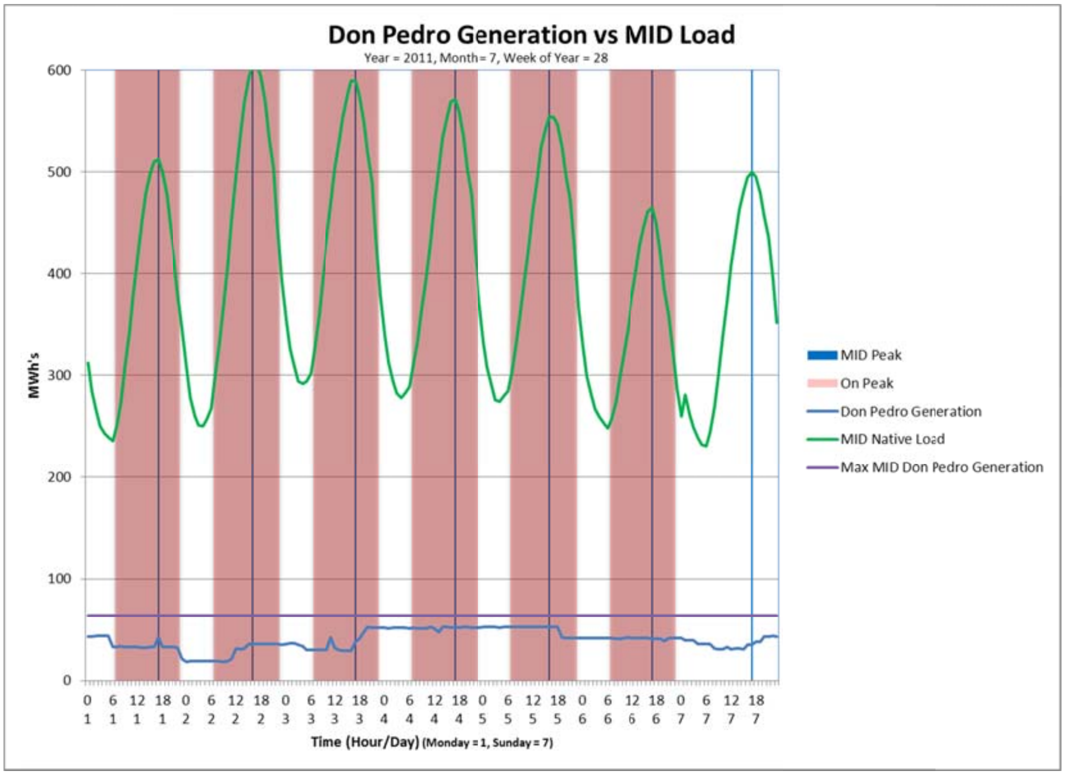

Figure 2.4-13. **MID's portion of Project generation versus MID load; July 2011.**

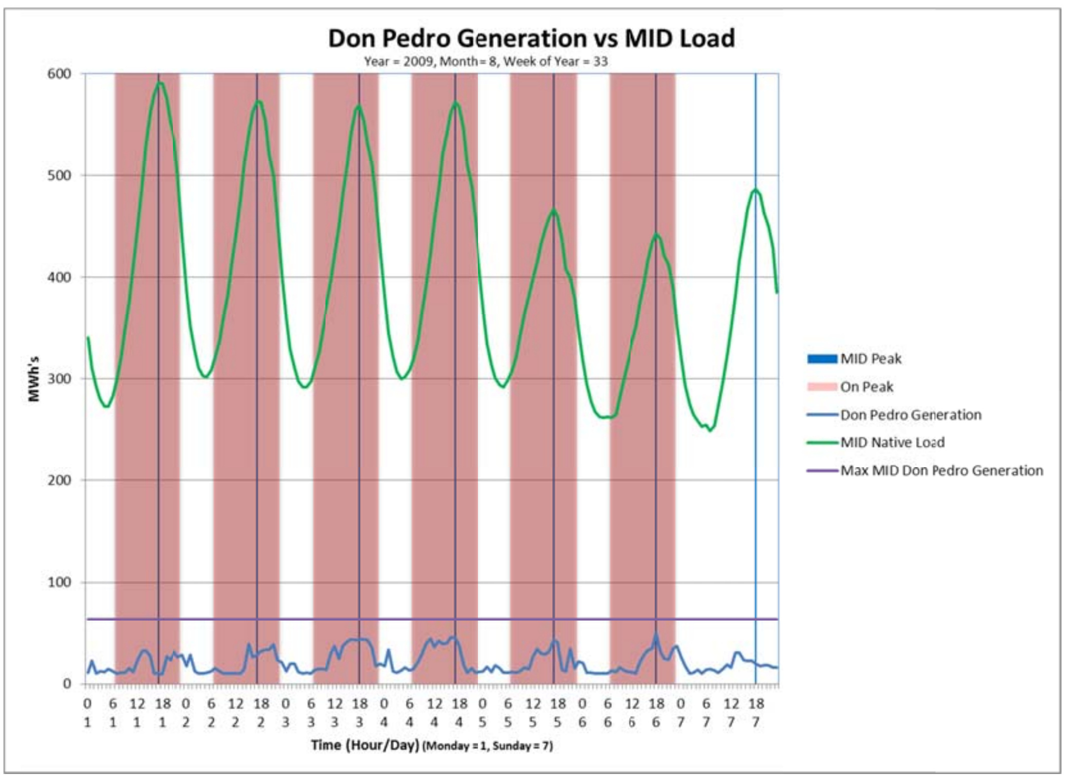

Figure 2.4-14. **MID's portion of Project generation versus MID load; August 2009.**

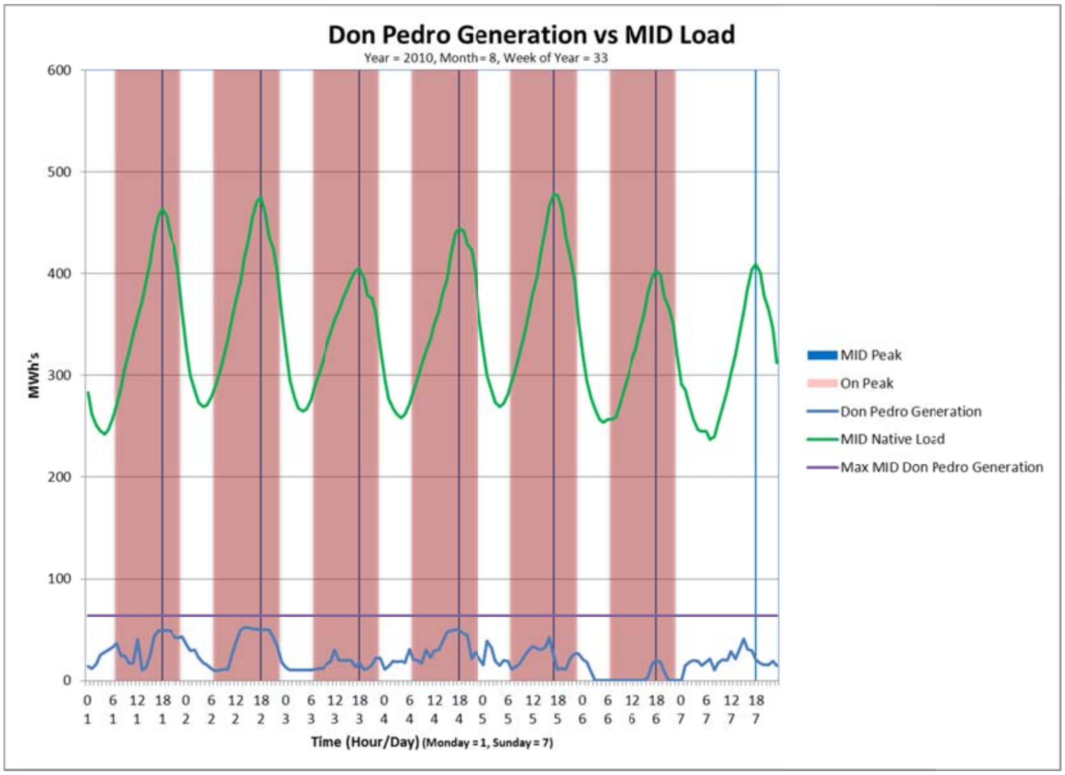

Figure 2.4-15. MID's portion of Project generation versus MID load; August 2010.

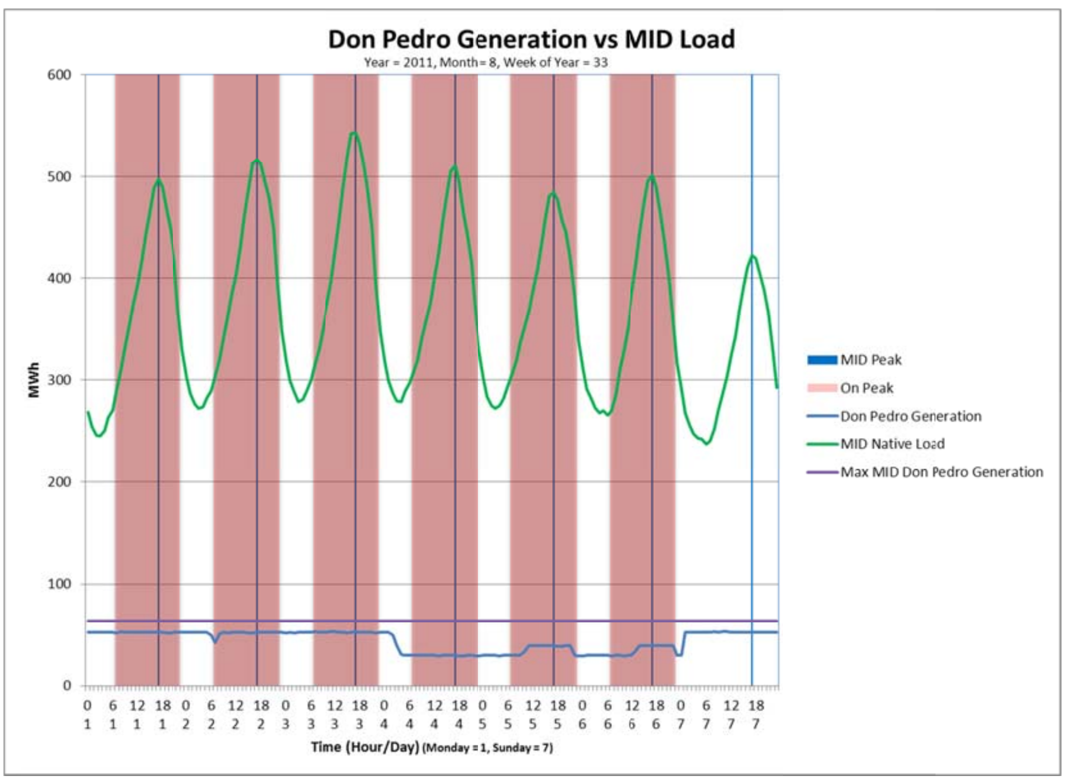

Figure 2.4-16. MID's portion of Project generation versus MID load; August 2011.

Table 2.4-5. Historical total Don Pedro Project release for the WY 1971 to 2012 (1,000 AF).

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1971	33	9	100	128	93	130	119	120	123	165	153	74	1,247
1972	86	38	50	28	36	150	101	94	129	125	118	64	1,017
1973	68	54	39	37	24	25	86	150	170	187	154	100	1,093
1974	77	43	39	86	64	84	105	161	156	183	176	180	1,354
1975	120	116	138	149	81	104	120	165	169	187	150	140	1,640
1976	134	125	148	121	101	124	144	113	158	162	140	63	1,533
1977	36	35	26	26	14	42	68	16	76	77	69	18	504
1978	7	2	9	5	26	27	120	317	148	186	178	86	1,110
1979	86	109	101	134	151	178	174	133	167	194	163	96	1,686
1980	109	63	65	281	302	377	271	285	264	187	176	197	2,578
1981	137	107	130	122	66	88	138	141	178	183	159	95	1,542
1982	42	34	46	73	163	295	513	520	278	296	207	230	2,697
1983	236	142	327	276	294	410	588	728	455	410	290	323	4,478
1984	288	104	311	367	276	280	174	182	163	180	161	93	2,580
1985	71	76	130	85	62	118	139	132	135	185	142	79	1,354
1986	57	45	62	29	110	387	426	289	246	173	144	100	2,069
1987	117	77	136	49	36	55	133	117	122	127	140	77	1,183
1988	39	43	27	13	9	106	65	40	61	137	61	29	631
1989	8	7	7	6	5	46	132	88	112	155	128	50	745
1990	14	16	24	17	20	70	108	106	104	158	135	45	817
1991	41	13	22	42	20	16	78	127	117	158	141	54	829
1992	48	9	12	16	10	27	129	139	118	143	128	62	840
1993	47	16	16	13	10	40	130	152	149	187	181	139	1,081
1994	87	23	24	41	24	98	135	106	137	159	164	68	1,066
1995	31	15	17	86	251	331	500	572	436	365	207	206	3,018
1996	175	24	24	56	295	348	270	352	187	193	171	106	2,202
1997	98	23	286	828	493	279	195	217	144	205	165	98	3,032
1998	81	29	29	141	364	368	377	291	377	335	219	171	2,783
1999	97	23	86	112	292	259	236	228	153	185	183	108	1,964
2000	81	35	44	35	135	334	195	189	166	199	201	120	1,733
2001	76	25	36	30	79	87	135	180	150	172	148	90	1,208
2002	63	13	16	15	14	100	157	139	141	172	140	83	1,052
2003	56	19	21	16	31	71	106	132	159	186	158	89	1,045
2004	87	24	17	21	33	153	179	148	145	170	143	71	1,189
2005	65	16	14	36	131	308	366	417	358	300	203	114	2,329
2006	63	31	88	301	169	309	489	609	421	226	189	116	3,011

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
2007	70	33	22	32	40	112	122	137	148	168	147	67	1,099
2008	47	22	14	12	18	101	117	152	122	148	136	70	960
2009	37	16	20	17	19	61	111	140	142	172	142	82	959
2010	51	23	17	22	23	70	142	271	291	207	168	112	1,398
2011	73	51	292	272	192	358	531	321	424	291	312	170	3,288
2012	77	37	24	79	35	70	70	171	138	170	146	90	1,108
Average	79	42	73	101	110	167	202	216	191	194	163	105	1,644
Min	7	2	7	5	5	16	65	16	61	77	61	18	504
Max	288	142	327	828	493	410	588	728	455	410	312	323	4,478

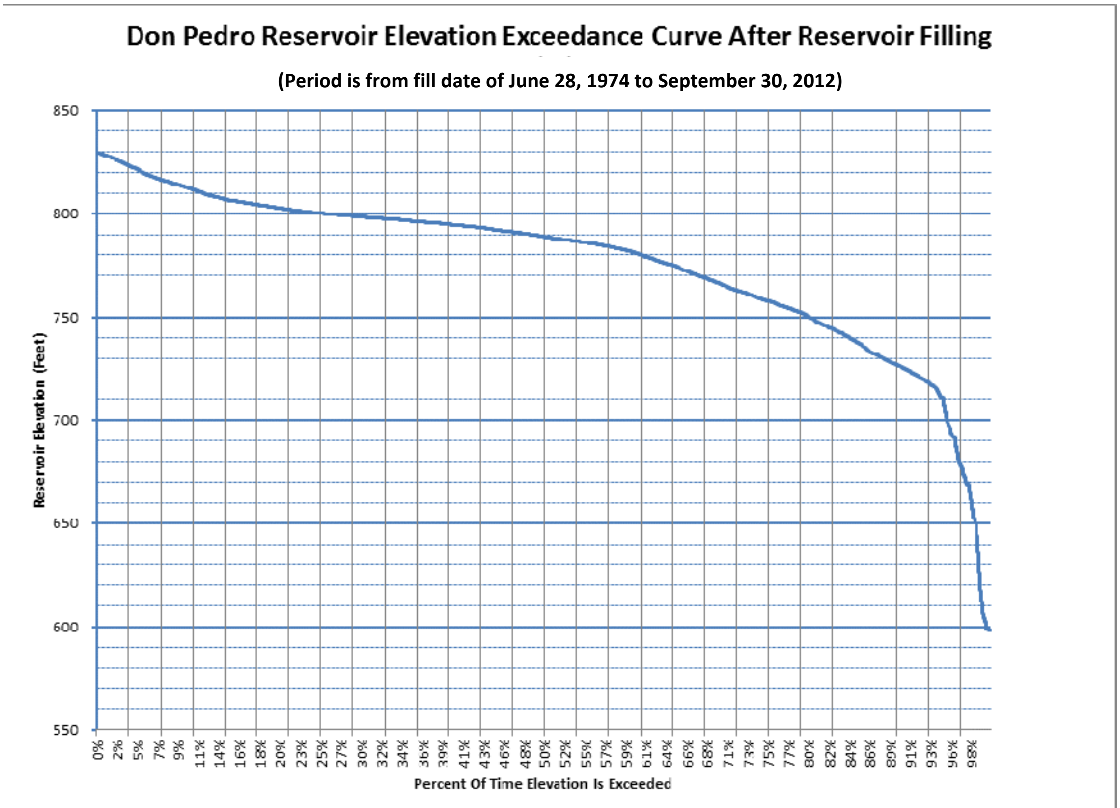

Figure 2.4-17. Don Pedro Reservoir elevation exceedance curve after initial reservoir filling.

Table 2.4-6. End of month and end of year reservoir levels for each year of the 1972 to 2012 period (AF).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1972	513,000	576,000	542,400	541,900	559,800	507,700	437,200	376,500	362,400	341,000	357,000	412,000
1973	542,000	701,000	873,000	964,000	1,057,000	1,174,000	1,056,000	958,000	913,000	904,600	977,000	1,080,000
1974	1,172,000	1,229,000	1,353,000	1,471,000	1,616,000	1,793,000	1,712,000	1,588,000	1,460,000	1,406,000	1,367,000	1,312,000
1975	1,258,000	1,353,000	1,477,000	1,537,000	1,631,000	1,849,000	1,762,000	1,677,000	1,598,000	1,538,000	1,505,000	1,446,000
1976	1,385,000	1,336,000	1,276,000	1,165,000	1,115,000	984,500	845,000	728,000	686,600	670,100	656,300	635,300
1977	619,200	614,200	581,800	524,400	525,900	458,500	383,600	319,600	306,400	304,300	322,100	365,100
1978	549,000	744,600	1,025,000	1,205,000	1,273,000	1,611,000	1,662,000	1,572,000	1,575,000	1,560,000	1,528,000	1,508,000
1979	1,537,000	1,563,000	1,613,000	1,630,000	1,826,000	1,877,000	1,757,000	1,648,000	1,605,000	1,566,000	1,569,000	1,597,000
1980	1,698,000	1,754,000	1,625,000	1,590,000	1,727,000	1,812,000	1,935,000	1,864,000	1,744,000	1,677,000	1,620,000	1,546,000
1981	1,504,000	1,481,000	1,495,000	1,465,000	1,459,000	1,377,000	1,258,000	1,160,000	1,120,000	1,130,000	1,180,000	1,300,000
1982	1,480,000	1,660,000	1,720,000	1,780,000	1,800,000	2,000,000	2,000,000	1,880,000	1,750,000	1,650,000	1,707,000	1,682,000
1983	1,686,000	1,730,000	1,884,000	1,671,000	1,469,000	1,825,000	2,016,000	1,932,000	1,702,000	1,521,000	1,688,000	1,766,000
1984	1,619,000	1,526,000	1,434,000	1,425,000	1,616,000	1,740,000	1,649,000	1,547,000	1,510,000	1,504,000	1,523,000	1,485,000
1985	1,496,000	1,537,000	1,546,000	1,555,000	1,536,000	1,459,000	1,325,000	1,238,000	1,212,000	1,200,000	1,207,000	1,218,000
1986	1,309,000	1,720,000	1,724,000	1,596,000	1,731,000	1,849,000	1,796,000	1,712,000	1,671,000	1,614,000	1,601,000	1,518,000
1987	1,516,000	1,524,000	1,527,000	1,435,000	1,349,000	1,239,000	1,120,000	993,600	932,600	909,600	876,600	874,500
1988	939,200	982,200	916,000	929,700	961,300	1,003,000	936,300	917,500	930,500	959,300	991,100	1,022,000
1989	1,056,000	1,098,000	1,183,000	1,174,000	1,223,000	1,278,000	1,166,000	1,082,000	1,070,000	1,102,000	1,135,000	1,167,000
1990	1,210,000	1,262,000	1,297,000	1,289,000	1,249,000	1,221,000	1,096,000	998,100	992,000	974,700	1,013,000	1,020,000
1991	1,005,000	993,600	1,067,000	1,085,000	1,122,000	1,134,000	1,050,000	968,700	946,600	934,100	955,400	977,000
1992	1,004,000	1,079,000	1,160,000	1,160,000	1,101,000	1,018,000	911,500	814,300	781,400	748,700	758,400	815,900
1993	1,064,000	1,234,000	1,476,000	1,595,000	1,776,000	1,966,000	1,954,000	1,808,000	1,690,000	1,611,000	1,602,000	1,592,000
1994	1,571,000	1,592,000	1,635,000	1,614,000	1,650,000	1,578,000	1,453,000	1,325,000	1,270,000	1,255,000	1,318,000	1,412,000
1995	1,671,000	1,622,000	1,812,000	1,674,000	1,731,000	1,810,000	2,024,000	1,947,000	1,772,000	1,624,000	1,607,000	1,633,000
1996	1,691,000	1,735,000	1,703,000	1,724,000	1,849,000	1,960,000	1,875,000	1,749,000	1,690,000	1,624,000	1,677,000	1,799,000
1997	1,880,000	1,633,586	1,594,460	1,625,922	1,763,500	1,864,438	1,744,978	1,633,586	1,588,010	1,551,000	1,536,000	1,542,000
1998	1,618,000	1,678,000	1,667,000	1,626,000	1,696,000	1,919,000	2,017,000	1,864,000	1,714,000	1,633,000	1,653,000	1,644,000
1999	1,656,000	1,664,000	1,645,000	1,656,000	1,795,000	1,958,000	1,861,000	1,718,000	1,638,000	1,579,000	1,559,000	1,529,000
2000	1,590,000	1,735,000	1,704,000	1,774,000	1,910,000	1,992,000	1,881,000	1,748,000	1,691,000	1,655,000	1,643,000	1,631,000
2001	1,643,000	1,651,000	1,679,000	1,673,000	1,650,000	1,528,000	1,384,000	1,267,000	1,198,000	1,146,000	1,153,000	1,260,000
2002	1,397,000	1,471,000	1,527,000	1,538,000	1,573,000	1,566,000	1,425,000	1,315,000	1,254,000	1,215,000	1,247,000	1,300,000
2003	1,375,000	1,414,000	1,434,000	1,510,000	1,675,000	1,843,000	1,698,000	1,572,000	1,515,000	1,441,000	1,445,000	1,480,000
2004	1,538,170	1,620,464	1,681,302	1,688,039	1,697,054	1,677,941	1,526,680	1,396,748	1,331,765	1,292,796	1,325,209	1,380,280
2005	1,574,102	1,661,185	1,704,972	1,640,178	1,902,345	2,009,383	1,944,629	1,769,319	1,675,703	1,634,683	1,619,374	1,706,105
2006	1,663,409	1,646,790	1,695,925	1,829,509	1,882,706	2,002,962	1,934,620	1,770,484	1,667,862	1,611,760	1,597,693	1,599,851
2007	1,606,339	1,643,481	1,641,278	1,609,590	1,611,760	1,524,598	1,400,645	1,301,072	1,267,304	1,239,501	1,222,692	1,222,692

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	1,290,962	1,367,788	1,364,917	1,385,108	1,344,952	1,347,790	1,223,572	1,110,427	1,053,229	1,026,576	1,035,928	1,046,127
2009	1,097,342	1,199,959	1,346,844	1,419,267	1,717,470	1,761,177	1,628,109	1,513,185	1,443,060	1,413,366	1,406,506	1,427,165
2010	1,490,556	1,552,889	1,645,686	1,744,978	1,899,882	2,009,383	1,903,600	1,755,379	1,660,075	1,643,481	1,665,634	1,716,331
2011	1,624,829	1,639,078	1,726,603	1,583,721	1,722,032	1,917,201	2,015,820	1,780,998	1,632,490	1,581,579	1,579,440	1,576,236
2012	1,525,639	1,514,220	1,522,518	1,652,315	1,672,350	1,577,303	1,430,135	1,301,995	1,223,572	1,183,542	1,189,571	1,327,080
2013	1,372,582	1,398,696	1,408,463	1,469,199	1,472,235	1,389,949	1,252,889	1,135,262	1,077,149	1,024,248	1,026,576	1,033,585
Years	44	44	44	44	44	44	44	44	44	44	44	44
Mean	1,307,112	1,354,767	1,396,747	1,403,980	1,468,300	1,527,087	1,457,565	1,347,165	1,281,739	1,242,901	1,256,160	1,280,117
Max	1,880,000	1,754,000	1,884,000	1,829,509	1,910,000	2,009,383	2,024,000	1,947,000	1,772,000	1,677,000	1,707,000	1,799,000
Min	179,300	157,700	181,100	180,100	262,100	290,500	242,200	150,100	111,000	146,500	241,000	282,400
Standard Deviation	407,390	396,064	389,676	382,659	409,724	457,627	483,721	466,092	434,559	411,357	401,811	392,285

The original gross storage capacity of Don Pedro Reservoir, including storage capacity in old Don Pedro Reservoir, was 2,030,000 AF at elevation 830 ft and 2,300,000 AF at 850 ft mean sea level (NGVD 29)[7]. In 2011, the Districts, as part of their development of a three-dimensional water temperature model of the Don Pedro Reservoir, undertook a reservoir bathymetry study to update the elevation-storage relationship following over 40 years of new Don Pedro Project operations and almost 90 years since the original construction of the old Don Pedro Dam in 1923. The 2011 bathymetry study indicated that the storage volume of the reservoir at elevation 830 ft is 2,014,306 AF. The resulting elevation-storage curve is provided in Figure 2.4-18. The bathymetry study found that the reservoir has lost less than one percent of its 2,030,000 AF of storage capacity at elevation 830 ft. This is likely due to the character of the watershed above Don Pedro, which primarily consists of undisturbed national park and national forest lands and the predominance of shallow soils and durable bedrock, and the existence of the three upstream reservoirs owned and operated by CCSF.

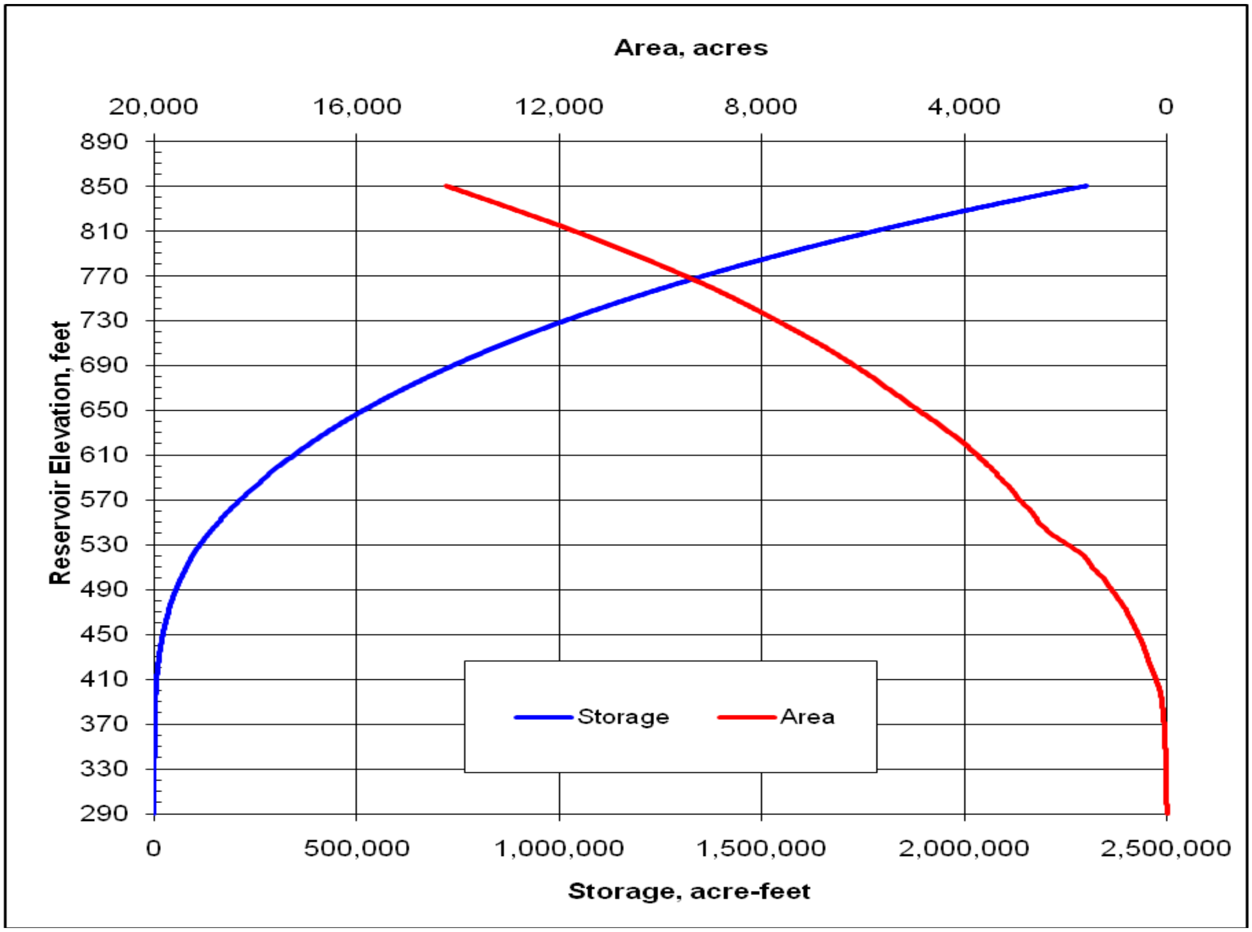

Figure 2.4-18. Don Pedro area-capacity curve based on 2011 bathymetry.

7 All elevations are NGVD 29.

2.4.9 Current Reservoir Recreation

Recreational use of the Don Pedro Reservoir is substantial. The recreation facilities are operated by the Don Pedro Recreation Agency (DPRA), an agency that is operationally a department within TID and sponsored by the Districts and CCSF. DPRA is responsible for managing the use of all lands within the Project Boundary.

As part of its responsibilities, DPRA manages, operates, and maintains the developed recreation facilities and lake surface facilities. DPRA also manages the campsite reservation system, entry gate administration, and maintenance of all associated facilities (drinking water plant, filtration plant, wastewater treatment plants, and solid waste disposal). The DPRA headquarters building overlooking Don Pedro Dam burned to the ground in 2016. The Districts are developing plans and designs for a new headquarters building located closer to the Fleming Meadows Recreation Area.

DPRA provides oversight of concessionaires licensed to provide services on the reservoir. DPRA activities also include some non-recreational management issues such as debris management at the upstream end of the reservoir with collection, corralling, and wintertime disposal of woody debris that accumulates where the Tuolumne River flows into the reservoir.

Recreation activities at the Don Pedro Reservoir include individual and group activities and organized and spontaneous events for both reserved and at-the-gate participants. Motorized and non-motorized boating, houseboating, camping and RV camping, waterskiing and wakeboarding, jet-skiing, fishing (including scheduled bass tournaments), swimming, and hiking are all recreation opportunities available at Don Pedro.

Typical annual recreational use at the Don Pedro Project exceeds 407,000 visitor-days (10 year average, 1999–2008), primarily comprised of use by local area residents from nearby counties (47 percent of use in 2008), and use by Bay Area residents (31.5 percent in 2008).

Dispersed use of the majority of the undeveloped Don Pedro Reservoir shoreline is permitted, including both daytime and overnight use. Use of some shoreline areas is restricted due to conditions such as on-shore hazards or potential for nuisance activity to adjacent property owners. Boat launching is only permitted at the designated launch ramps found in each of the three developed recreation areas.

DPRA maintains shoreline restrooms at five locations, in addition to those at the developed recreation areas, and floating restrooms on anchored platforms at six locations throughout the reservoir. Floating restrooms are located in areas with significant recreation but no shoreline or developed services.

2.4.10 Don Pedro Project Operations During Normal, Dry, and Wet Years

The Don Pedro Project was developed to provide reliable water storage for the irrigation and M&I water uses of the Districts’ customers and a water bank to ensure a reliable water supply for CCSF’s Bay Area customers. To accomplish the first of these purposes, sufficient carry-over storage is needed to provide reliable water supplies through drought periods. To accomplish the second purpose, CCSF must maintain a positive balance in the water bank or the Districts must consent to the balance going negative. Subsequent to the implementation of the 1995 Settlement Agreement, the first full year of which was WY 1997, both wet and dry year-types have occurred. The period WY 2001 through 2004 was relatively dry, with total unimpaired flow at La Grange gage averaging 1.37 million AF per year, or 70 percent of the long-term average. The longest drought since 1971 was the drought of 1987 through 1992 inclusive, which experienced an average annual unimpaired flow of 0.9 million AF over a six-year period, or 46 percent of the long-term average runoff. The extended drought of 2012 through 2015 saw a mean annual unimpaired flow of 0.8 million AF with driest year being 2015 with an estimated unimpaired runoff of 585,000 AF, or 30 percent of the average annual runoff. The two-year period of 1976-1977 was also dry, with 1977 being the driest year in the last 100 years with an annual runoff of 351,000 AF. The wettest year in the 1997 to 2012 period was WY 2011, with 1998 and 2006 also being wet years. The overall operation of the Don Pedro Project is shown for each year of the 1997 through 2012 period by calendar year in Figures 2.4-19 through 2.4-34.

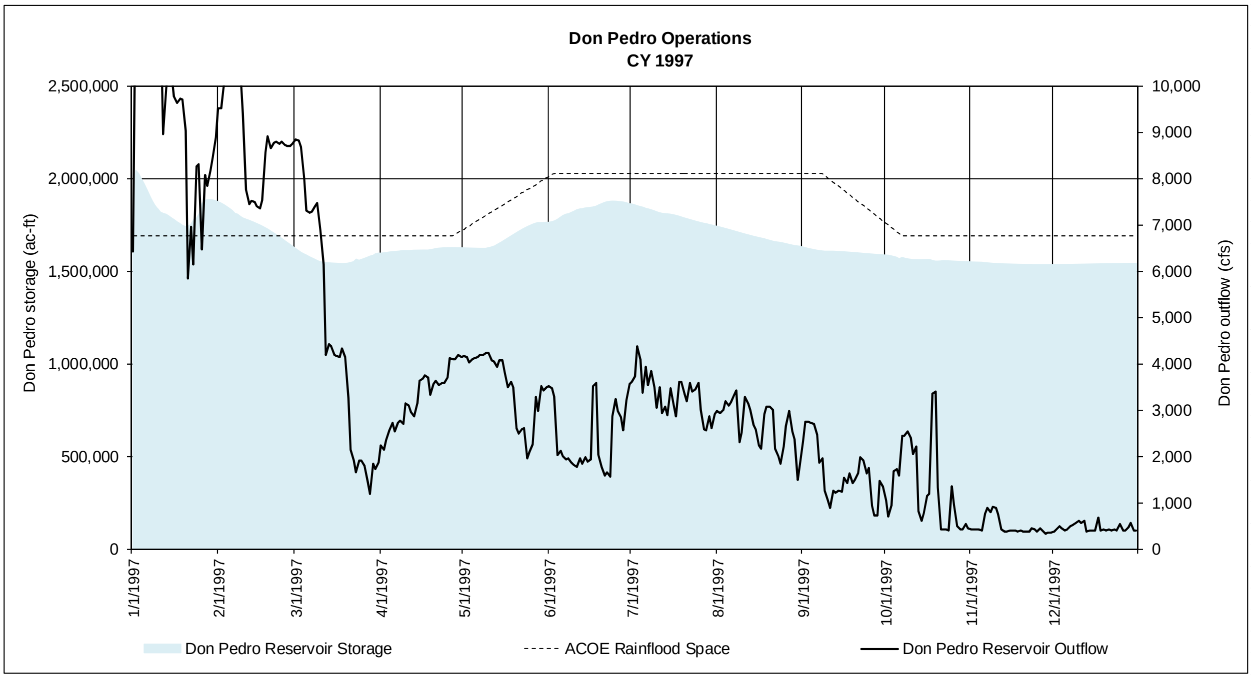

Figure 2.4-19. Don Pedro Project operations – 1997 (wet).

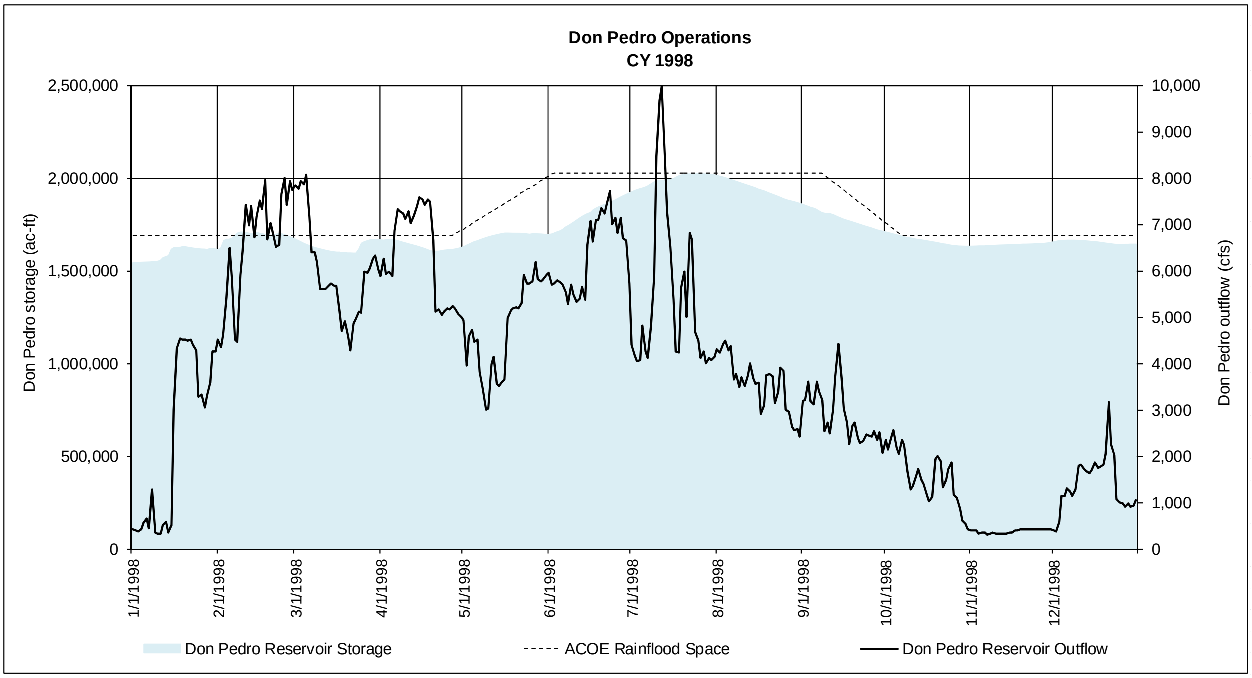

Figure 2.4-20. Don Pedro Project operations – 1998 (wet).

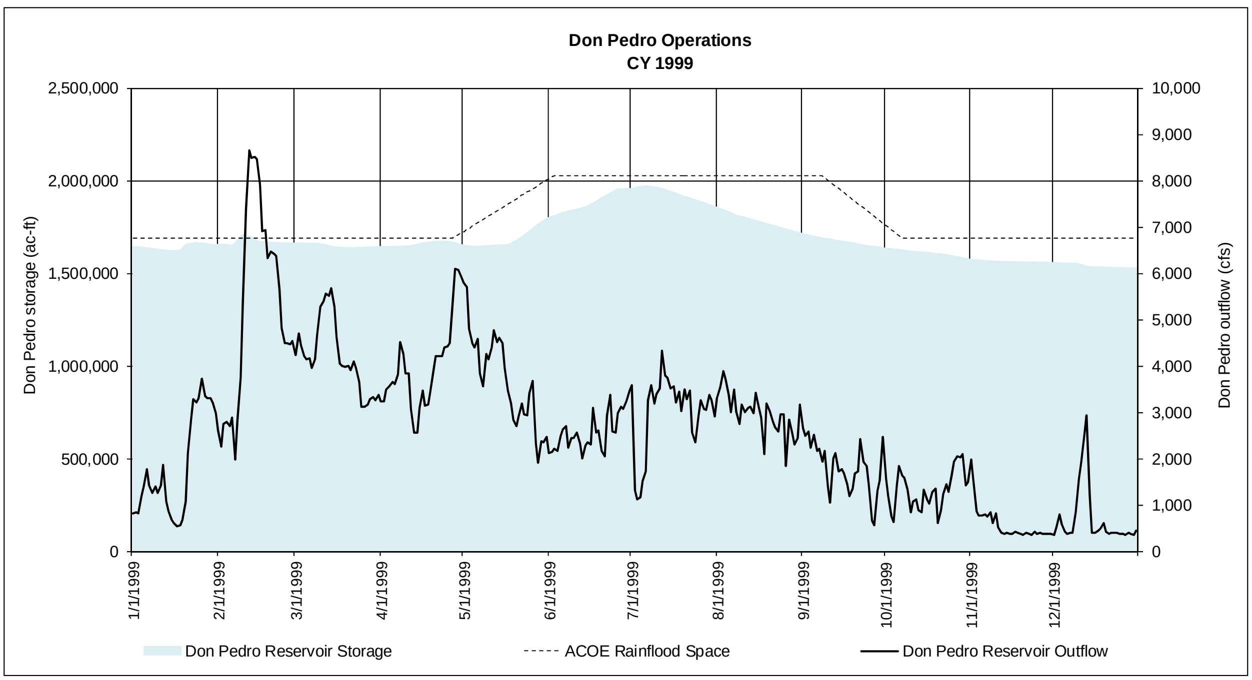

Figure 2.4-21. Don Pedro Project operations – 1999 (above normal).

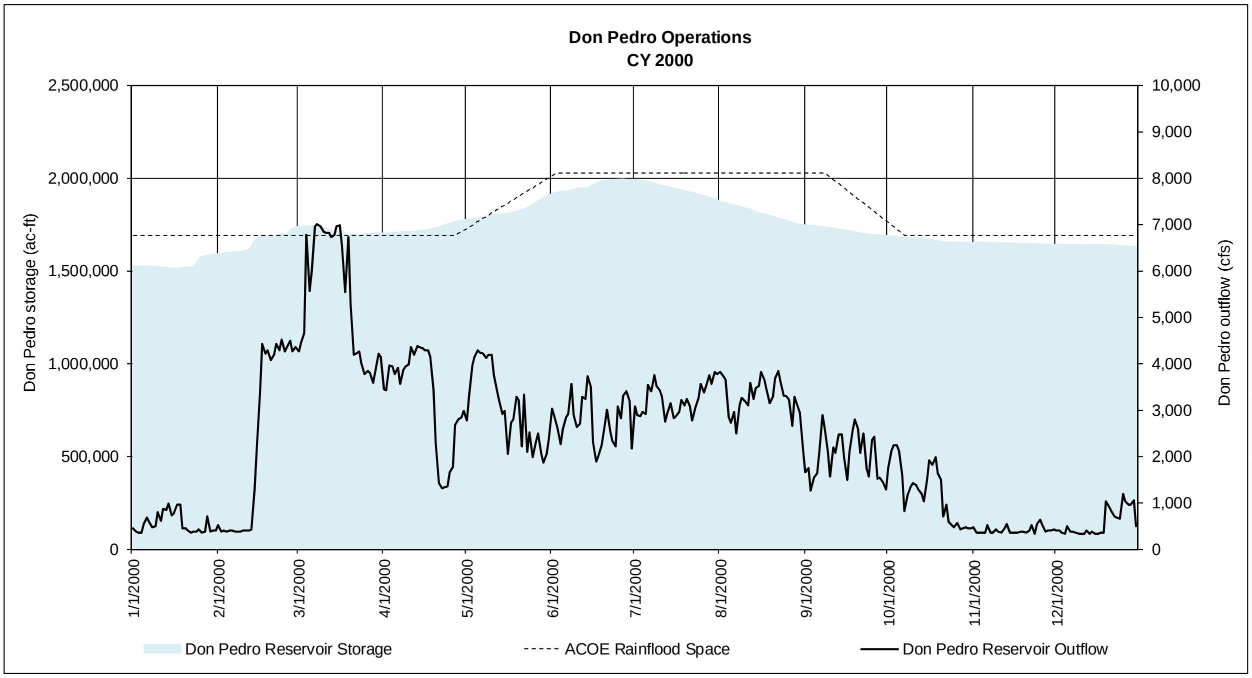

Figure 2.4-22. Don Pedro Project operations – 2000 (normal).

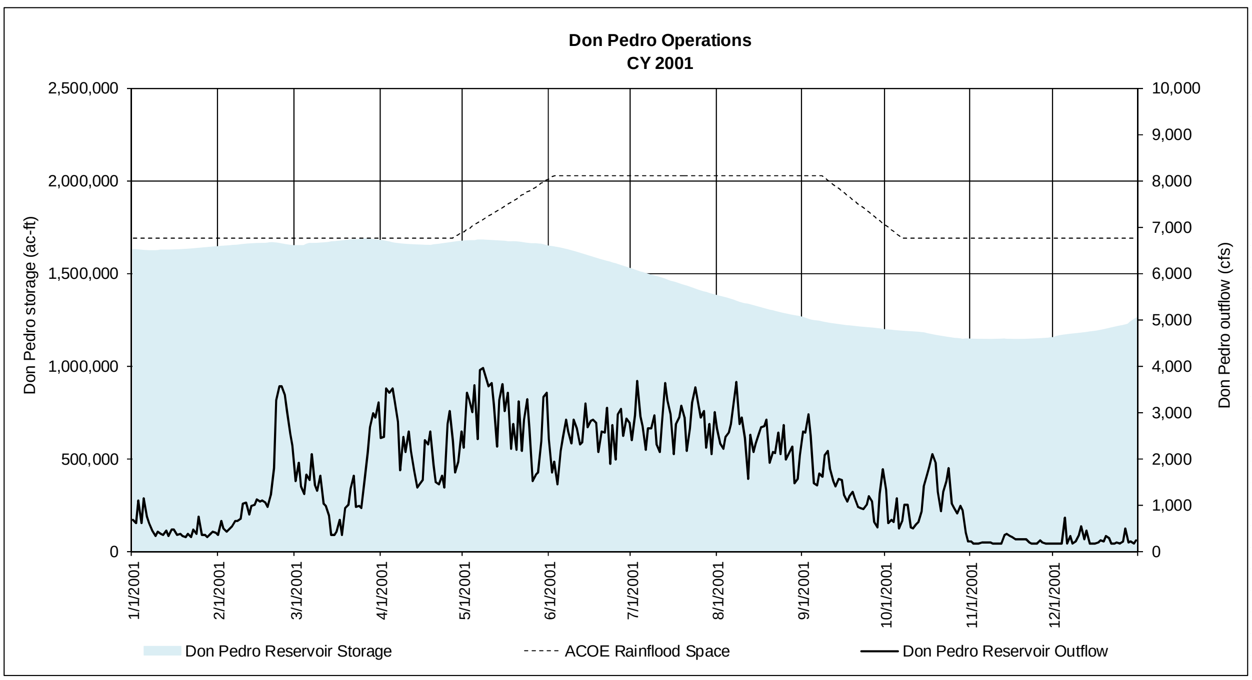

Figure 2.4-23. Don Pedro Project operations – 2001 (below normal).

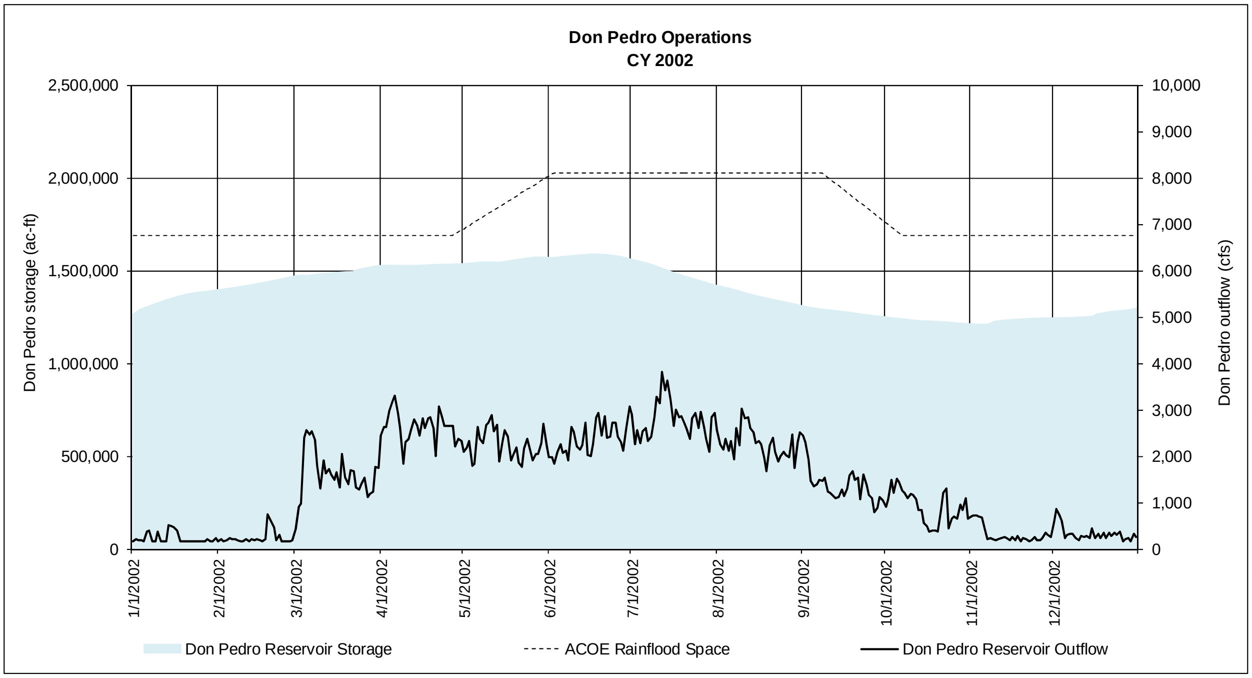

Figure 2.4-24. Don Pedro Project operations – 2002 (below normal).

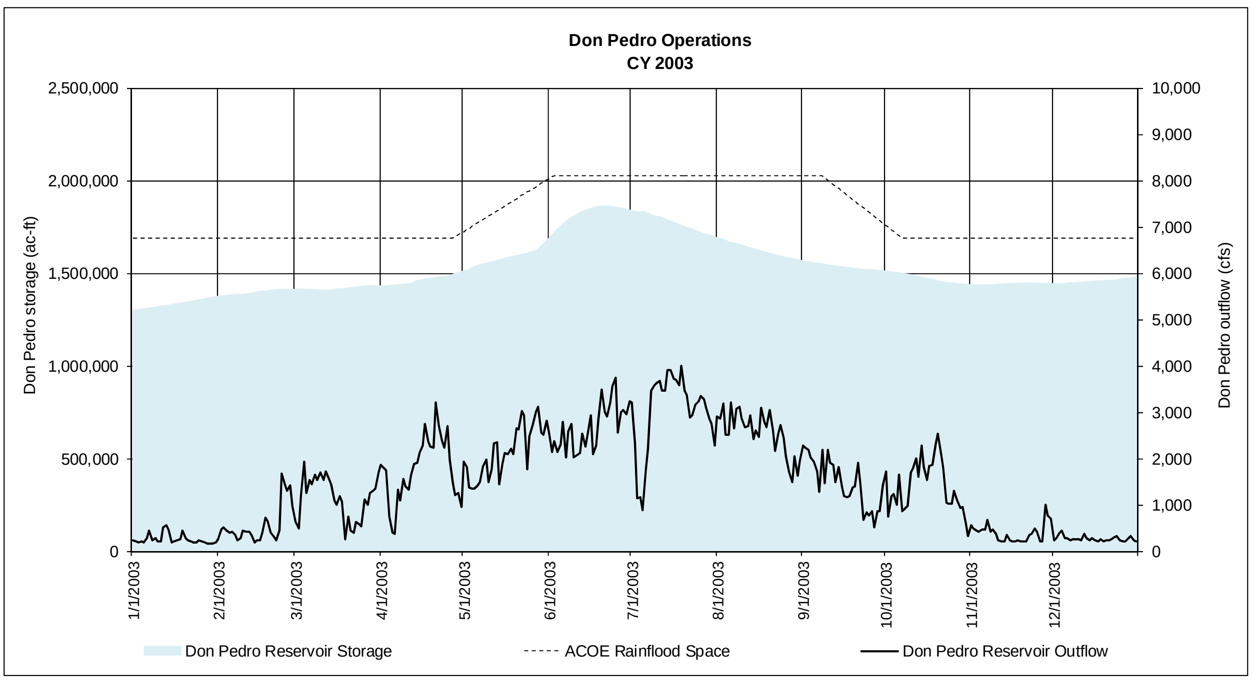

Figure 2.4-25. Don Pedro Project operations – 2003 (normal).

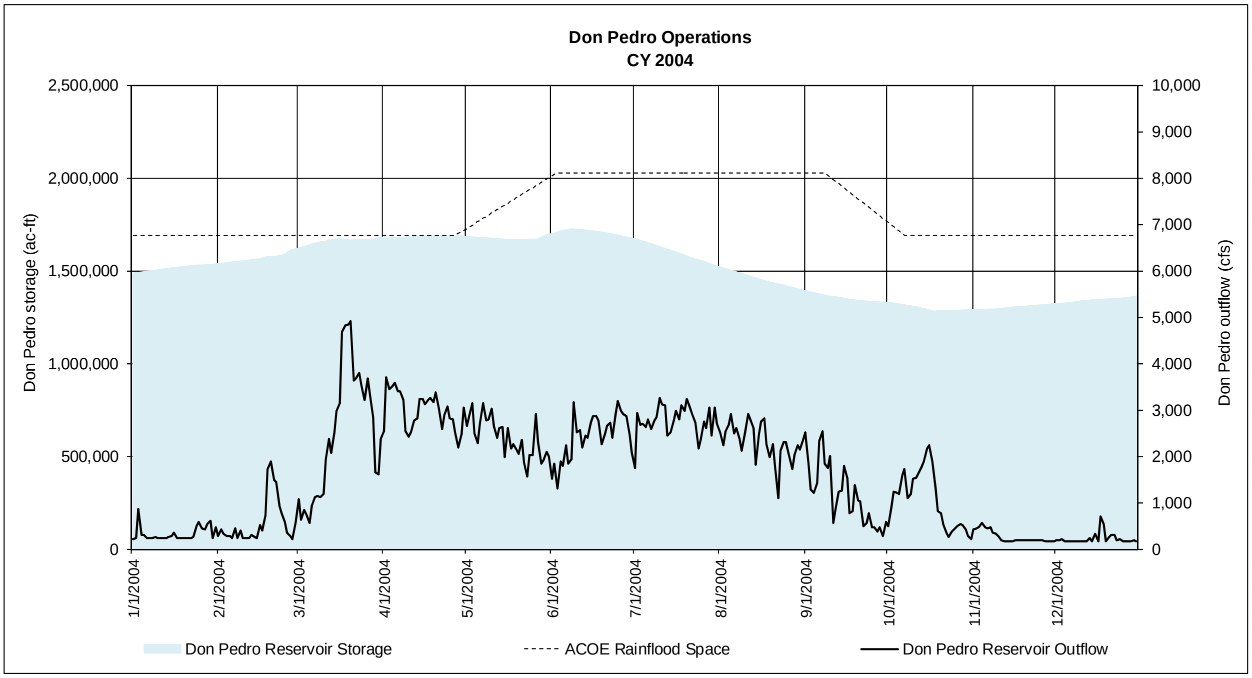

Figure 2.4-26. Don Pedro Project operations – 2004 (below normal).

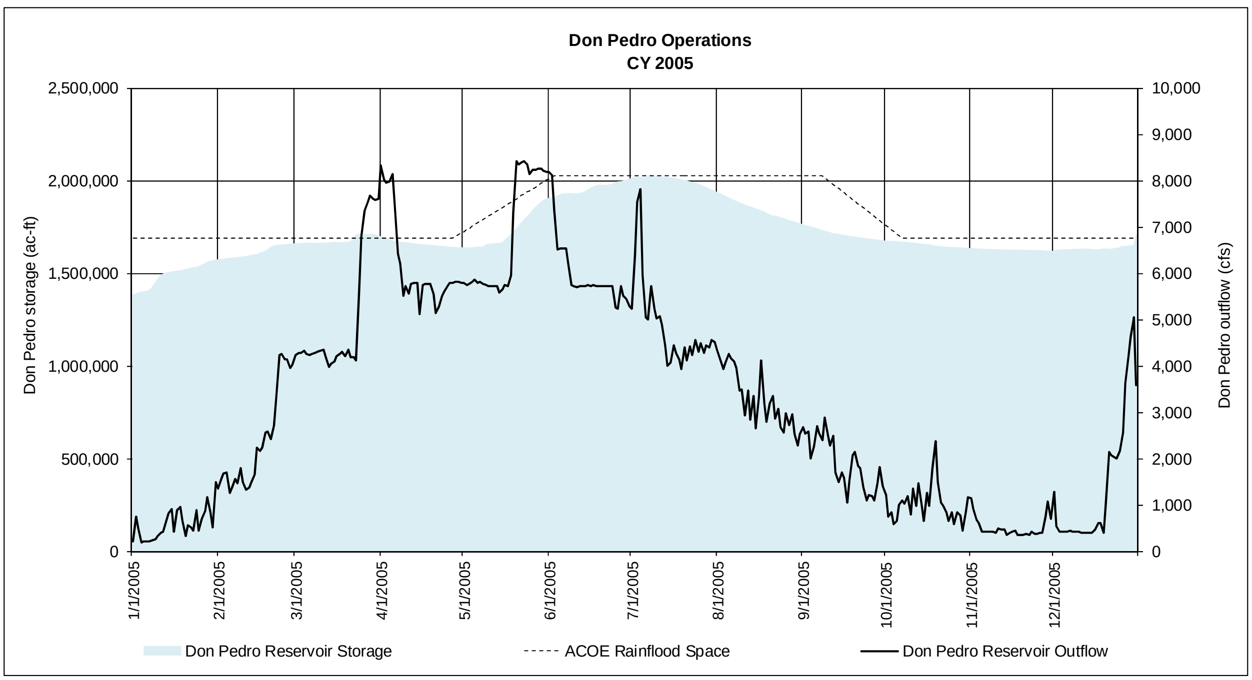

Figure 2.4-27. Don Pedro Project operations – 2005 (wet).

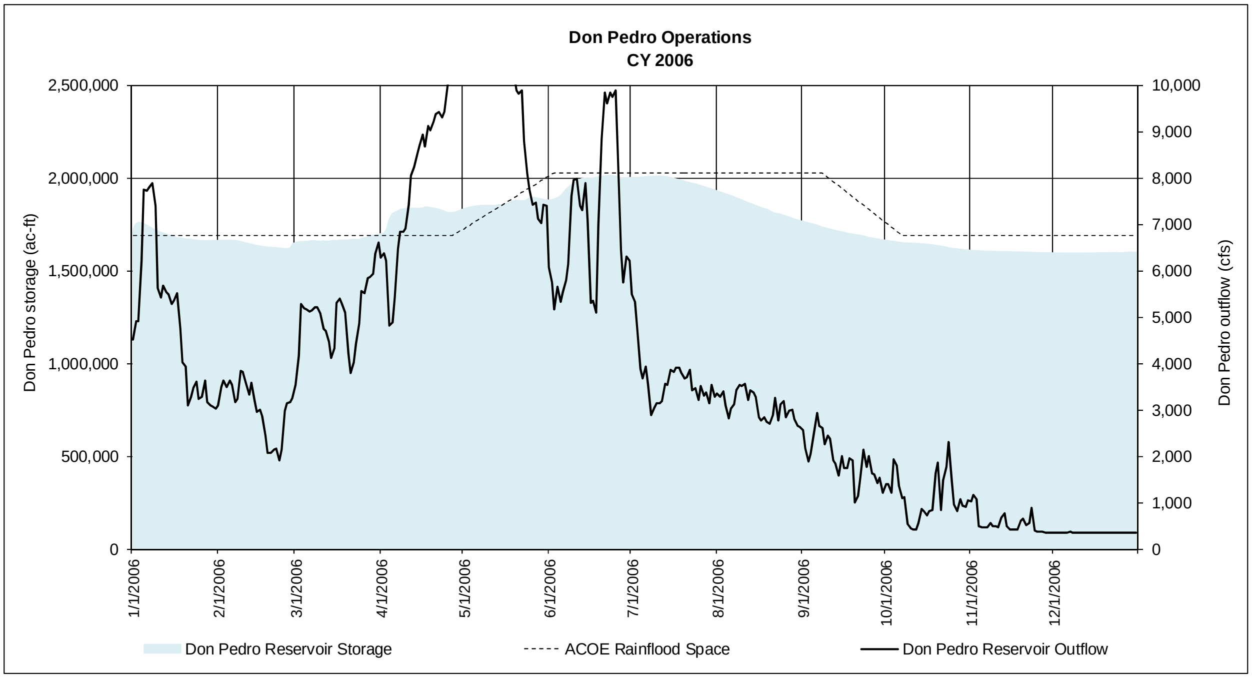

**Figure 2.4-28.	Don Pedro Project operations – 2006 (wet).**

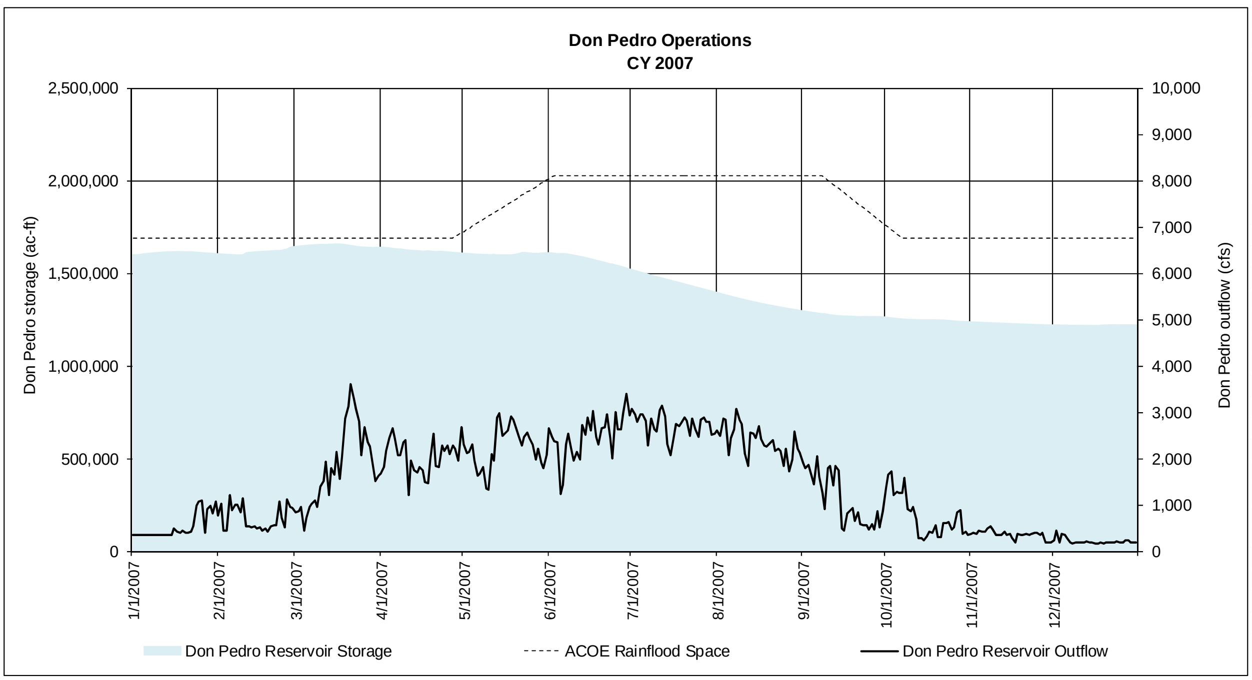

**Figure 2.4-29.	Don Pedro Project operations – 2007 (dry).**

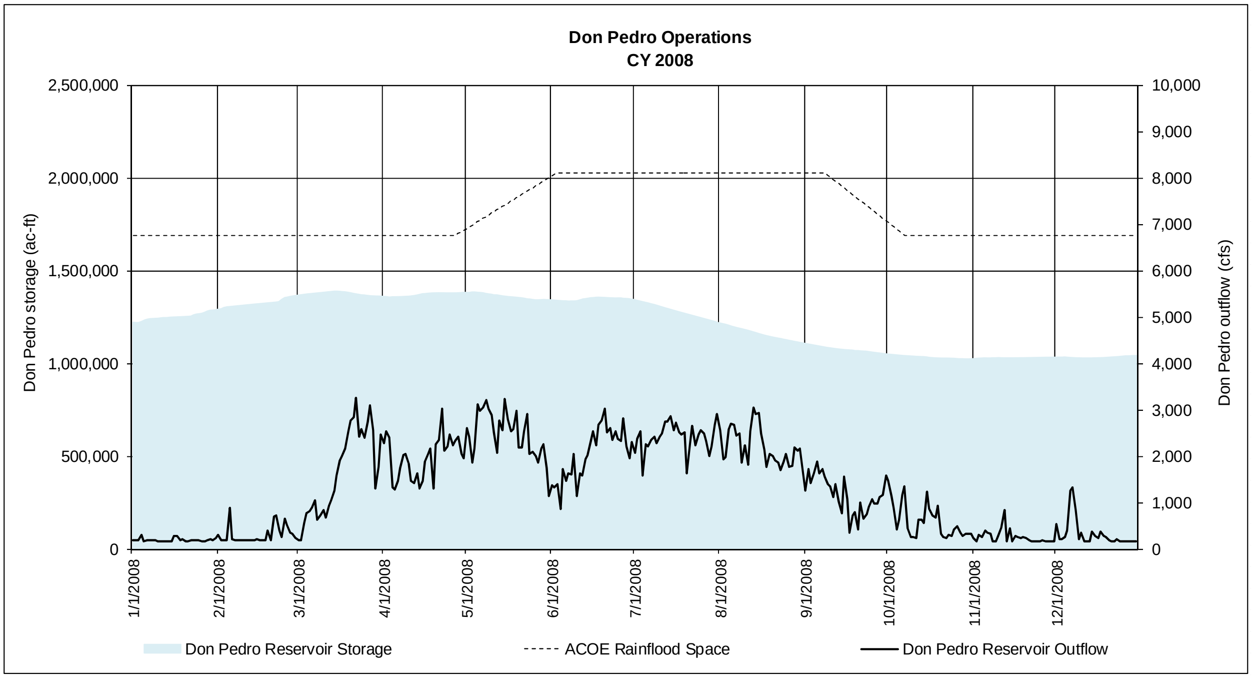

Figure 2.4-30. Don Pedro Project operations – 2008 (below normal).

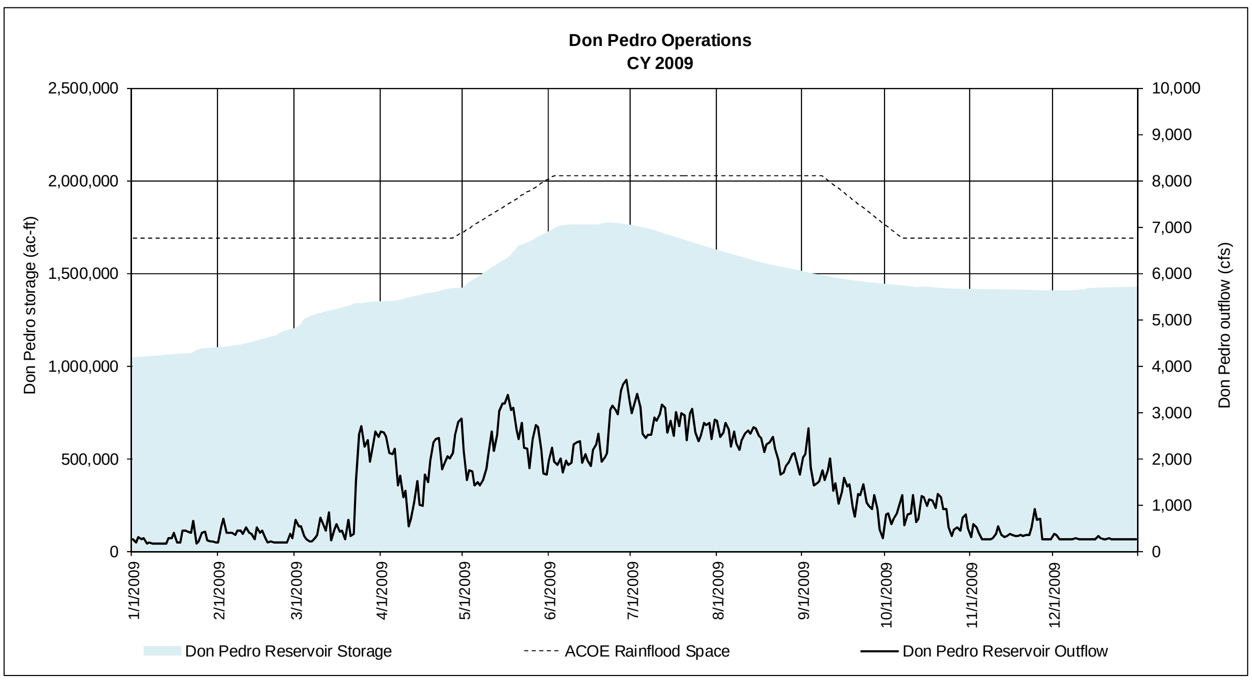

Figure 2.4-31. Don Pedro Project operations – 2009 (normal).

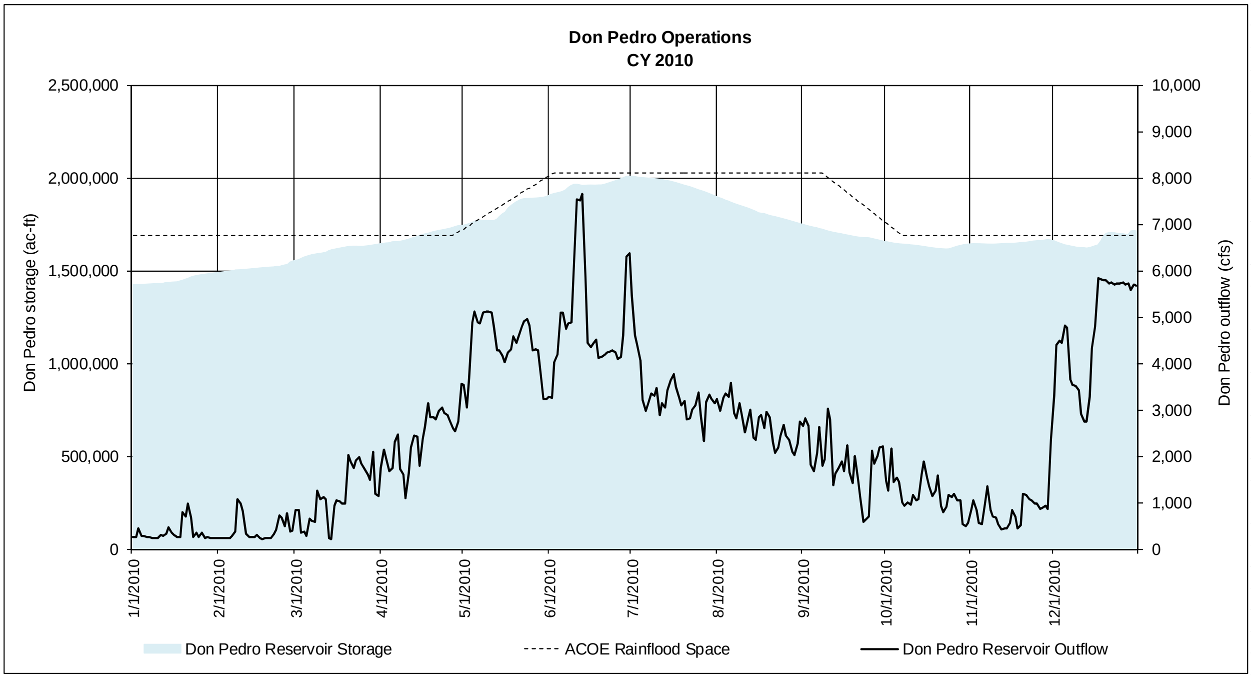

Figure 2.4-32. Don Pedro Project operations – 2010 (normal).

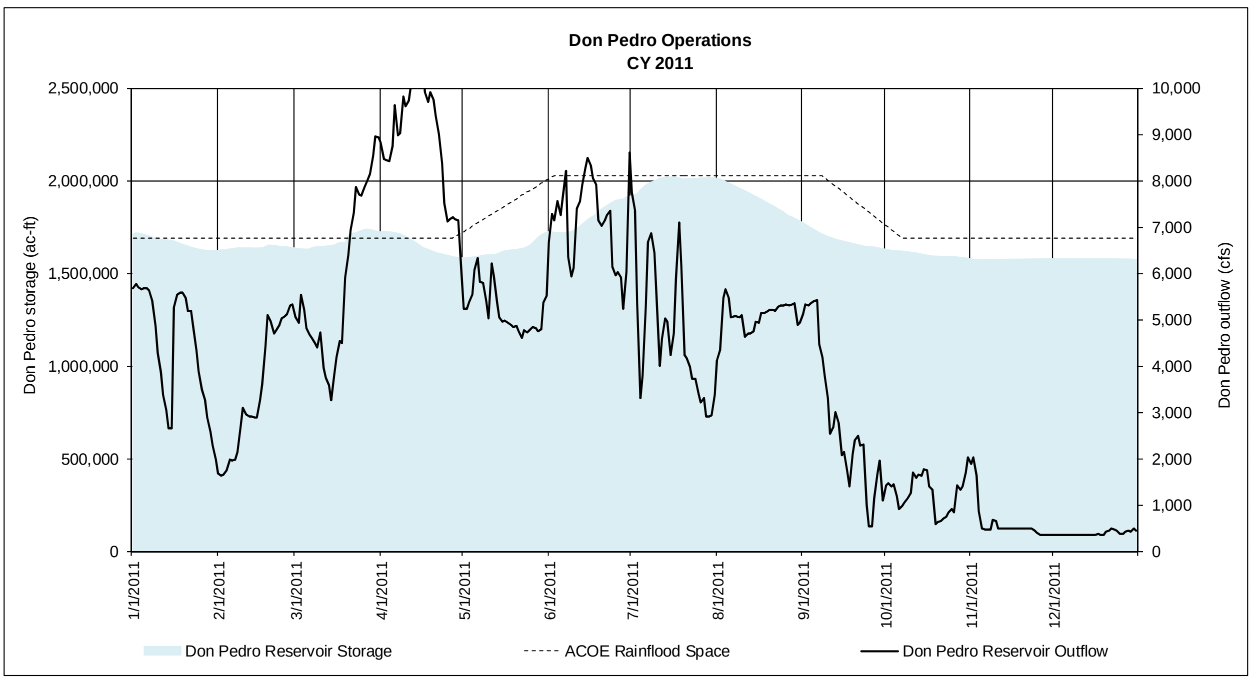

Figure 2.4-33. Don Pedro Project operations – 2011 (wet).

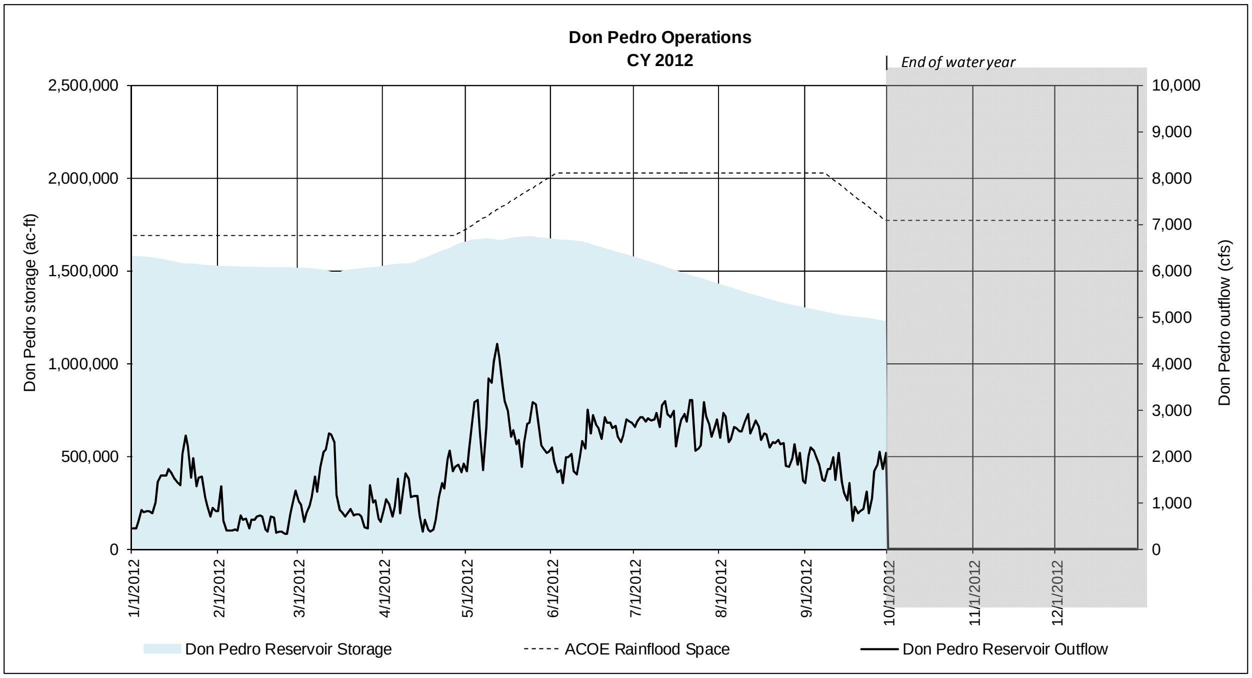

Figure 2.4-34. Don Pedro Project operations – 2012 (dry).

2.5 Tuolumne River Operations Model

2.5.1 Model Overview

As part of the relicensing process for the Project, the Districts developed the Tuolumne River Operations Model. The purpose of the Operations Model is to (1) represent the Base Case or "no action" alternative in the FERC relicensing process and (2) enable the analysis of the effects of potential changes to current operations. As part of the development of the Operations Model, a series of six separate workshops were held with relicensing participants to enhance the collaborative development of the model. There were two workshops devoted to hydrology and the remaining four focused on interim points in model development (i.e., model description, architecture, and configuration; model validation; Base Case description, and training in the use of the model).

To properly represent the Base Case conditions and the potential effects resulting from possible changes to current operations, all the affected benefits of the Don Pedro Project must be incorporated into the Base Case. This not only includes all the operations of the Don Pedro Project, but also the affected critical water supply operations of CCSF's Hetch Hetchy system. Therefore, the Tuolumne River Operations Model geographic scope extends from CCSF's O'Shaughnessy Dam and Hetch Hetchy Reservoir on the upper Tuolumne to the river's confluence with the San Joaquin River, inclusive of CCSF's Cherry and Eleanor dams and reservoirs on Cherry Creek, a tributary of the Tuolumne River. The modeled system is shown in Figure 2.5-1.

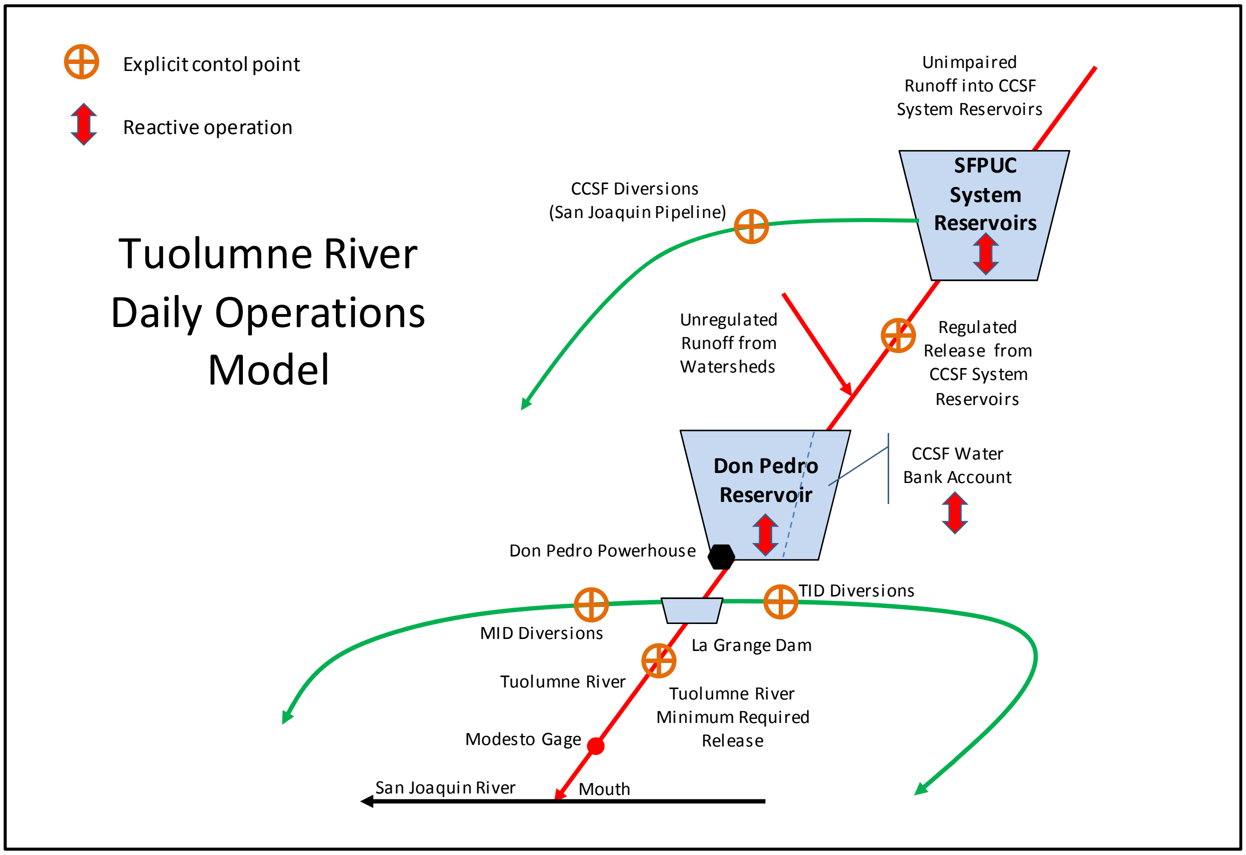

Figure 2.5-1. Tuolumne River daily operations model.

To represent the Base Case, the Operations Model fully depicts the current demands, regulatory requirements, and operational policies of the Districts' and CCSF's Hetch Hetchy water storage and delivery systems. The model uses an Excel platform for ease of use and complete transparency. The model comprises two primary subsystems, the Districts' Don Pedro Project and CCSF's Hetch Hetchy Project, which are independently owned and operated by the respective parties. The Don Pedro Project includes the Don Pedro Reservoir and powerhouse. Water that flows into Don Pedro Reservoir is either stored or passed through to the lower Tuolumne River. Also included in the model is the diversion of water at the Districts' La Grange Diversion Dam to serve irrigation and M&I customers of MID and TID. A model "node" (calculation point) is provided at La Grange Diversion Dam, where the model simulates flows to the Modesto Canal, the Turlock Canal, and the lower Tuolumne River. A node is also provided to represent the location of the existing USGS stream flow gage entitled *Tuolumne River at Modesto*. Additional nodes may be established above and/or below the Modesto gage node depending on user preferences.

The CCSF water system is modeled as three physical reservoirs (Hetch Hetchy Reservoir, Lake Lloyd and Lake Eleanor), the San Joaquin Pipeline that provides water to the Bay Area, and an accounting for the Don Pedro water bank account. All releases from the CCSF system, except those diverted to the San Joaquin Pipeline, enter Don Pedro Reservoir.

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

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

2.5.2 Model Hydrology

Inflow to Don Pedro Reservoir was developed for the WY 1971–2012 period. It consists of two basic components: (1) a fluctuating unregulated inflow to Don Pedro Reservoir, and (2) the regulated releases from the CCSF system. The inflow will reflect a daily fluctuating pattern mostly associated with the unregulated component of runoff, which amounts to approximately 40 percent of the total runoff in the basin. The unregulated component of inflow to Don Pedro Reservoir remains the same among all operation simulations. The regulated inflow to Don Pedro is based on the operations for the CCSF system. This component of Don Pedro Reservoir inflow may change among operation simulations due to changed flow requirements for the CCSF system demands, or due to user-controlled parameters.

The final model hydrology was based on collaboration among the Districts and relicensing participants. The selected approach was to develop a flow record for the Tuolumne River using a combination of gauge proration to develop daily flows while conforming to the underlying monthly mass balances developed using existing, reliable reservoir level and outflow data in order to maintain conservation of mass principles over the monthly time steps. Gauged data from both the Tuolumne River and nearby drainages were considered in the gauge proration portion of the analysis. In order to prorate the gauged data to a larger ungauged area, three physical variables were considered – elevation, drainage area, and average annual precipitation (precipitation). Each gauged basin, along with each application basin (Hetch Hetchy, Cherry/Eleanor, and Unregulated), was divided into 100 ft "elevation bands" for its entire drainage area. This was done using USGS National Elevation Dataset, 1/3 arc-second, 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 mi^2 of the Tuolumne River drainage that exists between elevation 500 and 600 ft) and precipitation (e.g., the average annual precipitation for the drainage area between elevation 500 and 600 ft).

The Oregon Climate Service's PRISM model was employed to estimate average annual precipitation from 1971–2000 (PRISM 2006) for each of the elevation bands represented by the basins being evaluated (elevation from 100 to 13,000 ft). 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 ft. 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 were poorly represented or not represented at all by the reference gauges were added into the elevation distributions of the most representative gauges in order to provide some amount of coverage for those elevation ranges. 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.

This method for development of the unimpaired hydrology and its results are explained in detail in Appendix B-2 of this Exhibit B and were previously described to relicensing participants in the Districts’ April 9, 2013 submittal to FERC entitled *Districts Response to Relicensing Participants Comments on the Initial Study Report (Attachment 2).* A comparison of the 1997 through 2012 historical flows and the modeled Base Case flows are provided in Appendix B-3 of this Exhibit.

2.5.3 Model Simulation of Districts’ Operation of Don Pedro Project

The components of the Operations Model depicting the current operation of the Don Pedro Project included all of the reservoir operations related to water management, including irrigation and M&I use, flood flow management, and providing downstream flows in accordance with current FERC requirements. To represent the Districts’ canal demands, a methodology utilizing estimates of recent agricultural land use within the Districts and current MID municipal and industrial water demands was employed. This methodology was chosen because it is consistent with California’s statewide water plan modeling practices. The Operations Model also incorporated the most recent data available from the Districts related to water use as contained in TID’s and MID’s 2012 filings with the State of California entitled *Agricultural Water Management Plans* as required by state regulations. The depiction of the irrigation water system demand is provided in Figure 2.5-2.

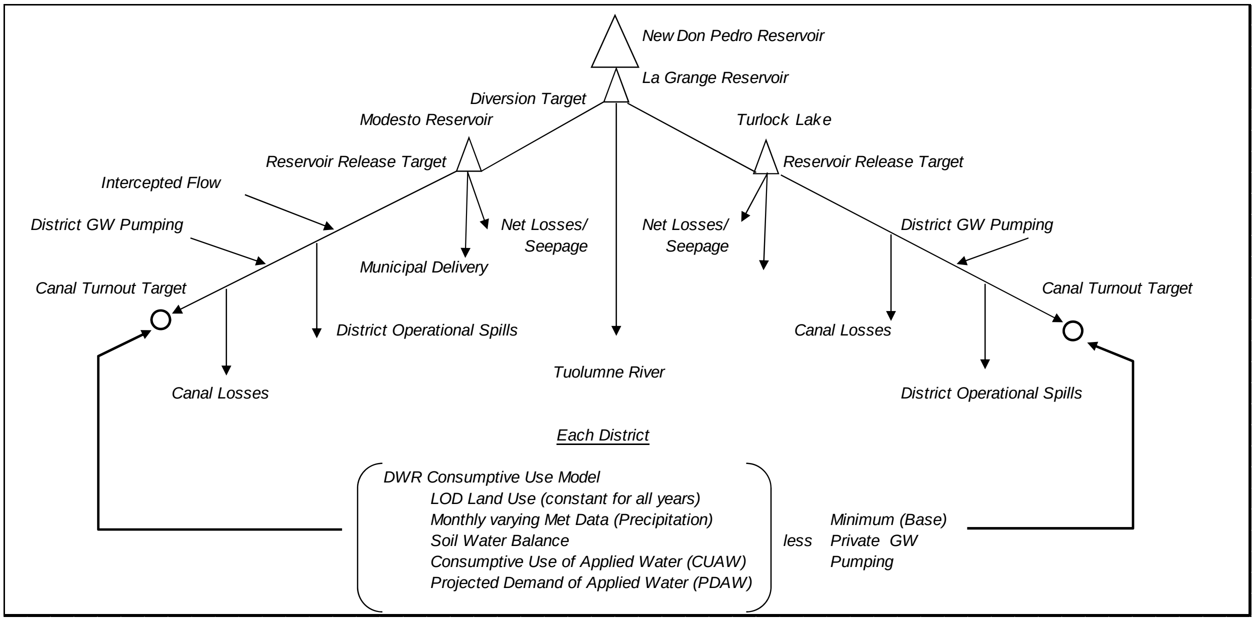

Figure 2.5-2. District canal demand parameters.

Due to changing land use and cropping patterns, groundwater use and irrigation and canal management practices throughout history, the historical record of recorded diversions does not always provide a consistent definition of water diversion needs. Similar to depicting inflow, the Operations Model uses a consistent level of development for establishing irrigation and canal diversion demand, reflective of recent data. The canal diversions are driven by three components: (1) a fluctuating customer component, the Projected Demand of Applied Water (PDAW) that varies year to year and month to month, (2) a relatively constant depiction of Districts and land owner system losses and efficiencies, and (3) a water supply availability factor based on Don Pedro Reservoir storage and inflow. The PDAW is developed through use of the CDWR consumptive use model, and considers precipitation, ET rates, soil moisture criteria, rooting depth, irrigation indicators, and other factors along with land use to estimate the consumptive use of applied water (CUAW) on a monthly basis. A complete description of the methods employed are provided in the Project Operations/Water Balance Model Study Report (TID/MID 2017), which is included in Attachment C to this AFLA.

Don Pedro Project operations also include management of flood flows consistent with the ACOE Flood Control Manual and the guide curve provided in Figure 2.4-1 above. During the relicensing process, the Districts explored the potential to modify the ACOE guideline of maintaining flows at Modesto below 9,000 cfs. The ACOE indicated that it would not agree to any such modification.

The Operations Model also includes the most recent requirements of the Don Pedro Project related to providing flows to the lower Tuolumne River. These flow requirements were discussed in Section 2.4.5 of this Exhibit. The Operations Model also incorporates the Don Pedro hydropower generation resulting from flow releases to meet these other requirements.

2.5.4 Model Simulation of City and County of San Francisco System

The Operations Model representation of the CCSF system on the Tuolumne River includes the three physical reservoirs (Hetch Hetchy Reservoir, Lake Lloyd and Lake Eleanor), diversions to the Bay Area through the San Joaquin Pipeline, and an accounting for the Don Pedro water bank account. The CCSF system is illustrated in Figure 2.5-3, with detail provided for the components of explicitly modeled hydrologic parameters.

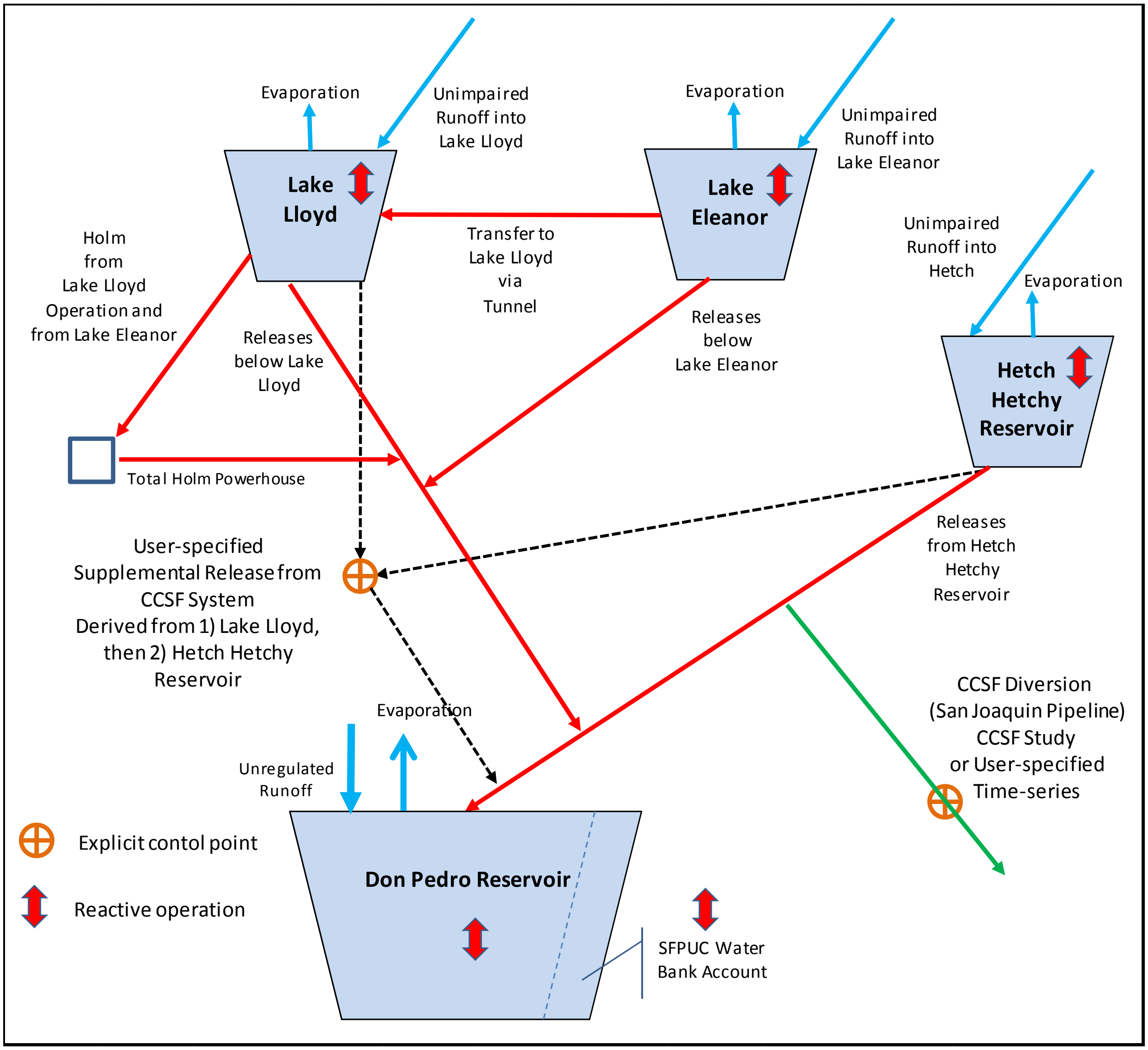

Figure 2.5-3. City and County of San Francisco's Hetch Hetchy system.

Each CCSF system reservoir has the same underlying operation protocol. A daily mass balance is performed: change in reservoir storage = inflow minus outflow (releases) minus reservoir losses. If the calculation results in reservoir storage exceeding preferred/maximum capacity, an additional release of water is made. Each reservoir assumes a common "hold-unless-need-to-release" protocol, except as conditioned by minimum release requirements, diversions, preferred/maximum storage, snowmelt management releases, hydropower, or other flow or management objectives. In essence, each reservoir operates for its own "reservoir conservation" goal of retaining storage unless drawn down by demands or reservoir management objectives. CCSF is required by State law and its Charter to operate its system for "water first".

A full description of model design related to CCSF's system is provided in the Project Operations/Water Balance Model Study Report (TID/MID 2017).

2.5.5 Model Base Case

To represent the Base Case, the Operations Model fully depicts the current demands, regulatory requirements, and operational policies of the Districts' and CCSF's Hetch Hetchy water storage and delivery systems. The Base Case model is a simulation used (1) to represent current Tuolumne River operating conditions and (2) for comparison to other alternative operating scenarios. Graphical representation of operations under the Base Case from 1971 to 2012 are provided in Appendix B-4.

2.5.6 Model Refinements Since April 2014

Following the Districts' submittal of the Final License Application with FERC in April 2014, ongoing use and review of the model resulted in development of a number of refinements to the model. As a continuation of the Consultation Workshop process undertaken by the Districts related to all studies involving the development and use of computer models, the Districts held a Workshop on May 18, 2017 to present and describe the changes to the Project Operations/Water Balance Model that have occurred since April 2014. Meeting notes were prepared and provided to relicensing participants for review and comment, and the final notes are included in Attachment B to this AFLA. These changes reflect minor adjustments and corrections to the model and are described in detail in an addendum to the original report, provided as Attachment D to the Project Operations/Water Balance Model Study Report (TID/MID 2017).

2.6 Proposed Future Project Operations

The Districts have developed, as fully described in this AFLA, a number of measures related to instream flows and flow management, habitat improvements, fish populations, and recreation that, in total, are expected to improve targeted fish populations substantially in the lower Tuolumne River, while adequately protecting the Districts' water supplies, as well as the water supply of the Bay Area. This comprehensive set of water supply and resource protection, mitigation, and enhancement (PM&E) measures strikes a balance among competing water uses. Modifications to individual measures may substantially undo the careful balance of benefits and costs at the core of the Districts' preferred plan for future Project operations (Preferred Plan) as described in this AFLA.

In this Exhibit B – Project Operations and Resource Utilization -- the Districts describe the operations-related measures included within their integrated set of flow and non-flow related proposed measures. Measures which do not affect Project operations (e.g., lower river physical habitat improvements) are analyzed and described in relevant sections of Exhibit E, and the

Districts' proposal as a whole is described and evaluated in detail in the Developmental Analysis section of Exhibit E.

2.6.1 Future Availability of Groundwater as a Source of Water Supply

2.6.1.1 Sustainable Groundwater Management Act

In 2014, the State of California enacted the Sustainable Groundwater Management Act (SGMA). SGMA requires local public agencies to form Groundwater Sustainability Agencies (GSAs) to assess conditions in their local basins and to oversee the management of groundwater within their respective groundwater basins. SGMA requires that each GSA adopt and implement a locally-based Groundwater Sustainability Plan (GSP). In the case of the Districts, the law requires that these GSPs be adopted by January 31, 2022, and that the groundwater basins be sustainable within 20 years after adoption of the GSP. The act provides for state intervention when a GSA is not formed and/or fails to create and implement a GSP.

SGMA defines "sustainable groundwater management" as the management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results, which are defined as any of the following effects:

- chronic lowering of groundwater levels (not including overdraft during a drought, if a basin is otherwise managed);
- significant and unreasonable reductions in groundwater storage;
- significant and unreasonable seawater intrusion;
- significant and unreasonable degradation of groundwater quality;
- significant and unreasonable land subsidence; and
- surface water depletions that have significant and unreasonable adverse impacts on beneficial uses.

In relevant part, the California Legislature intended the SGMA to provide for the sustainable management of groundwater basins, to enhance local management of groundwater, to establish minimum standards for sustainable groundwater management, and to provide local groundwater agencies with the authority and the technical and financial assistance necessary to sustainably manage groundwater to the greatest extent feasible (California Water Code [WC] § 10720.1).

2.6.1.2 Modesto Subbasin GSA

The Modesto Subbasin is defined as that area of land lying between the Stanislaus River on the north, the Tuolumne River on the south, the Sierra Nevada foothills on the east and the San Joaquin River on the west. MID's irrigation service area and traditional electric service areas are entirely located within the Modesto Groundwater Subbasin.[8]

[8] http://www.water.ca.gov/groundwater/bulletin118/sanjoaquinriver.cfm (website visited, September 2017).

On February 16, 2017, MID partnered with all the public agencies situated within the Modesto Groundwater Subbasin to formally establish the Stanislaus and Tuolumne River Groundwater Basin Association GSA as the exclusive GSA for the subbasin. In so doing, the STRGBA members agreed to become responsible parties to manage the basin in order to "exert local control over the management of the subbasin" and "to act on behalf of its member agencies to coordinate the [STRGBA agencies'] activities and actions to further sustainable management of the subbasin and…compliance with SGMA." (2017 MOU Forming STRGBA GSA, Section 4.2) The STRGBA "…shall determine and evaluate the subbasin's existing groundwater supply" and, further, shall have the powers and authorities granted to GSAs under SGMA.

2.6.1.3 Turlock Subbasin GSAs

Similarly, TID and the public agencies within the Turlock Groundwater Subbasin have formed two separate GSAs—the West Turlock Subbasin GSA and the East Turlock Subbasin GSA. The Turlock Subbasin is defined as that area of land lying between the Tuolumne River on the north, the Merced River on the south, the San Joaquin River on the west, and the Sierra Nevada foothills on the east. The TID water service boundary lies entirely within the West Turlock Subbasin GSA.

Established in March 2017, the five members of the East Turlock Subbasin (ETS) GSA include Eastside WD, Merced County, Stanislaus County, Ballico-Cortez WD, and Merced ID; listed in the order of groundwater use. Eastside Water District (EWD) has taken a leadership role in forming the ETS GSA, and as a water district has assumed water supply and management responsibilities for the 61,293 acres of land within its boundary.

Also established in March 2017, the West Turlock Subbasin Groundwater Sustainability Agency (WTSGSA) is a Joint Powers Authority. Member agencies include the cities of Turlock, Ceres, Hughson and Modesto, Stanislaus and Merced counties, Denair Community Services District, Delhi and Hilmar county water districts, and the Turlock Irrigation District. Associate members include the City of Waterford (which provides water supplies for the community of Hickman), Stevinson Water District and Keyes Community Services District. All or a portion of the member and associate member agencies' service areas are located within the Turlock Subbasin. TID and Stevinson Water District provide surface water and groundwater supplies to agricultural customers within their respective service areas.

2.6.1.4 Current Practices

Both MID and TID use a combination of surface water and groundwater to supply irrigation and municipal/industrial water to its customers. In dry years, groundwater pumping helps meet irrigation demand that cannot be supplied by surface water. In normal and wetter years, surface water makes up the bulk of the supply with groundwater being drawn upon to a much lesser extent. This practice of utilizing surface and ground water to meet local requirements is known as conjunctive use.

Additionally, each District has maintained a historical groundwater recharge program with its irrigation customers when the water is available. While the details of these programs are often dependent upon the water year in which it is offered, each program's fundamental goals are to facilitate and incentivize customers to irrigate certain fields with the deliberate intent of recharging the underlying groundwater basin.

The Districts' use of groundwater also plays an important role in water conservation. District-owned and rented pumps (distributed throughout each respective irrigation service area) not only provide an additional source of water, they are used to help stabilize flow fluctuations in the conveyancing system. This helps District water operators conserve water by reducing spills at the end of the canal systems.

2.6.1.5 GSA Jurisdiction as Primary Regulator

The SGMA empowers each GSA to "exercise any of the powers described in this chapter" to implement the SGMA and may use its powers "to provide the maximum degree of local control and flexibility consistent with the [SGMA's] sustainability goals." (WC §10725) The GSA is also responsible for integrating the most recent planning assumptions stated in local general plans of jurisdictions overlying the basin into the subbasin's GSP. However, consistent with the Legislature's intent, nothing in a GSP can supersede the land use authority of cities and counties (e.g., city or county general plan) within the overlying basin. (WC §10726.8)

With respect to the contents of a GSP, GSAs must choose "[m]easurable objectives, as well as interim milestones in increments of five years, to achieve the sustainability goal in the basin within 20 years of the implementation of the plan" (WC §10727.2) and identify the environmental and pumping metrics to define "sustainable yield" for the subbasin.[9]

2.6.1.6 Jurisdictional Conflicts Pending Resolution

Increased demands on surface water, including instream flow requirements, will adversely affect the Districts' ability to comply with the requirements of SGMA. As less water is made available for local demands, there is a resulting reduction in groundwater recharge further impacting the Districts' ability to conjunctively manage surface and groundwater resources within their service areas and within the larger groundwater subbasins.

On September 15, 2016, the State Water Resources Control Board released a revised Water Quality Control Plan and Substitute Environmental Document (SED) for San Joaquin River Flows and South Delta Salinity. The plan proposes a San Joaquin River flow objective requiring a percent of unimpaired flow of 30 percent to 50 percent from each of the Stanislaus, Tuolumne, and Merced rivers, maintained from February through June. (see Draft Revised SED, Appendix K, Table 3.)

Comments on the SED submitted by the Districts maintained that the SED greatly underestimated the impact of reduced surface water deliveries on groundwater levels. This was

[9] "Sustainable yield" means the maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus that can be withdrawn annually from a groundwater supply without causing an undesirable result. (Wat. Code, § 10721)

the result of inappropriately averaging the impacts over a wide area and unrealistic assumptions regarding future increases in groundwater pumping in response to decreased surface water deliveries. The SED also summarily dismissed concerns regarding the economic impacts of groundwater declines by asserting that such impacts would be addressed through the implementation of the GSPs within each groundwater subbasin. However, even a cursory review of local groundwater conditions indicates that SGMA implementation will not be able to offset future increases in groundwater pumping with increased recharge because nearly all potential sources of water for replenishment are similarly affected by the SED. Those sources could not be developed without decreasing river flows elsewhere. The result is that reduced water deliveries to the Districts at anywhere near the magnitudes contemplated in the SED will lead to fallowing of substantial amounts of cropland with significant associated local and regional economic impacts.

As an example, TID used its existing groundwater flow model of the Turlock Subbasin to obtain more realistic estimates of the effects of the SED flow program on groundwater levels, groundwater budgets and river flows. Simulated groundwater levels for the 40 percent unimpaired flow scenario steadily declined relative to Base Case water levels throughout the simulation period at all locations. Furthermore, the amount of divergence increased from west to east because of greater distance from rivers. At the westernmost hydrograph location, water levels were 18-20 feet lower than Base Case water levels at the end of the simulation. Near the center of the subbasin near the eastern edge of TID, water levels were 30 feet lower than Base Case water levels in both the shallow and intermediate zones. The amount of water-level divergence between the two scenarios diminished farther to the east, outside the area that currently receives surface water deliveries. During the entire simulation period (2013-2052), groundwater storage was estimated to decline by an average of more than 51,000 acre-feet per year.

As further example, under the SED's 40 percent unimpaired flow obligation, MID would have needed to pump an additional one million acre-feet of groundwater over the 1971-2012 timeframe in order to have provided the level of service historically provided during that timeframe.

The STRGBA provided comments to the SED that are instructive of the emerging but untested roles of the GSAs to manage their respective subbasin's sustainability.[10] The ETS GSA and the WTSGSA were established in the same month that SED comments were due to the SWRCB and so these GSAs did not provide any comments. However, the sole predecessor agency to the two GSAs, the Turlock Groundwater Basin Association (TGBA), did provide comment to the SED. Both agencies identified their past groundwater management activities, their forthcoming duties under the SGMA and the SED's fundamental failure to analyze the LSJR objective with respect to the SGMA.

Most objectionable to the local agencies, the SED identifies groundwater as the primary mitigation measure to mitigate for the surface water that would be removed from the local supply due to the LSJR objective. The SED's mitigation measure proposes to replace the lost surface

[10] http://www.waterboards.ca.gov/public_notices/comments/2016_baydelta_plan_amendment/john_davids.pdf

water (dedicated to the LSJR objective) with local groundwater supplies until the groundwater basin declines sufficiently to conflict with the locally-adopted GSPs, at which point the SED identifies the SGMA as the authority upon which the local agencies could thereafter prohibit groundwater pumping. As TGBA stated, "SGMA was not developed to mitigate for the SED."[11]

Further, the local agencies protest that the SED's conclusion that the LSJR objective "will substantially deplete groundwater supplies or interfere substantially with groundwater recharge" is in direct conflict with the sustainability directives of the SGMA. The local agencies protested that the SWRCB could not impose a plan that deliberately imposed an adverse impact on the local groundwater subbasins without running afoul of the SGMA's sustainability objective.

In addition, the SED's assumptions of groundwater pumping are without citation or correlation to the publicly-available groundwater data and reporting that the local agencies had spent decades gathering, were publicly available at the time of the SED's drafting, and would serve as the basis for all GSP planning and implementation.

And finally, the local agencies were concerned that the SED's impacts on available surface water and groundwater supply would impose catastrophic impacts onto the public water systems and private domestic wells in the local area who solely depend on groundwater.

All evidence indicates that it is not prudent for the Districts to depend on an increased use of groundwater in the future to offset or mitigate reduced surface water supplies. In addition to the groundwater model results presented above and the likelihood that SGMA regulations will result in *less*, not more, groundwater availability than present, the current use of the Turlock and Modesto groundwater basins by irrigators outside the Districts' service territories continues to grow. Since 1990, actively farmed land within the Turlock and Modesto groundwater basins using only groundwater sources to meet irrigation needs has increased almost four-fold from 29,000 acres to the present 106,000 acres (see Figure 2.6-1). The overwhelming majority of these lands consist of permanent crops, primarily nut orchards.

[11] http://www.waterboards.ca.gov/public_notices/comments/2016_baydelta_plan_amendment/debra_liebersbach.pdf.

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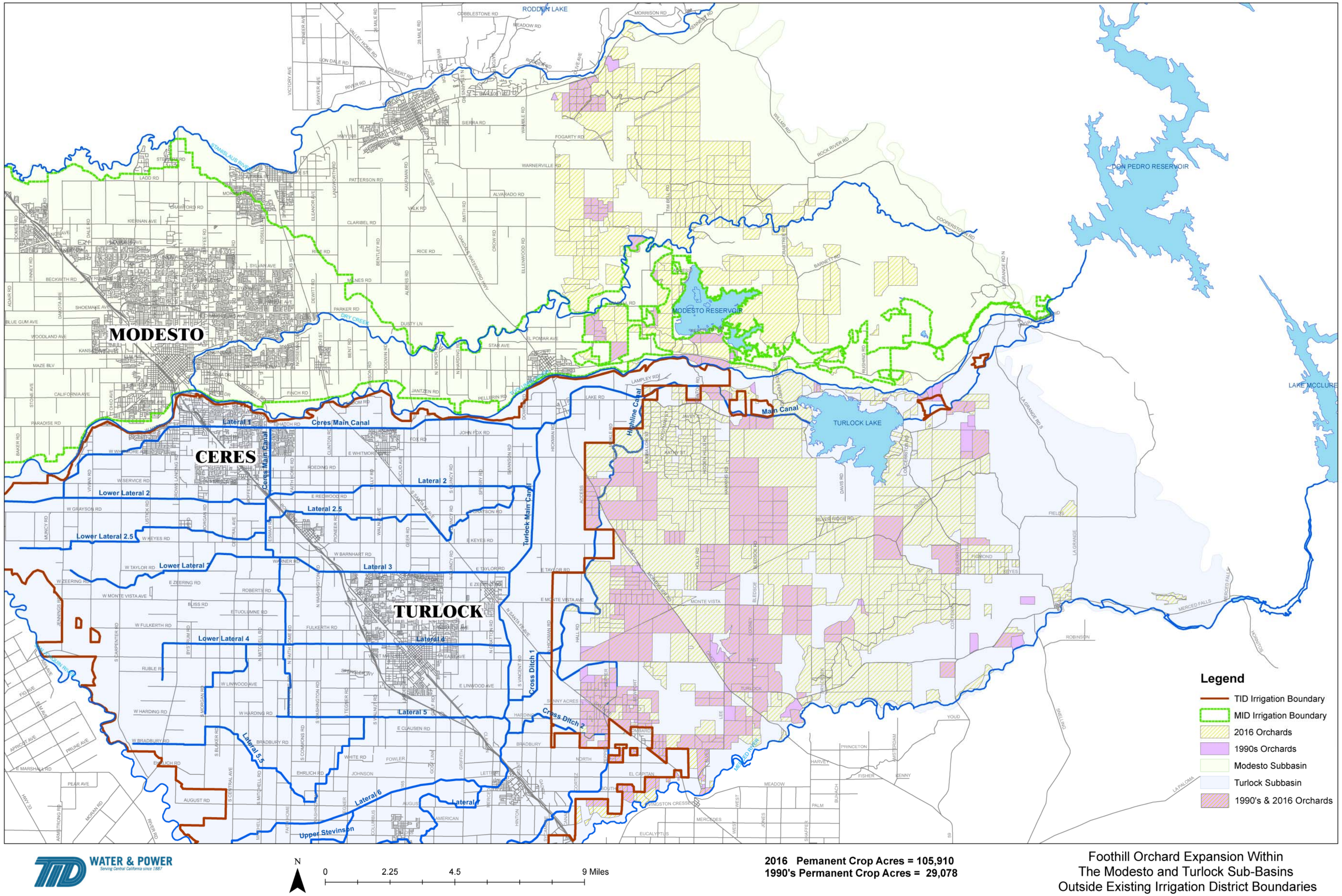

Figure 2.6-1. **Expansion of irrigated lands since 1990 within the Modesto and Turlock groundwater sub-basins outside of existing irrigation district boundaries.**

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2.6.2 Water Supply Measures

The Districts recognize the existence of potential threats to the surface water supply, not only the potential reduced availability of groundwater, but also demands by others on the Districts surface water supplies, notably, other regulatory agencies with license conditioning authority. The Districts are proposing to amend the elevation of the Don Pedro minimum pool from the current elevation 600 ft to elevation 550 ft. The additional storage to be made available by this change is approximately 150 TAF. The additional storage would be used infrequently and likely only during times of extended drought. Once the reservoir level drops below elevation 600 feet, flows able to be passed through the powerhouse units and power tunnel are reduced. Flows would then be diverted through the diversion tunnel works where the intake elevation is approximately 350 ft.

2.6.3 Fish Counting and Barrier Weir

The Districts propose to install a fish counting and barrier weir with a nominal head of five feet at approximately RM 25.5. The barrier weir would serve two distinct Project purposes: (1) to act as a permanent fish counting facility for upmigrating fall-run Chinook Salmon and *O. mykiss*, thereby replacing the seasonally-installed weir currently located roughly 1.3 miles downstream, and (2) to exclude non-native predator fish species from accessing the primary salmon and *O. mykiss* fry and juvenile rearing reaches of the Tuolumne River. Flows permitting, the barrier weir will count fish every year from mid- to late-September through the end of April, to encompass the upmigration seasons of both fall-run Chinook Salmon and *O. mykiss*. The barrier weir flap gates will be lowered any time flows exceed 7,000 cfs. The fish barrier and counting weir would be a Project facility of the Don Pedro Hydroelectric Project, non-contiguous with the current Project Boundary. Exhibit G provides a proposed facility boundary.

2.6.4 Infiltration Galleries 1 and 2

The Districts are proposing to install and operate two in-river infiltration galleries (IG) at approximately RM 25.9 just downstream of Fox Grove Park on the lower Tuolumne River. IG-1 was previously installed by TID in 2001 during the restoration of Special-run Pool-9 (SRP-9) at RM 25.8 located below the Geer Road Bridge. IG-2 would be installed just upstream of IG-1 (Figure 2.6-2). Both IGs would have a flow capacity of approximately 100 cfs and be connected via steel pipe to a pump station located on the south bank of the river. Water withdrawn at the IGs would become part of TID’s water supplies by being transported to TID’s Ceres Canal or other non-Project facilities. The infiltration galleries would be operational starting June 1, except in years experiencing high flows, and extend through about October 15. As explained further in Section 2.6.5.11 below and in Exhibit E, the infiltration galleries would be turned off during certain summer weekends and holidays to provide greater recreational boating opportunities throughout the lower Tuolumne River from RM 25.5 to the confluence with the San Joaquin River. The IGs would be non-contiguous Project facilities and would be located within the facility boundary associated with the fish barrier and counting weir as shown in Exhibit G of this AFLA.

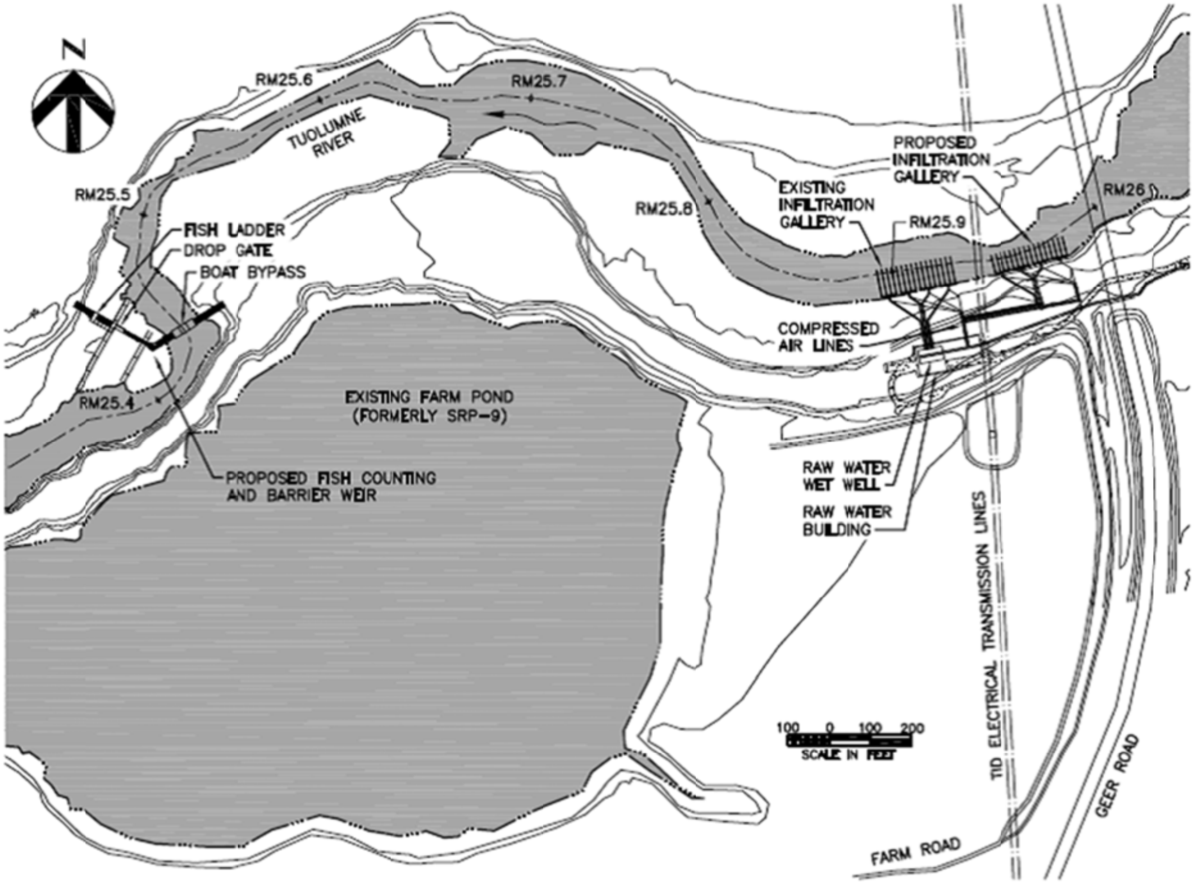

Figure 2.6-2. **Location and general site layout of Infiltration Gallery 1 and Infiltration Gallery 2.**

2.6.5 Fall-run Chinook Salmon Restoration Hatchery

The Districts are proposing to design and construct, in cooperation with CDFW, a fall-run Chinook Salmon restoration hatchery to be located upstream of Basso Bridge at RM 50.7, about 1.5 miles downstream of the Districts' La Grange Diversion Dam. The general purpose of the hatchery would be to improve the viability of the Tuolumne River fall-run Chinook Salmon population through supplementation and genetic management. The Districts would fund CDFW's operation and maintenance of the hatchery for a period of 20 years. The hatchery would be operated annually from October through May. Further details of the proposed hatchery and its operations are provided in Exhibit E, Section 5.

2.6.6 Flow-Related Measures

The Districts propose a number of flow-related measures to benefit the aquatic resources of the Tuolumne River. All flow-related measures are based on using five water-year types determined using the 60-20-20 San Joaquin River Index. These five water-year types are (1) Wet, (2) Above Normal, (3) Below Normal, (4) Dry, and (5) Critical. The current method used by TID operators to determine the water year type and the required flow release schedule would remain unchanged.[12] There would be two flow monitoring locations for compliance: (1) the existing USGS Tuolumne River at La Grange gage and (2) a flow measurement at each of the two infiltration galleries. Compliance would be achieved if flows equaled or exceeded the amounts identified over monthly timeframes, with no exceedance of more than 10 percent below the minimum for more than 60 minutes, and no flow exceedance allowed that is greater than 20 percent less than the flows described in this Section. Exhibit E of this AFLA contains detailed descriptions of biological purposes of each of the proposed flow-related measures.

2.6.6.1 Gravel Mobilization Flows

For purposes of gravel mobilization and the scouring of fines from the spawning gravels, the Districts propose to provide at least two days of flow between 6,000 cfs and 7,000 cfs to occur in years when sufficient spill is projected to occur and is anticipated to occur at an average frequency of approximately once in four years over the longer-term. Monitoring associated with this measure consists of conducting a survey of pre-selected and previously monitored test sites following high flow events.[13] In years when the Districts' available information indicates that spill at La Grange gage may exceed 5,500 cfs, the Districts would notify downstream farmers of the potential for gravel-cleaning spills to occur.

2.6.6.2 Early Summer Flows (June 1 – June 30)

To support *O. mykiss* fry rearing, the District propose to provide, in all water years, for the period from June 1 through June 30, base flows of 200 cfs.

2.6.6.3 Late Summer Flows (July 1 – October 15)

To support juvenile and adult *O. mykiss*, from July 1 through October 15, the Districts propose to provide 350 cfs in Wet, Above Normal, and Below Normal water years. In Dry and Critical water years, the Districts will provide 300 cfs. IGs at RM 25.8 would normally be "on" during this time frame.

In early October, the Districts propose to provide a flushing flow to clean gravels of built up algae and unimbedded fines prior to the start of substantial spawning. The Districts will provide an instream flow totaling 1,000 cfs (not to exceed 5,950 AF) on October 5, 6, and 7, with appropriate up and down ramps and the infiltration galleries turned off. These flows would be provided in Wet, Above Normal, and Below Normal years only. In Dry and Critical years, the flows at La Grange gage would be 300 cfs with withdrawals of 225 cfs at the infiltration galleries, leaving 75 cfs in the river below RM 25.5.

[12] TID operators currently determine the water-year type in early April and issue, after consultation with resource agencies, the schedule of releases for April 15 of the current year through April 14 of the next calendar year.
[13] Details of operations and monitoring associated with this measure are provided in section 5 of Exhibit E of the AFLA.

2.6.6.4 Fall-run Chinook Salmon Spawning (October 16 – December 31)

To support fall-run Chinook salmon spawning, the Districts propose minimum instream flows during the period of October 16 through December 31. The minimum instream flow would be 275 cfs in Wet, Above Normal, and Below Normal years, 225 cfs in Dry years, and 200 cfs in Critical years.

2.6.6.5 Fall-run Chinook Salmon Fry-Rearing (January 1 – February 29)

To support fall-run Chinook salmon fry rearing, the Districts propose minimum instream flows during the period of January 1 through February 29. The minimum instream flow would be 225 cfs in Wet, Above Normal, and Below Normal years, 200 cfs in Dry years, and 175 cfs in Critical years.

2.6.6.6 Fall-run Chinook Salmon Juvenile Rearing (March 1 – April 15)

To support fall-run Chinook salmon juvenile rearing, the Districts propose minimum instream flows during the period of March 1 through April 15. The minimum instream flow would be 250 cfs in Wet, Above Normal, and Below Normal years, 225 cfs in Dry years, and 200 cfs in Critical years.

2.6.6.7 Outmigration Base Flows (April 16 – May 15)

To support outmigrating fall-run Chinook salmon, the Districts propose a base flow schedule for the period of April 16 through May 15. The base flows would be 275 cfs in Wet, Above Normal, and Below Normal years, 250 cfs in Dry years, and 200 cfs in Critical years.

2.6.6.8 Outmigration Base Flows (May 16 – May 31)

To support outmigrating fall-run Chinook salmon, the Districts propose a base flow schedule for the period of May 16 through May 31. The base flows would be 300 cfs in Wet, Above Normal, and Below Normal years, 275 cfs in Dry years, and 225 cfs in Critical years.

2.6.6.9 Outmigration Pulse Flows (April 16 – May 31)

The Districts propose to increase the pulse flow volumes substantially over the current levels, except in the second or greater years of Critical flow conditions as follows:

- W and AN WYs 150 TAF
- BN WYs 100 TAF
- D WYs 75 TAF
- Sequential D WYs 45 TAF[14]
- First year C WY 35 TAF

[14] To provide water supply protection in extended droughts, in sequential Critical WYs, the required outmigration pulse flow is reduced from 35 TAF to 11 TAF. In sequential Dry WYs, it is reduced from 75 TAF to 45 TAF. Any combination of "C" and "D" WYs also result in pulse flow reductions. For example, in a six-year sequence of C-D-C-D-C-D WYs, the second and third "C" and "D" WYs would have reduced pulse flows.

- Sequential C WYs 11 TAF

The pulse flow volume would continue to be determined as done under the current license; however, moving from ten to five water year types should reduce the frequency of the need for "true-up water."

2.6.6.10 Flow Hydrograph Shaping

In spill years, the Districts would make reasonable efforts to shape the descending limb of the snowmelt runoff hydrograph to mimic natural conditions.

2.6.6.11 Boating Improvements

The Districts propose improvements to recreational boating opportunities for non-motorized canoeing and kayaking on the lower Tuolumne River (Table 2.6-1). These improvements assume the boating season extends from April 1 to October 31. The Districts' Lowest Boatable Flow Study (RR-03) (TID/MID 2013) found that flows above 175 cfs on the lower Tuolumne River were considered to be boatable with non-motorized craft. For purposes of compliance with these flows, the compliance point for all boatable flows is the USGS La Grange gage.

Table 2.6-1. Proposed improvements to recreational boating opportunities.

Time Period	Improvements
April 1 – May 31	▪ 200 cfs or greater provided in all WYs for the entire lower Tuolumne River from RM 52 to RM 0.
June 1 – June 30	▪ Boatable flow of 200 cfs occurs in all water years from RM 52 to RM 25.7. ▪ In W, AN, and BN, cease IG withdrawal for one pre-scheduled weekend in June to provide boating opportunity from RM 25.5 to RM 0 of 200 cfs.
July 1 – October 15	▪ Boatable flow of at least 325 cfs provided at all times from RM 52 to RM 25.7 in all WYs, subject to rules related to flows during extended IG unplanned outages. ▪ In all but C WYs, provide a boatable flow of 200 cfs from RM 25.7 to RM 0 for 3-day July 4th holiday, for three day Labor Day holiday, and for two-pre-scheduled additional weekends in either July or August. ▪ Provide a new take out-put in facility at RM 25.7 (fish counting and barrier weir)

2.6.7 Don Pedro Reservoir Resource Protection

The Districts propose to implement a number of management plans related to natural resources associated with Don Pedro Reservoir (Table 2.6-2). These management plans are more fully described in Exhibit E to this AFLA.

Table 2.6-2. Proposed management plans.

No.	Title
1	Fire Prevention and Response Plan
2	Spill Prevention, Control, and Countermeasure Management Plan
3	Aquatic Invasive Species Management Plan
4	Woody Debris Management Plan
5	Terrestrial Resources Management Plan

No.	Title
6	Recreation Resource Management Plan
7	Draft Historical Properties Management Plan

3.0 RESOURCE UTILIZATION

3.1 Existing Powerhouse Hydraulic Capacity

As discussed previously, hydropower generation at the Don Pedro Project occurs as a consequence of other demands for water releases. In fact, if hydropower did not exist at the Don Pedro Project, there would essentially be no change in the day-to-day operations of the Don Pedro Project. Clean, renewable hydropower generation is, however, a valuable benefit of the Project. The average annual electrical generation of the Project from 1997 through 2012 was 622,440,000 kilowatt hours (kWh). The current maximum hydraulic capacity of the four turbines is 5,500 cfs and the current FERC-authorized capacity is 168 MW.

3.2 Powerhouse Capability versus Head

The output of the four turbines at Don Pedro varies with the available head at the Project. Table 3.2-1 and Table 3.2-2 show the current turbine and generator capabilities. At 450 ft of net head, the maximum output of each of Units 1, 2, and 3 is approximately 56.8 MW. At 425 ft of net head, the maximum output of Unit 4 is 37 MW.

Table 3.2-1. Don Pedro Units 1, 2, and 3 turbine performance characteristics.

Net Head (ft)	Flow (cfs)	Turbine Output (hp)	Generator Output (MW)	Turbine Efficiency
530	545	24,000	17.2	73.5%
530	800	39,000	28.2	81.3%
530	1,000	51,300	37.5	85.6%
530	1,200	65,200	47.6	90.6%
530	1,350	75,000	54.8	92.7%
530	1,510	85,000	62.1	93.9%
450	400	14,500	10.4	71.2%
450	600	24,650	17.8	80.7%
450	800	34,900	25.5	85.7%
450	1,000	45,550	33.3	89.5%
450	1,200	56,800	41.5	93.0%
450	1,400	67,150	49.1	94.2%
450	1,579	75,000	54.8	93.3%
450[1]	1,641	77,700	56.8	93.0%
375	400	12,350	8.8	72.8%
375	600	20,400	14.6	80.2%
375	800	29,100	21.1	85.8%
375	1,000	38,300	27.7	90.3%
375	1,200	47,300	34.2	92.9%
375	1,400	55,100	39.9	92.8%
375	1,460	56,800	41.1	91.7%

[1] Head at nameplate rating.

Table 3.2-2. Don Pedro Unit 4 turbine performance characteristics.

Net Head (ft)	Flow (cfs)	Turbine Output (hp)	Generator Output (MW)	Turbine Efficiency
500	210	6,793	4.43	57.0%
500	485	22,707	16.3	82.5%
500	725	36,618	26.5	89.0%

Net Head (ft)	Flow (cfs)	Turbine Output (hp)	Generator Output (MW)	Turbine Efficiency
500	940	50,678	36.7	95.0%
500	1000	53,629	38.8	94.5%
425	185	4,908	3.20	55.0%
425	440	17,404	12.5	82.0%
425	650	27,592	20.0	88.0%
425	850	38,132	27.8	93.0%
425	1010	45,797	33.4	94.0%
425	1155	50,700	37.0	91.0%
275	310	5,080	3.3	52.5%
275	475	10,082	7.0	68.0%
275	625	14,728	10.5	75.5%
275	770	19,587	14.1	81.5%
275	890	22,640	16.4	81.5%

3.3 Tailwater Rating Curve

Tailwater elevation varies as a function of plant flow and is primarily used for determination of the turbine cavitation limit and total available head. Tailwater levels, provided in Figure 3.3-1, were estimated by extrapolating the index test data noted in the April 2005 Hydraulic Conveyance Review. Using a relatively flat extrapolation gives a conservative estimate of maximum power output since the cavitation characteristics will be a more dominant factor than headloss.

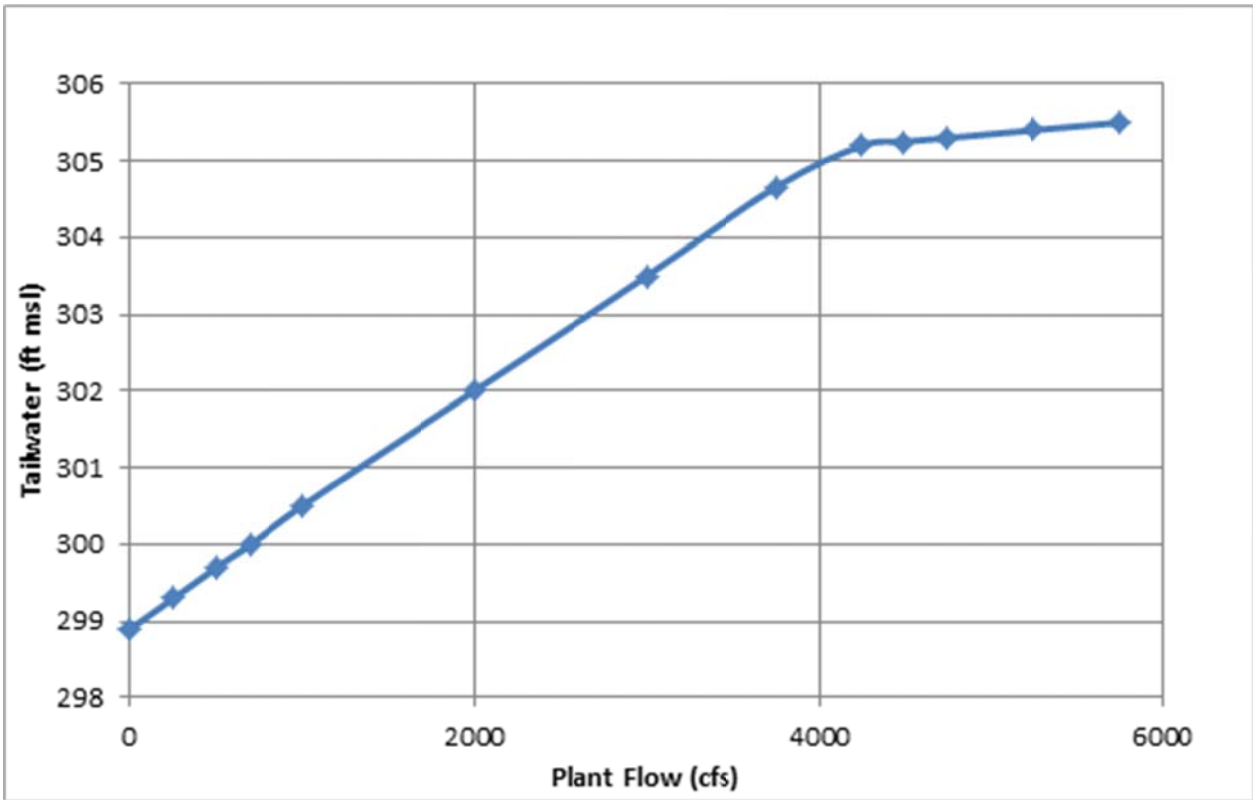

Figure 3.3-1. Don Pedro powerhouse tailwater rating curve.

3.4 Average Annual Energy Production

Historical monthly and annual energy production from 1997 to 2012 are provided in Table 3.4-1.

3.5 Estimate of Dependable Capacity

The dependable capacity at the plant varies with the available head. At 530 ft of net head, the dependable capacity would be 220 MW; at 450 ft of net head, the dependable capacity is 207 MW; and at 375 ft of net head, it is it is 168 MW. Linear interpolation can be used to approximate dependable capacity between these heads.

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Table 3.4-1. Monthly Project generation for 1997 through 2012 at Don Pedro powerhouse (MWh).

Year	January	February	March	April	May	June	July	August	September	October	November	December	Calendar Year Total
1997	125,807	112,176	79,403	79,955	91,751	62,960	84,199	64,326	36,628	31,271	9,585	9,543	787,610
1998	56,357	123,068	135,338	125,292	117,338	120,149	120,217	100,448	75,210	40,680	7,151	34,072	1,055,327
1999	44,765	81,324	96,268	41,266	68,889	64,896	76,417	75,500	40,689	31,869	11,881	14,937	648,706
2000	11,795	55,976	110,295	83,714	81,391	71,623	86,957	86,278	48,789	29,422	8,090	12,897	687,232
2001	10,538	30,737	33,242	53,223	72,264	58,898	65,789	54,452	30,734	21,270	4,137	4,900	440,188
2002	5,078	4,258	38,044	61,818	54,412	54,340	66,447	52,811	28,789	18,759	6,073	7,004	397,839
2003	5,394	11,275	25,075	39,599	51,963	65,441	75,800	61,666	32,692	33,134	8,342	6,261	416,648
2004	7,508	12,122	62,984	72,157	58,301	58,788	68,904	54,145	25,451	23,118	4,564	4,401	452,449
2005	12,339	48,759	98,232	137,057	143,776	137,290	122,689	84,792	43,861	22,202	9,831	33,044	893,877
2006	111,668	72,155	125,740	110,498	131,216	124,759	97,386	80,643	46,356	26,151	11,631	8,204	946,413
2007	12,597	15,207	45,087	48,189	54,255	57,215	64,530	53,546	22,956	15,460	7,032	3,779	399,858
2008	3,183	5,562	37,289	43,157	58,311	45,852	54,811	46,689	22,416	11,466	4,646	6,113	339,501
2009	4,911	5,325	21,733	41,083	55,266	56,221	67,625	53,082	28,387	18,050	7,780	5,495	364,964
2010	6,865	7,736	27,539	58,257	119,843	119,846	92,165	70,799	43,904	28,570	19,302	120,918	715,749
2011	114,959	82,977	112,795	109,858	120,545	114,007	105,415	138,488	70,250	29,961	6,913	7,188	1,013,360
2012	32,928	13,185	26,369	27,095	69,323	54,121	66,022	54,510	31,515	17,446	3,900	2,892	399,312
Average	35,418	42,615	67,215	70,764	84,303	79,150	82,211	70,761	39,289	24,927	8,179	17,603	622,440

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4.0 POTENTIAL FUTURE DEVELOPMENT

The Districts have investigated the feasibility of increasing the installed capacity of the existing hydropower units. It presently appears to be technically and economically feasible to expand the hydropower capacity by replacing the turbines and rewinding the generators of Units 1, 2, and 3; therefore, the Districts are proposing to increase the generation capacity of the Project. The investigations conducted by the Districts are summarized below.

4.1 Turbine Upgrade

A number of alternatives were investigated for increasing the performance of the turbines of Units 1, 2, and 3. As described above, the existing turbines are capable of producing 85,000 hp and the generators 62 MW at 530 ft of net head. The turbine hydraulic capacity at this condition would be 1,510 cfs. At 500 ft net head, the existing turbines can pass approximately 1,540 cfs within their cavitation limits, and produce 61,000 hp. The Districts' analysis of the existing turbine components indicates that the current turbine shafts would limit the maximum turbine upgrade to approximately 70 MW and a flow of approximately 1,700 cfs per unit at 530 ft of net head. The replacement runner would be designed to fit within the existing turbine wheel-case; however, it is possible that a band extension would be required to maintain cavitation to acceptable levels. Wicket gate rotation would expand to pass the increased flow. Expanding each of Units 1, 2, and 3 would bring the new plant maximum capacity to approximately 244 MW, assuming the capacity of Unit 4 is maintained at the existing 38 MW.

4.2 Generator Upgrade

Initial analyses indicate that a generator upgrade limit of 70 MVA is feasible. At 0.95 power factor, this represents a generator output turbine limit of approximately 67 MW. The generator upgrade would include installation of a replacement stator winding that fits within the existing stator core. However, temperature limitations may require replacement of the stator cores at the 70 MVA rating. A replacement bus will also be required at the 70 MVA unit rating. Further analysis of the rim-to-spider connection and assessment of potential for unbalanced magnetic forces must be conducted prior to final unit upgrade selection.

4.3 Energy and Capacity Benefits

The new Units 1, 2, and 3 are expected to produce energy benefits of approximately 20,000 MWh per year, or approximately 3 percent resulting from improved efficiency and greater capacity. Capacity benefits are more difficult to estimate at this time, but are expected to be significant in the California market in the future, potentially greater than current energy benefits.

4.4 Cost Estimate

Total upgrade costs are currently estimated to be approximately $48.8 million (2016 $). Turbine related costs are estimated at $19.3 million, generator costs are estimated at $23.7 million, and related balance of plant at $5.8 million.

5.0 LITERATURE CITED

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DON PEDRO HYDROELECTRIC PROJECT
FERC NO. 2299

AMENDMENT OF 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 Stated 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	(*deleted March 1964 - cost determination*)	36	Reservoir clearing
7	(*deleted May 1964 - rate of return*)	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	(*deleted March 1964 - Recreation facilities*)	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	(*deleted 1993 - Lands*)
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 (*added 1980*)
20	Clearing of transmission line rights-of-way on U.S.-owned lands	50	Granting permission for use of Project lands (*added 1980*)
21	Clearing of reservoir margins	51	Construction erosion and dust control plan (*added 1987*)
22	Fire prevention	52	Woody debris removal plan (*added 1987*)

Article #	Topic	Article # (con't.)	Topic
23	Use of water for fire prevention, sanitary and domestic needs on U.S.-owned lands	53	Ward's Ferry Bridge restroom facilities (*added 1987*)
24	Construction liability	54	Addition of fourth generating unit (*added 1987*)
25	Permits for use of U.S.-owned lands for transportation and communication	55	Filing of drawings for fourth generating unit (*added 1987*)
26	Takeover of Project roads	56	The Districts' approval and filing of cofferdam and excavation drawings (*added 1987*)
27	Ownership of Project property	57	Filing of revised Exhibit Drawings (*added 1987*)
28	Gaging and stream gaging	58	Chinook monitoring program (*added 1987, revised in 1996, 1999, and 2009*)
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 from 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 Classification[1]	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

[1]The 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 Licenses 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.

DON PEDRO HYDROELECTRIC PROJECT
FERC NO. 2299

AMENDMENT OF 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.)

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<u>Districts "Strawman" for Considering Further Development of Unimpaired Hydrology for the Tuolumne River in Advance of Workshop On March 27, 2013</u>

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.

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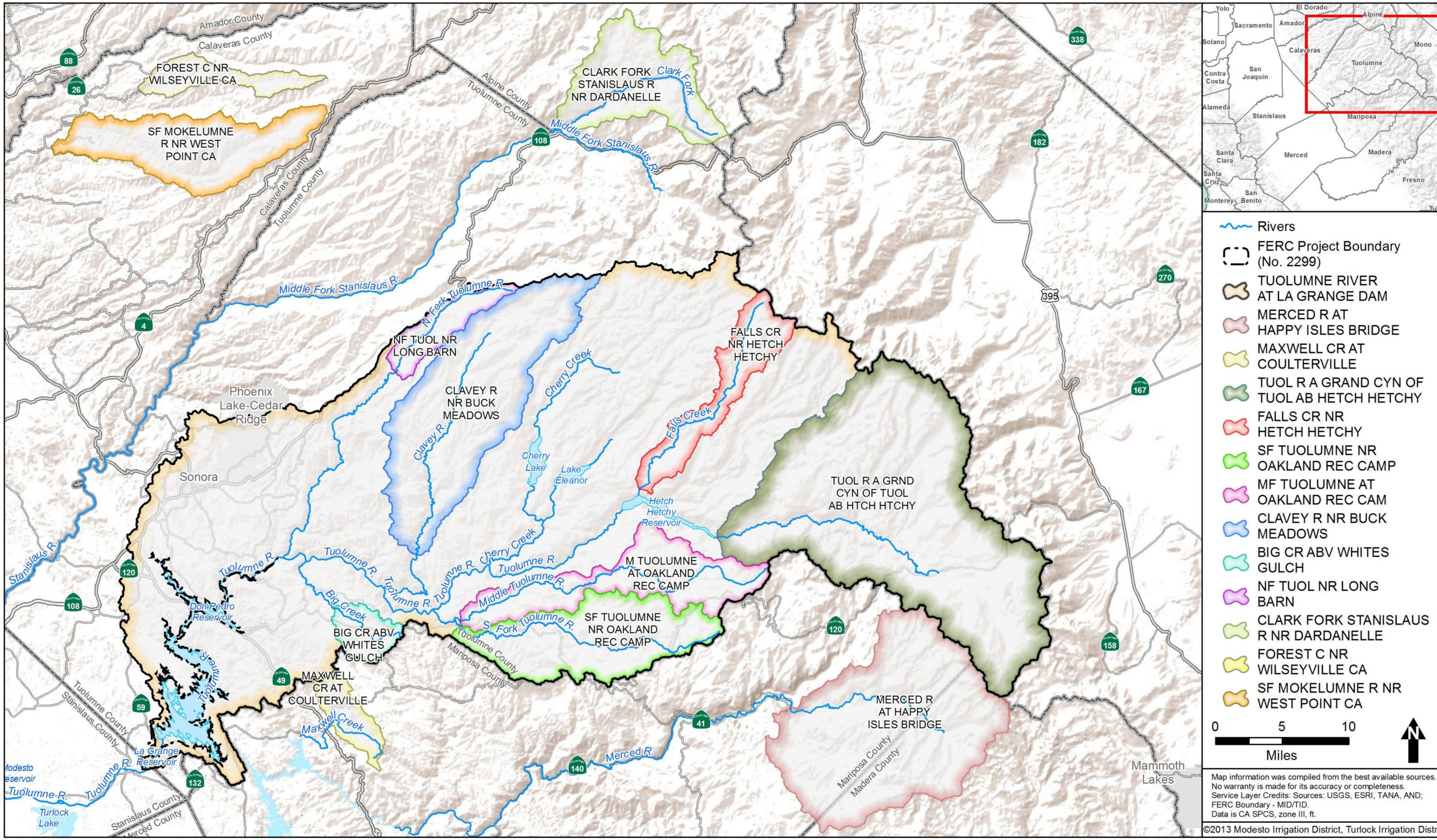

Figure 3.1.1 Map of gauges used in proration method for unimpaired hydrology

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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

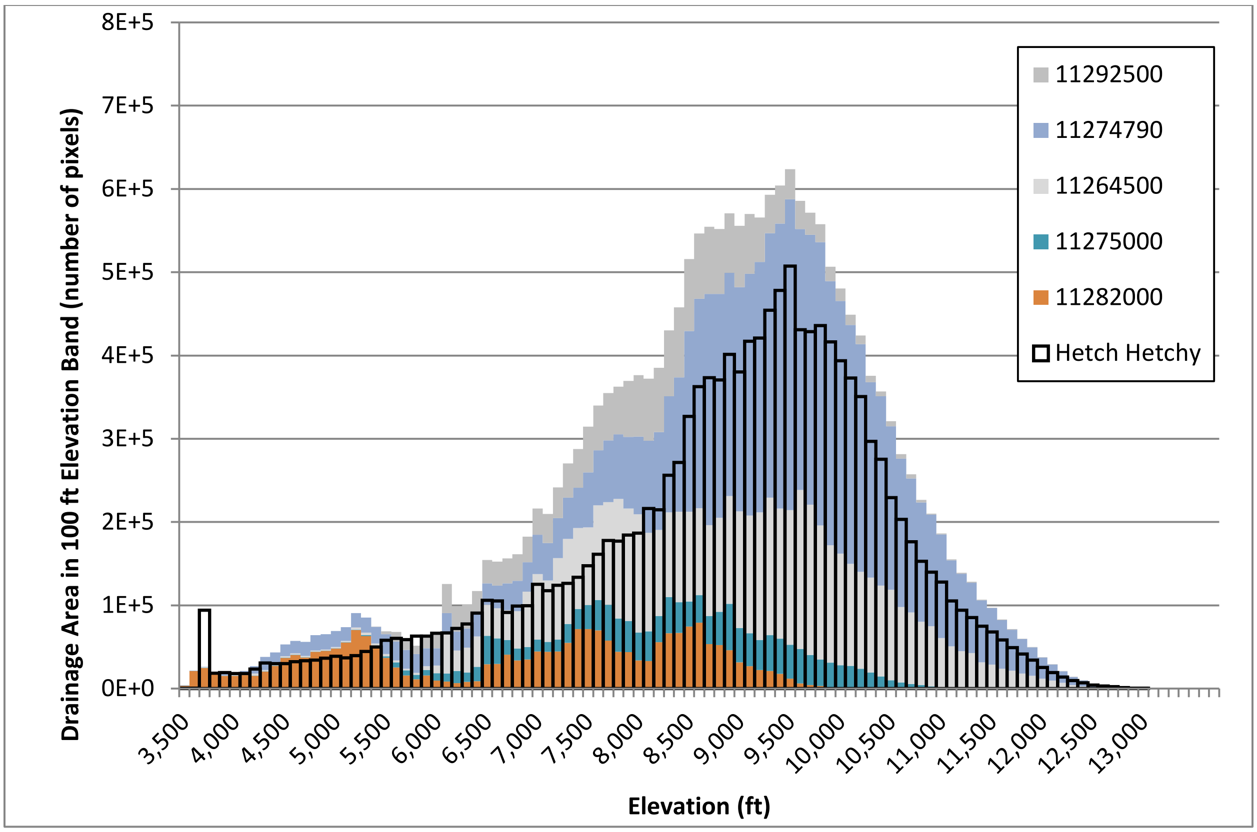

Figure 3.1.2 Elevation histograms for unimpaired gauges, compared to the Hetch Hetchy subbasin

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					
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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

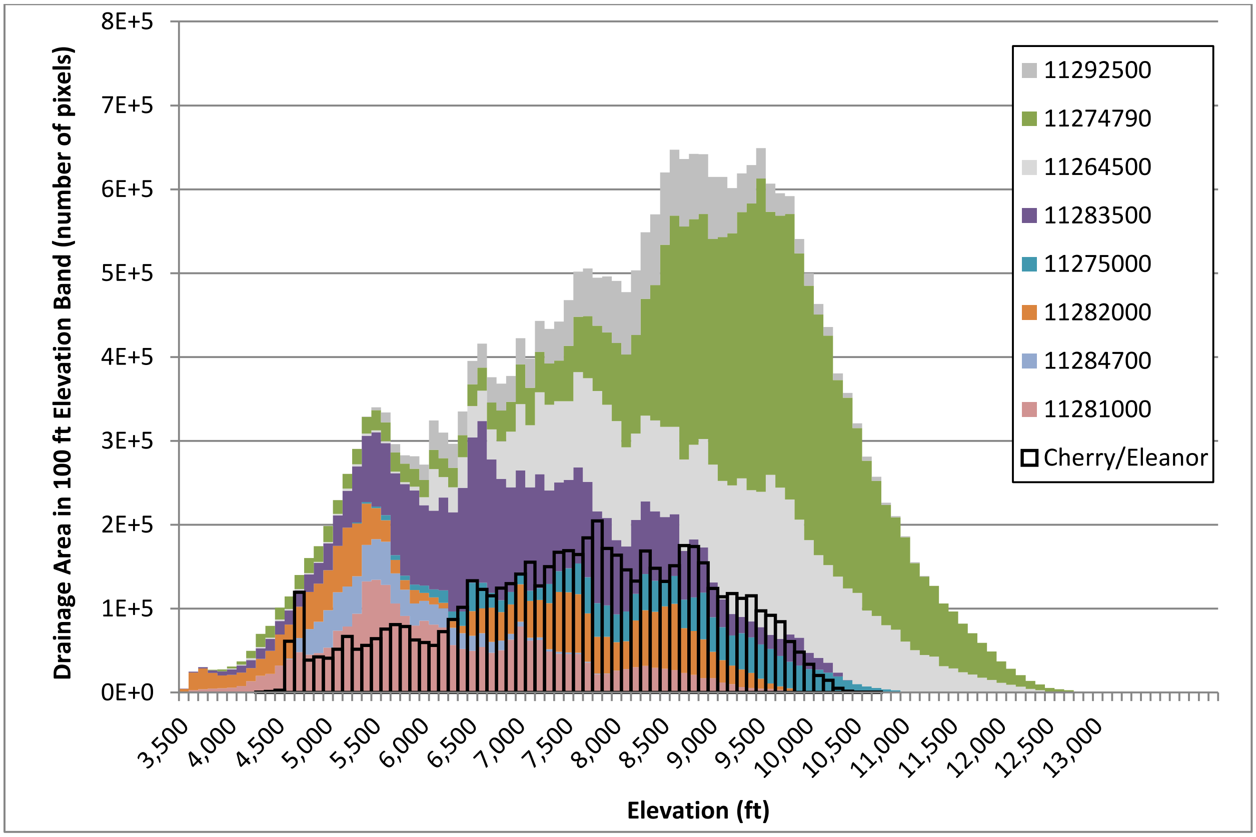

Figure 3.1.3 Elevation histograms for unimpaired gauges, compared to the Cherry/Eleanor subbasin

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								
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2001								
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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

11**3185**00	SF MOKELUMNE R NR WEST POINT CA
11**2693**00	MAXWELL C A COULTERVILLE CA
11**3168**00	FOREST C NR WILSEYVILLE CA
11**2844**00	BIG CR ABV WHITES GULCH

11**2835**00	CLAVEY R NR BUCK MEADOWS CA
11**2645**00	MERCED R A HAPPY ISLES BRIDGE NR YOSEMITE CA
11**2820**00	M TUOLUMNE R A OAKLAND RECREATION CAMP CA
11**2847**00	NF TUOLUMNE R NR LONG BARN CA
11**2810**00	SF TUOLUMNE R NR OAKLAND RECREATION CAMP CA

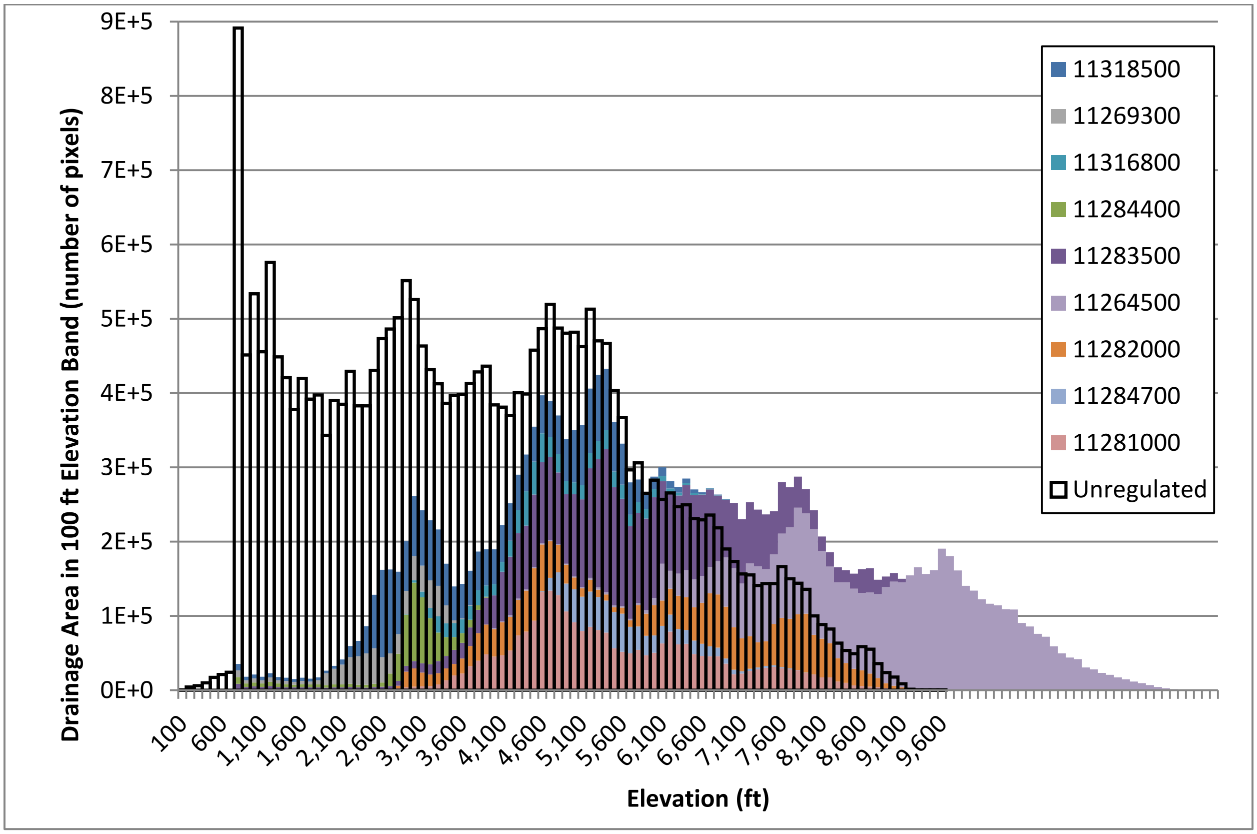

Figure 3.1.4 Elevation histograms for unimpaired gauges, compared to the Unregulated subbasin

Table 3.1.6 Gauge inventory for gauge proration of Unregulated subbasin

WY	3185	2693	3168	2844	2835	2645	2820	2847	2810
1971									
1972									
1973									
1974									
1975									
1976									
1977									
1978									
1979									
1980									
1981									

WY	3185	2693	3168	2844	2835	2645	2820	2847	2810
1982									
1983									
1984									
1985									
1986									
1987									
1988									
1989									
1990									
1991									
1992									
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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	*0.97*
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.

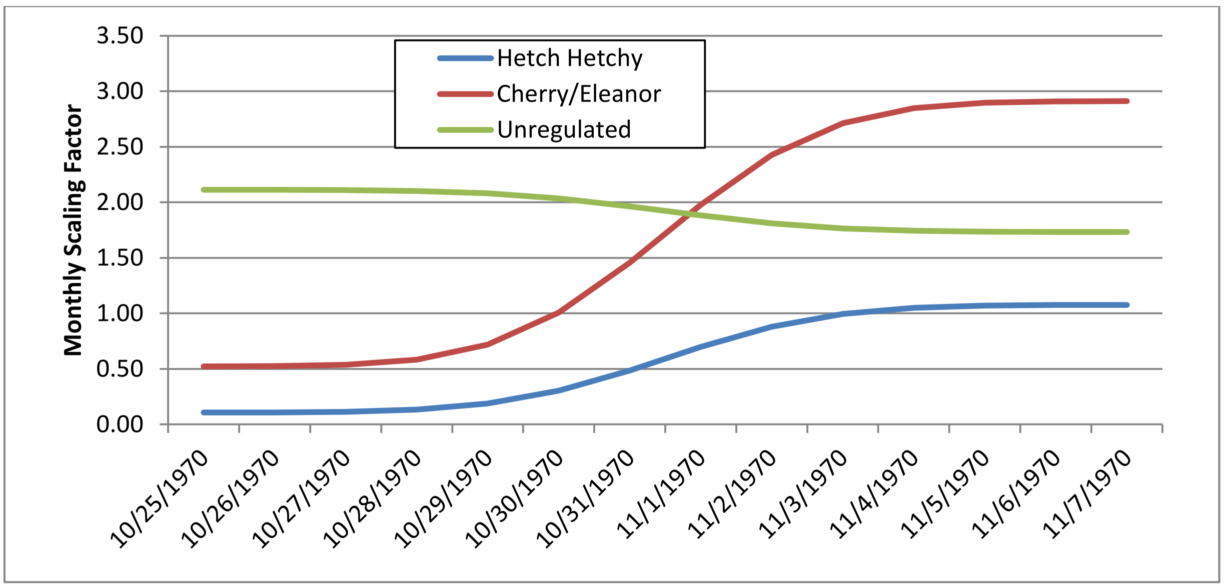

Figure 3.3.1 Typical daily scaling factor smoothing

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

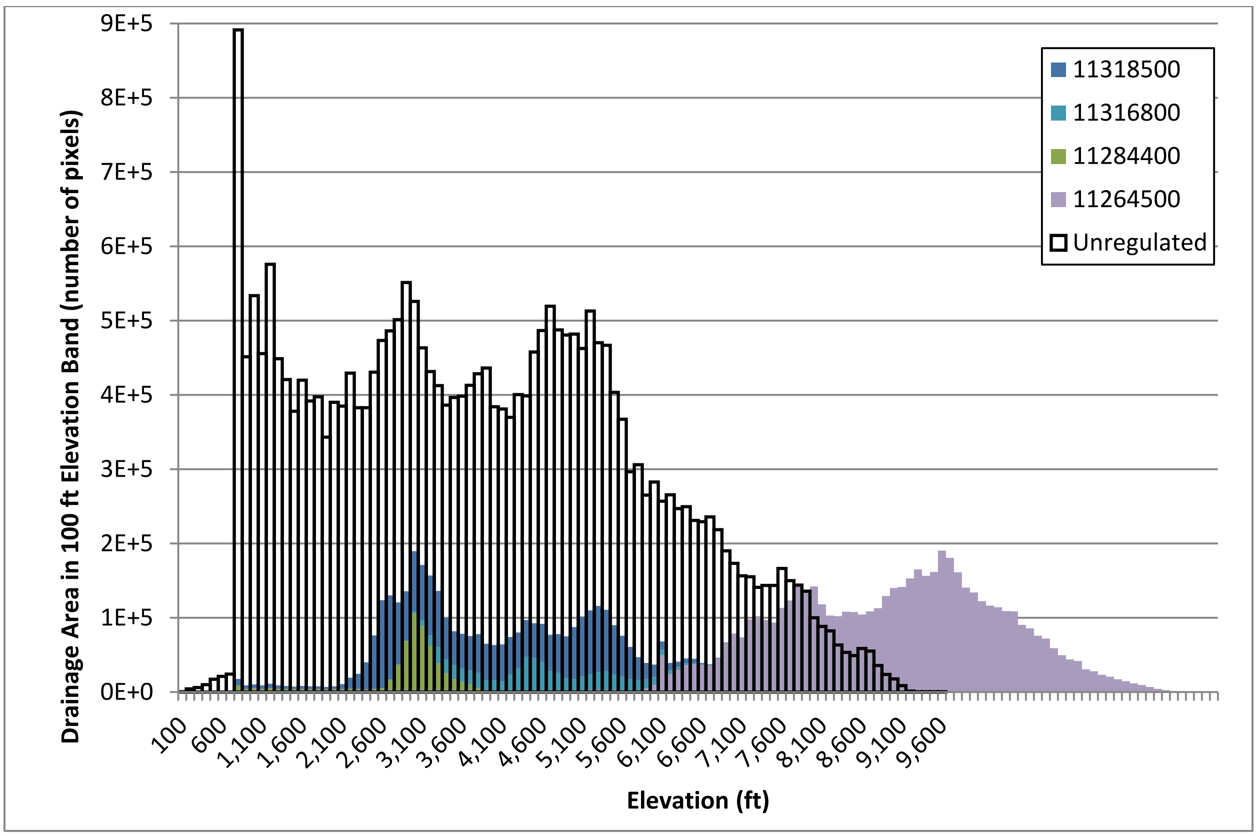

Figure 5.1 Elevation histogram for Unregulated subbasin gauge proration (WY 97, 02-08)

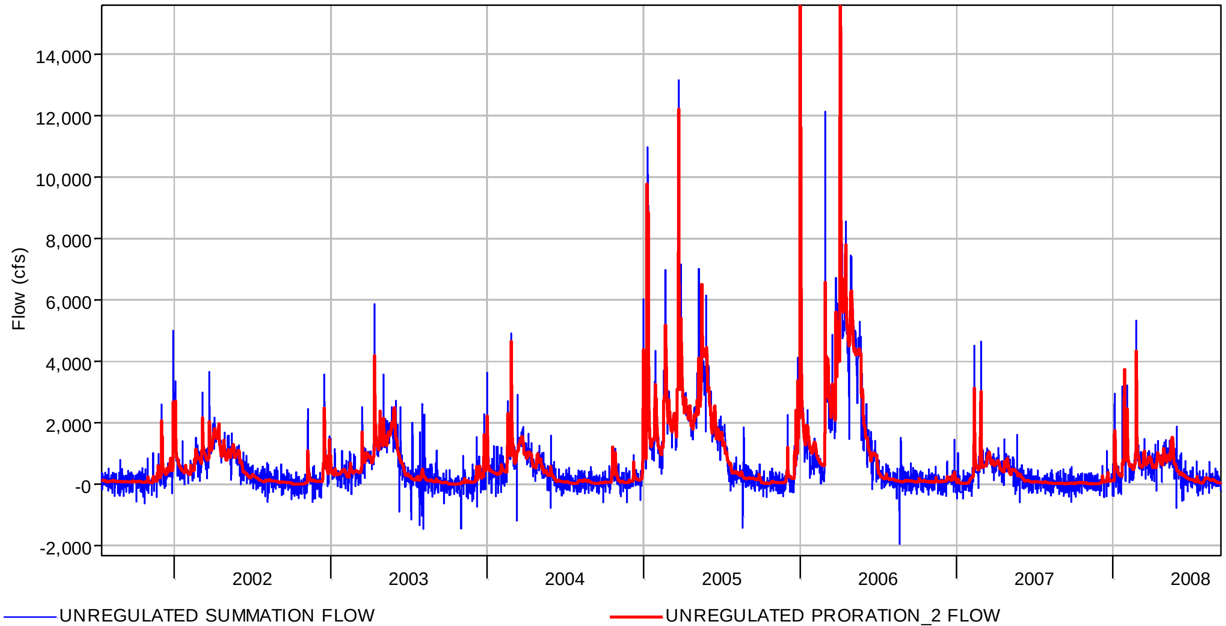

Figure 5.2 Hydrograph comparison gauge summation (W&AR-02) and gauge proration

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
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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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List of Figures

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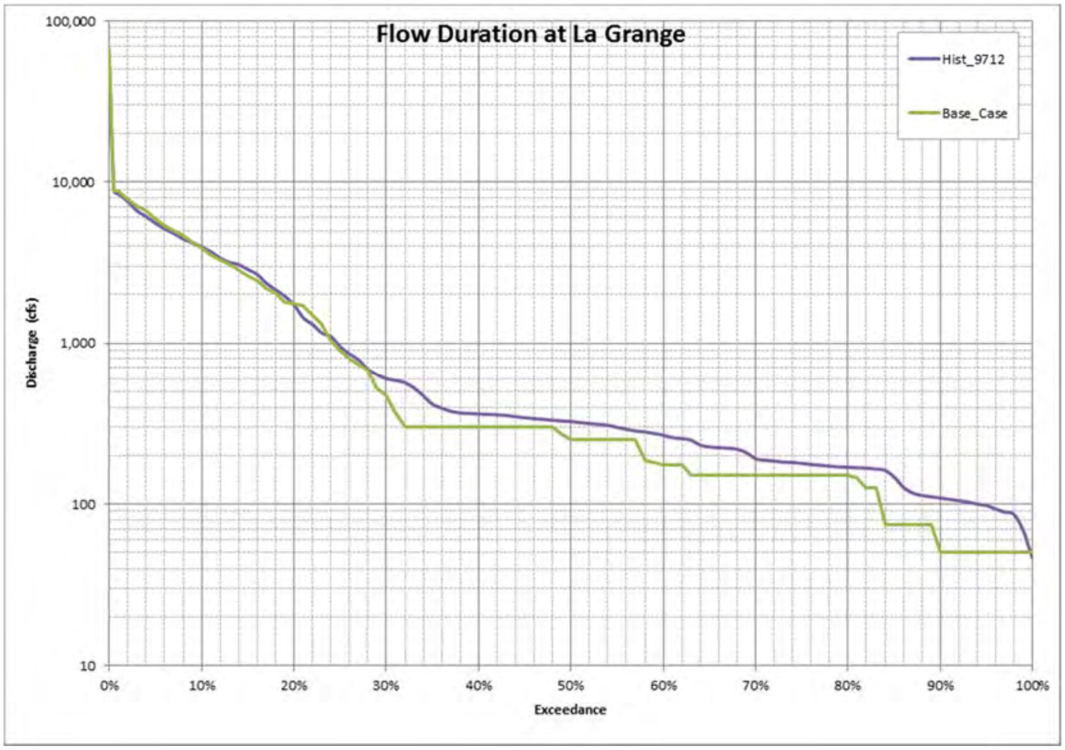

Figure B-1. **Annual flow duration at USGS La Grange gage for historical and Base Case operations.**

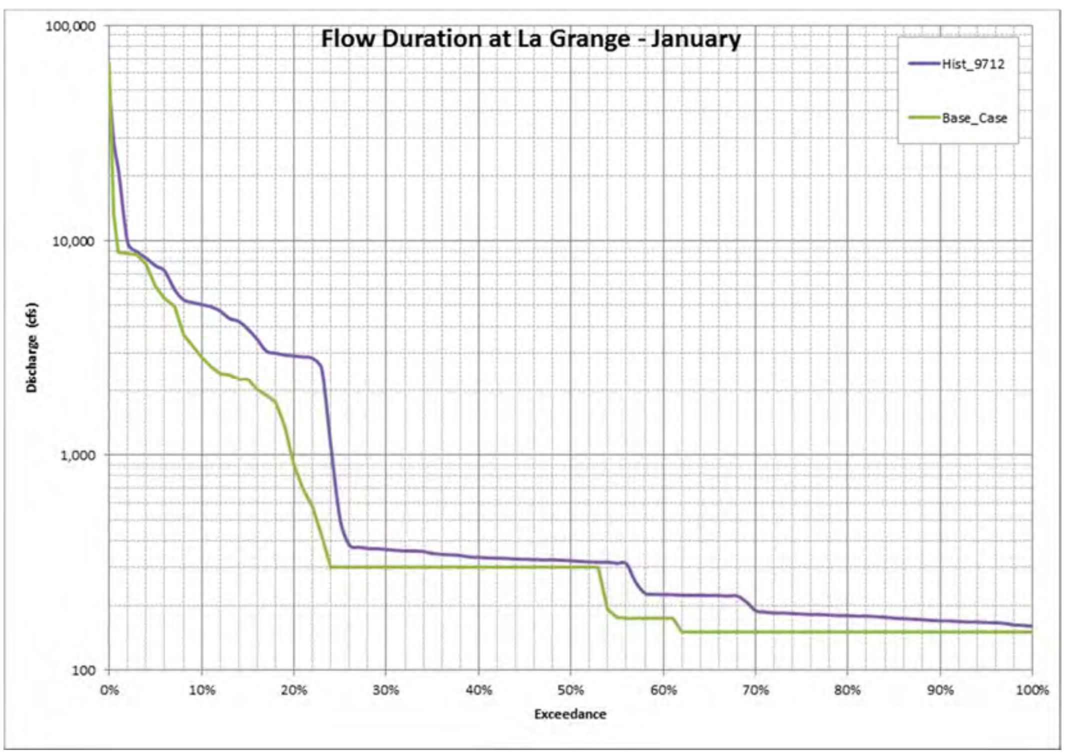

Figure B-2. **Flow duration at USGS La Grange gage for historical and Base Case operations -- January.**

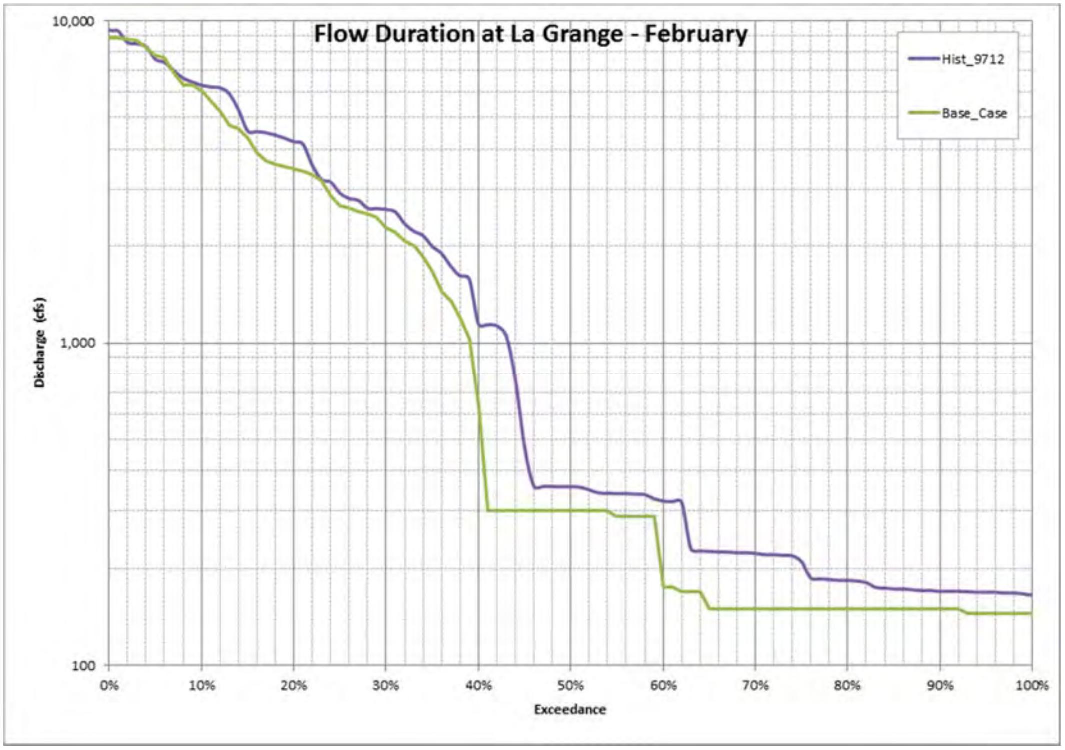

Figure B-3. **Flow duration at USGS La Grange gage for historical and Base Case operations -- February.**

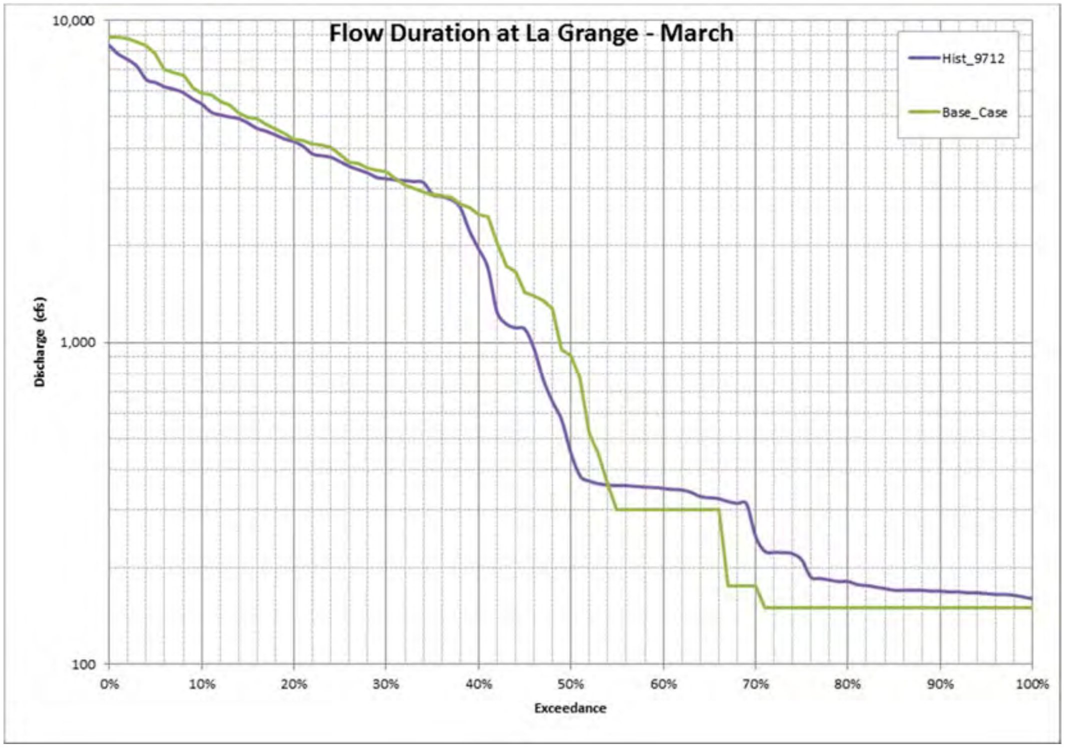

Figure B-4. **Flow duration at USGS La Grange gage for historical and Base Case operations -- March.**

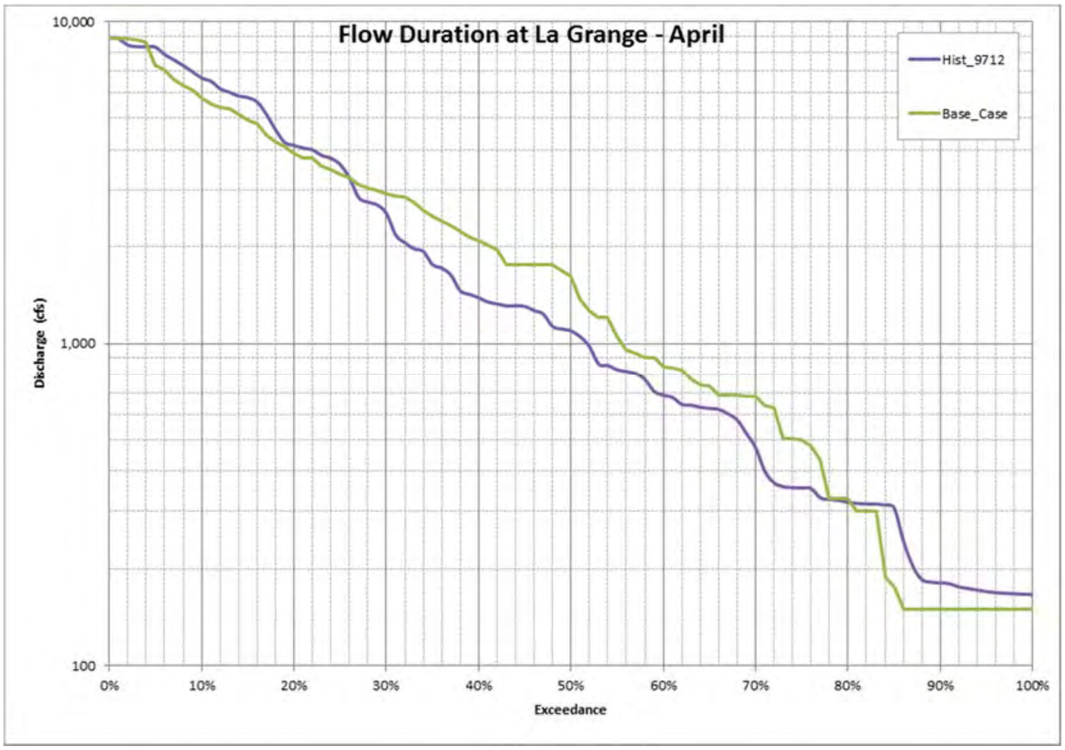

Figure B-5. **Flow duration at USGS La Grange gage for historical and Base Case operations -- April.**

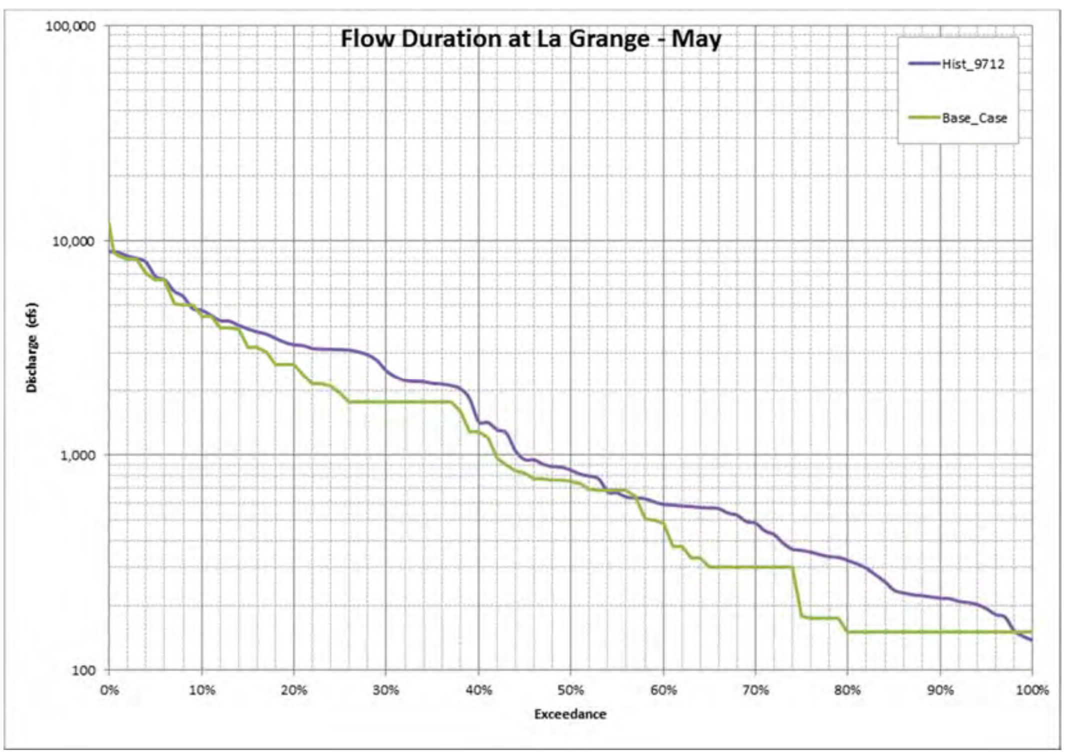

Figure B-6. **Flow duration at USGS La Grange gage for historical and Base Case operations -- May.**

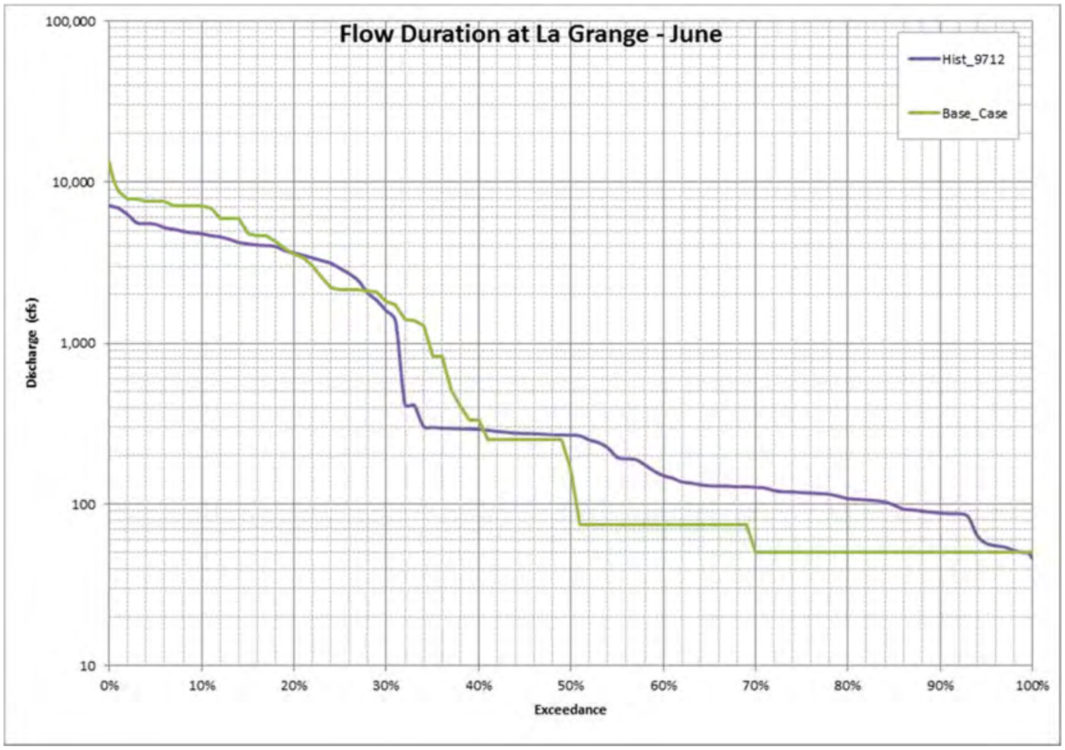

Figure B-7. **Flow duration at USGS La Grange gage for historical and Base Case operations -- June.**

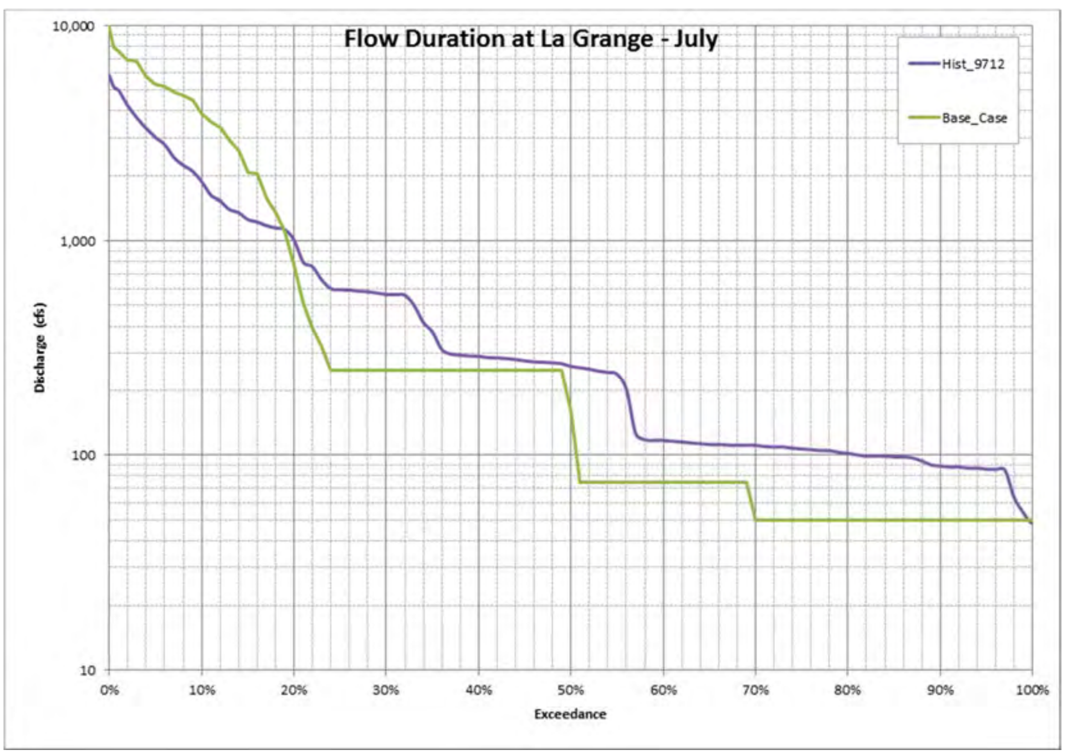

Figure B-8. **Flow duration at USGS La Grange gage for historical and Base Case operations -- July.**

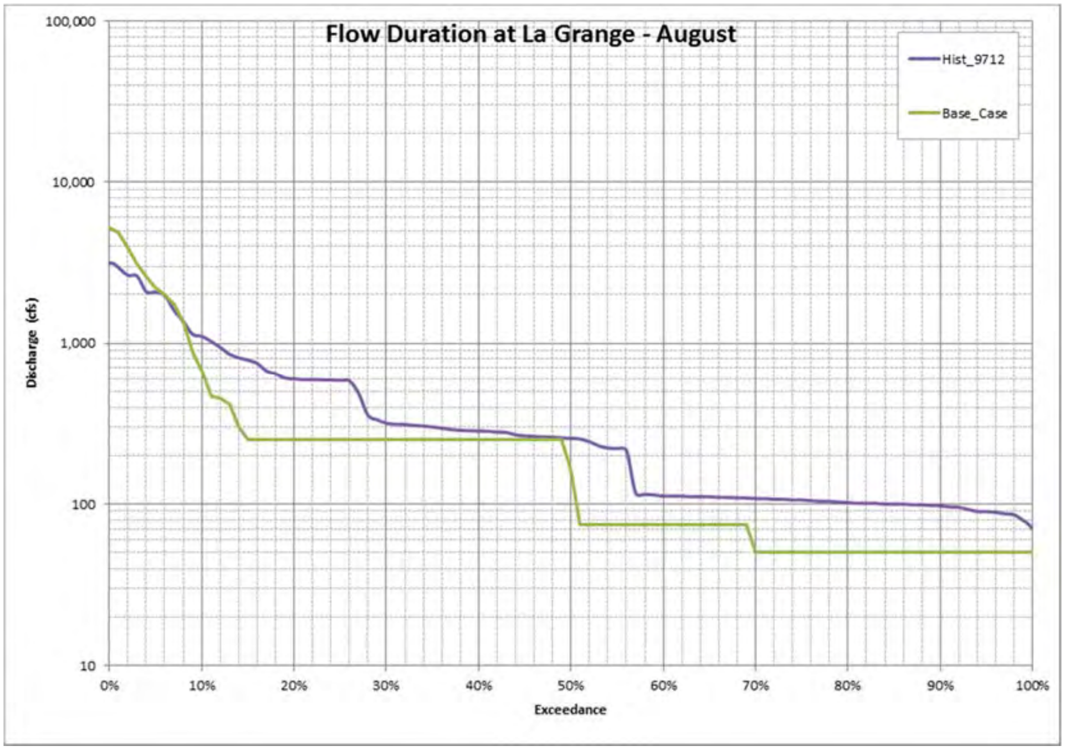

Figure B-9. **Flow duration at USGS La Grange gage for historical and Base Case operations -- August.**

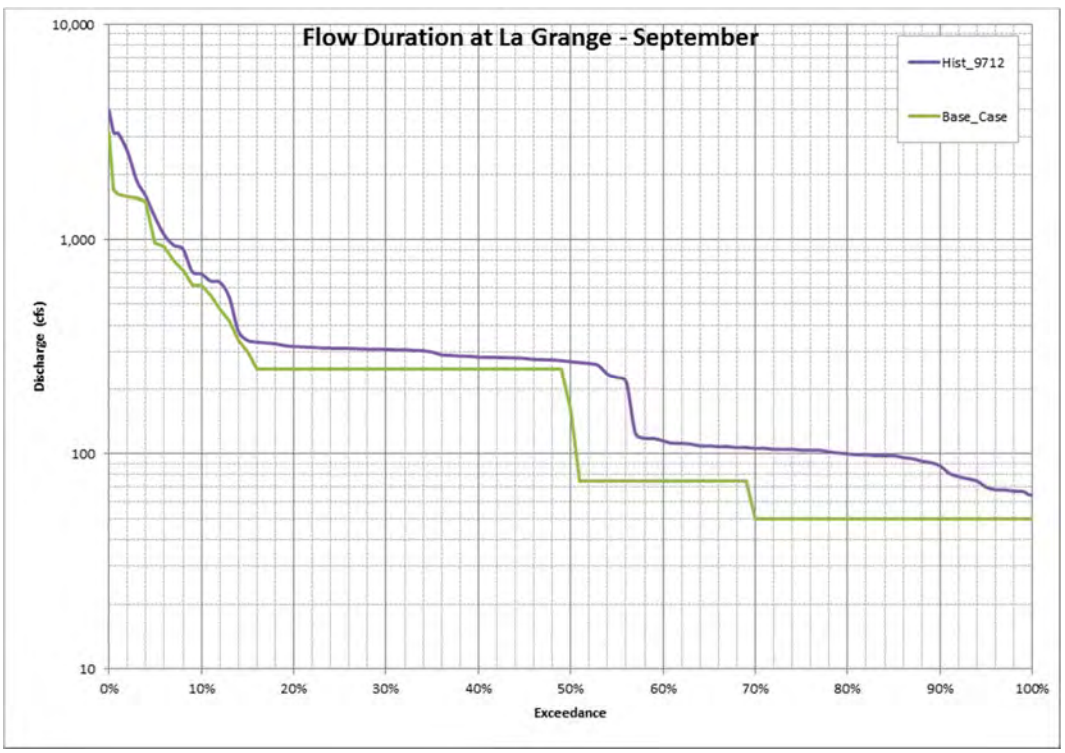

Figure B-10. **Flow duration at USGS La Grange gage for historical and Base Case operations -- September.**

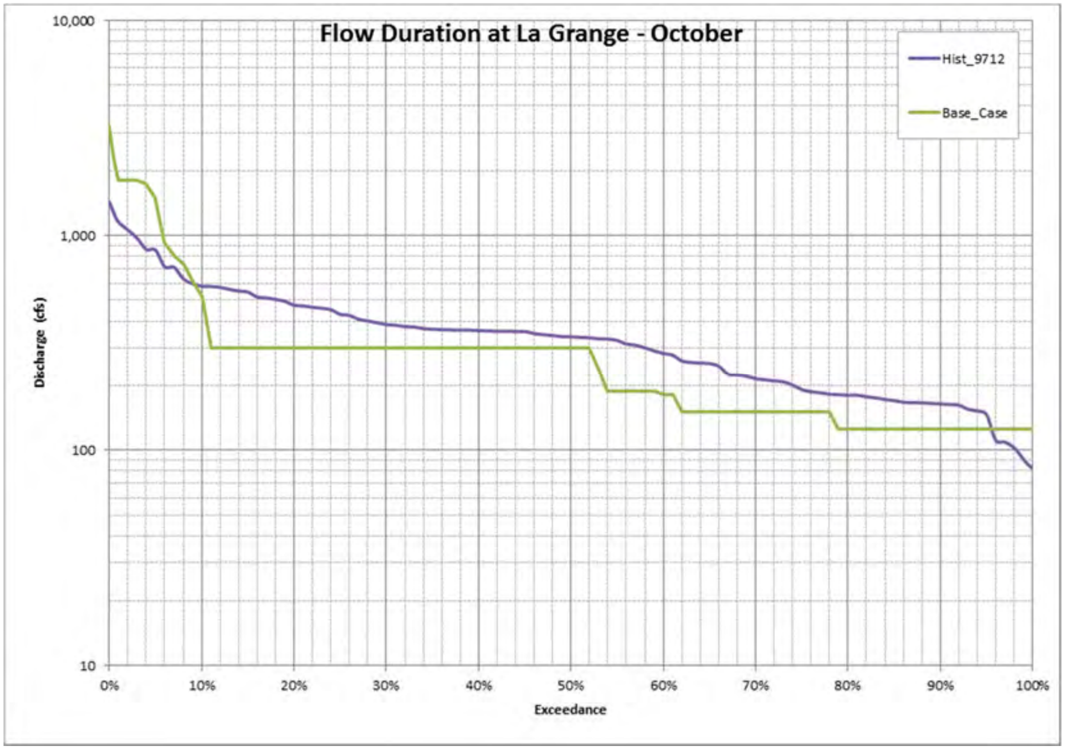

Figure B-11. **Flow duration at USGS La Grange gage for historical and Base Case operations -- October.**

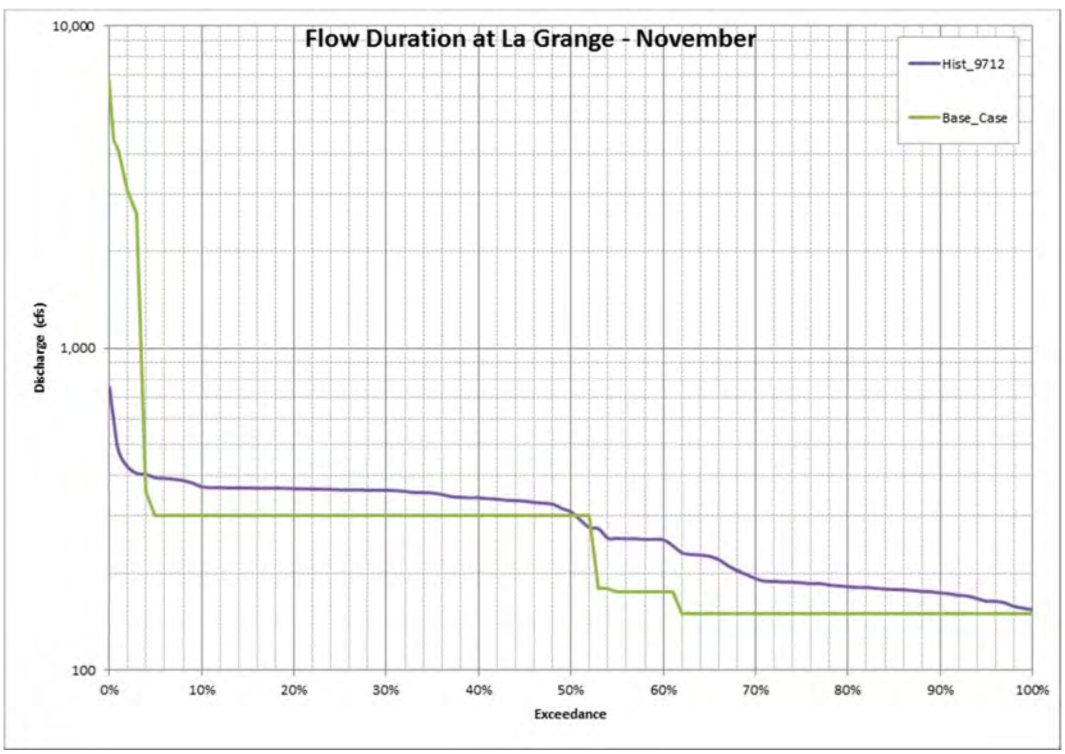

Figure B-12. **Flow duration at USGS La Grange gage for historical and Base Case operations -- November.**

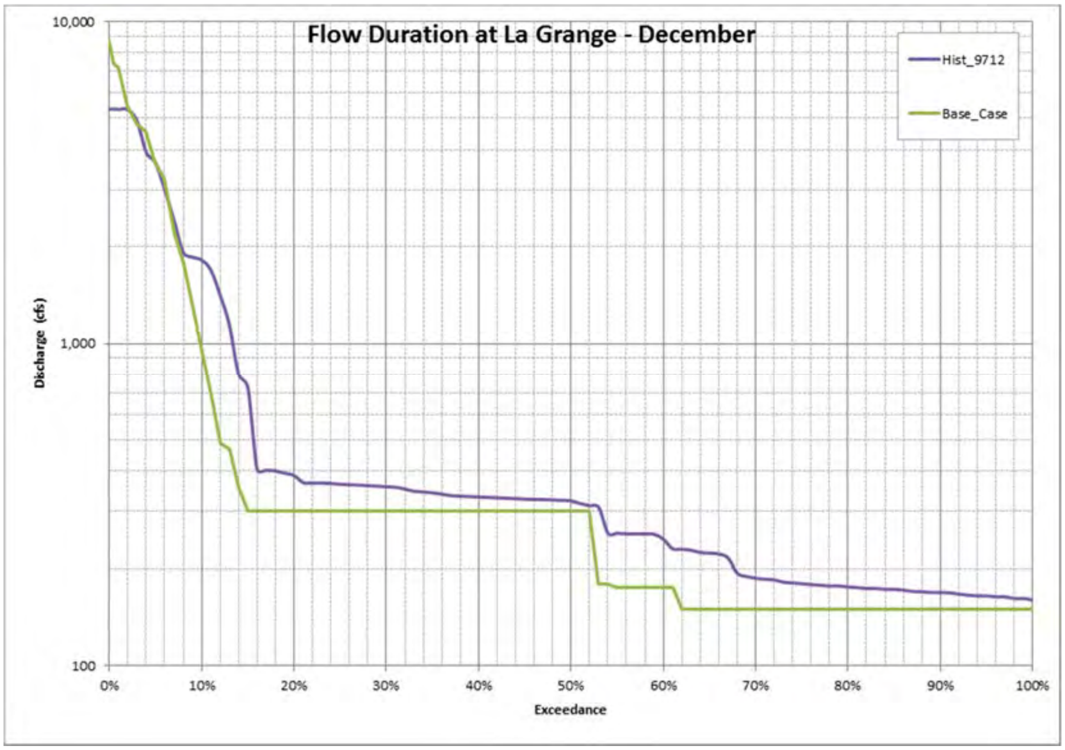

Figure B-13. Flow duration at USGS La Grange gage for historical and Base Case operations -- December.

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EXHIBIT B – DON PEDRO PROJECT OPERATIONS AND RESOURCE UTILIZATION

APPENDIX B-4
BASE CASE CONDITIONS 1971-2012

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Figure No.	Description	Page No.

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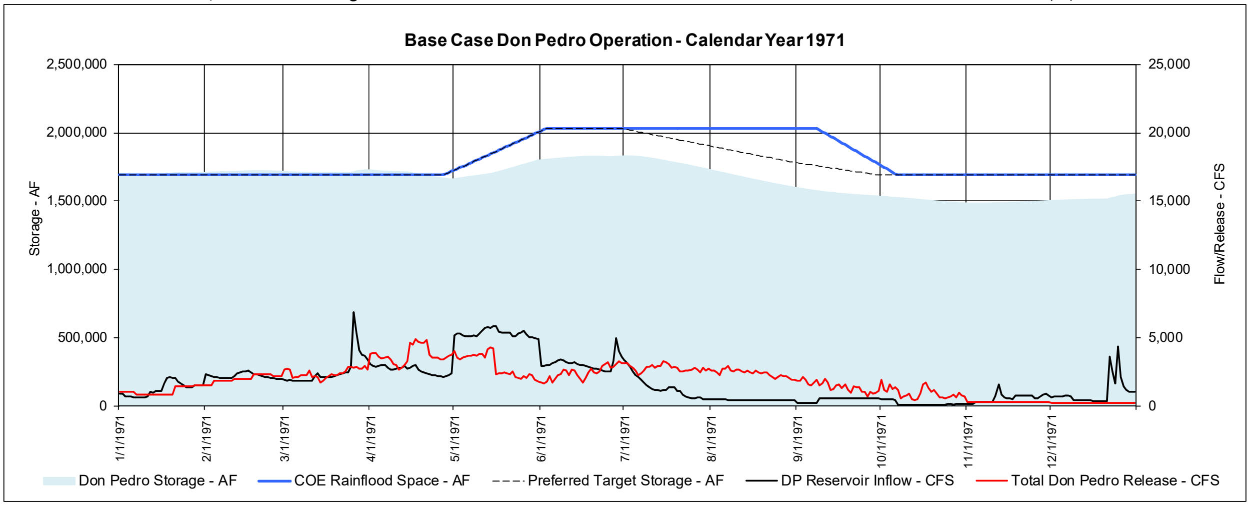
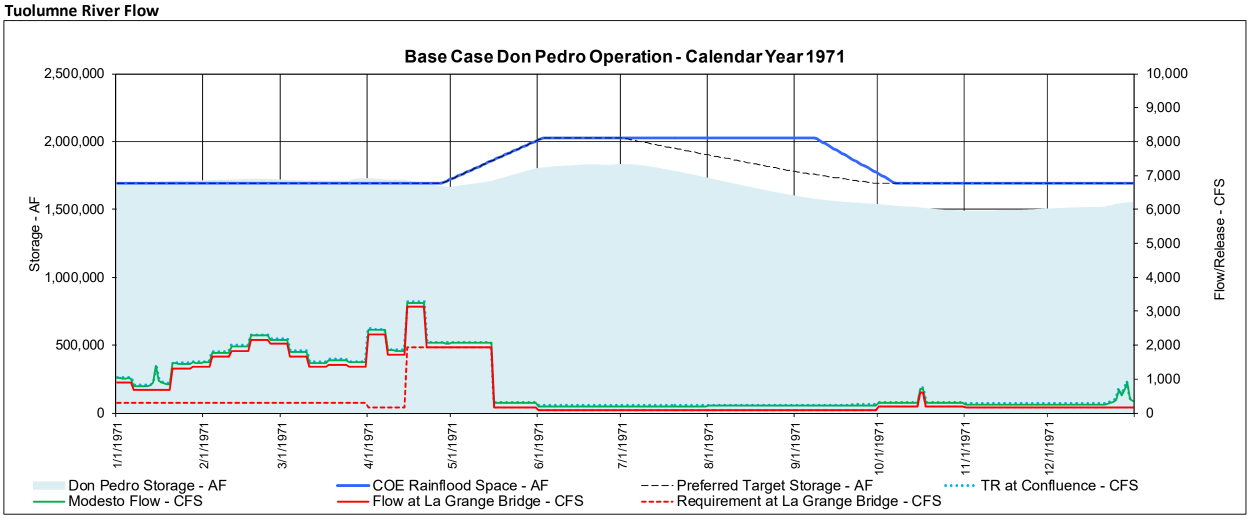
Don Pedro Reservoir Inflow, Release and Storage

Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

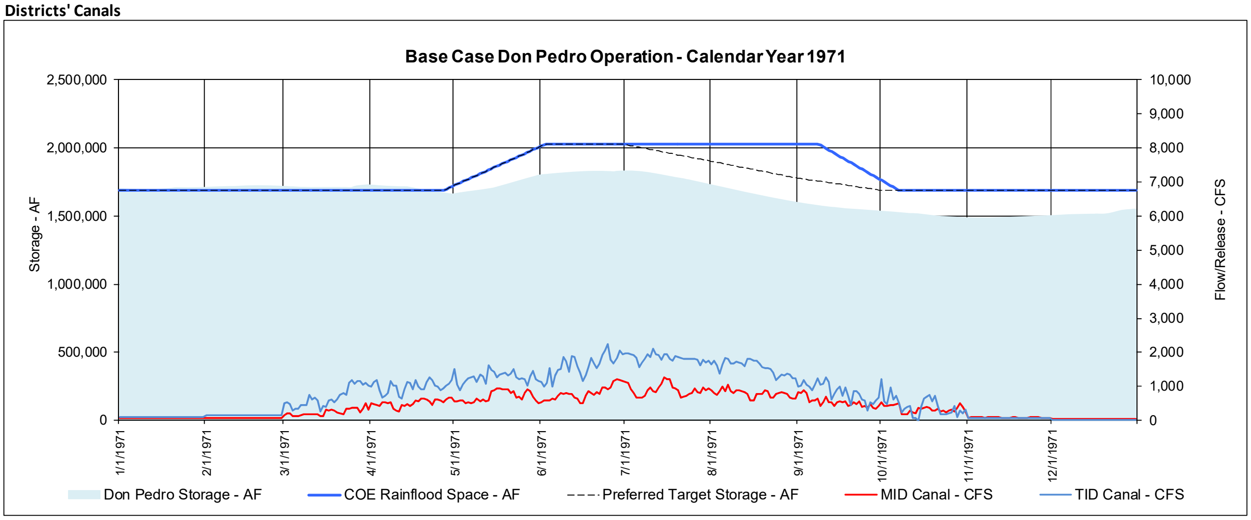
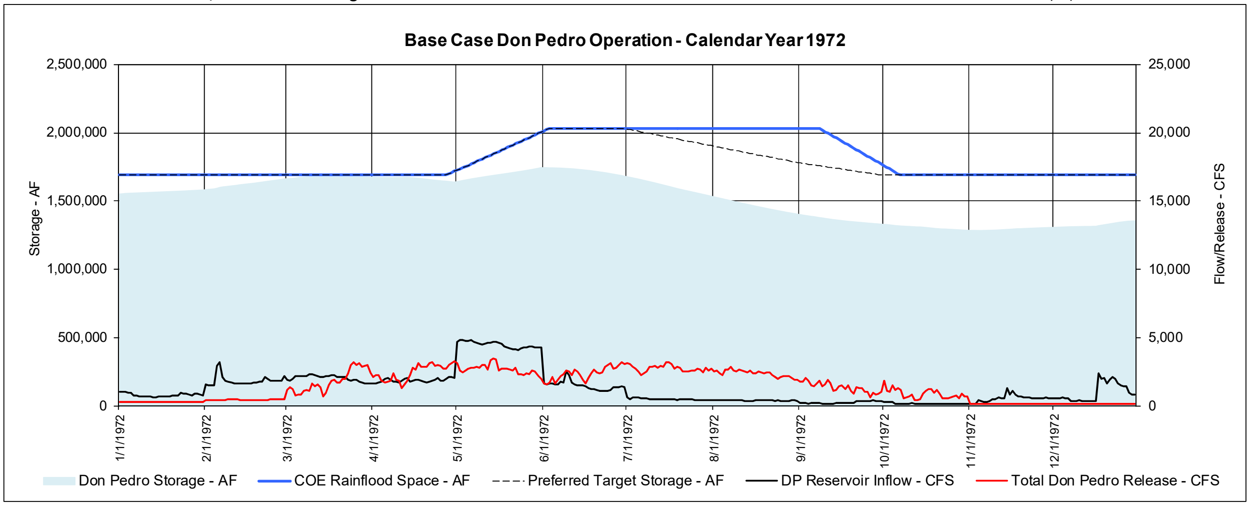
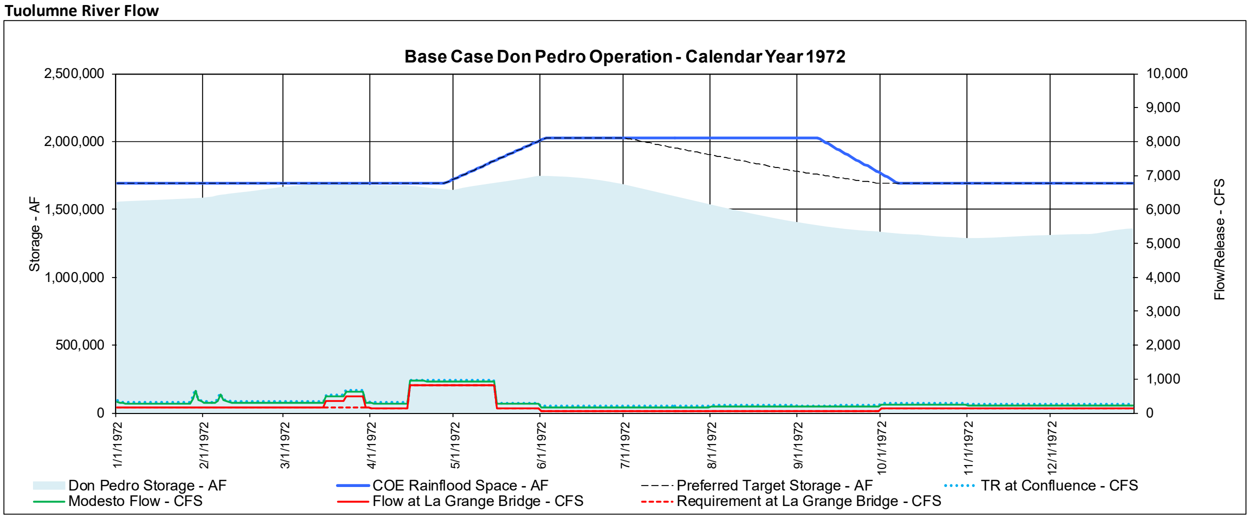


Figure B-1. Base Case conditions – calendar year 1971 (Source: Version 3.00 of the Tuolumne River Operations Model).

Don Pedro Reservoir Inflow, Release and Storage Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

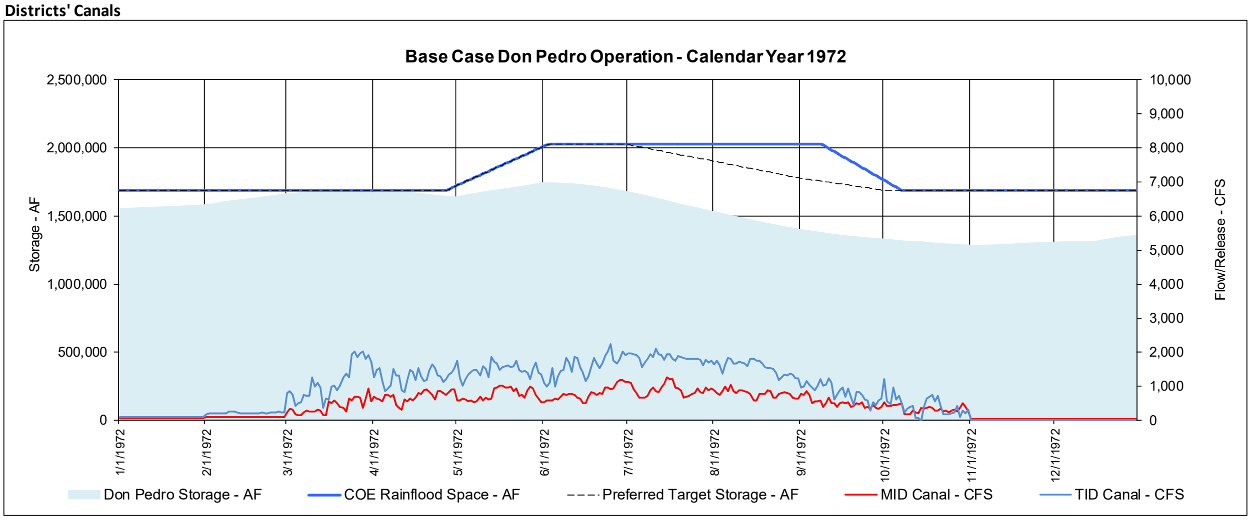
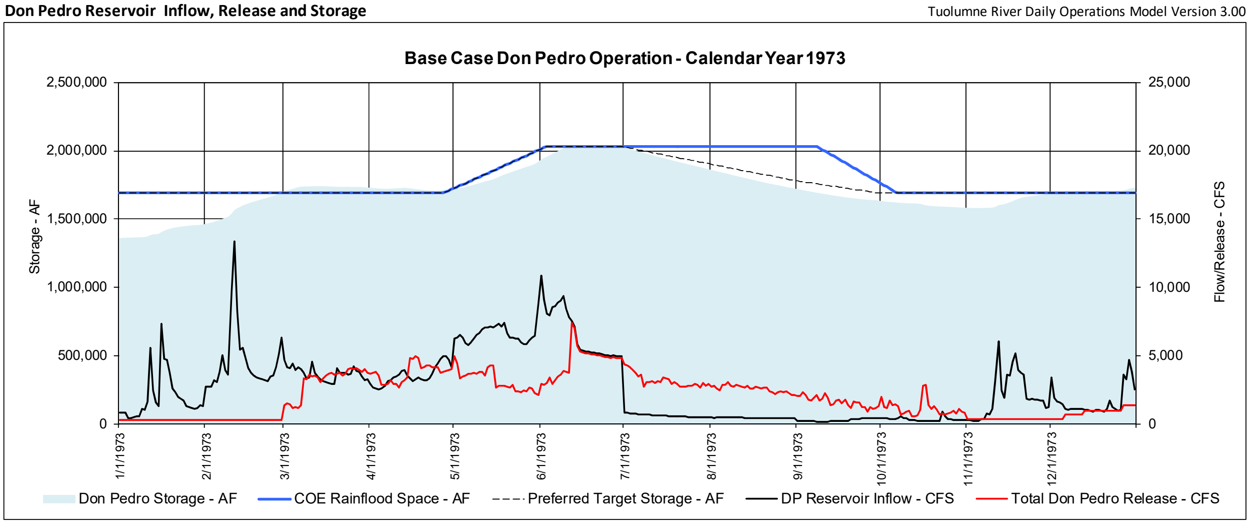


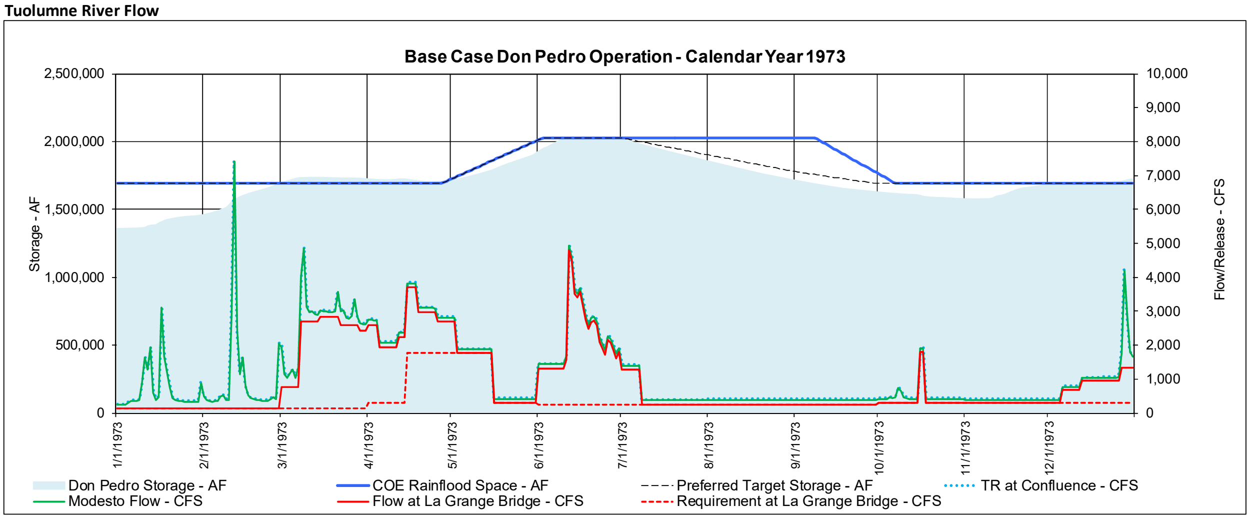
Figure B-2. Base Case conditions – calendar year 1972 (Source: Version 3.00 of the Tuolumne River Operations Model).

Don Pedro Reservoir Inflow, Release and Storage

Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

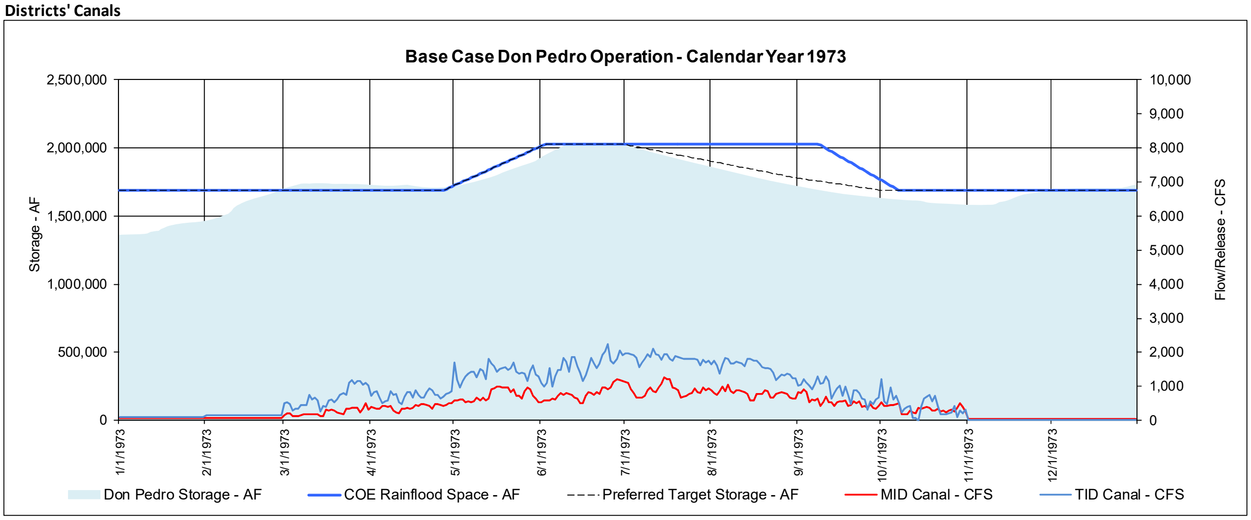
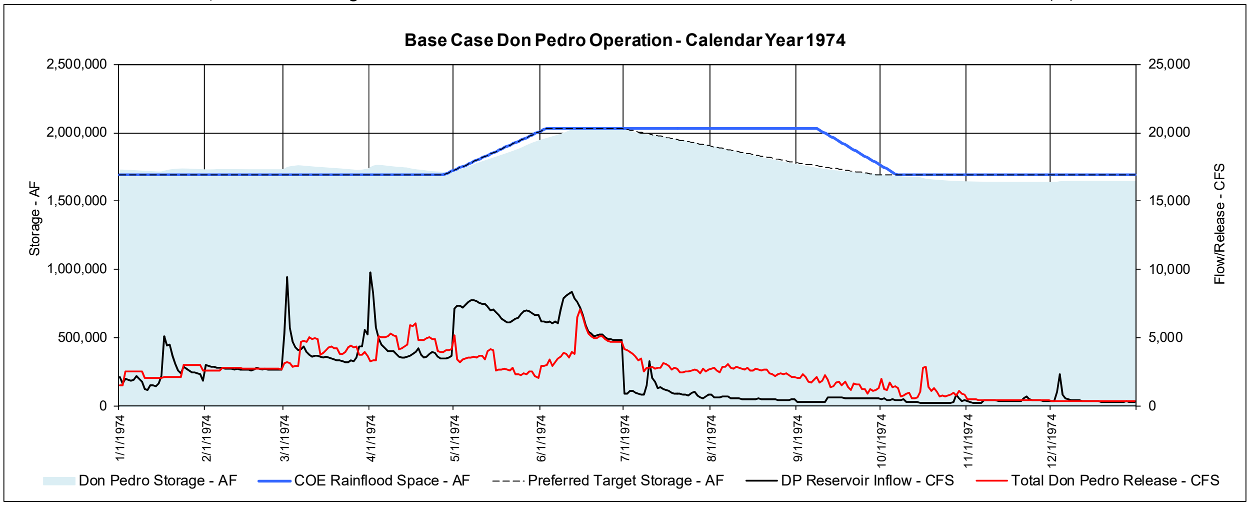
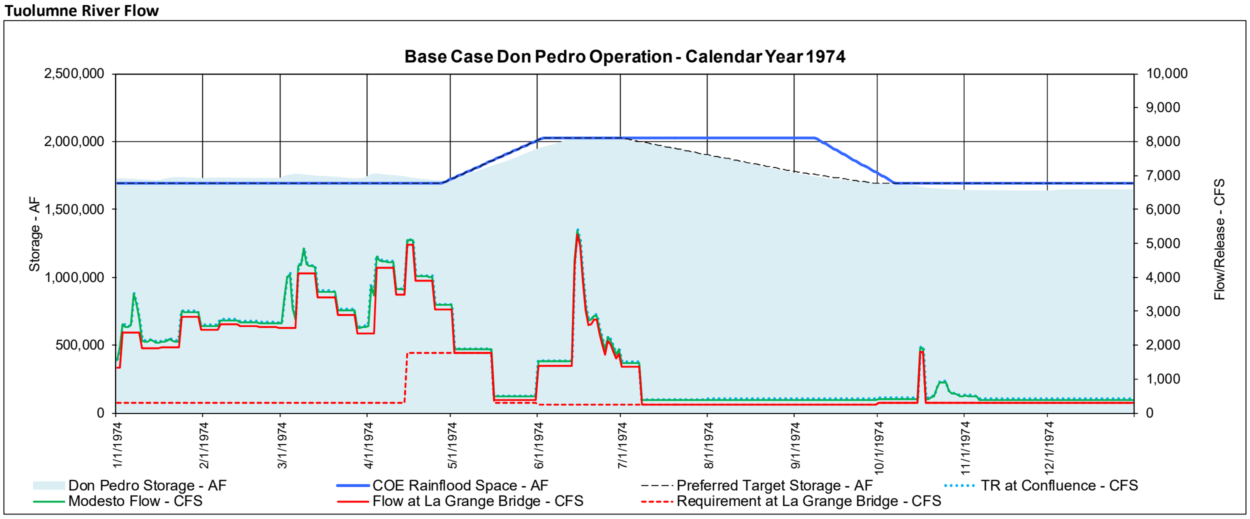


Figure B-3. Base Case conditions – calendar year 1973 (Source: Version 3.00 of the Tuolumne River Operations Model).

Don Pedro Reservoir Inflow, Release and Storage



Tuolumne River Flow



Districts' Canals

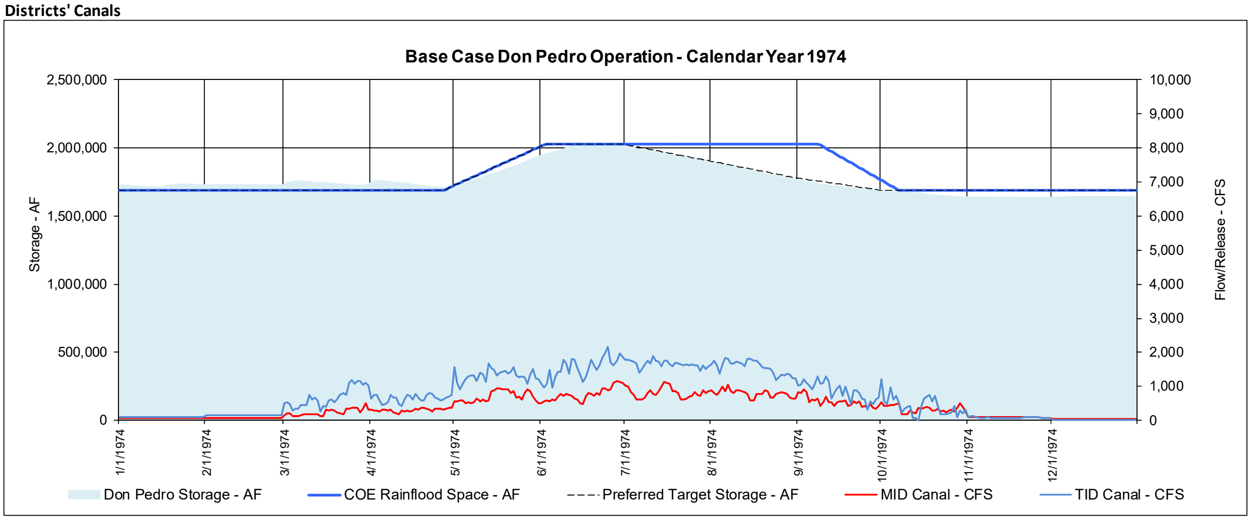
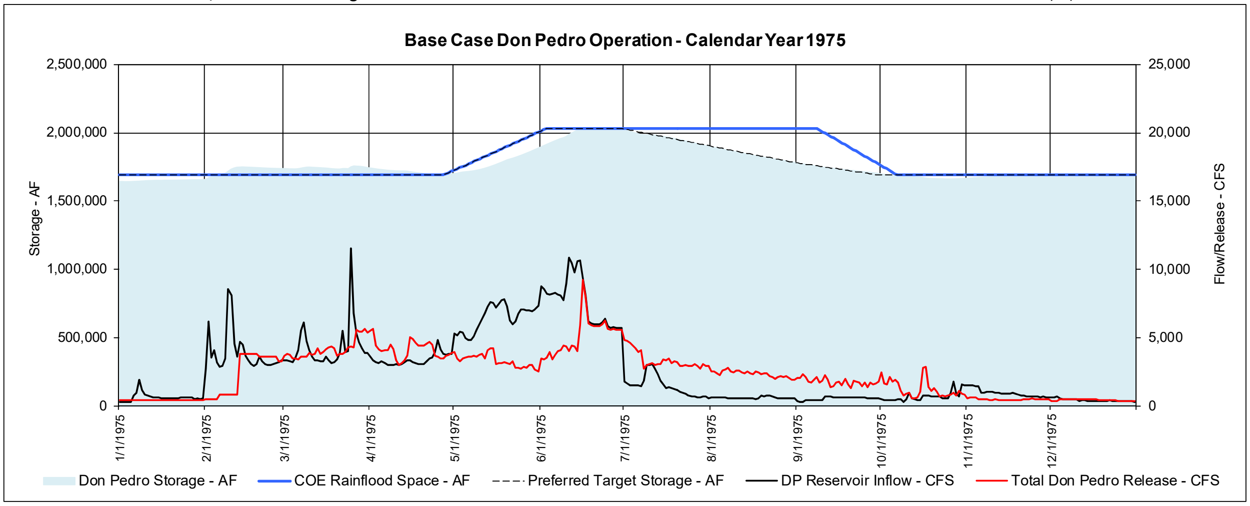


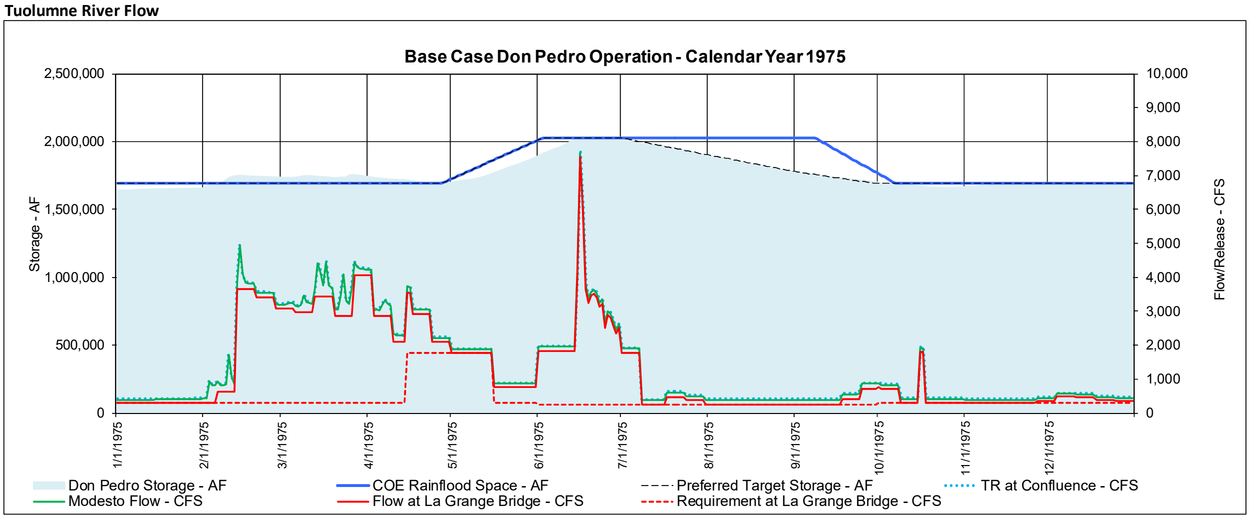
Figure B-4. Base Case conditions – calendar year 1974 (Source: Version 3.00 of the Tuolumne River Operations Model).

Don Pedro Reservoir Inflow, Release and Storage

Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

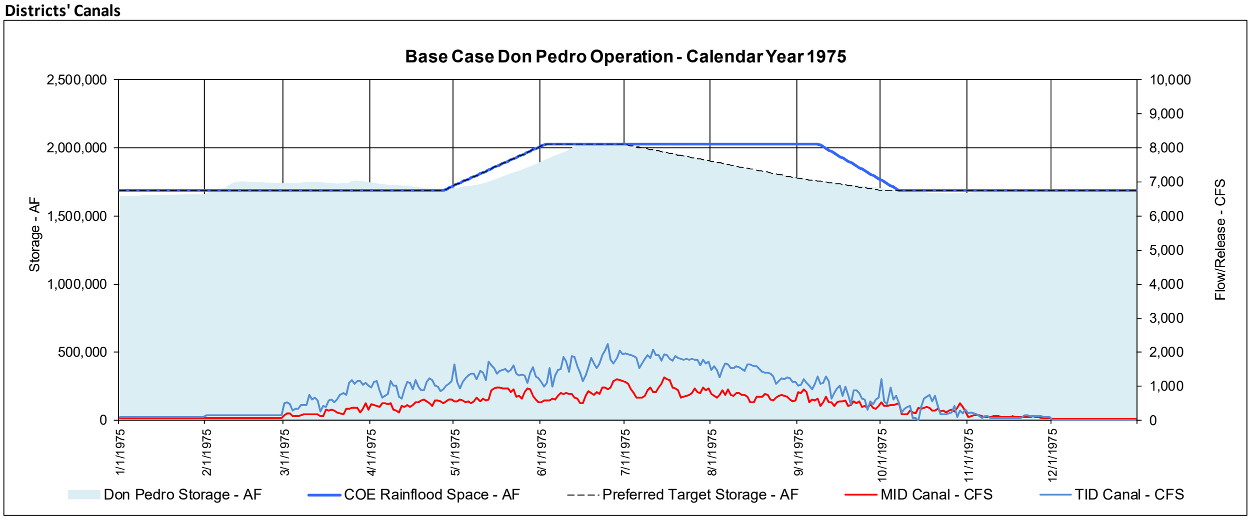
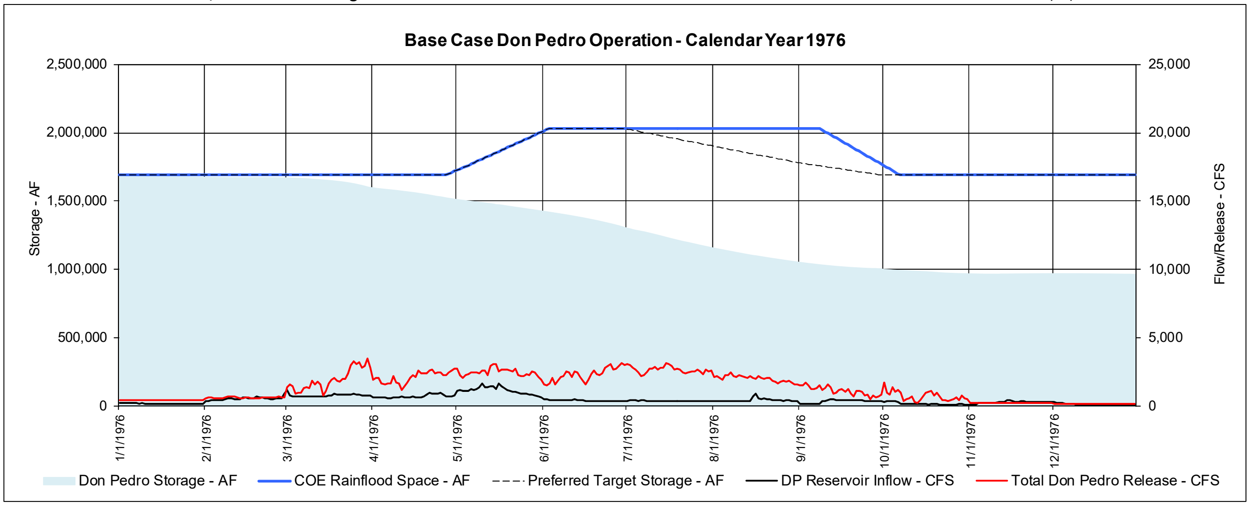


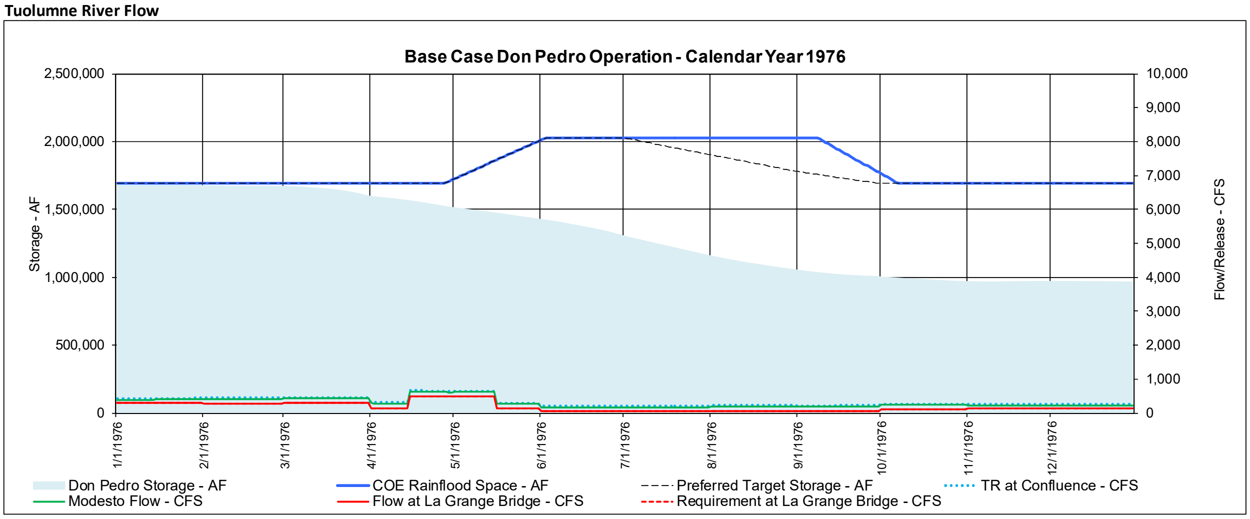
Figure B-5. Base Case conditions – calendar year 1975 (Source: Version 3.00 of the Tuolumne River Operations Model).

Don Pedro Reservoir Inflow, Release and Storage

Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



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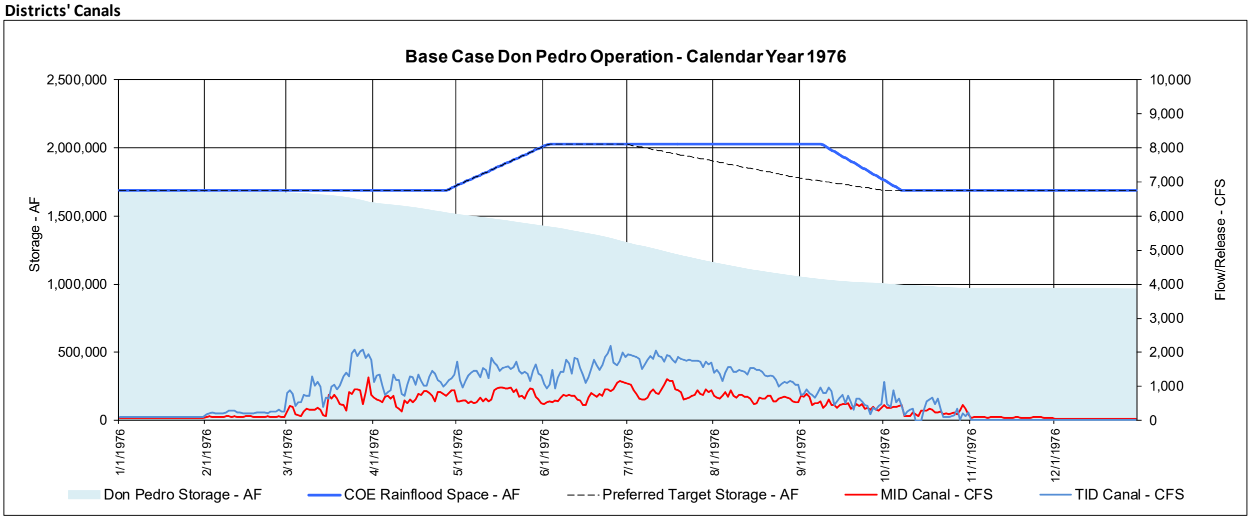
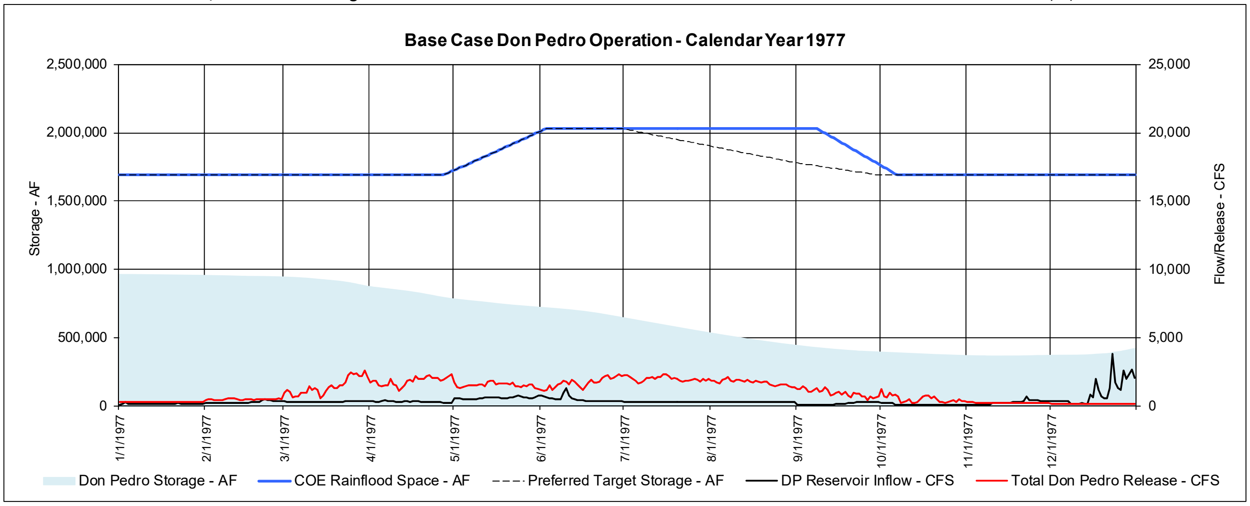
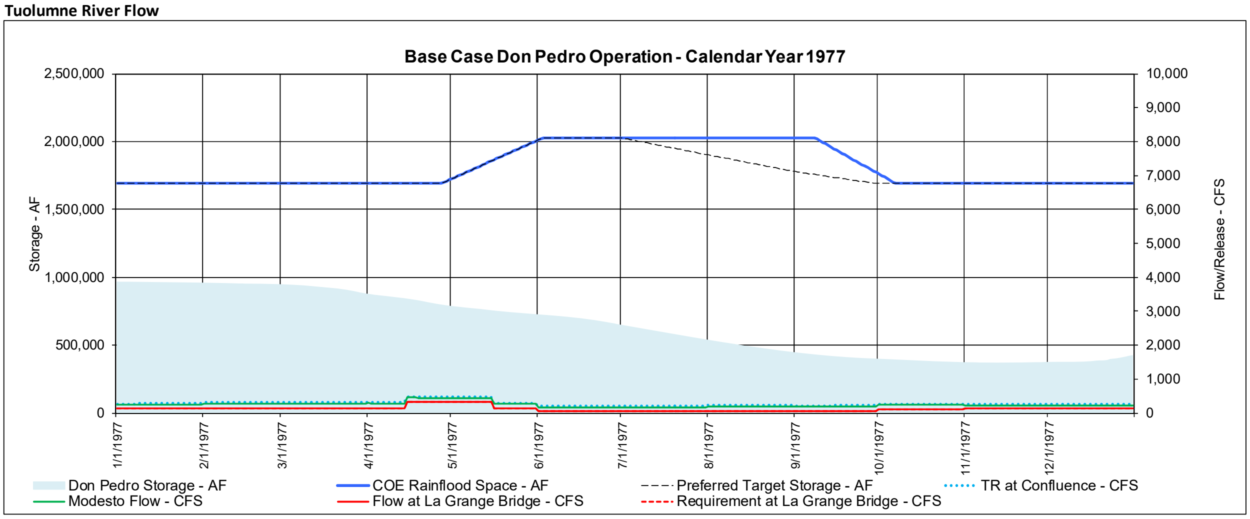


Figure B-6. Base Case conditions – calendar year 1976 (Source: Version 3.00 of the Tuolumne River Operations Model).

Don Pedro Reservoir Inflow, Release and Storage Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

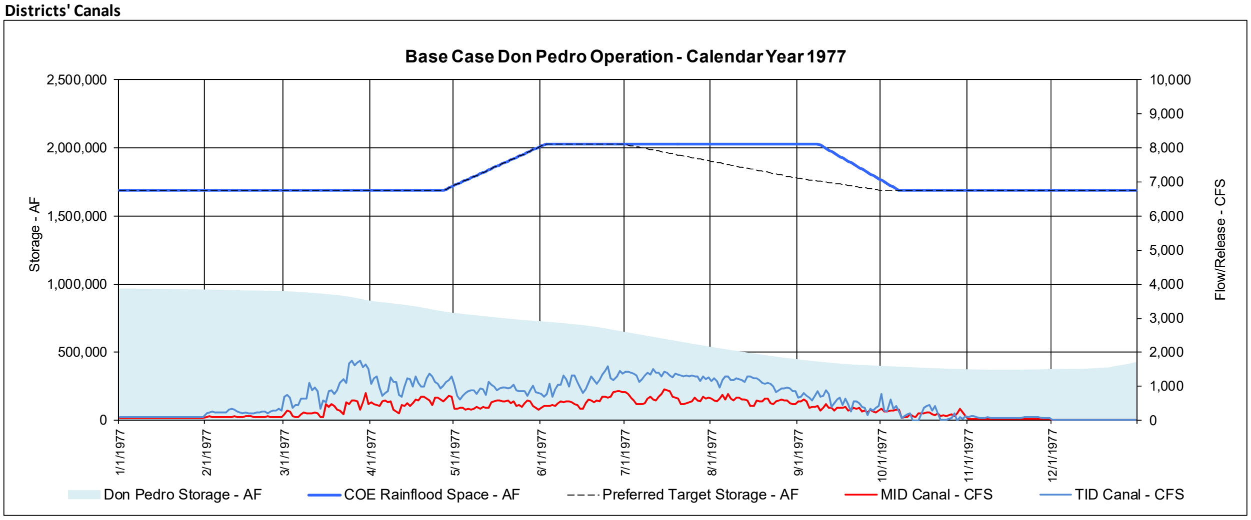
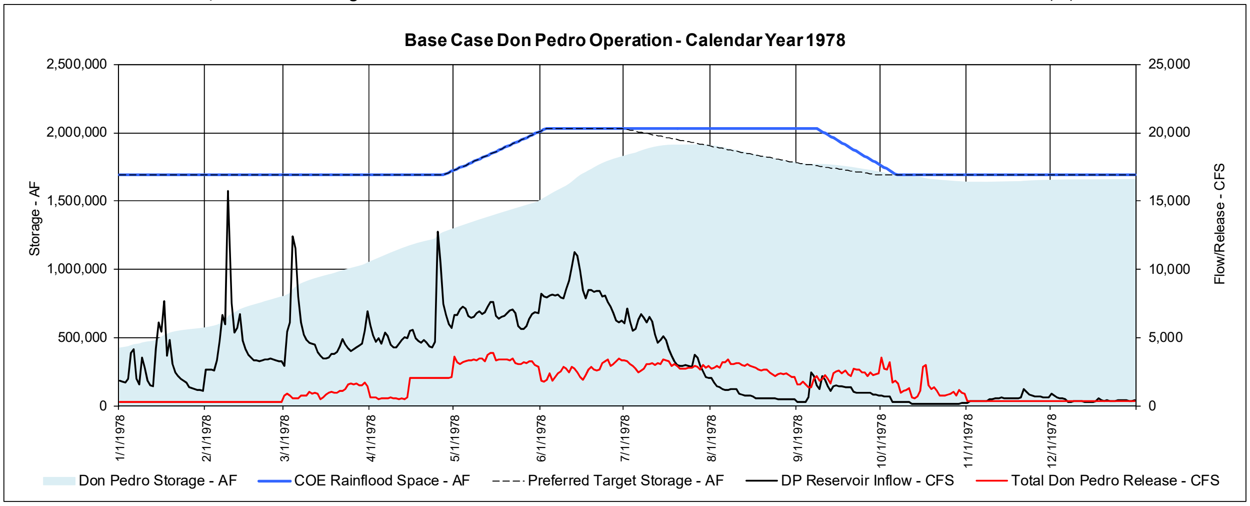
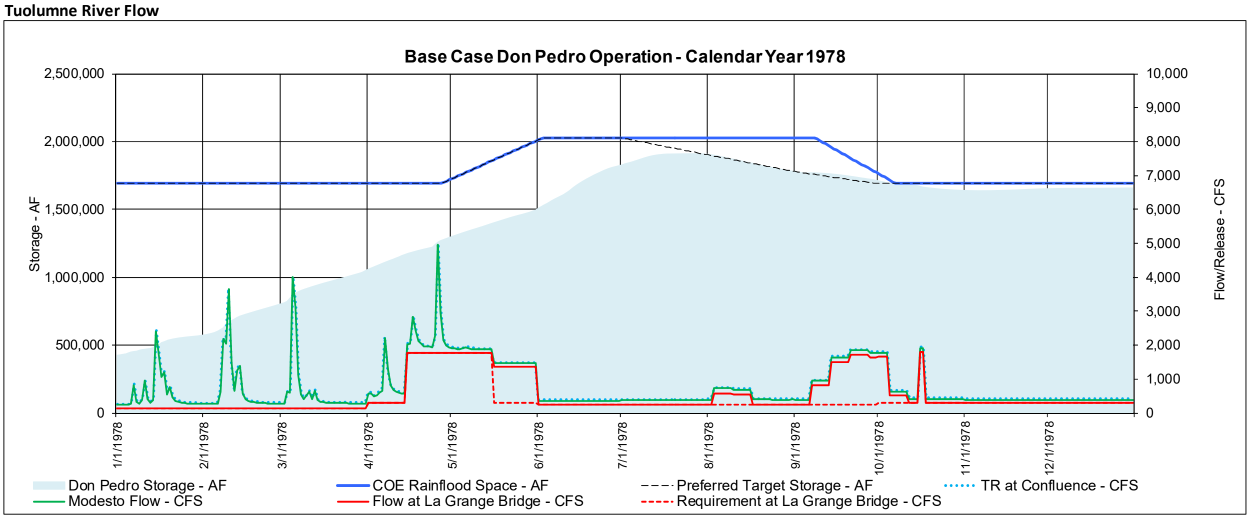


Figure B-7. **Base Case conditions – calendar year 1977 (Source: Version 3.00 of the Tuolumne River Operations Model).**

Don Pedro Reservoir Inflow, Release and Storage Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

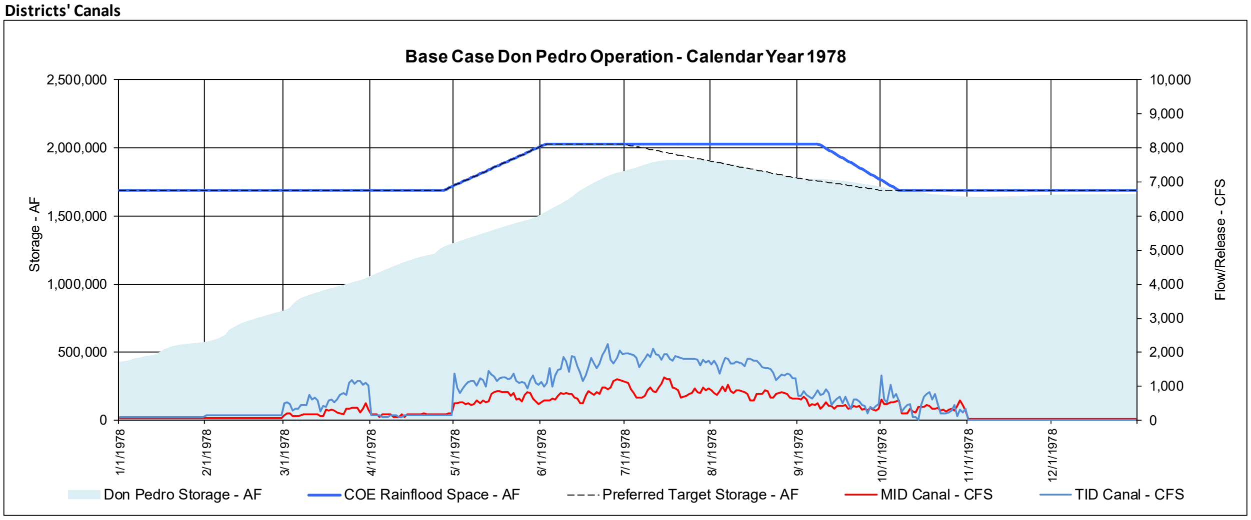
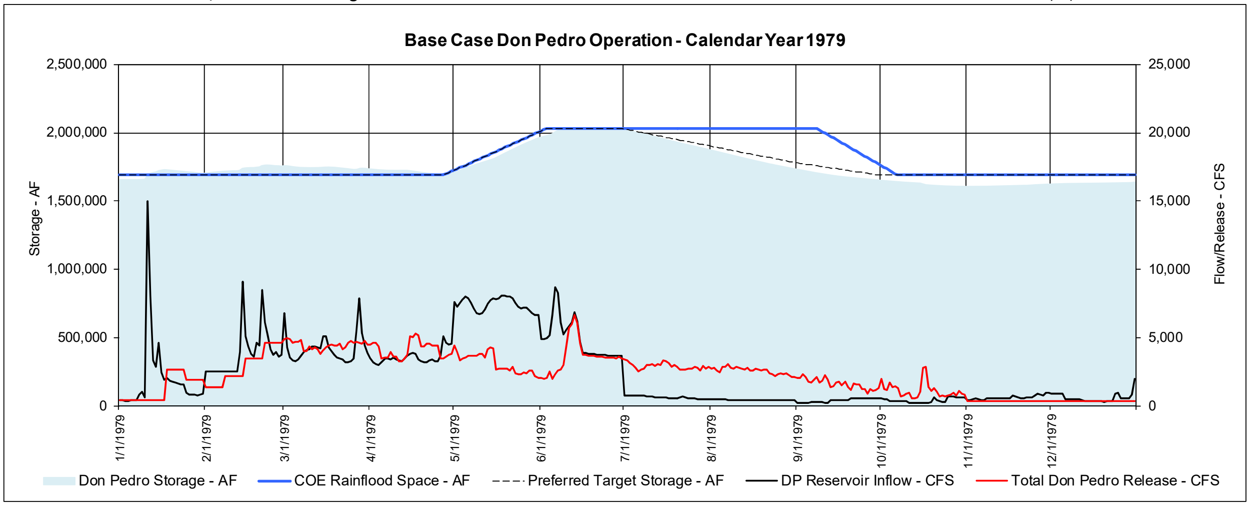


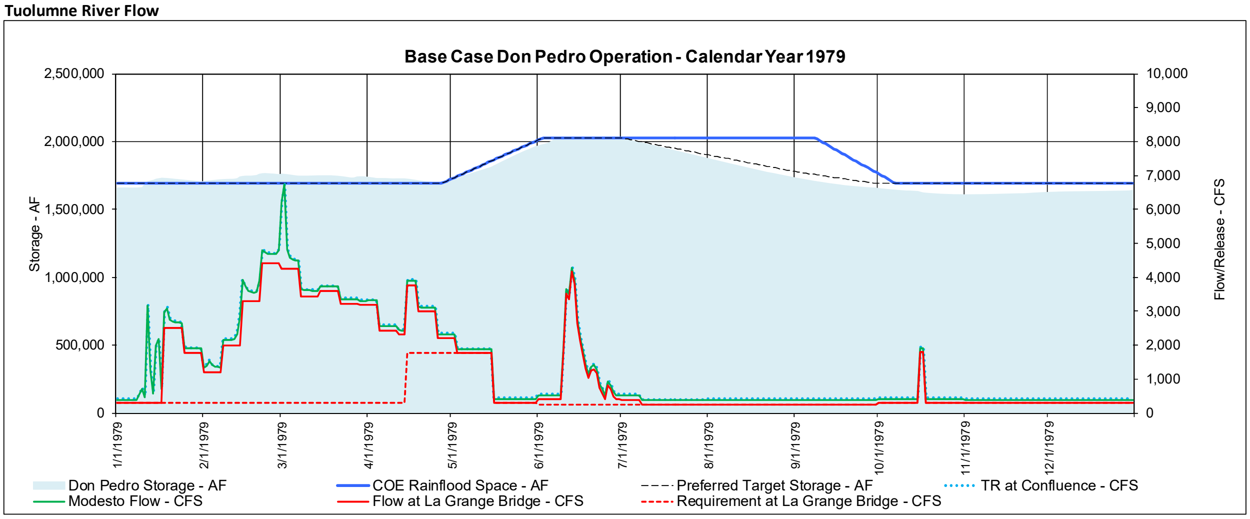
Figure B-8. Base Case conditions – calendar year 1978 (Source: Version 3.00 of the Tuolumne River Operations Model).

Don Pedro Reservoir Inflow, Release and Storage

Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

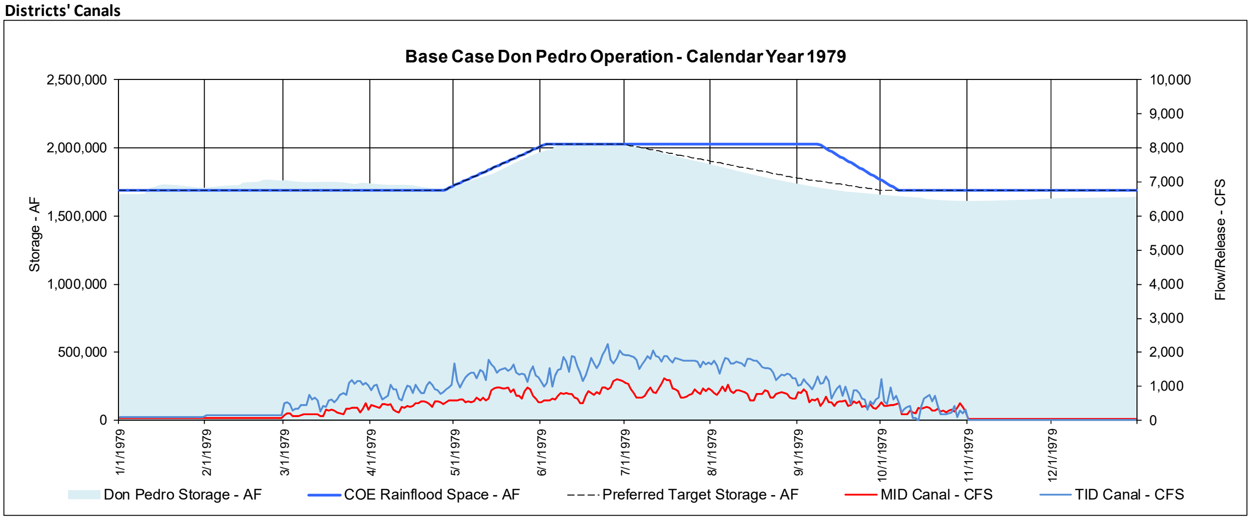
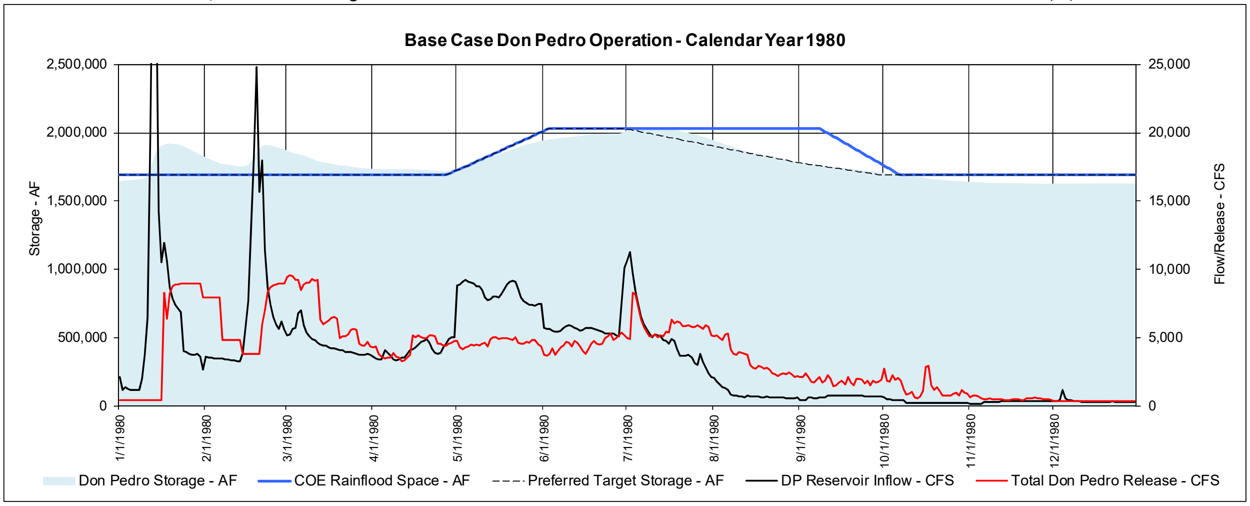


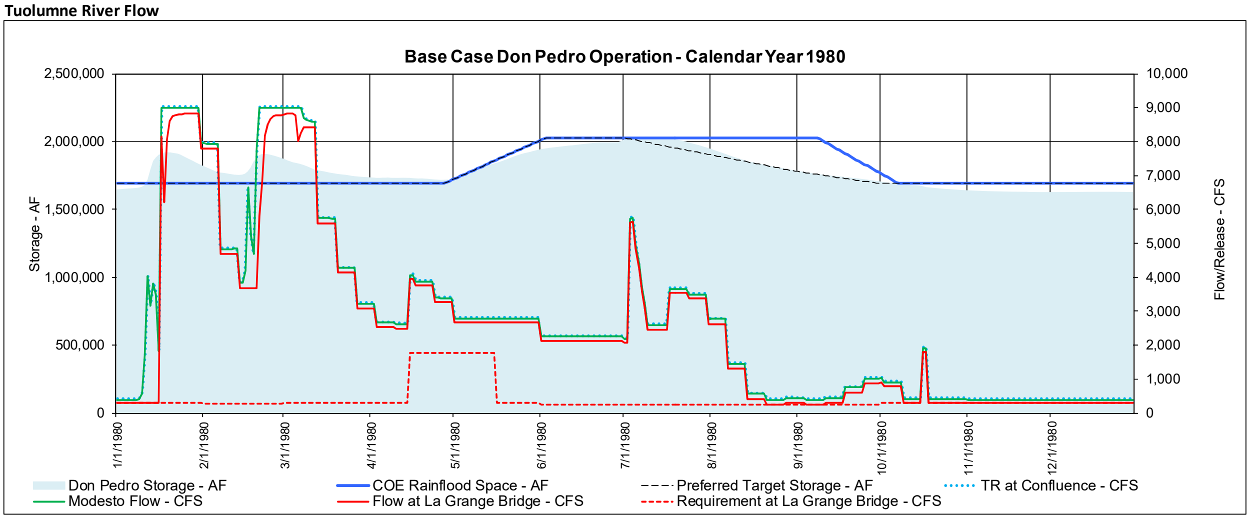
Figure B-9. Base Case conditions – calendar year 1979 (Source: Version 3.00 of the Tuolumne River Operations Model).

Don Pedro Reservoir Inflow, Release and Storage

Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

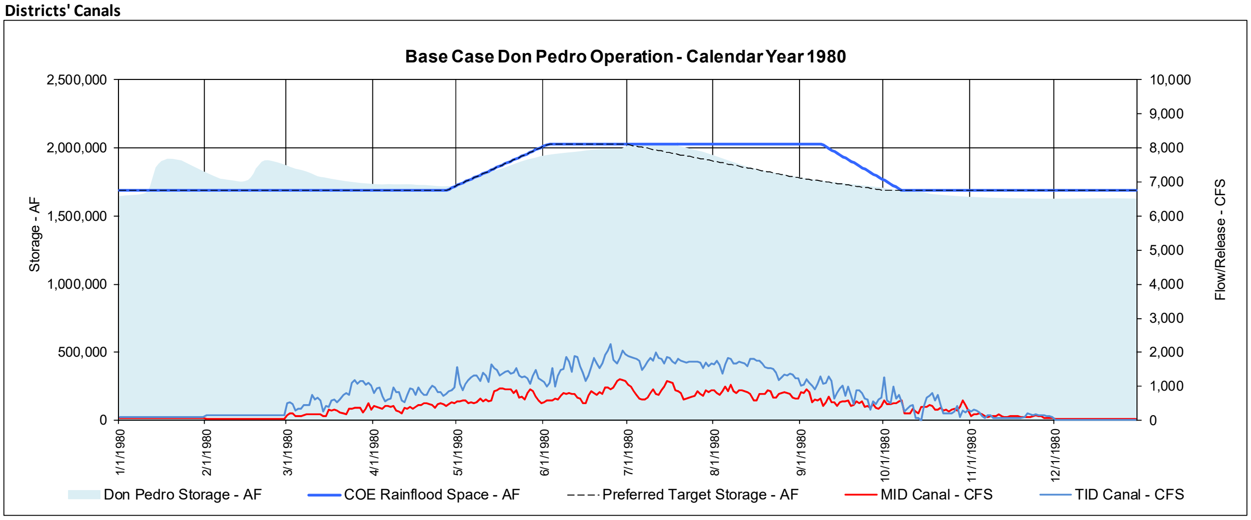
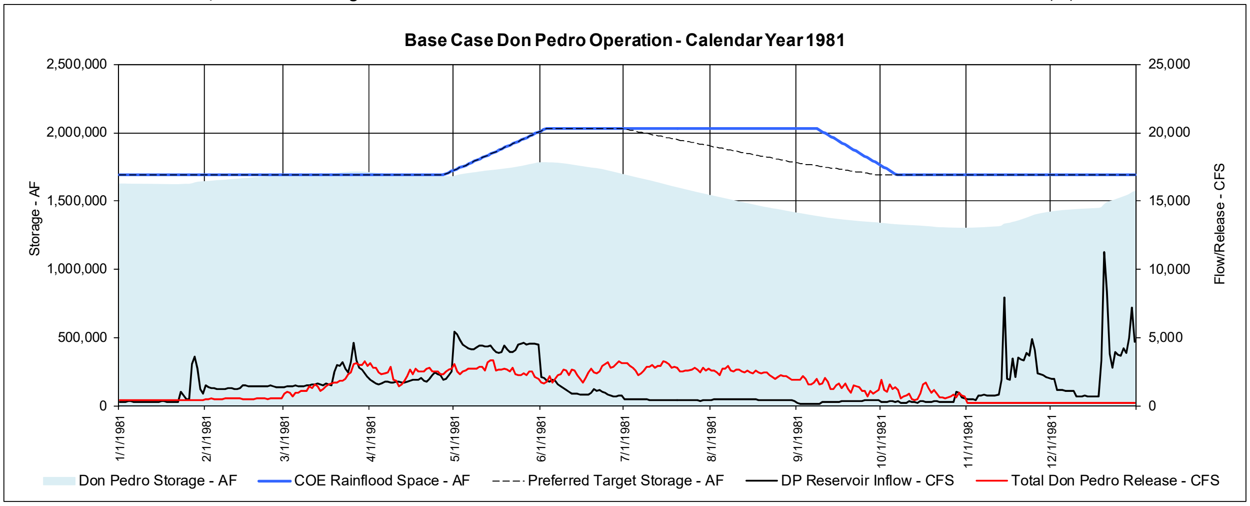


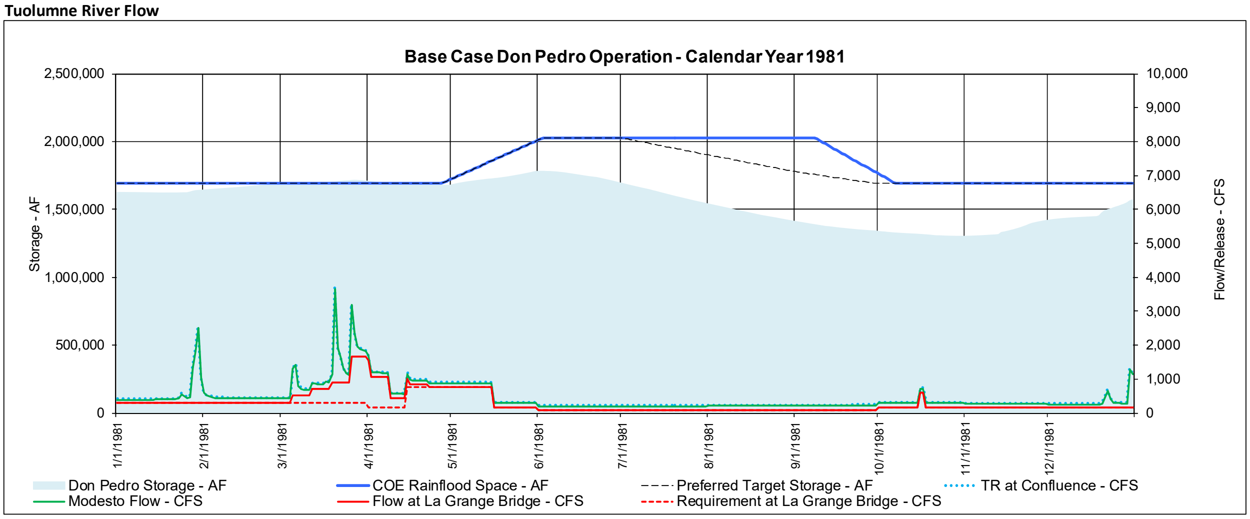
Figure B-10. Base Case conditions – calendar year 1980 (Source: Version 3.00 of the Tuolumne River Operations Model).

Don Pedro Reservoir Inflow, Release and Storage

Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

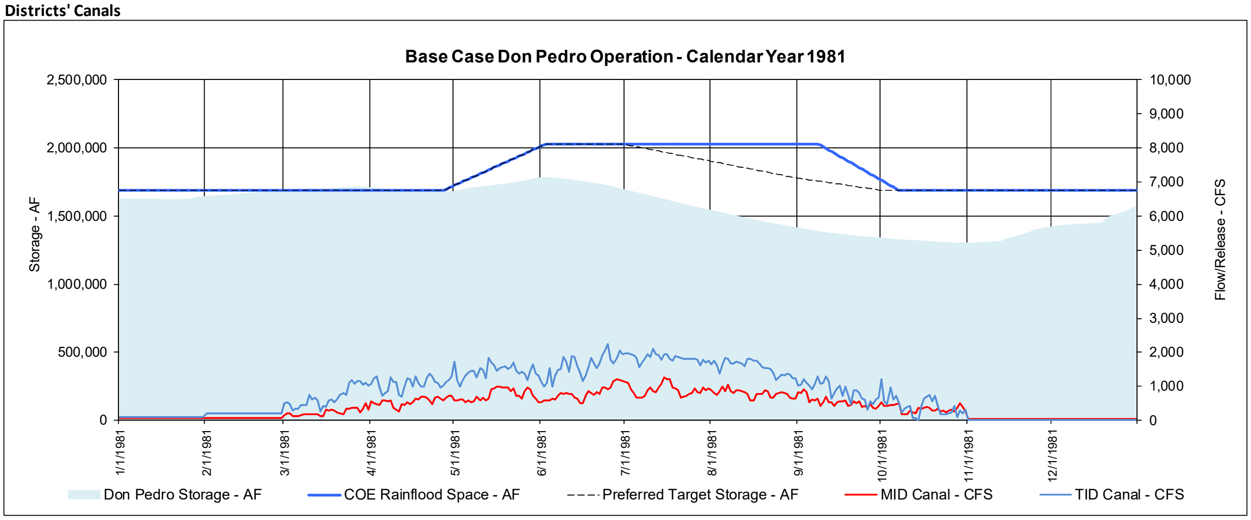
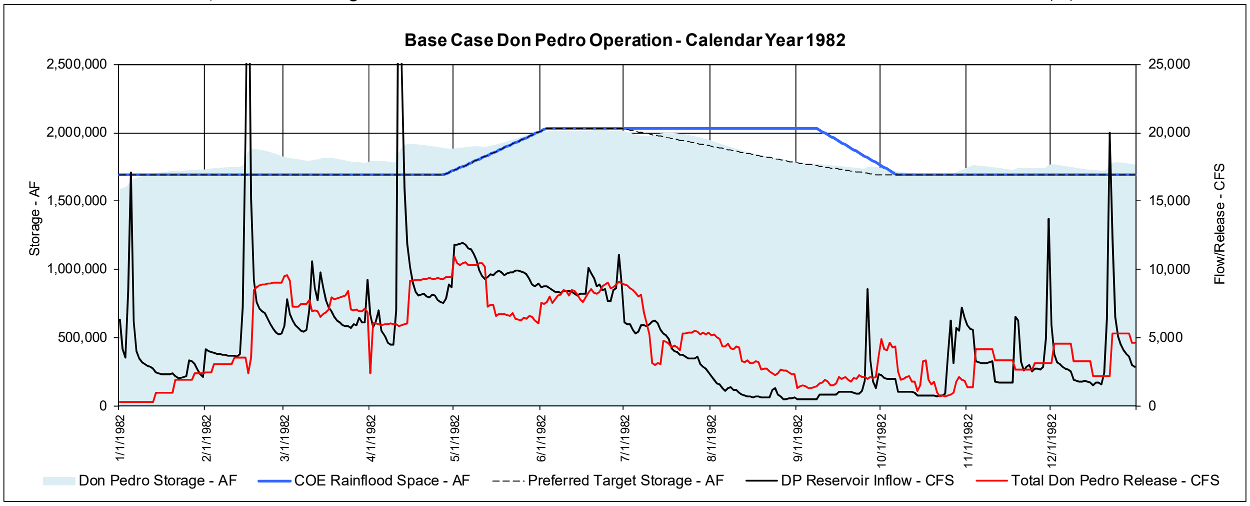


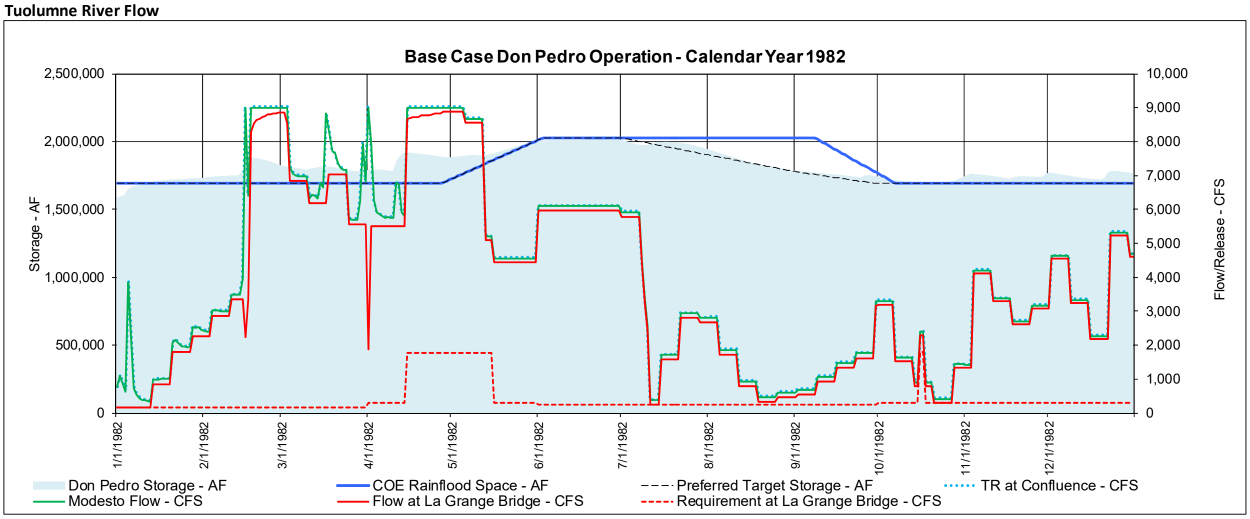
Figure B-11. Base Case conditions – calendar year 1981 (Source: Version 3.00 of the Tuolumne River Operations Model).

Don Pedro Reservoir Inflow, Release and Storage

Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

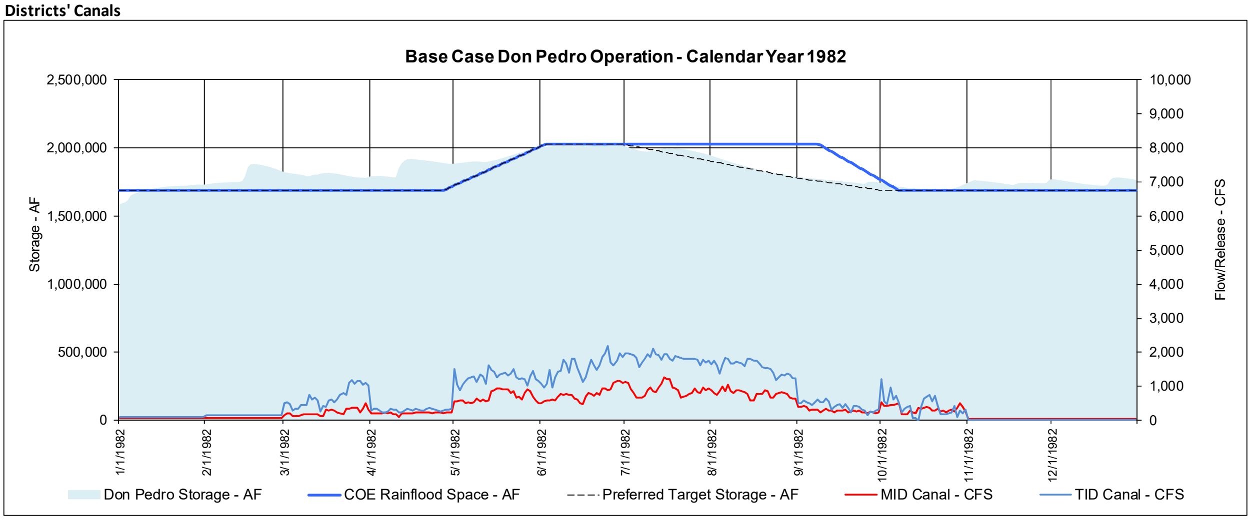
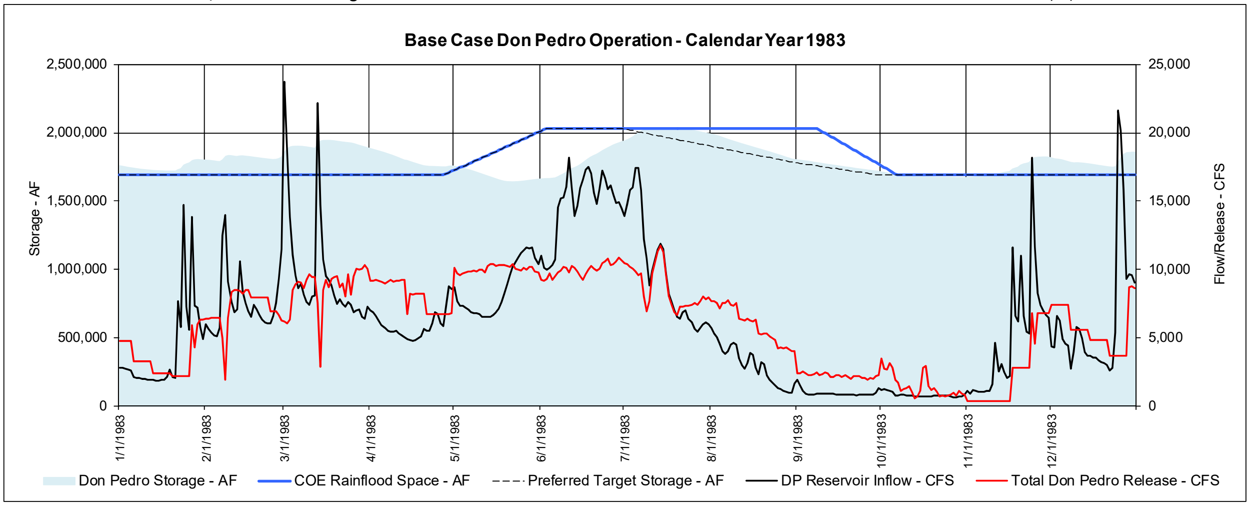
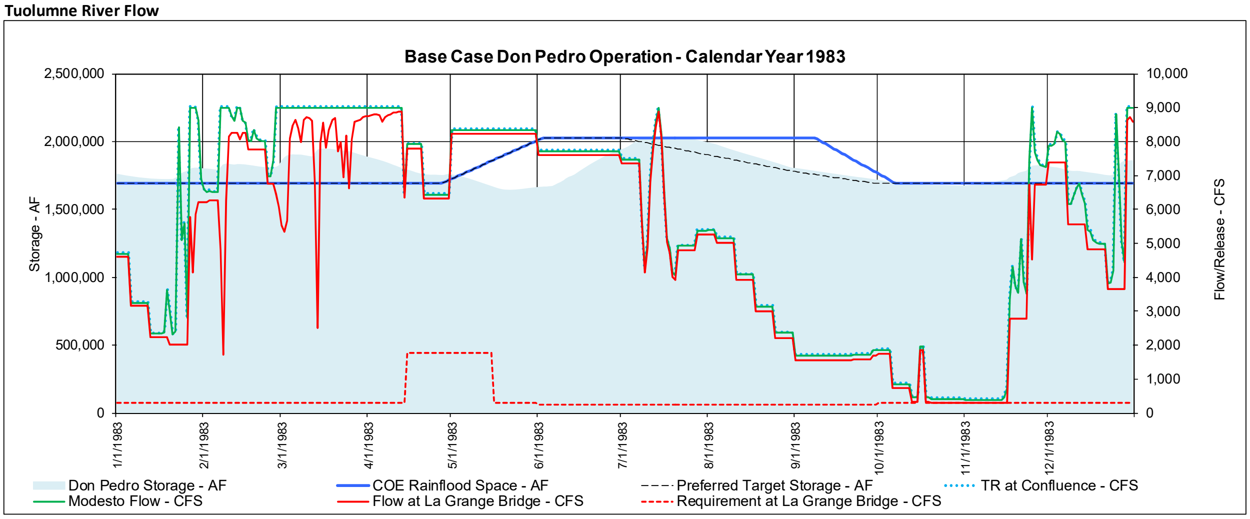


Figure B-12. Base Case conditions – calendar year 1982 (Source: Version 3.00 of the Tuolumne River Operations Model).

Don Pedro Reservoir Inflow, Release and Storage Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

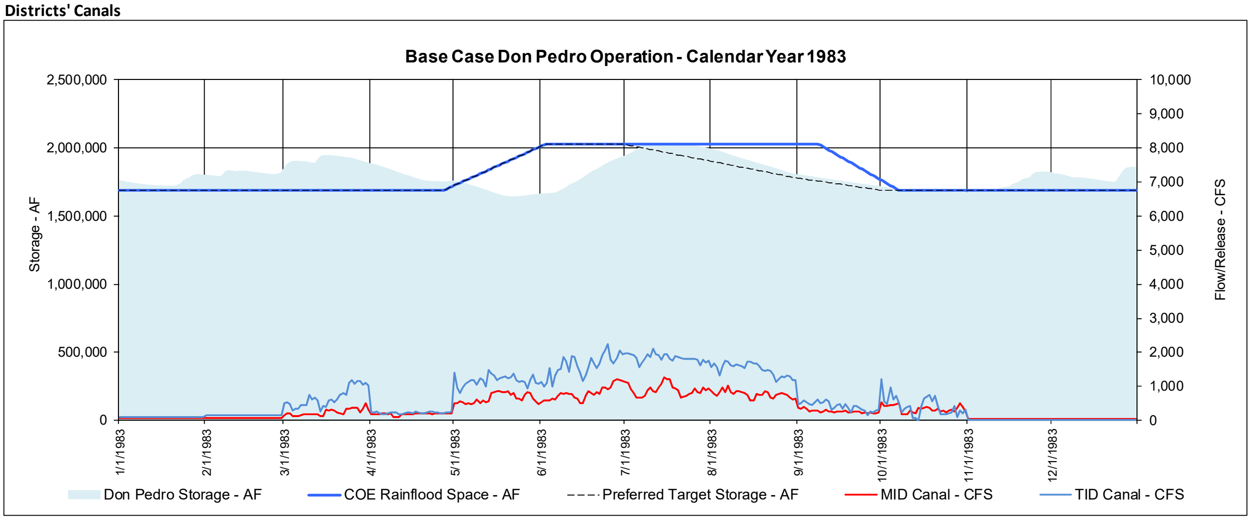
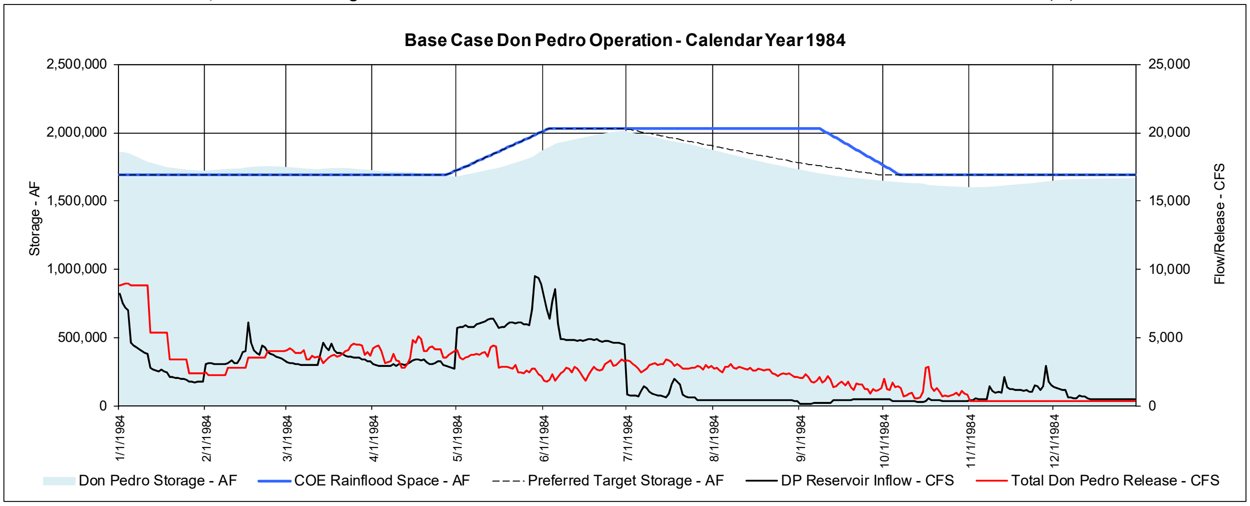


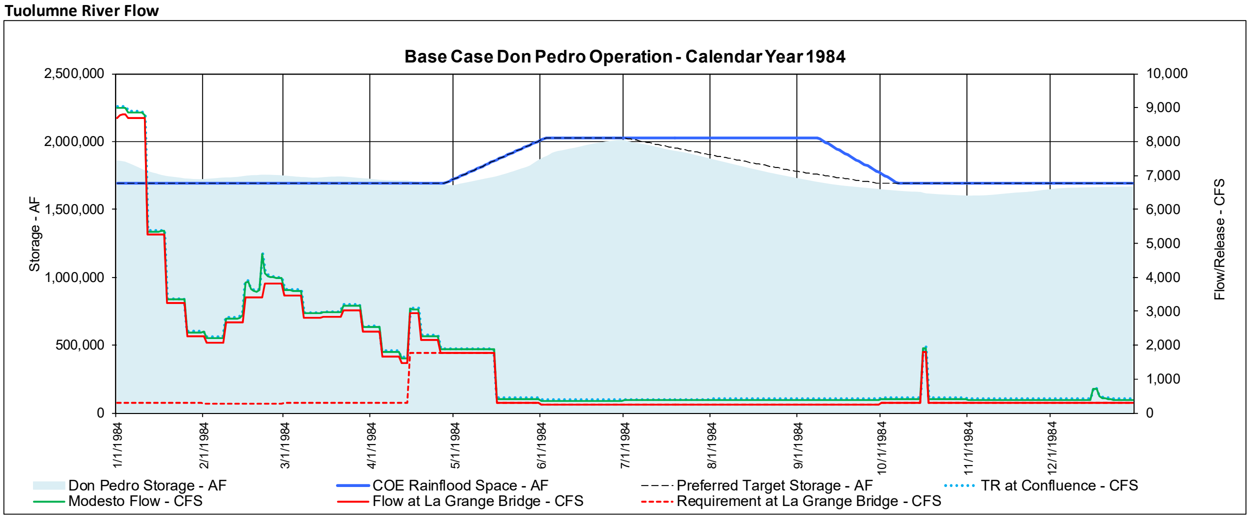
Figure B-13. Base Case conditions – calendar year 1983 (Source: Version 3.00 of the Tuolumne River Operations Model).

Don Pedro Reservoir Inflow, Release and Storage

Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

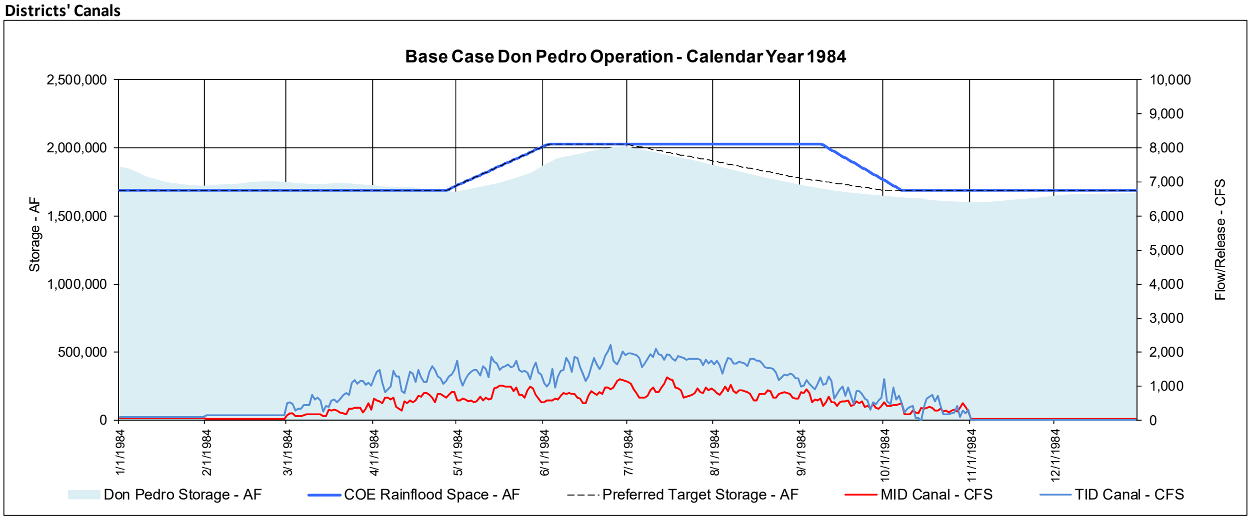
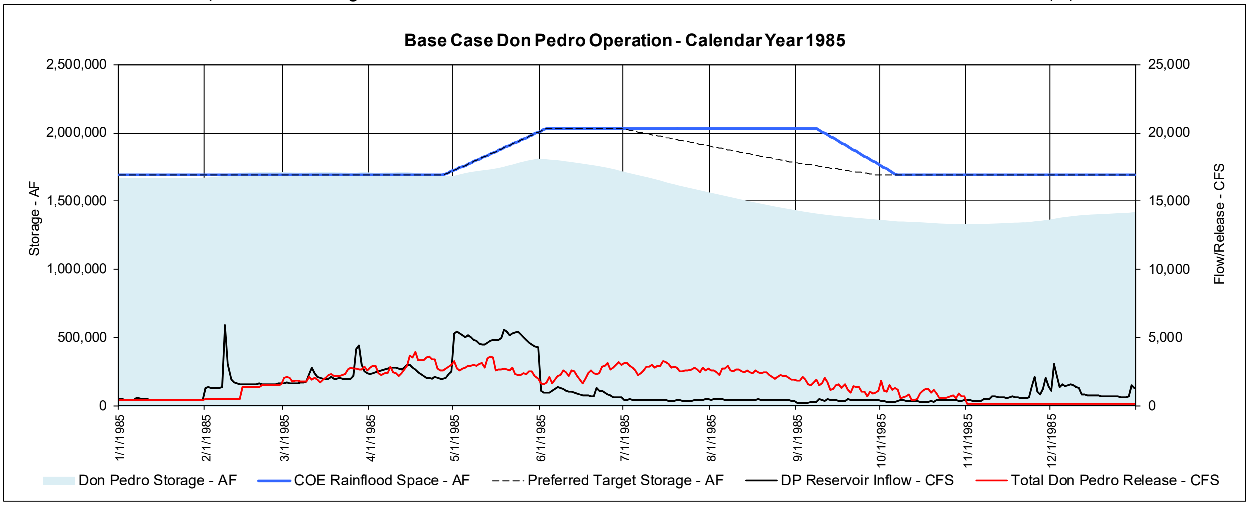
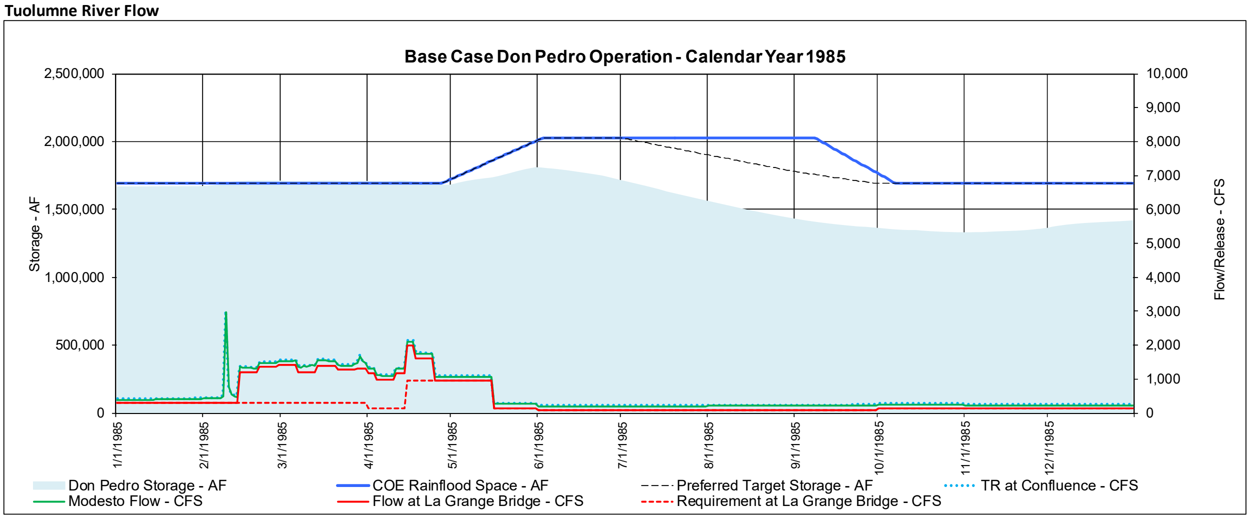


Figure B-14. Base Case conditions – calendar year 1984 (Source: Version 3.00 of the Tuolumne River Operations Model).

Don Pedro Reservoir Inflow, Release and Storage Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

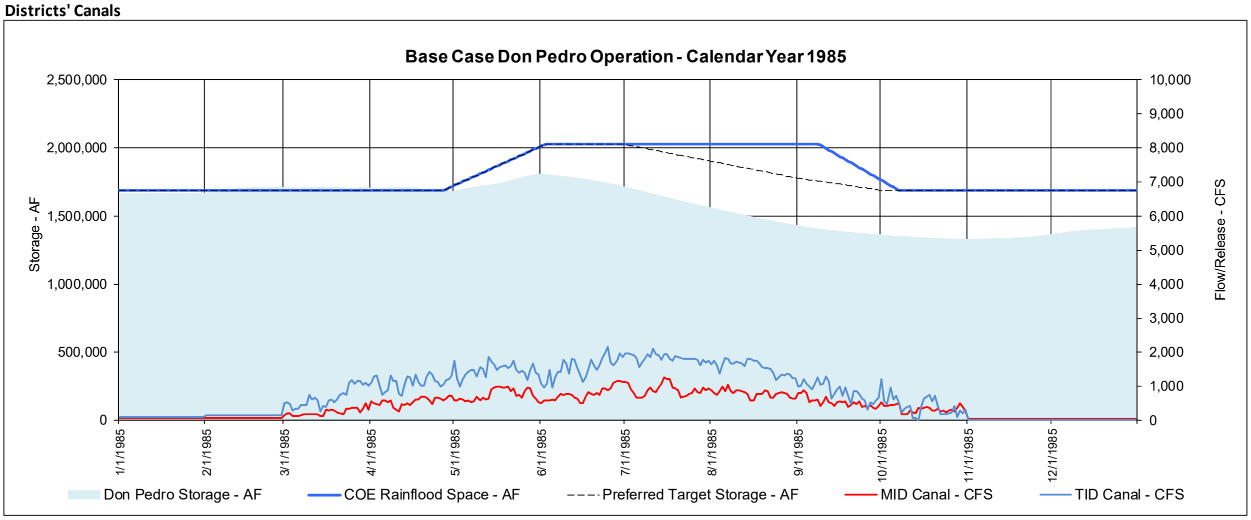
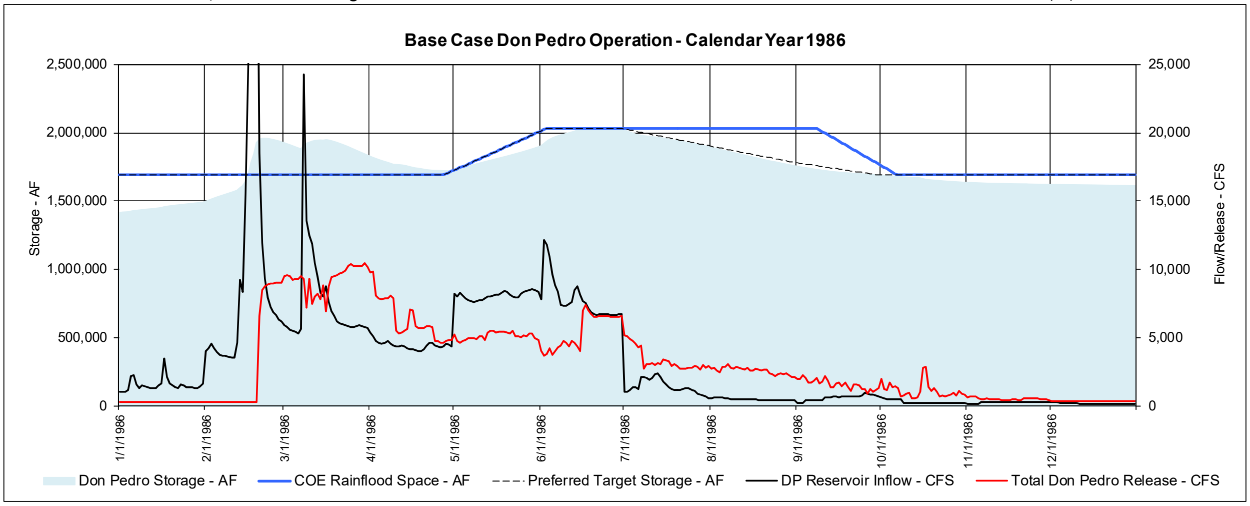
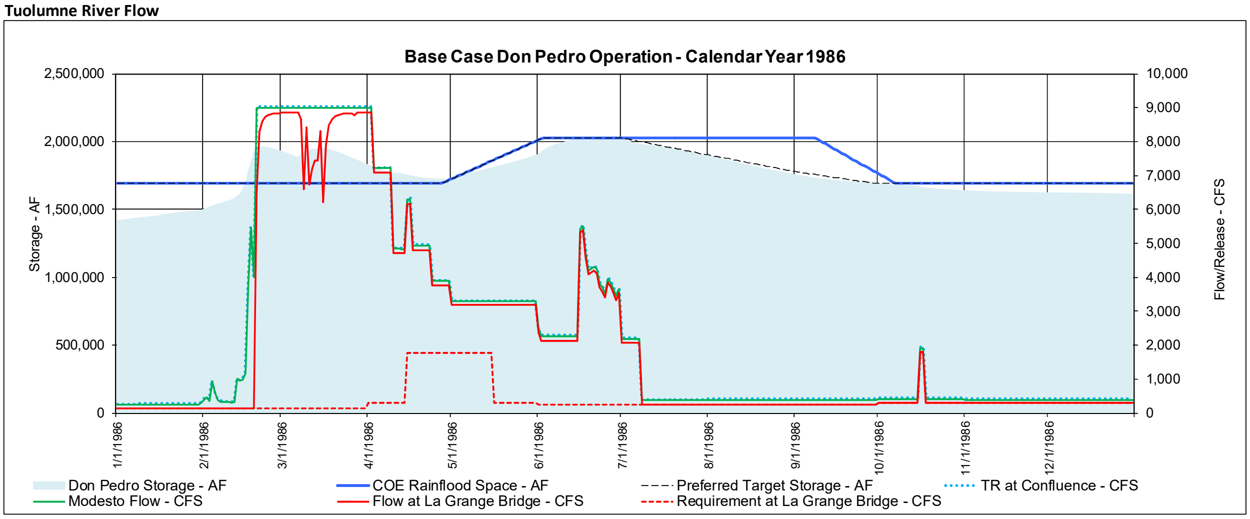


Figure B-15. Base Case conditions – calendar year 1985 (Source: Version 3.00 of the Tuolumne River Operations Model).

Don Pedro Reservoir Inflow, Release and Storage Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

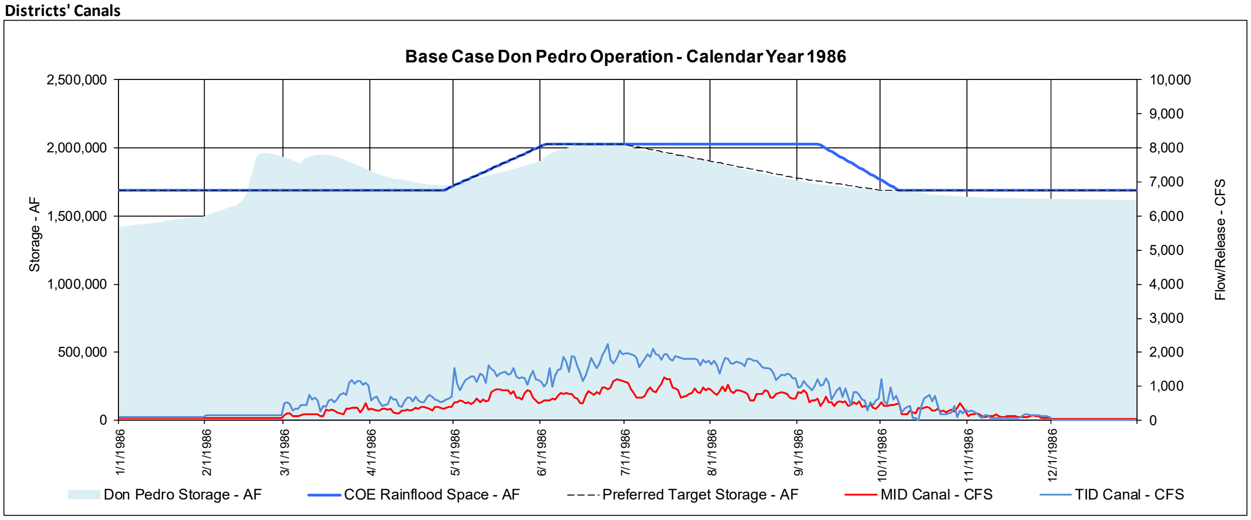
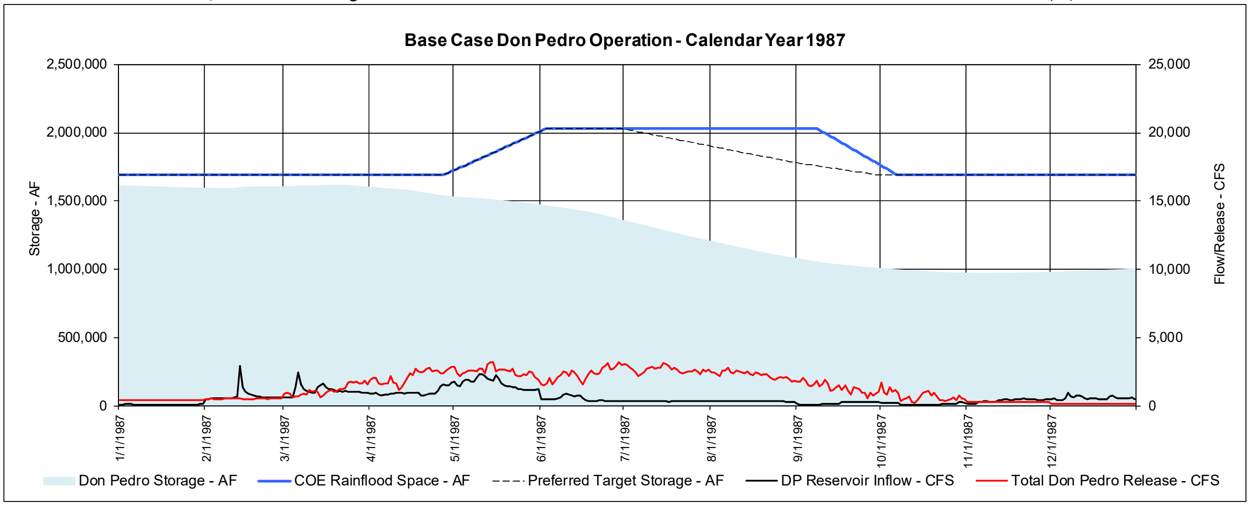
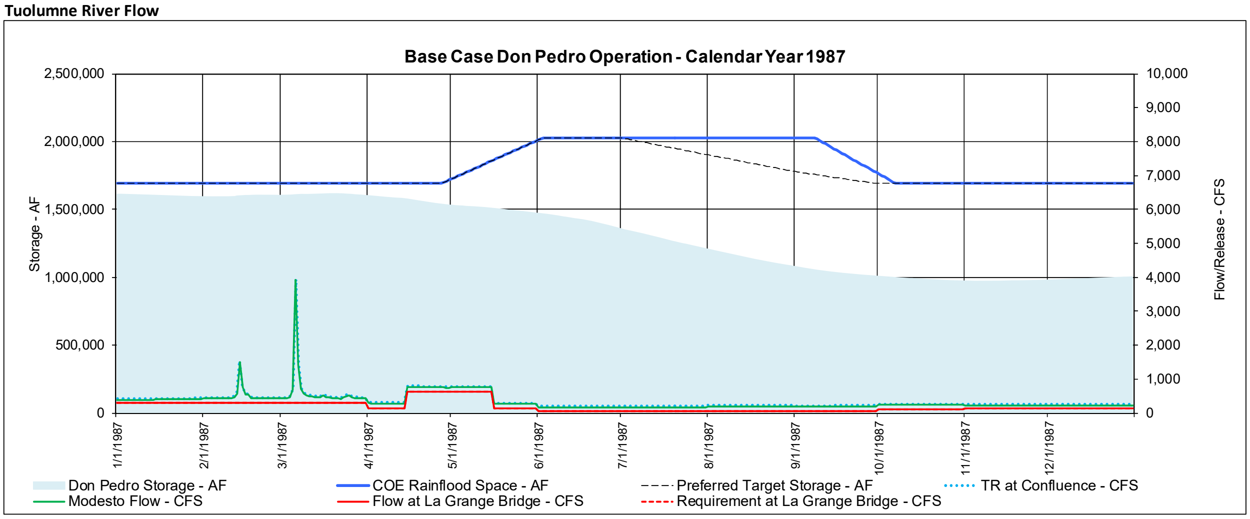


Figure B-16. Base Case conditions – calendar year 1986 (Source: Version 3.00 of the Tuolumne River Operations Model).

Don Pedro Reservoir Inflow, Release and Storage Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

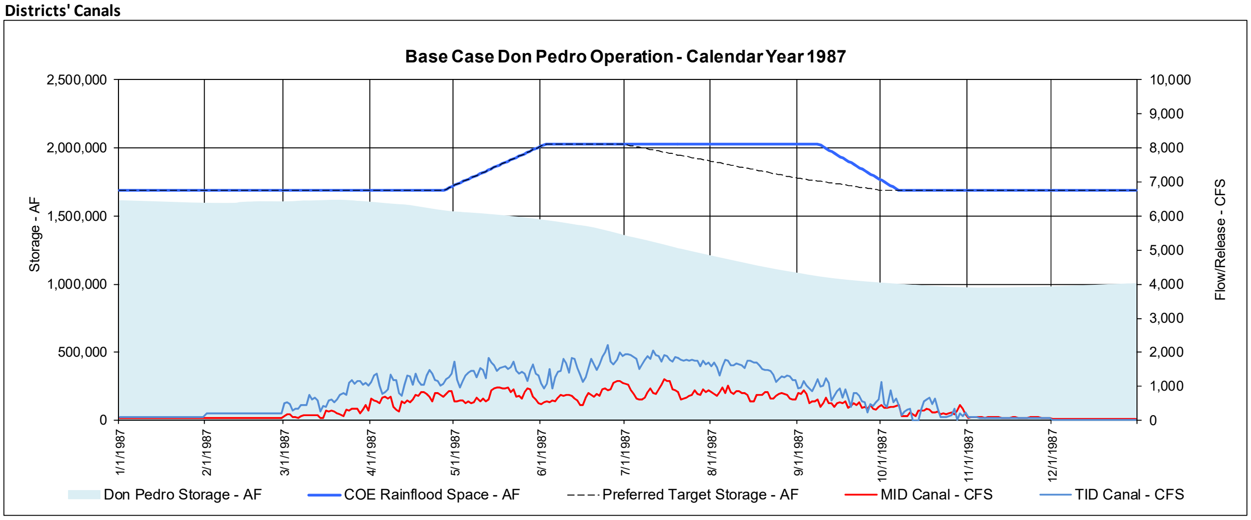
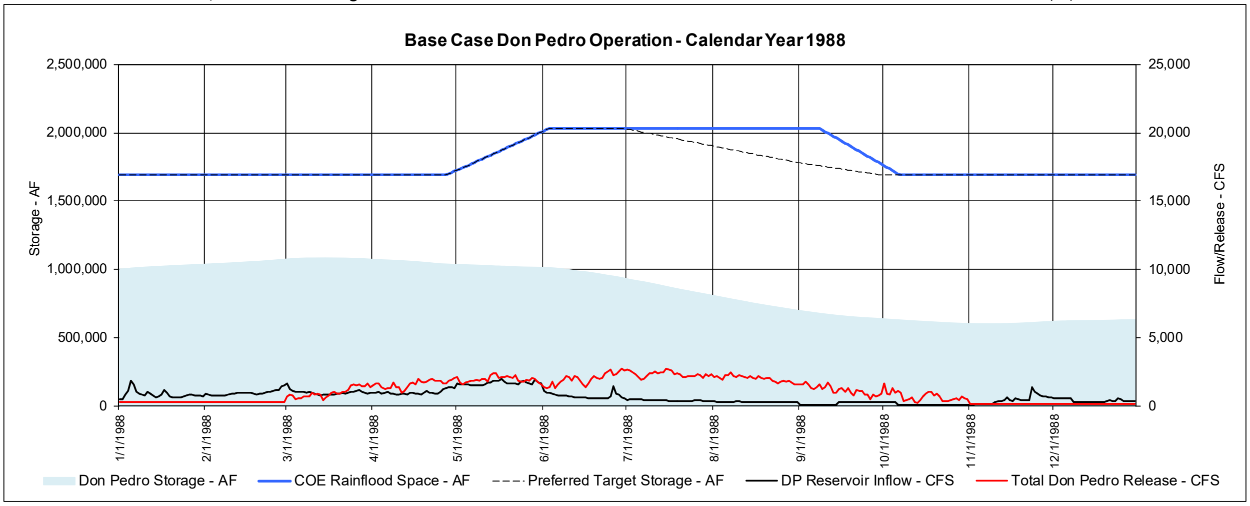


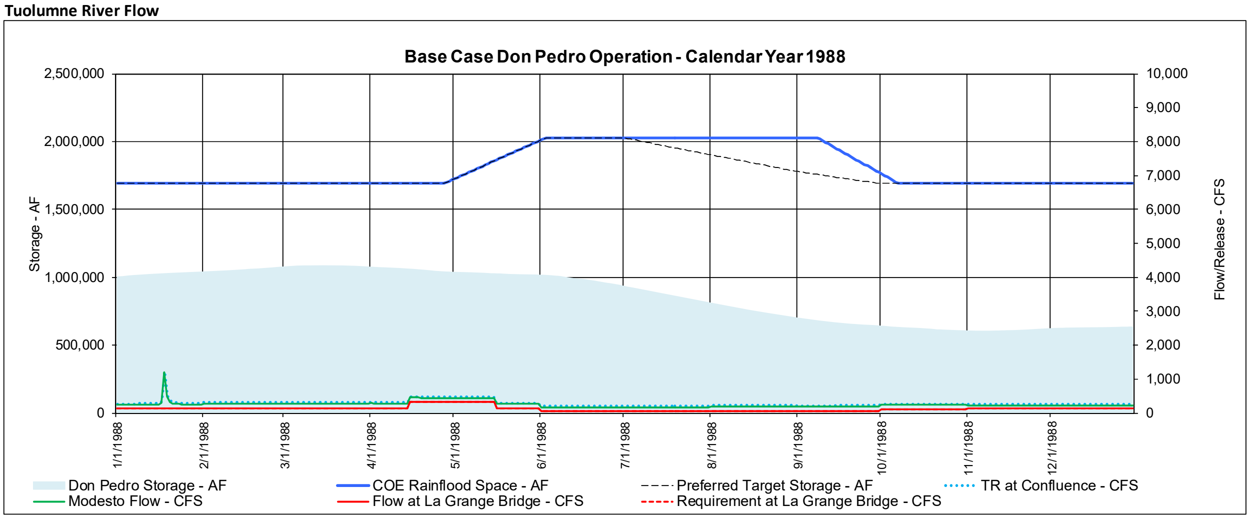
Figure B-17. Base Case conditions – calendar year 1987 (Source: Version 3.00 of the Tuolumne River Operations Model).

Don Pedro Reservoir Inflow, Release and Storage

Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

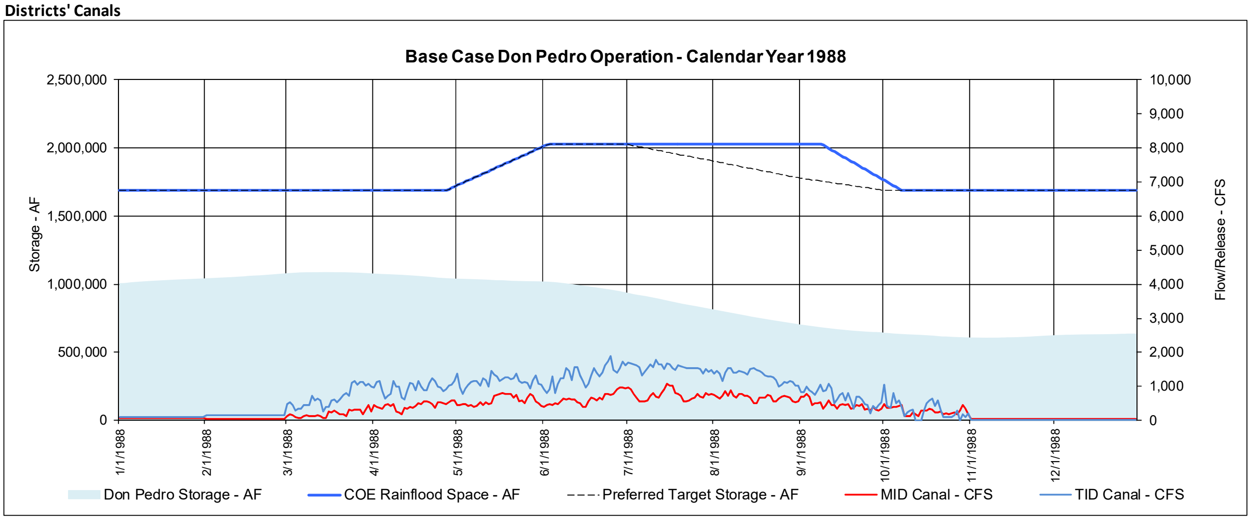
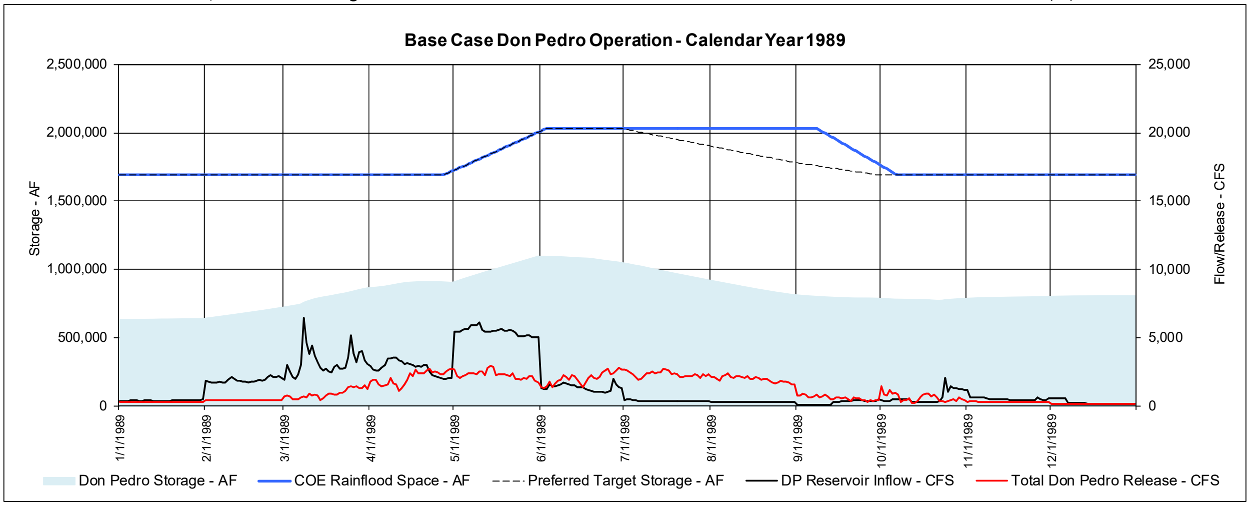


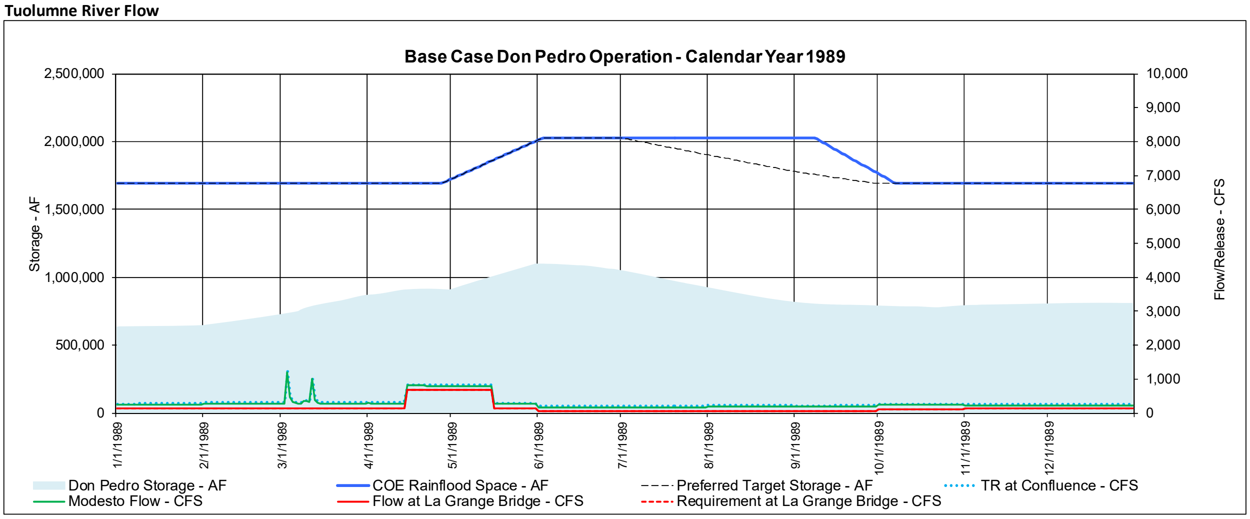
Figure B-18. Base Case conditions – calendar year 1988 (Source: Version 3.00 of the Tuolumne River Operations Model).

Don Pedro Reservoir Inflow, Release and Storage

Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

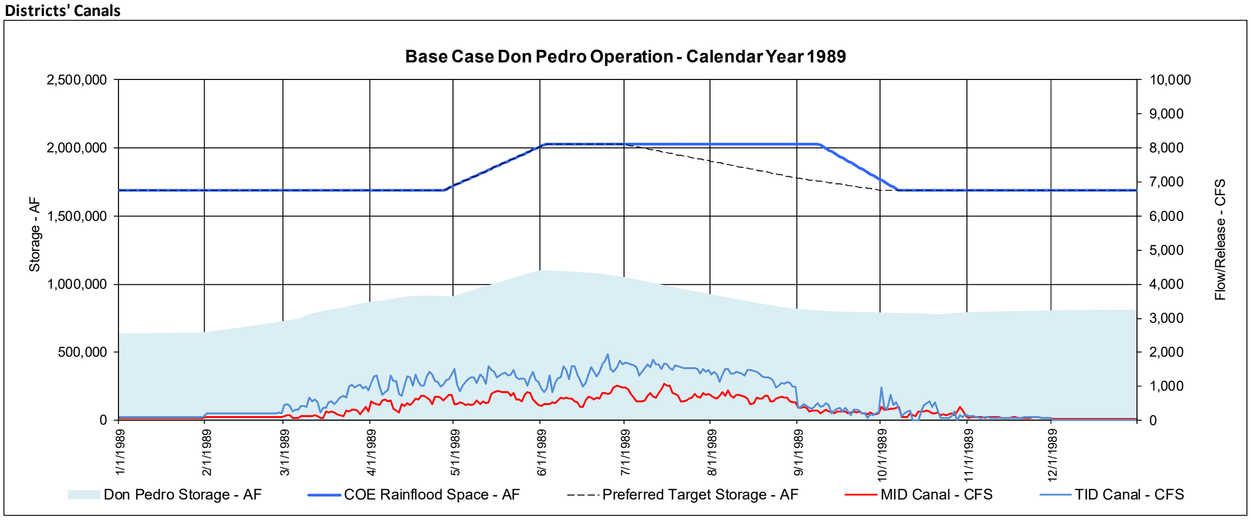
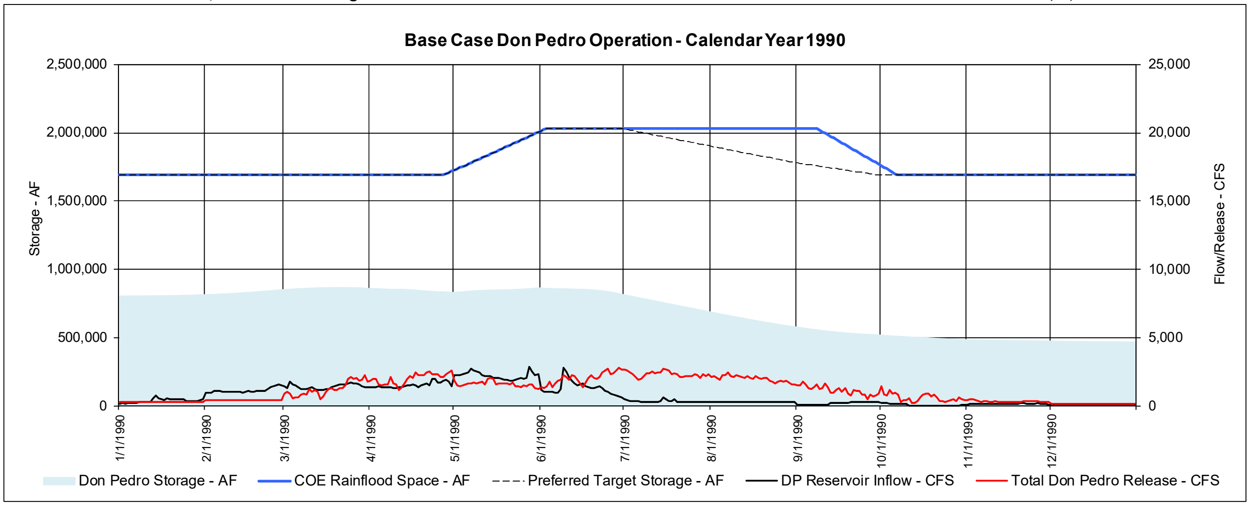
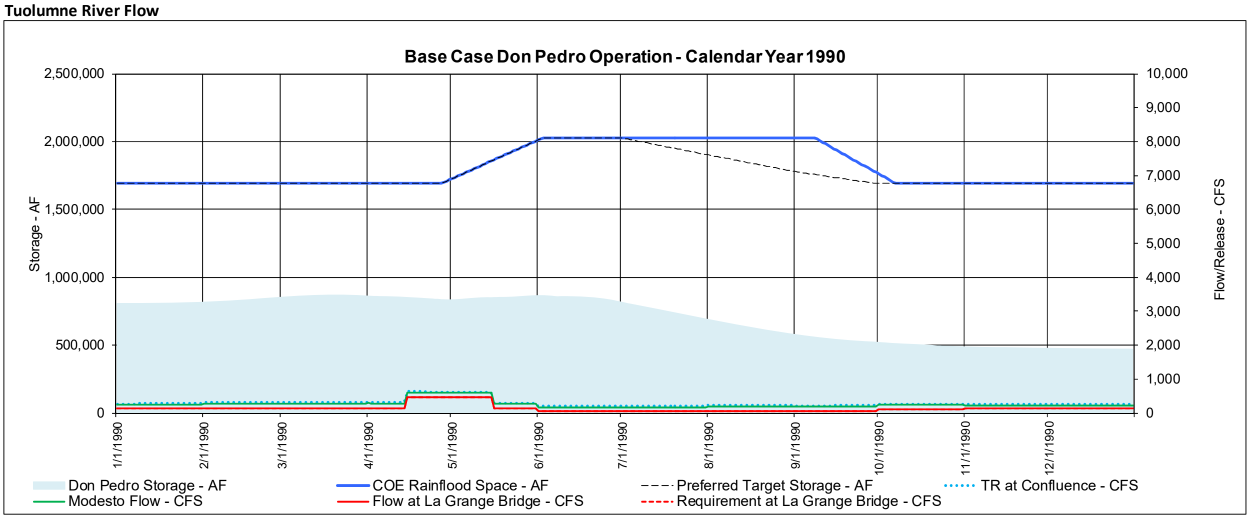


Figure B-19. Base Case conditions – calendar year 1989 (Source: Version 3.00 of the Tuolumne River Operations Model).

Don Pedro Reservoir Inflow, Release and Storage Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

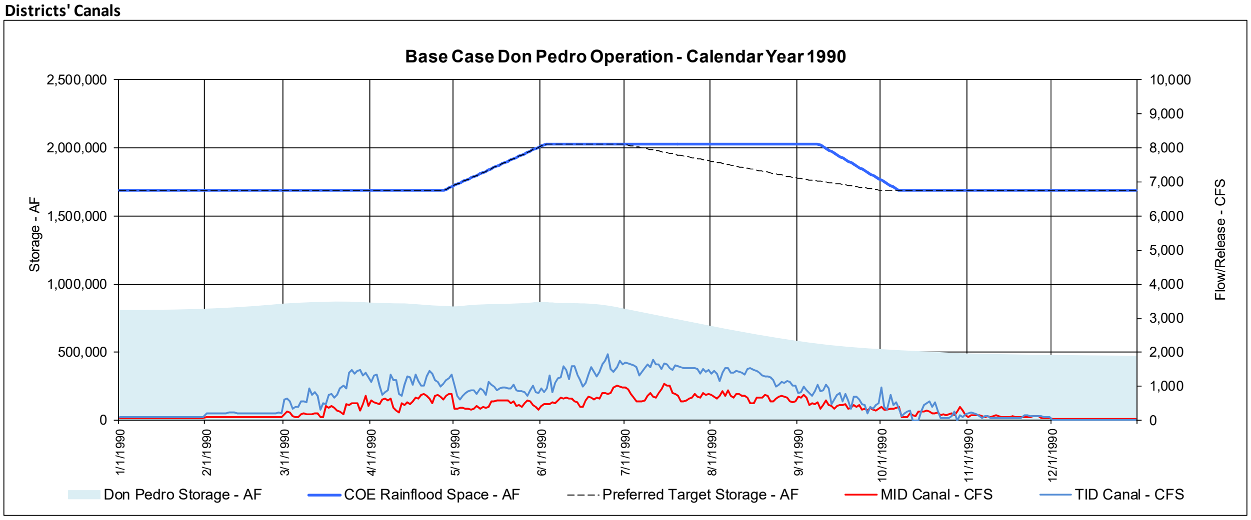
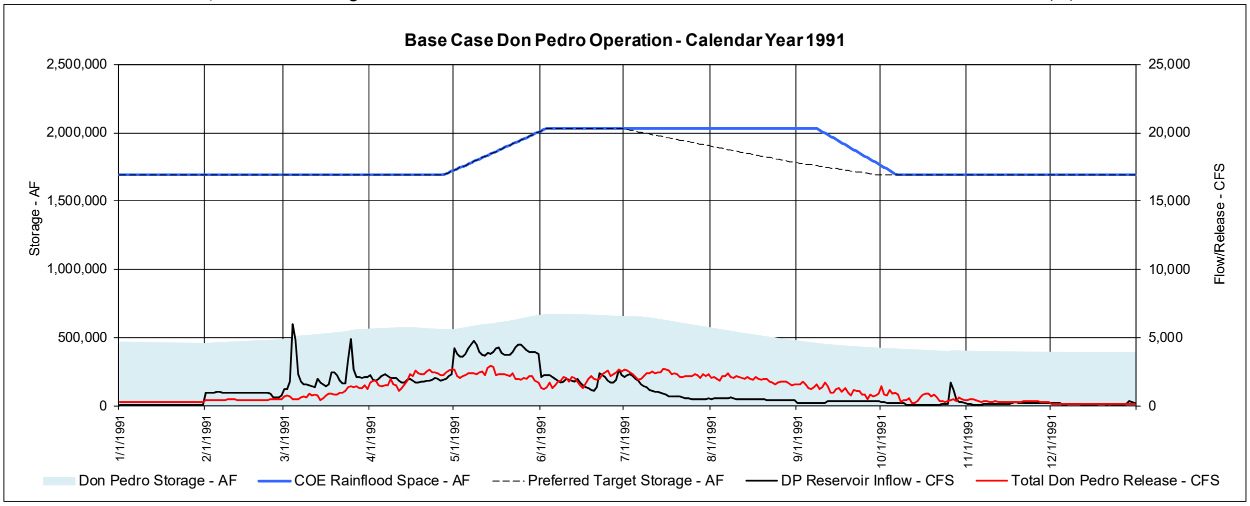


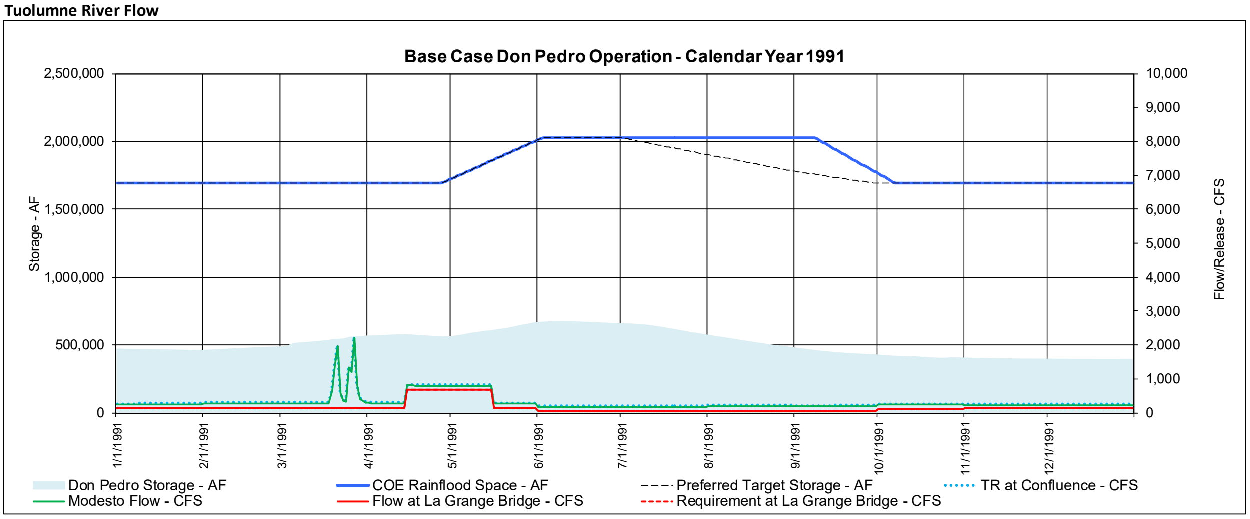
Figure B-20. Base Case conditions – calendar year 1990 (Source: Version 3.00 of the Tuolumne River Operations Model).

Don Pedro Reservoir Inflow, Release and Storage

Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

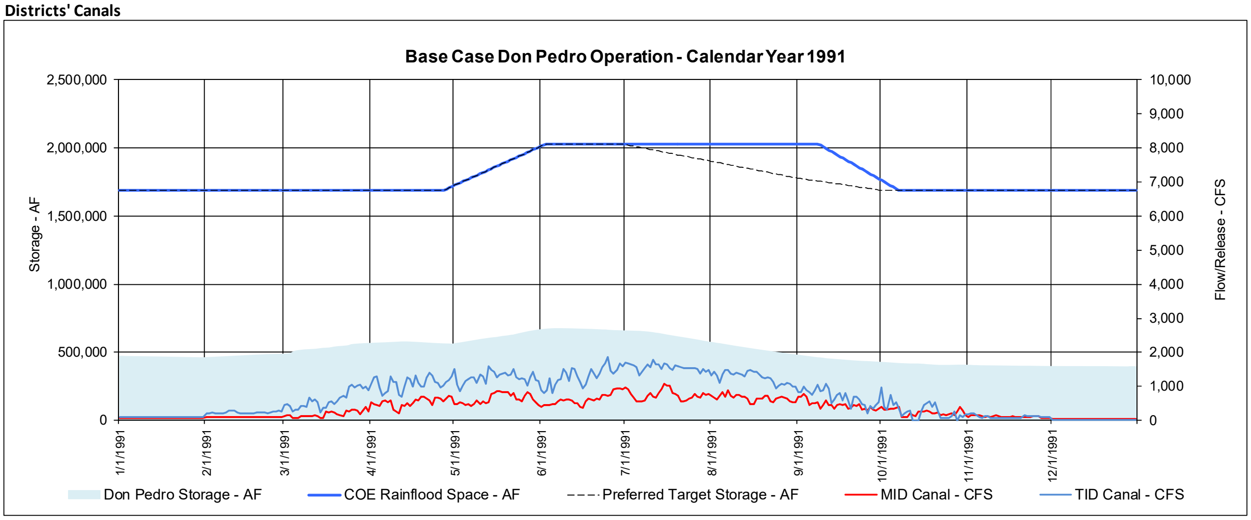
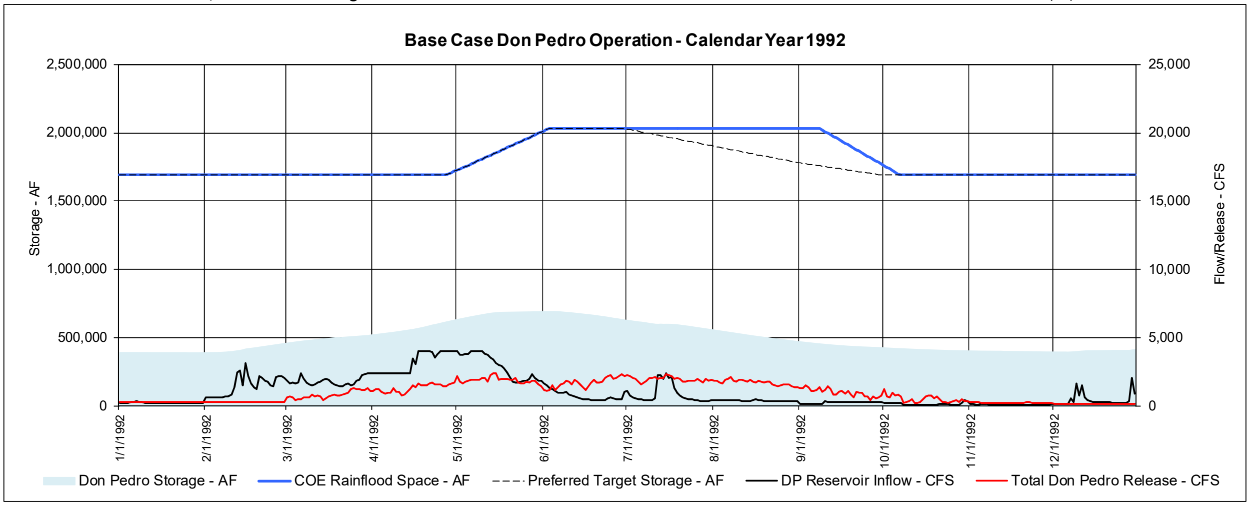
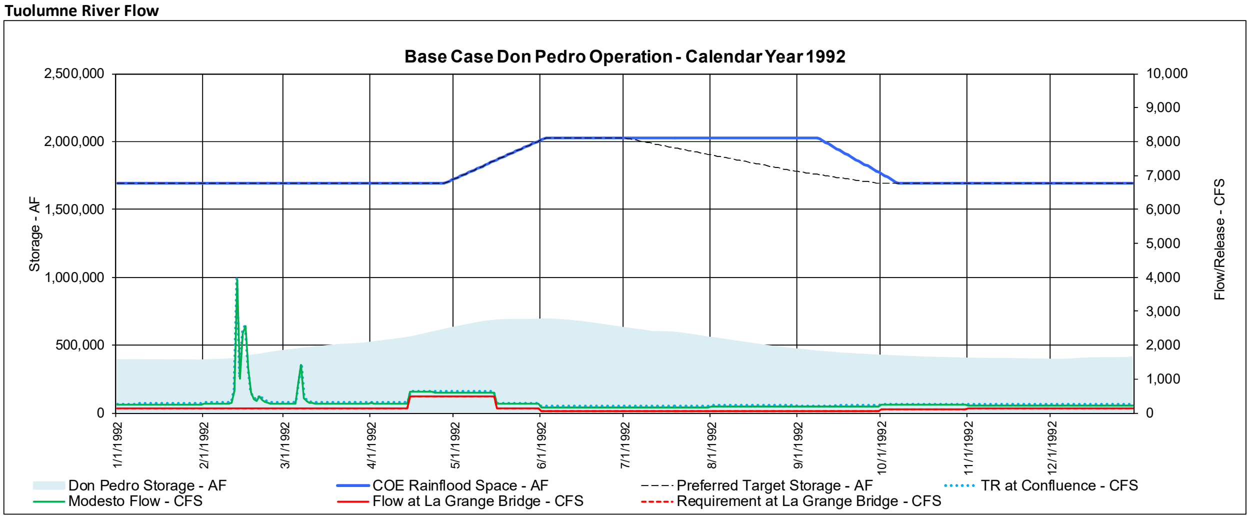


Figure B-21. Base Case conditions – calendar year 1991 (Source: Version 3.00 of the Tuolumne River Operations Model).

Don Pedro Reservoir Inflow, Release and Storage Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

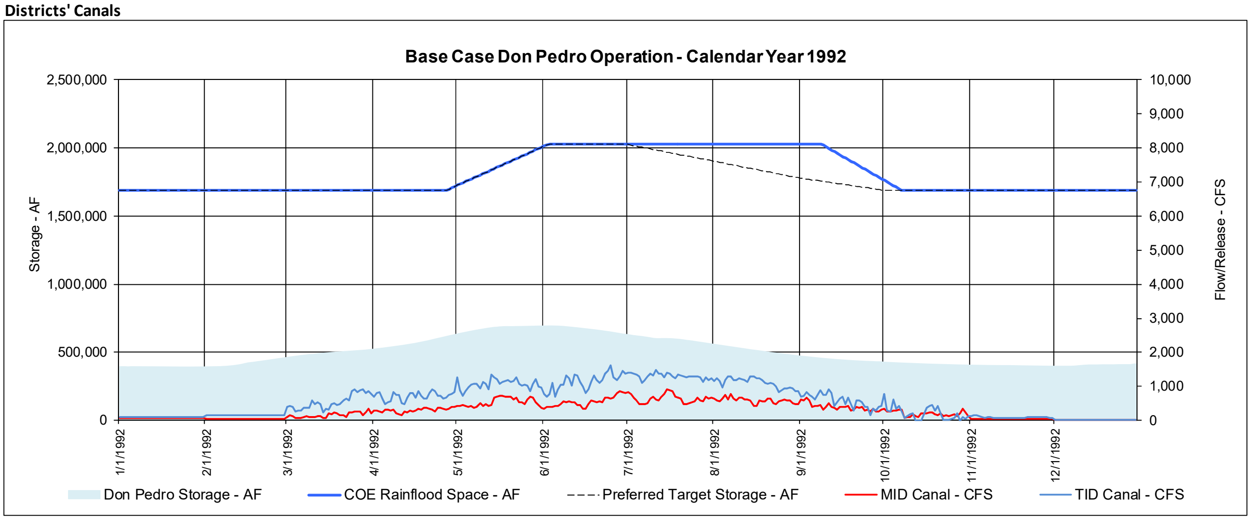
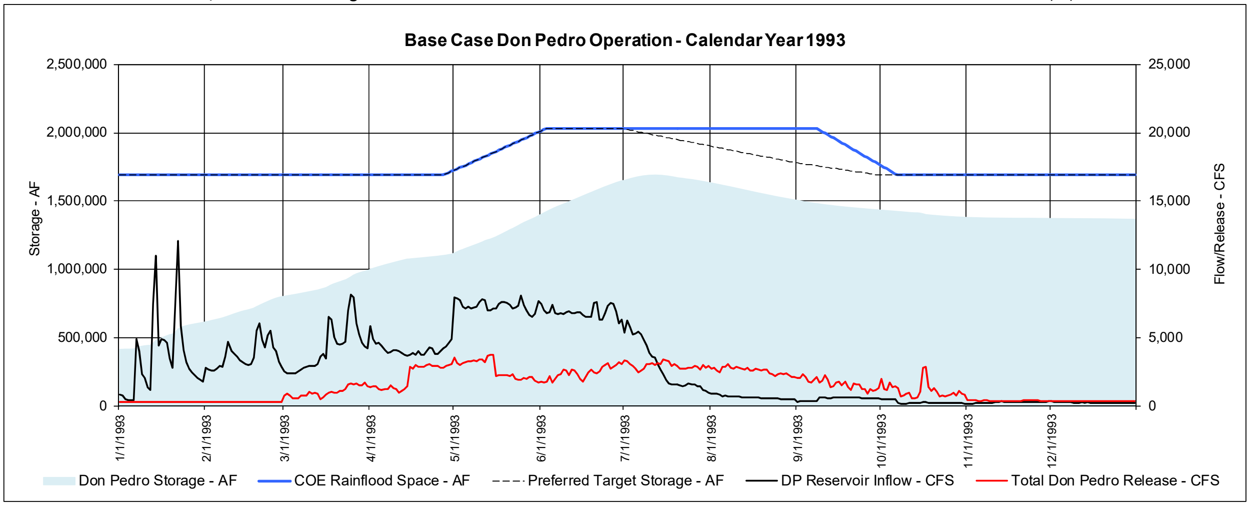


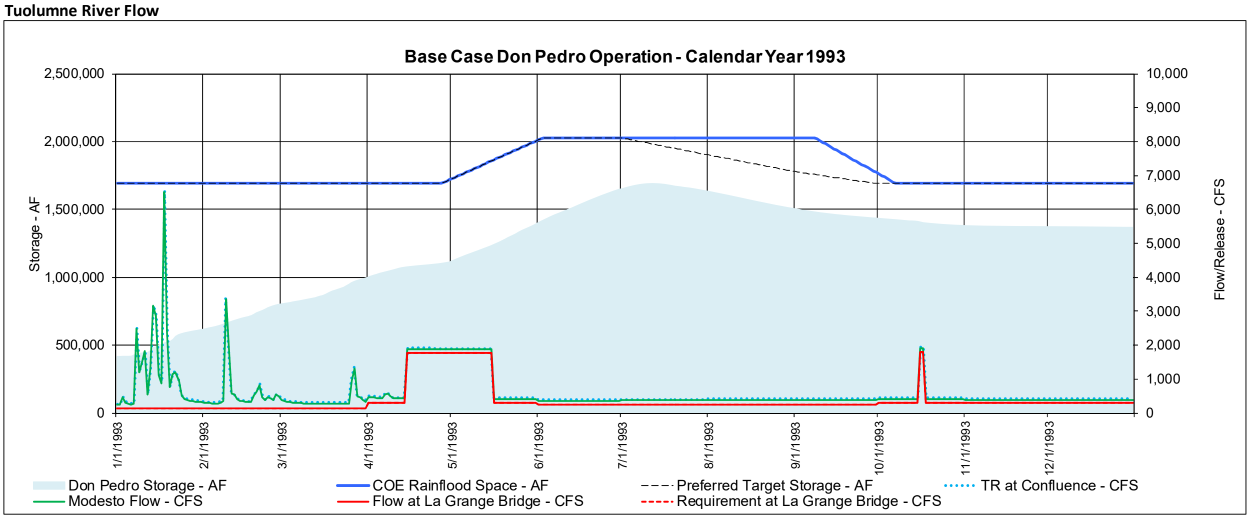
Figure B-22. Base Case conditions – calendar year 1992 (Source: Version 3.00 of the Tuolumne River Operations Model).

Don Pedro Reservoir Inflow, Release and Storage

Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

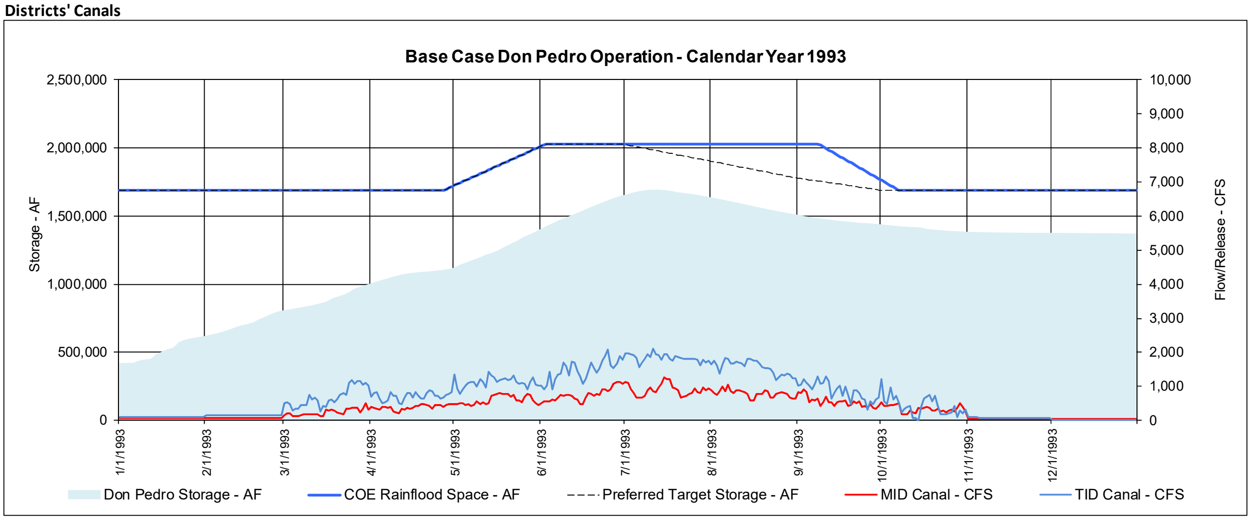
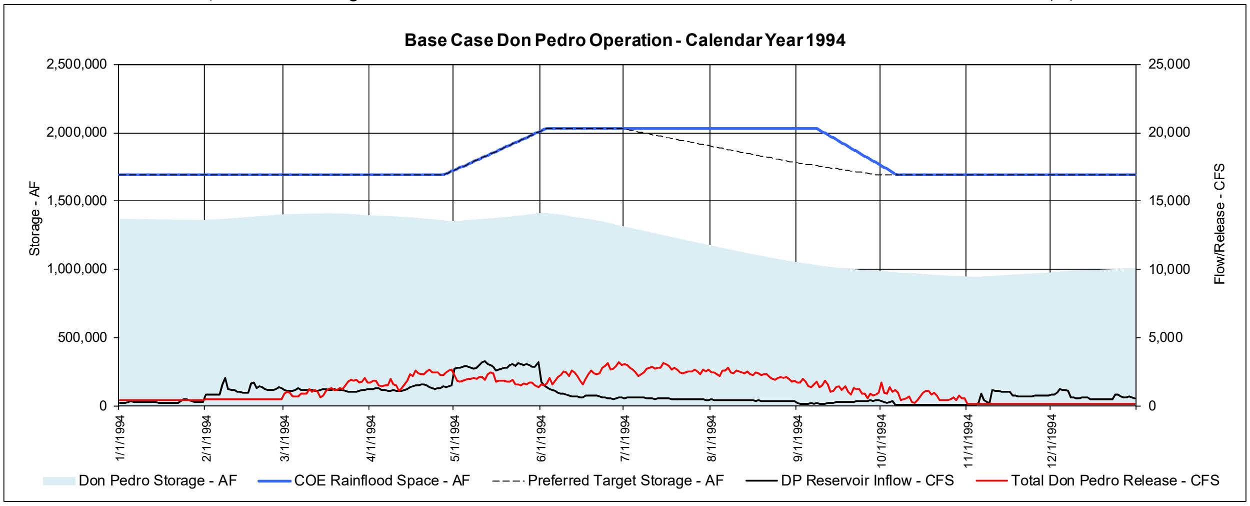
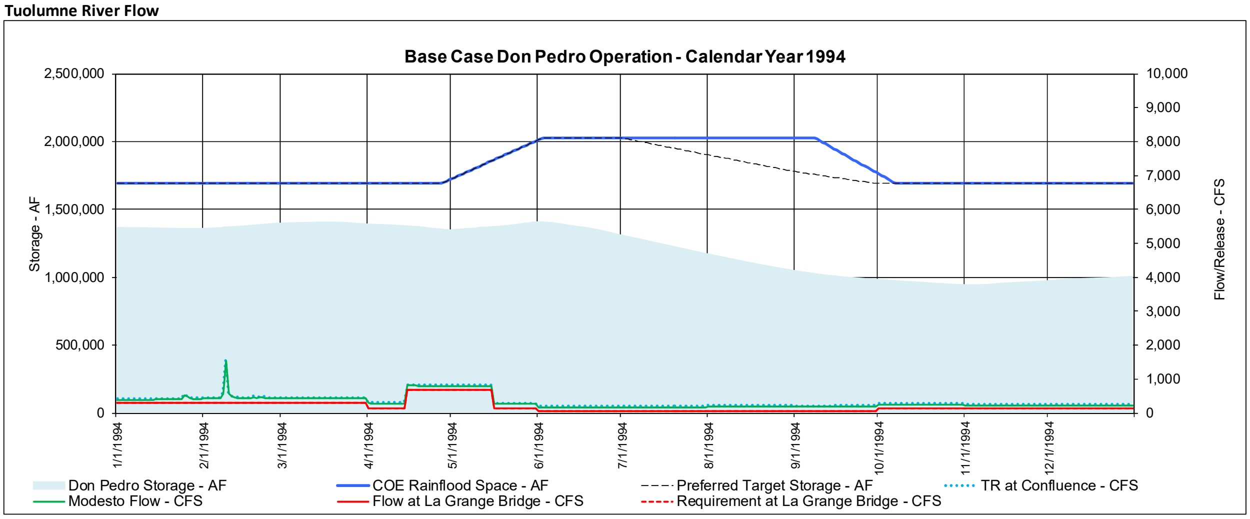


Figure B-23. Base Case conditions – calendar year 1993 (Source: Version 3.00 of the Tuolumne River Operations Model).

Don Pedro Reservoir Inflow, Release and Storage Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

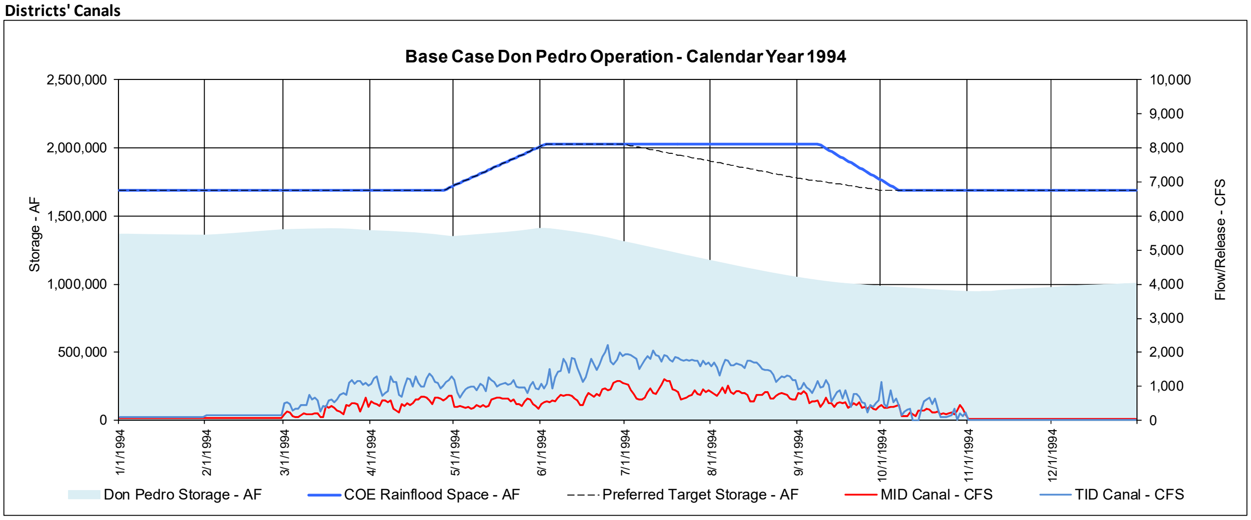
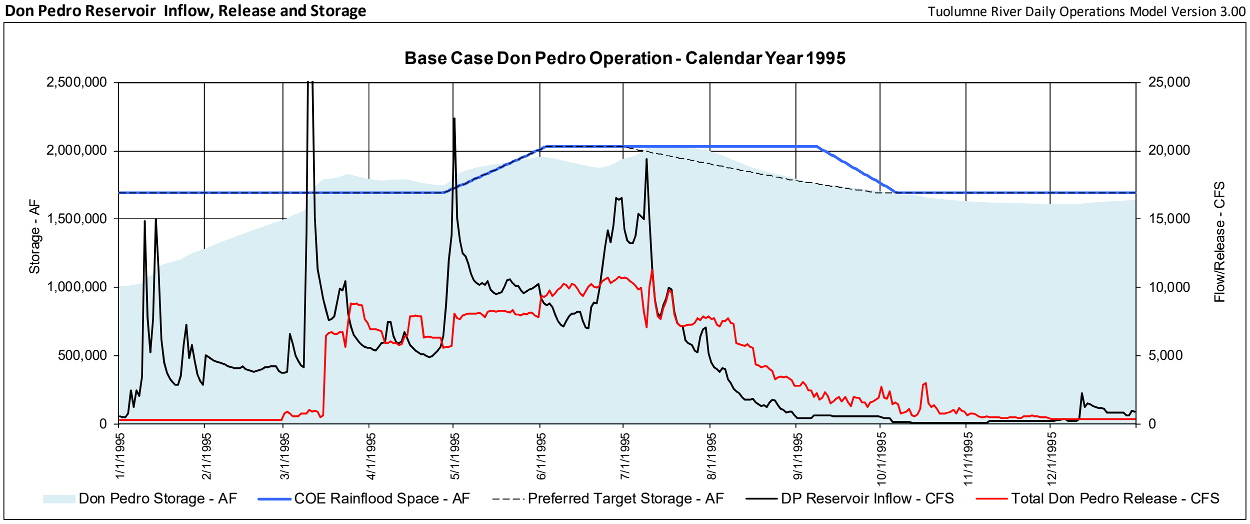
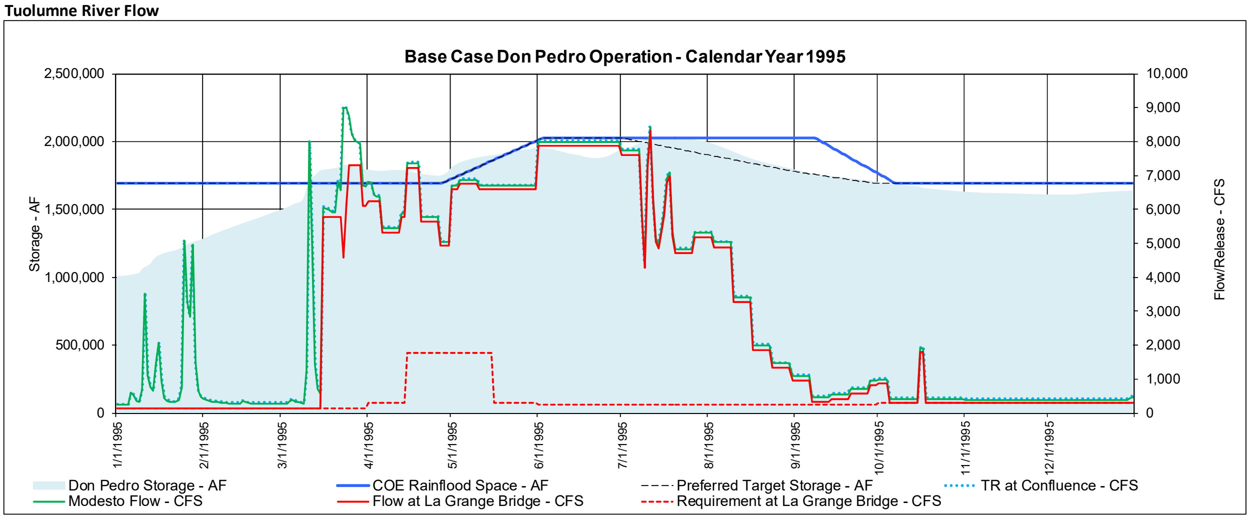


Figure B-24. Base Case conditions – calendar year 1994 (Source: Version 3.00 of the Tuolumne River Operations Model).

Don Pedro Reservoir Inflow, Release and Storage Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

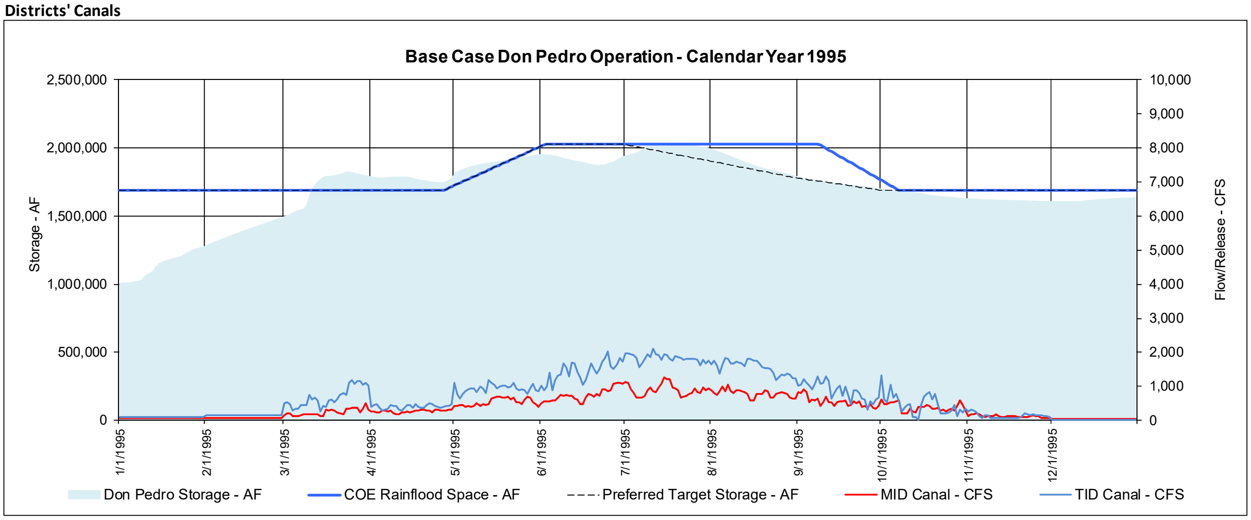
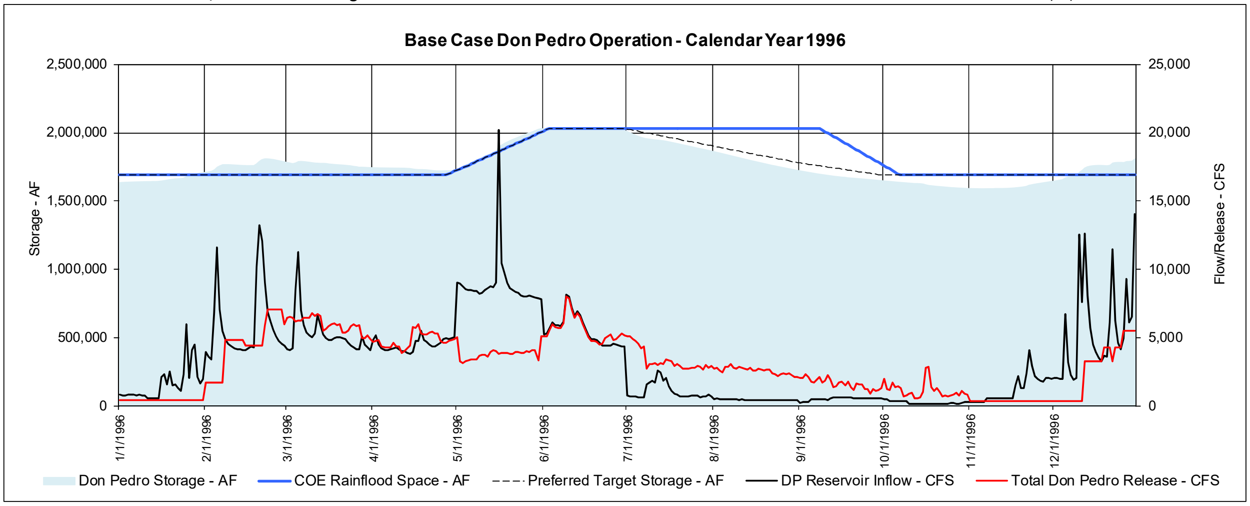
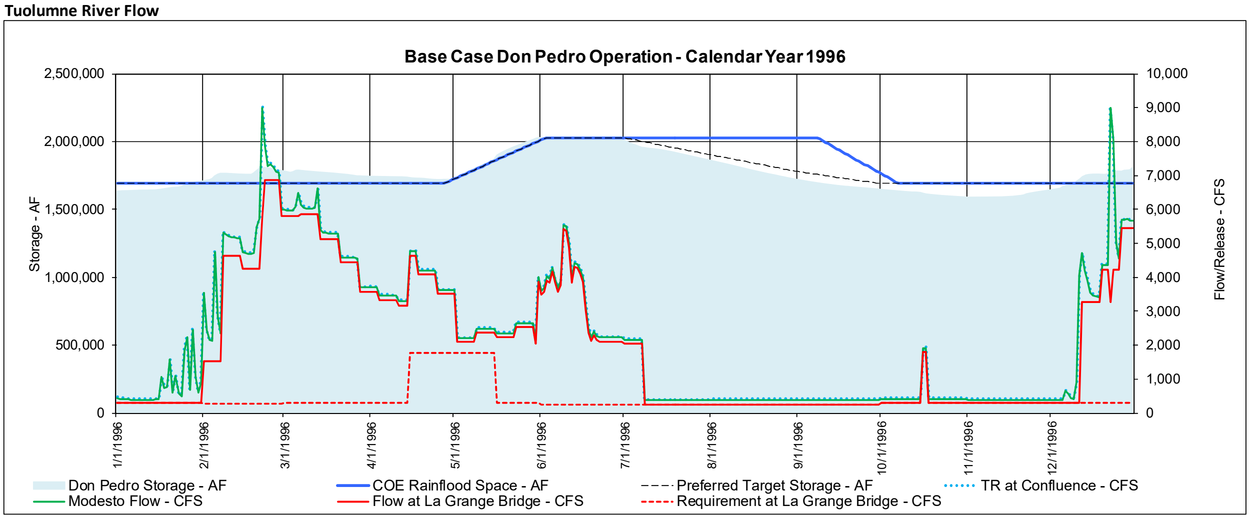


Figure B-25. Base Case conditions – calendar year 1995 (Source: Version 3.00 of the Tuolumne River Operations Model).

Don Pedro Reservoir Inflow, Release and Storage Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

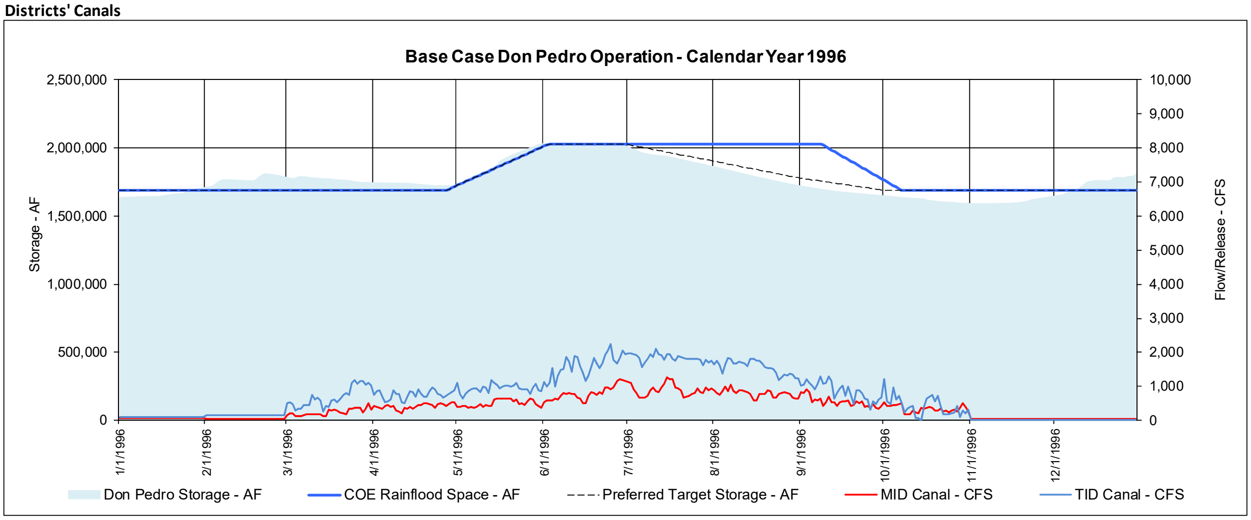
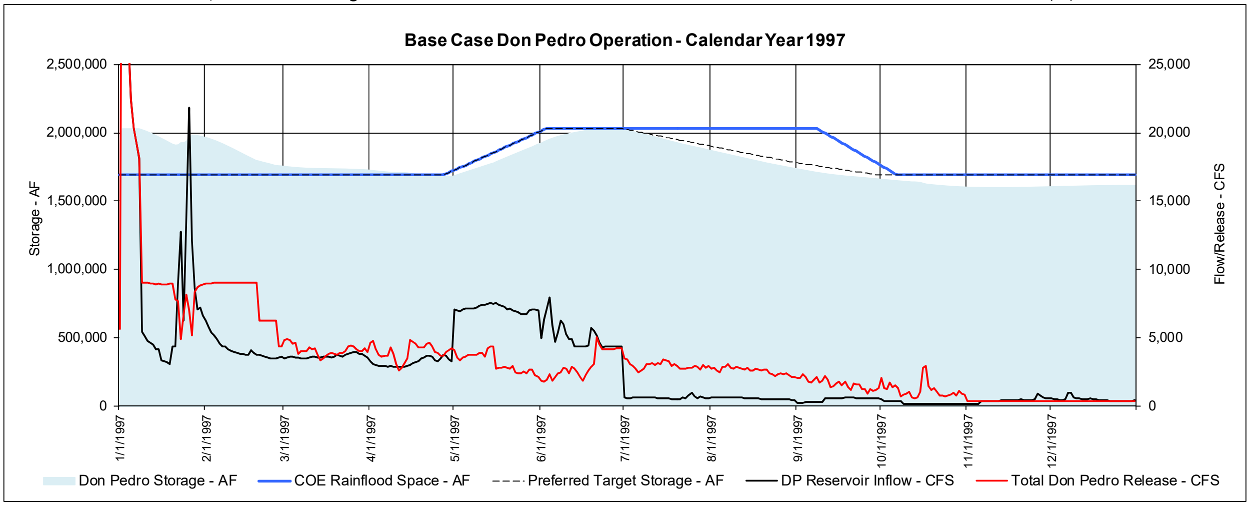
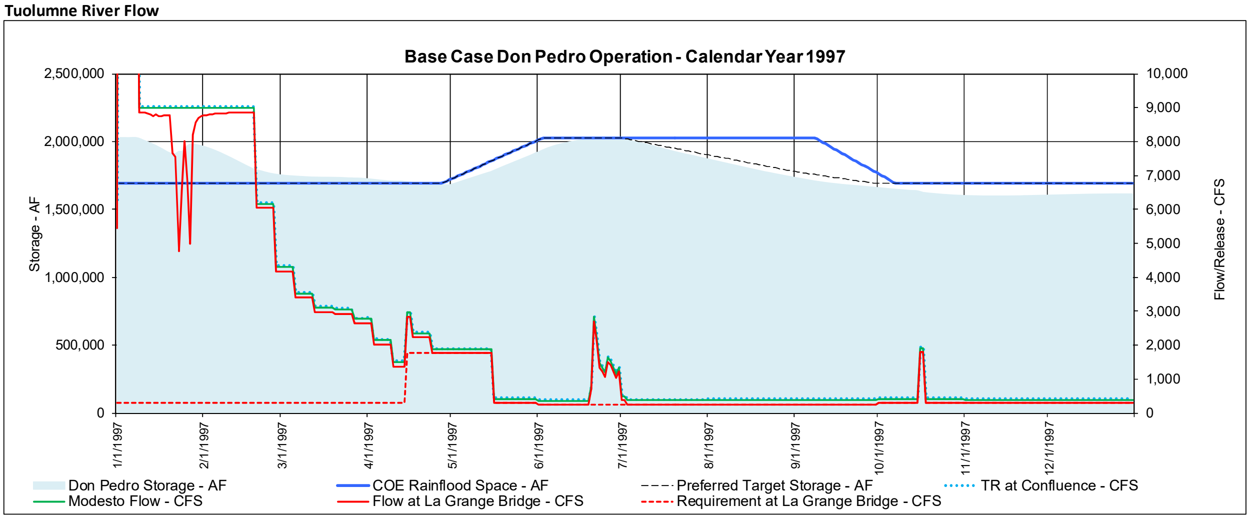


Figure B-26. Base Case conditions – calendar year 1996 (Source: Version 3.00 of the Tuolumne River Operations Model).

Don Pedro Reservoir Inflow, Release and Storage Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

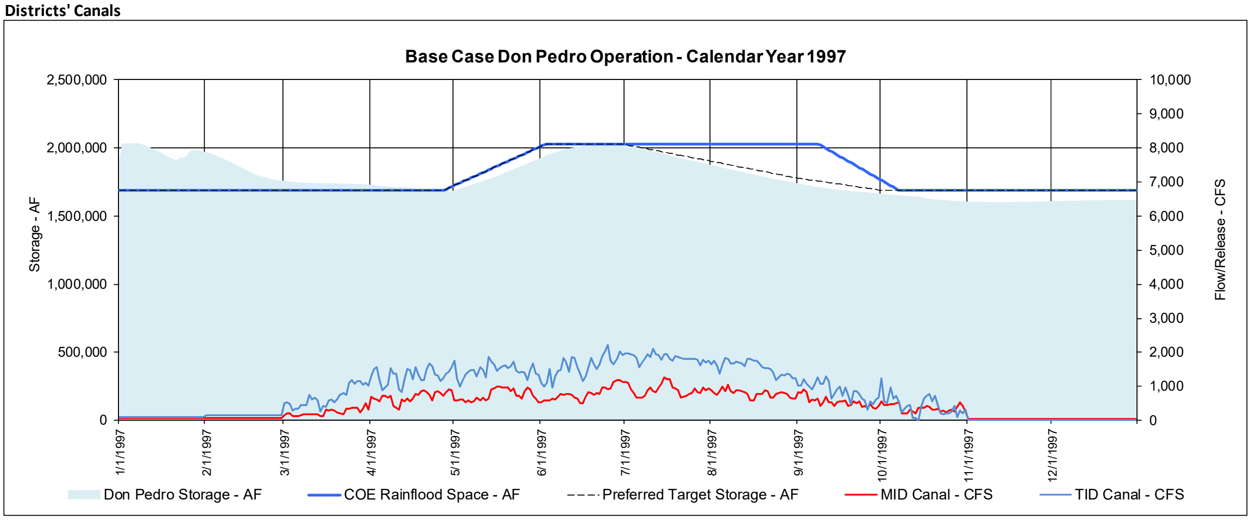
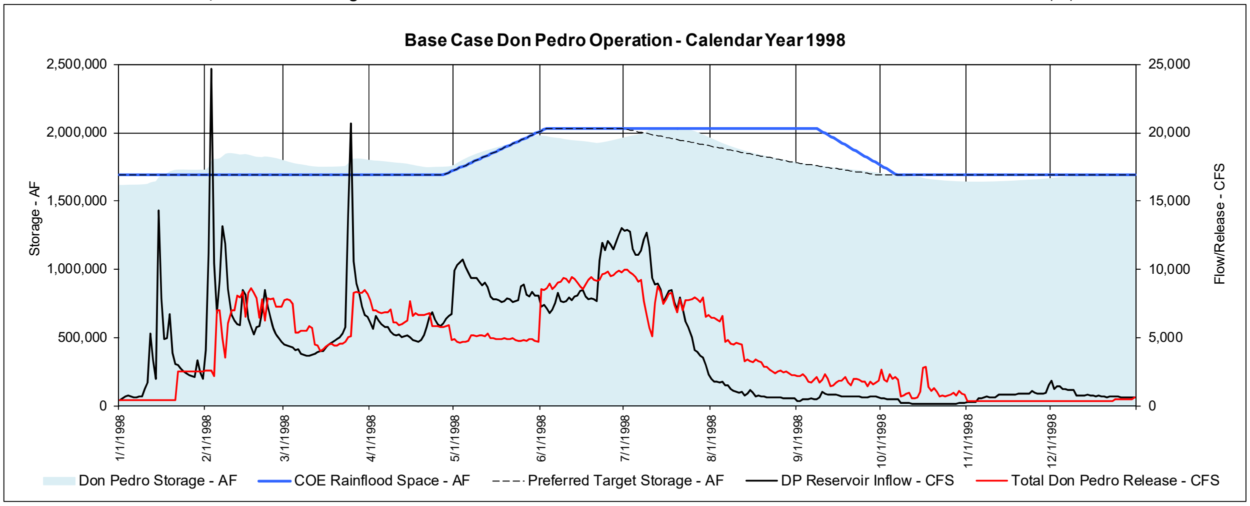


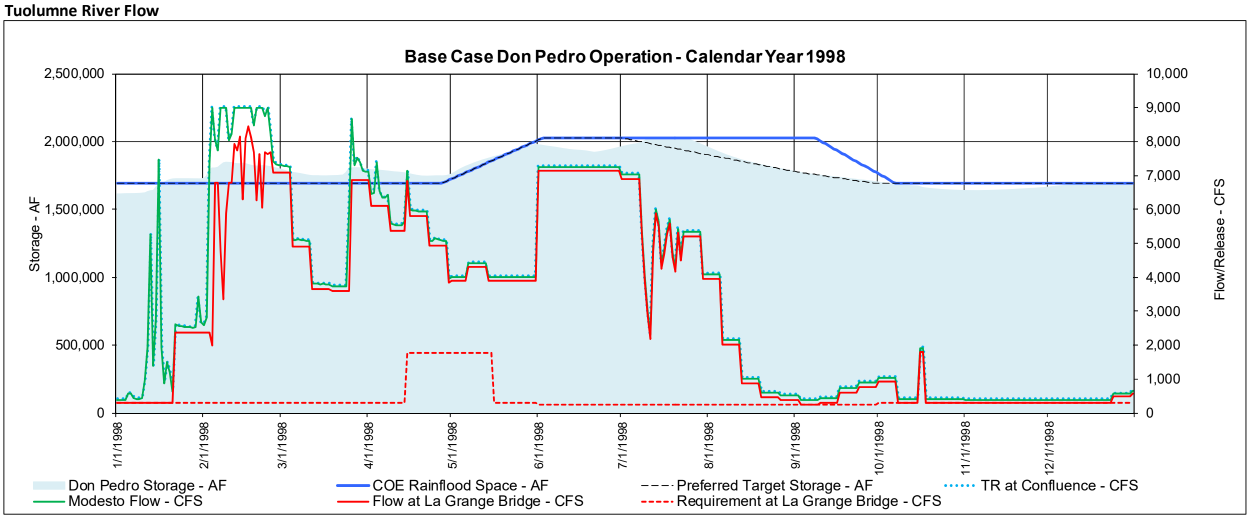
Figure B-27. Base Case conditions – calendar year 1997 (Source: Version 3.00 of the Tuolumne River Operations Model).

Don Pedro Reservoir Inflow, Release and Storage

Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

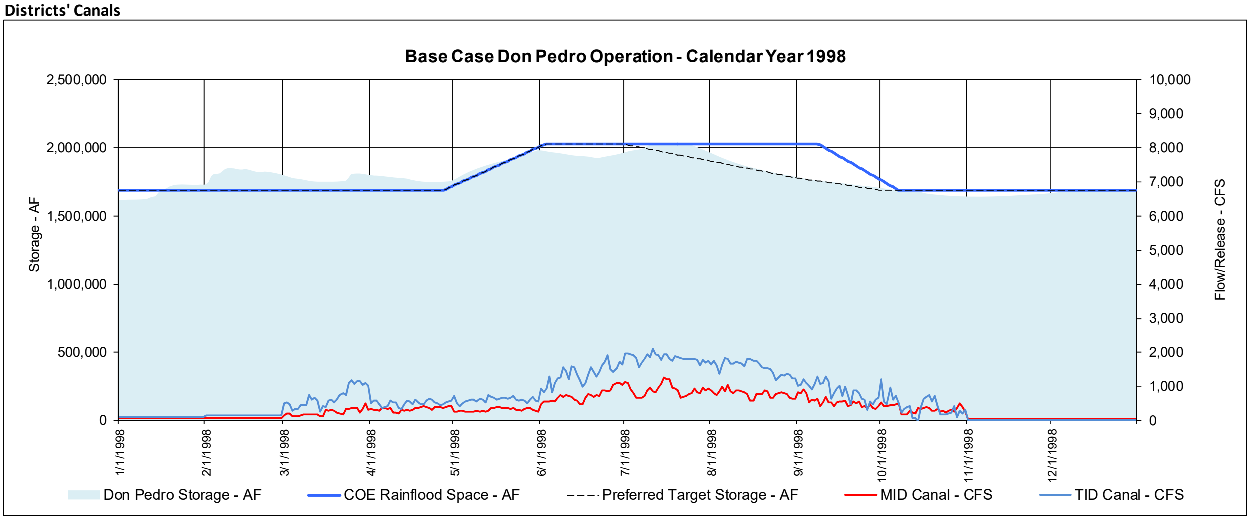
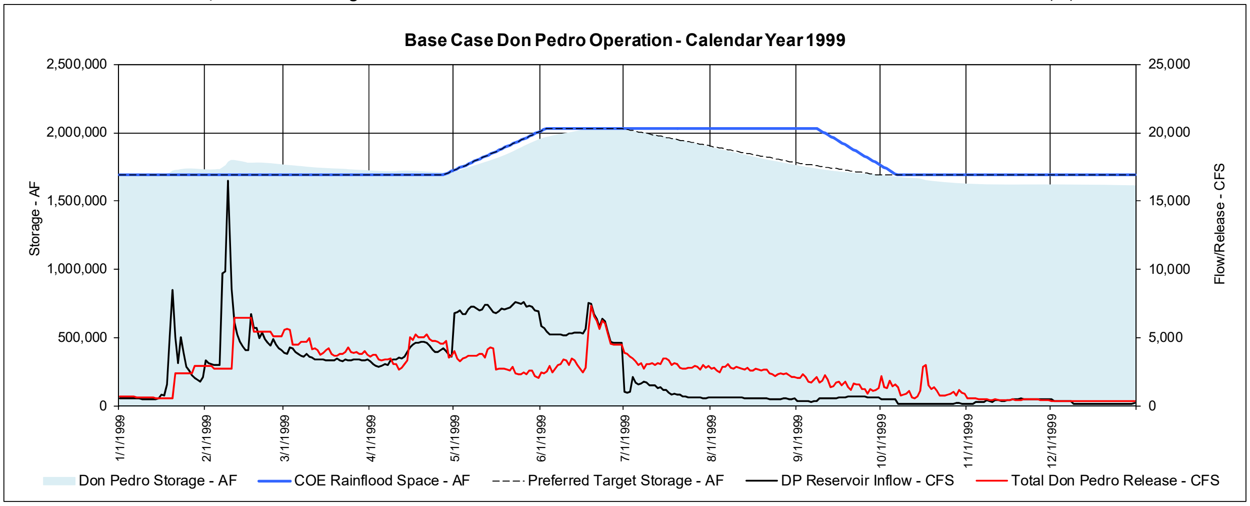
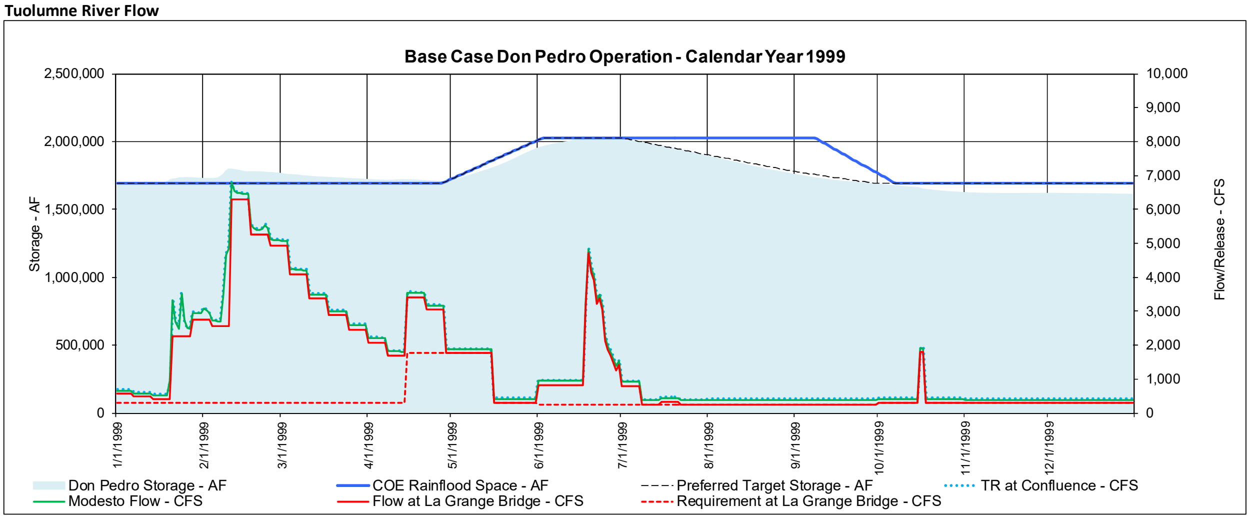


Figure B-28. Base Case conditions – calendar year 1998 (Source: Version 3.00 of the Tuolumne River Operations Model).

Don Pedro Reservoir Inflow, Release and Storage Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

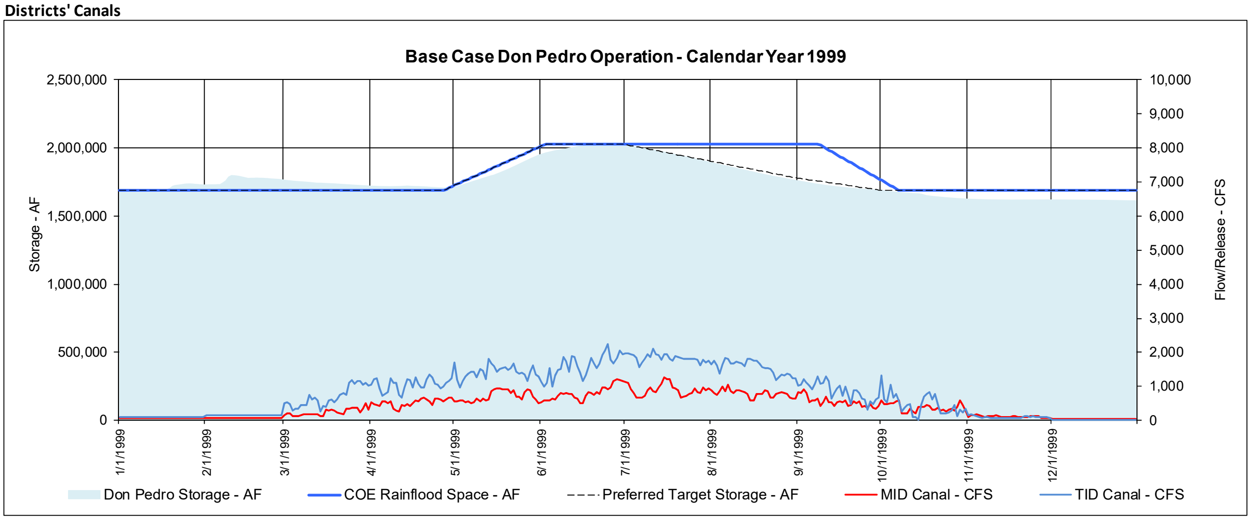
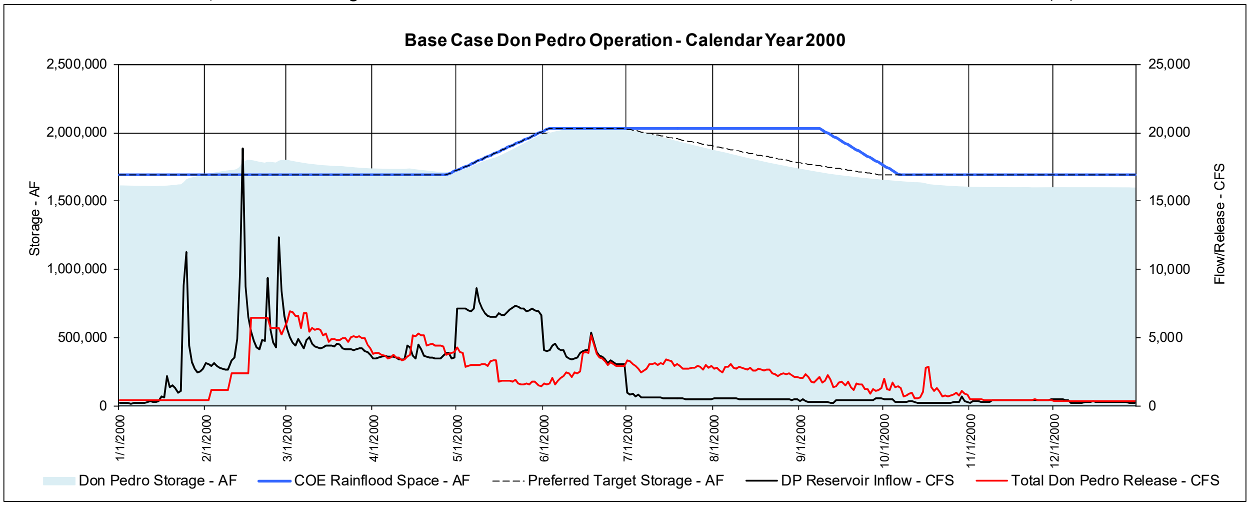


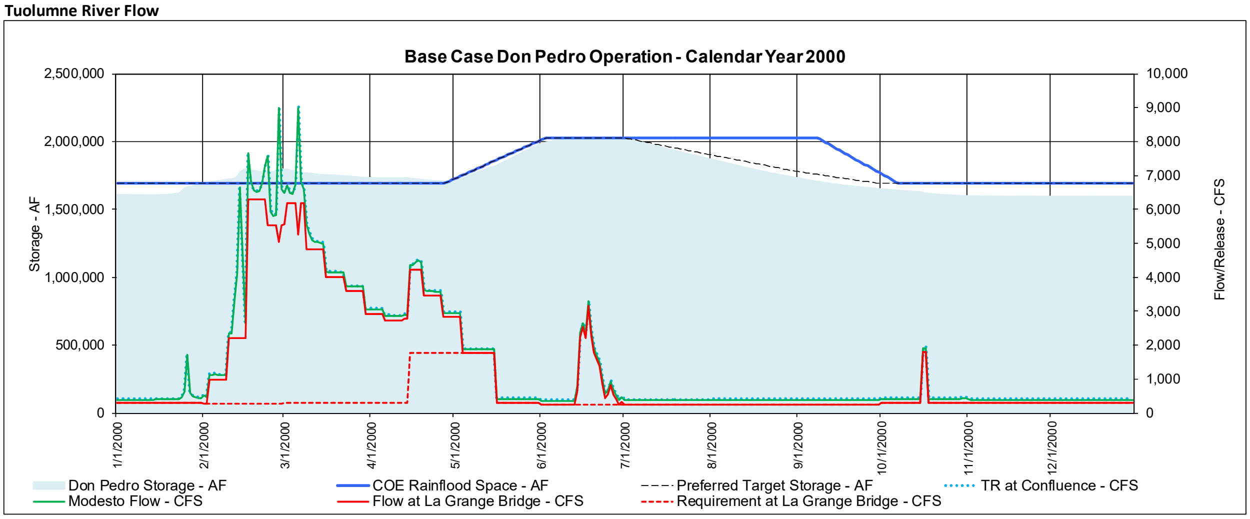
Figure B-29. Base Case conditions – calendar year 1999 (Source: Version 3.00 of the Tuolumne River Operations Model).

Don Pedro Reservoir Inflow, Release and Storage

Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

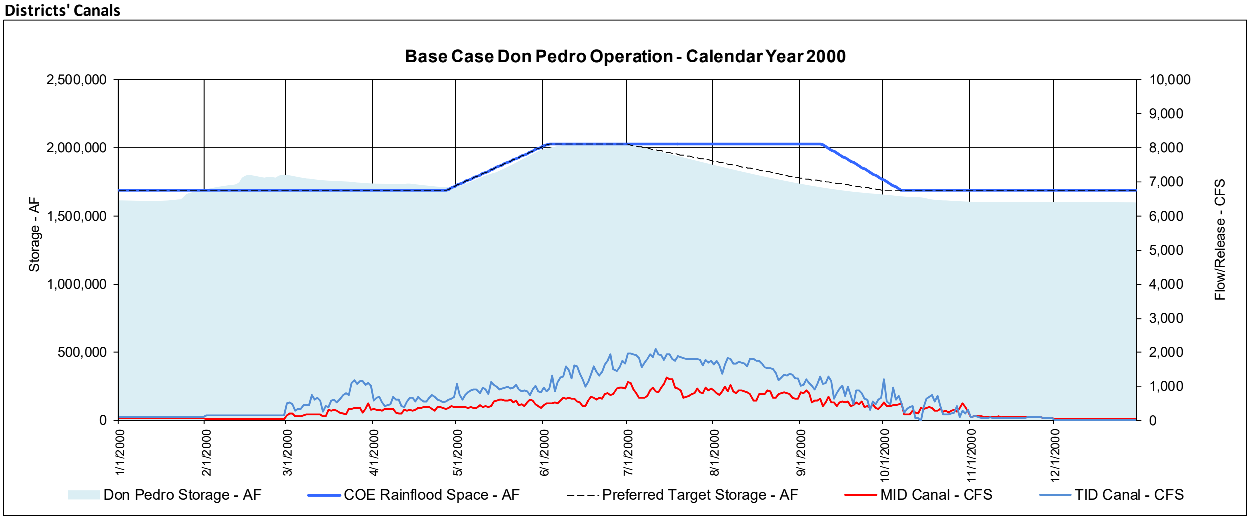
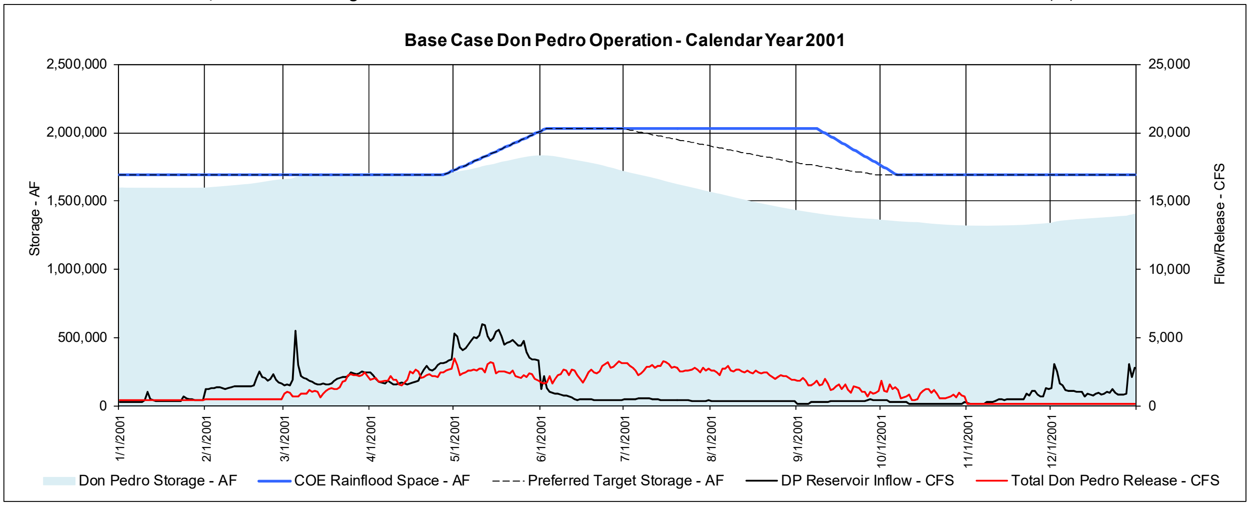
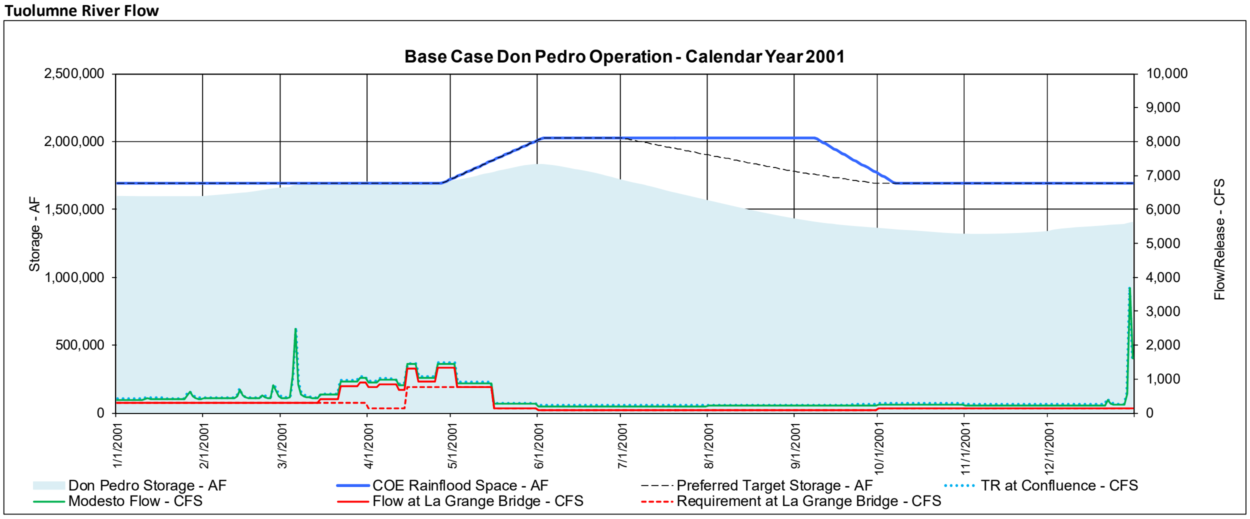


Figure B-30. Base Case conditions – calendar year 2000 (Source: Version 3.00 of the Tuolumne River Operations Model).

Don Pedro Reservoir Inflow, Release and Storage Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

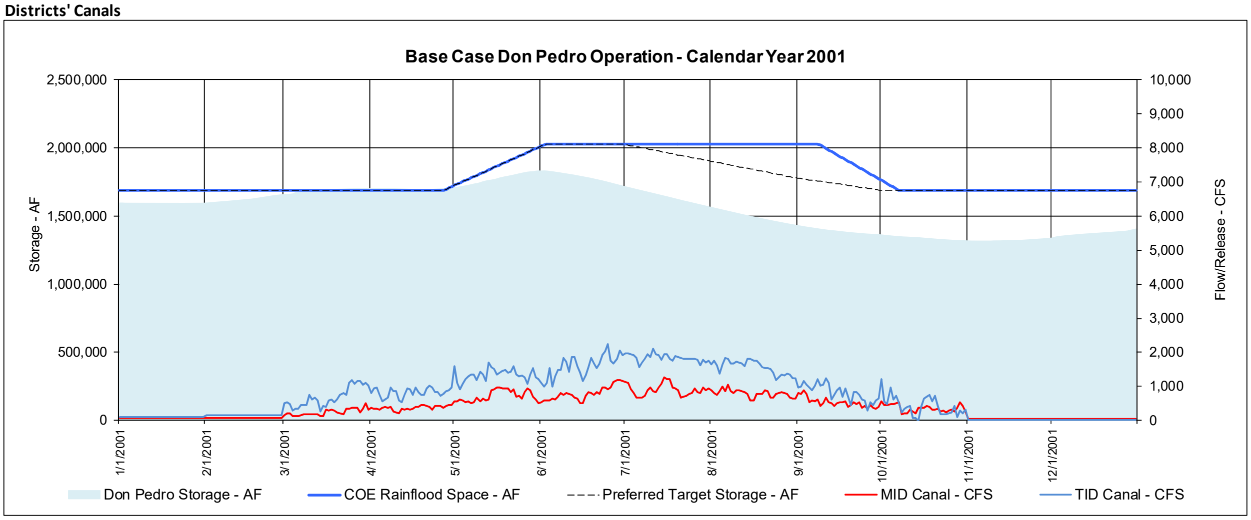
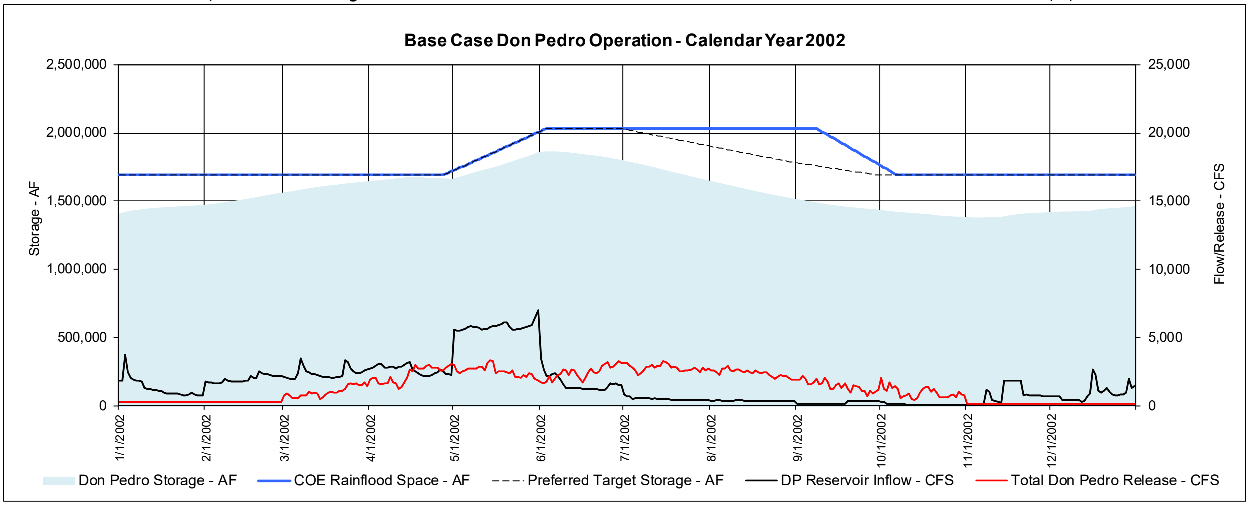


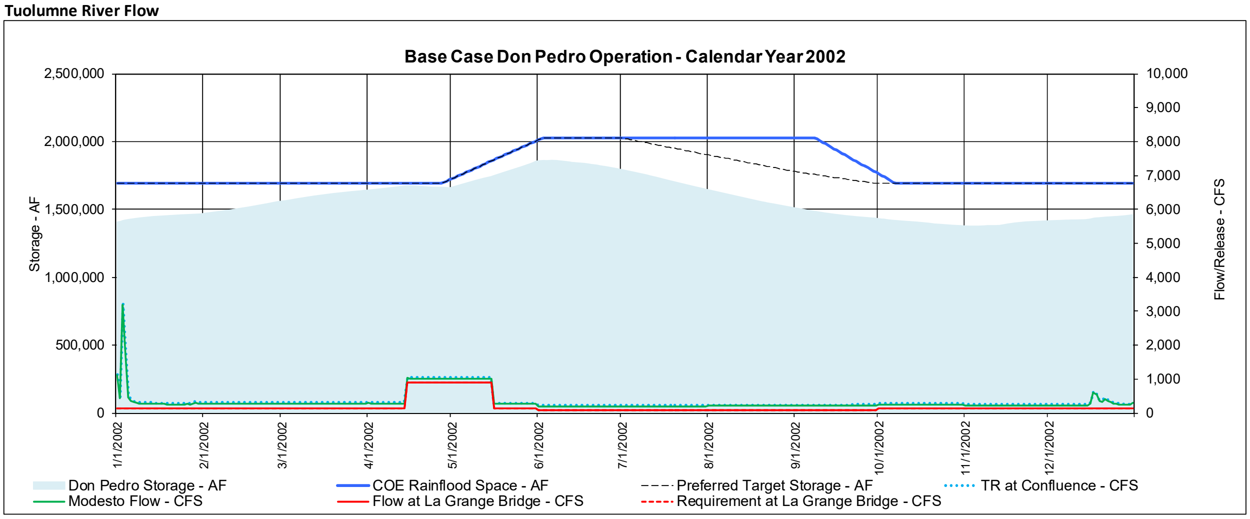
Figure B-31. Base Case conditions – calendar year 2001 (Source: Version 3.00 of the Tuolumne River Operations Model).

Don Pedro Reservoir Inflow, Release and Storage

Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

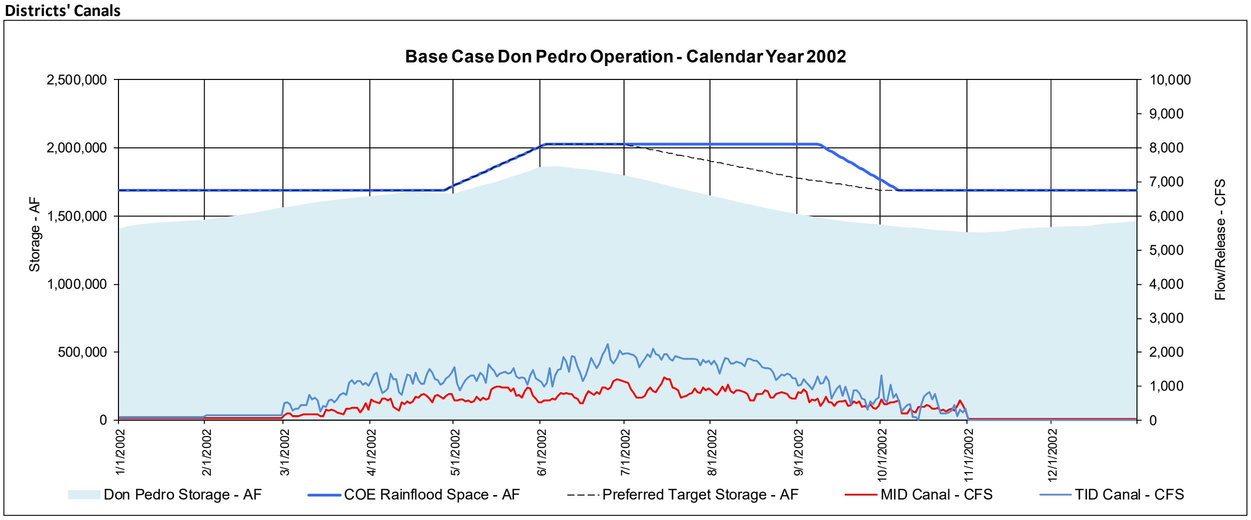
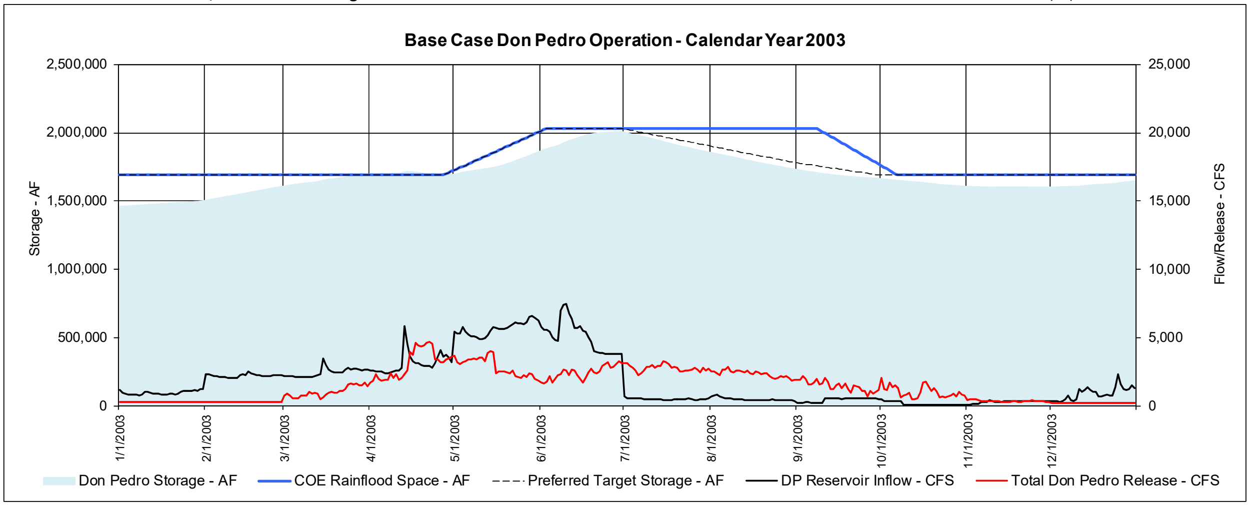


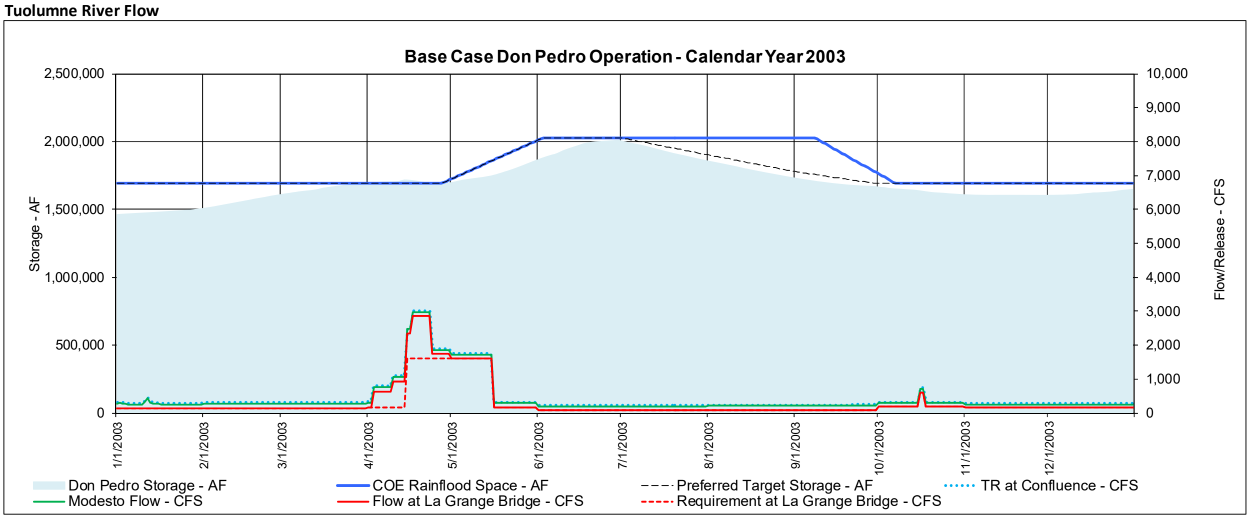
Figure B-32. Base Case conditions – calendar year 2002 (Source: Version 3.00 of the Tuolumne River Operations Model).

Don Pedro Reservoir Inflow, Release and Storage

Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

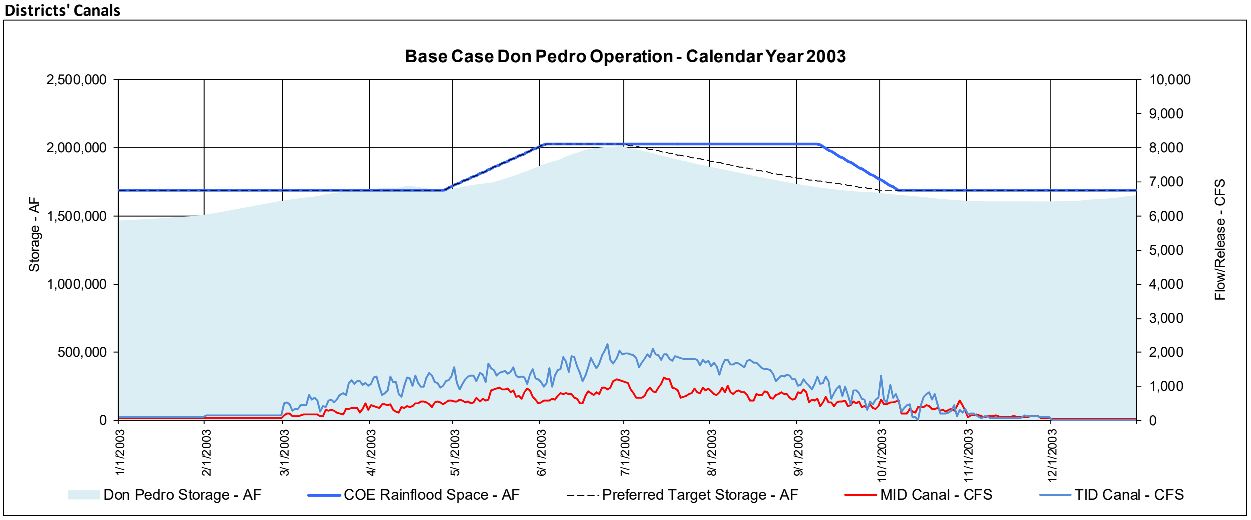
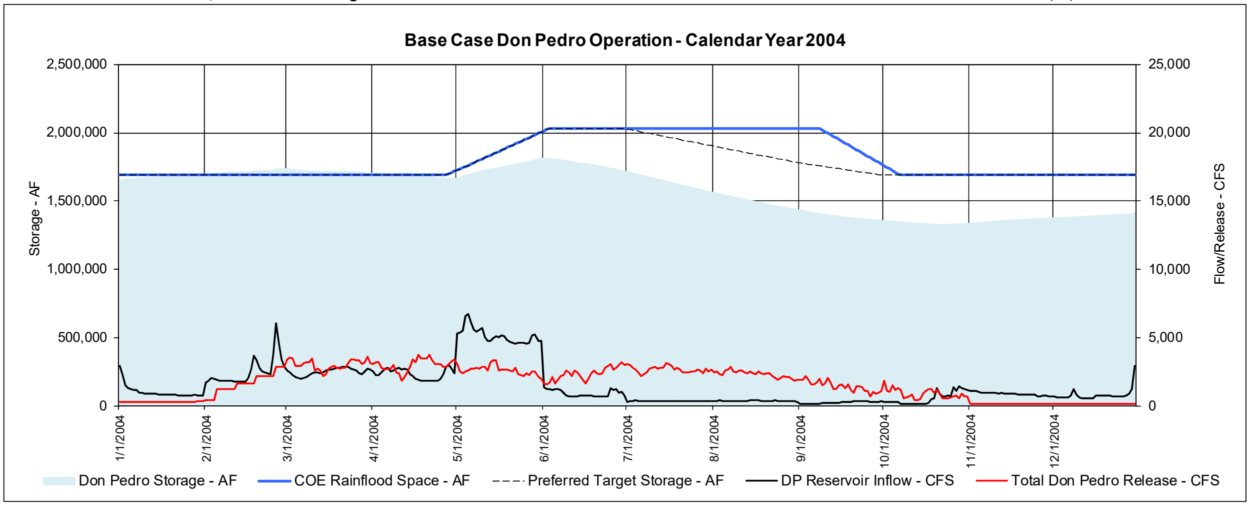


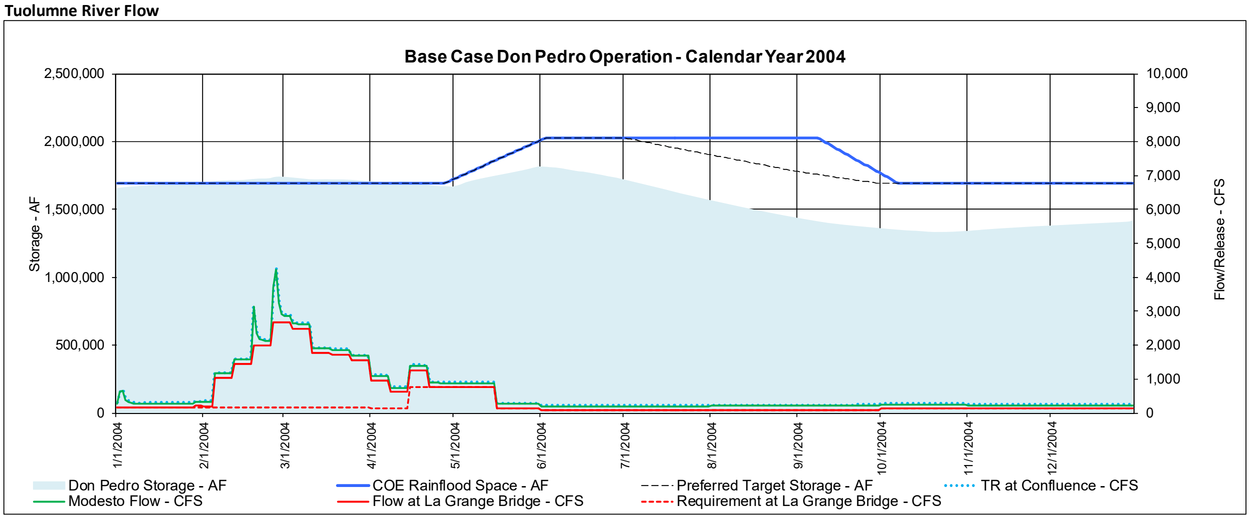
Figure B-33. Base Case conditions – calendar year 2003 (Source: Version 3.00 of the Tuolumne River Operations Model).

Don Pedro Reservoir Inflow, Release and Storage

Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

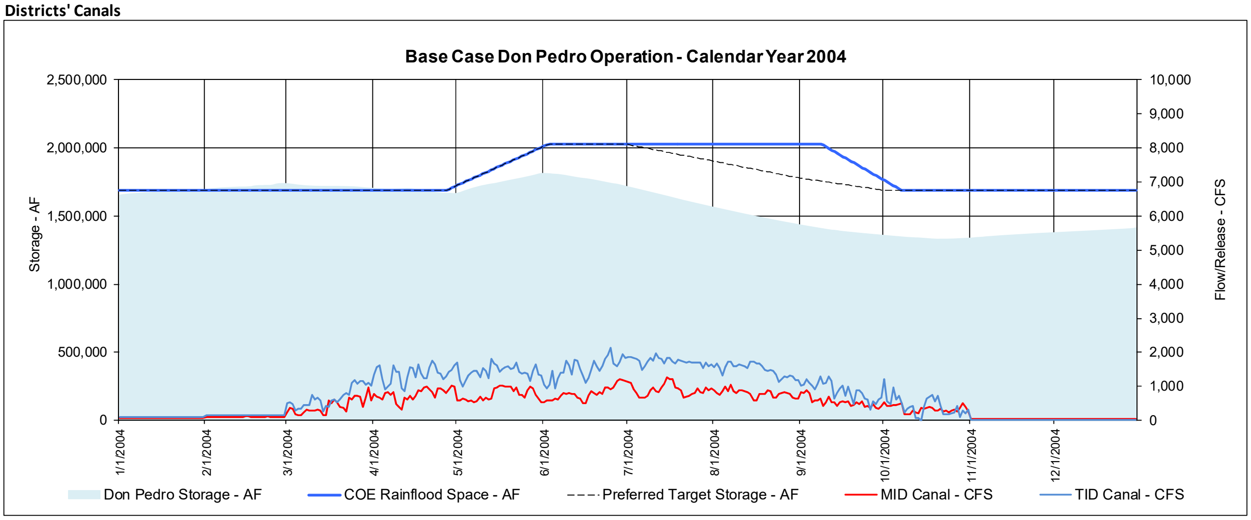
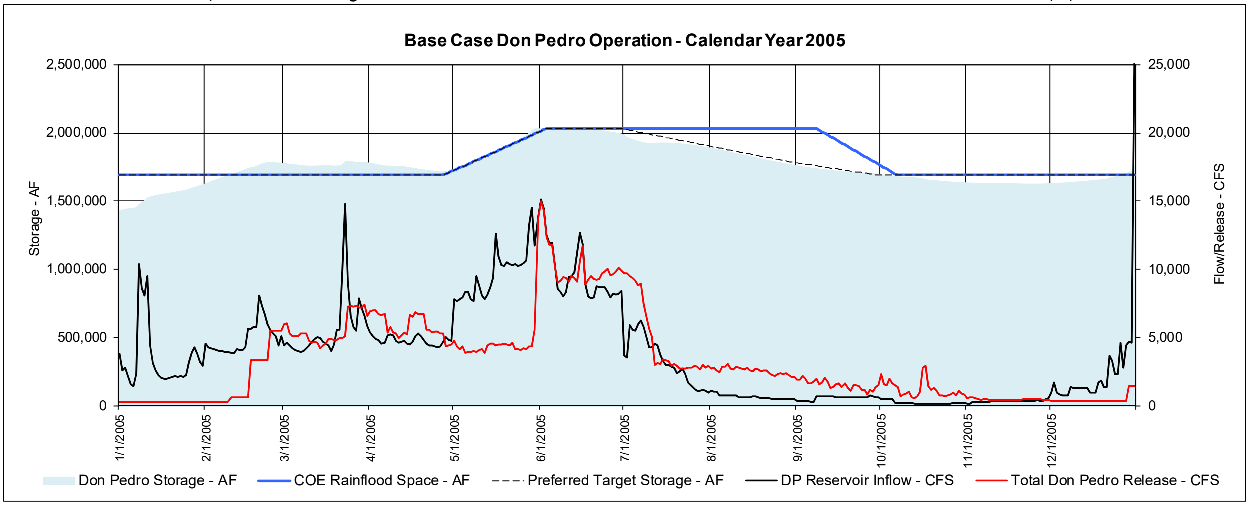
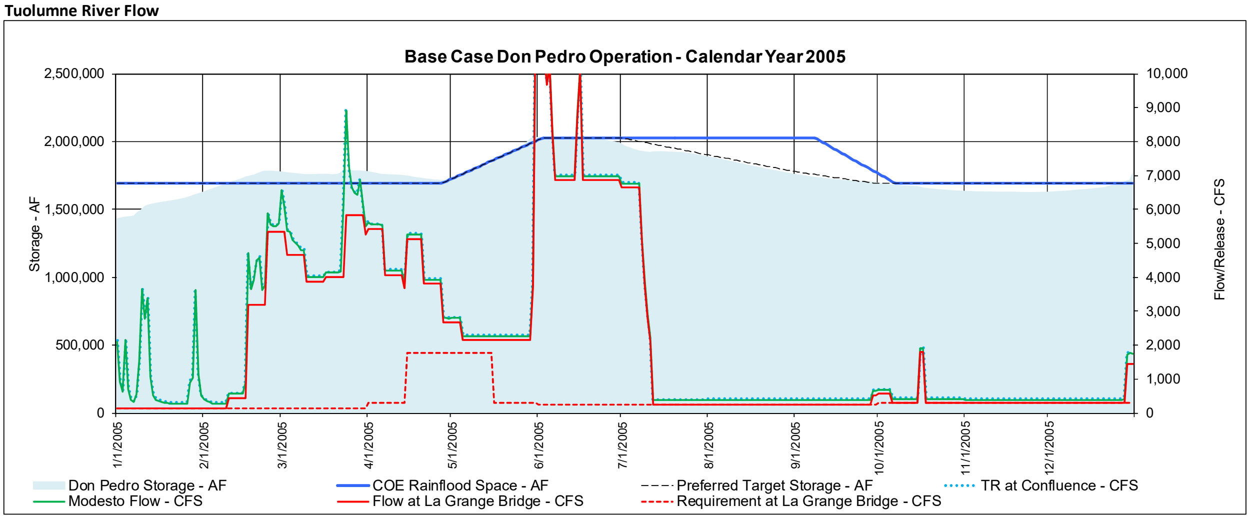


Figure B-34. Base Case conditions – calendar year 2004 (Source: Version 3.00 of the Tuolumne River Operations Model).

Don Pedro Reservoir Inflow, Release and Storage Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

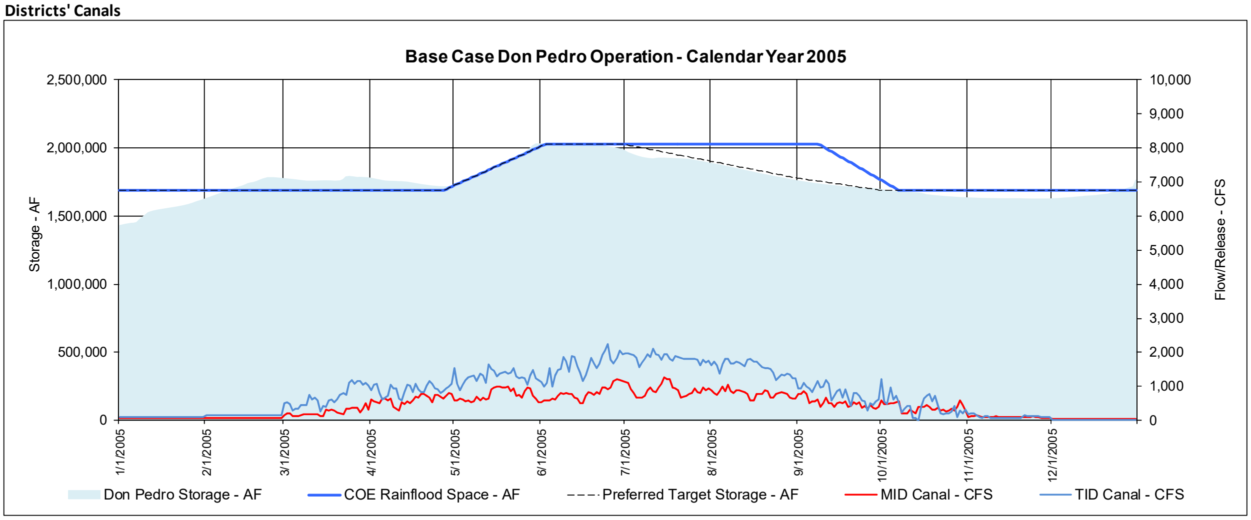
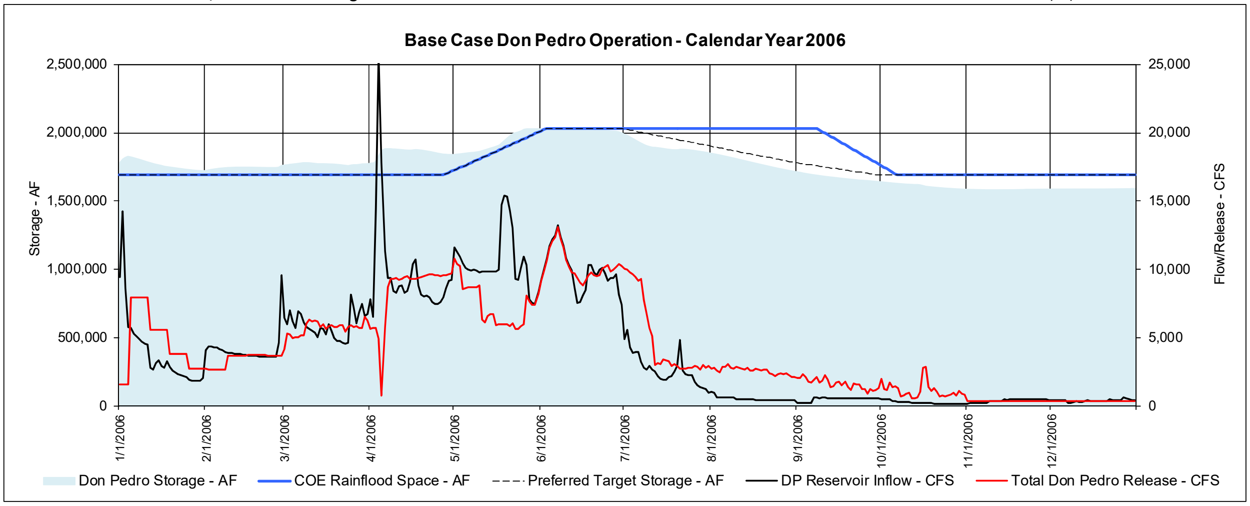


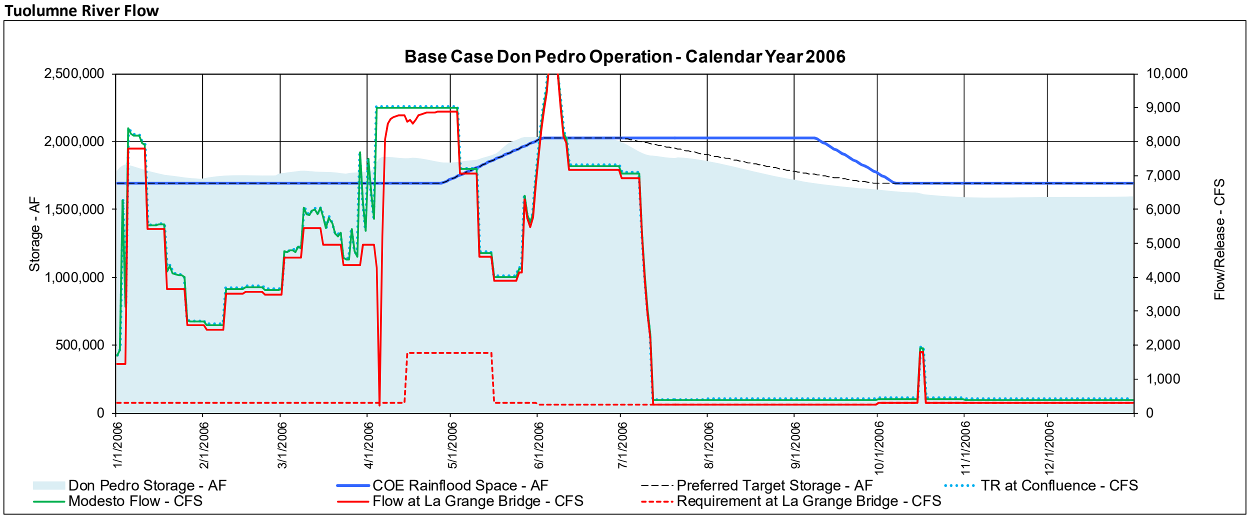
Figure B-35. Base Case conditions – calendar year 2005 (Source: Version 3.00 of the Tuolumne River Operations Model).

Don Pedro Reservoir Inflow, Release and Storage

Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

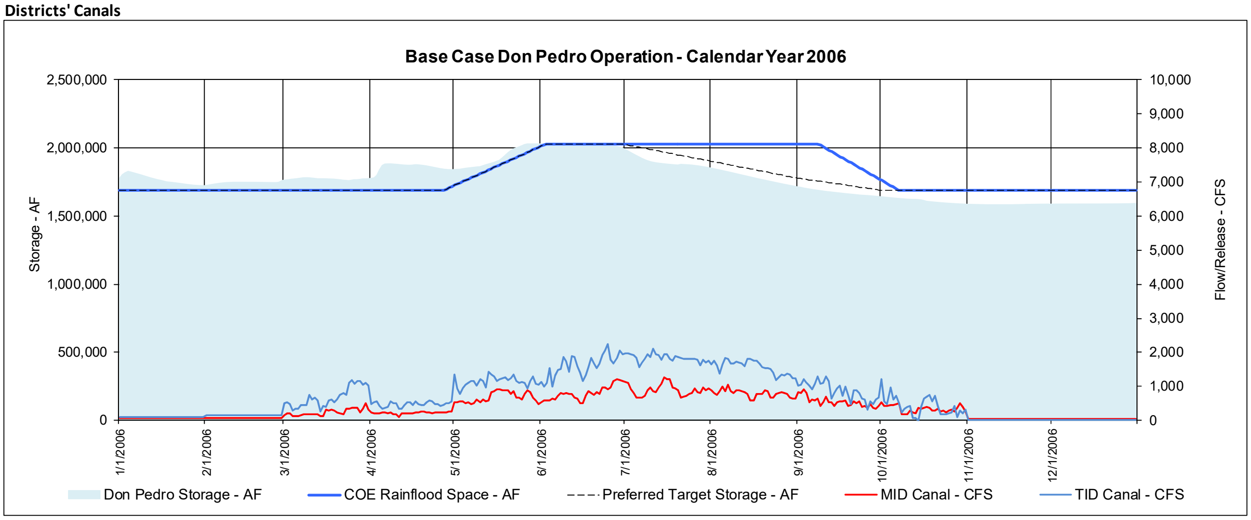
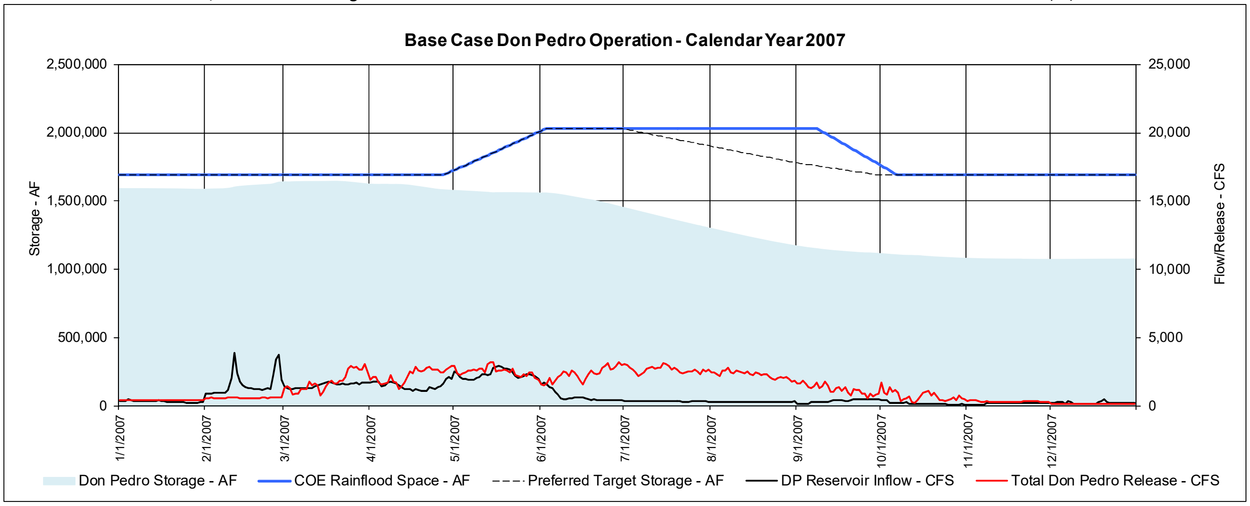
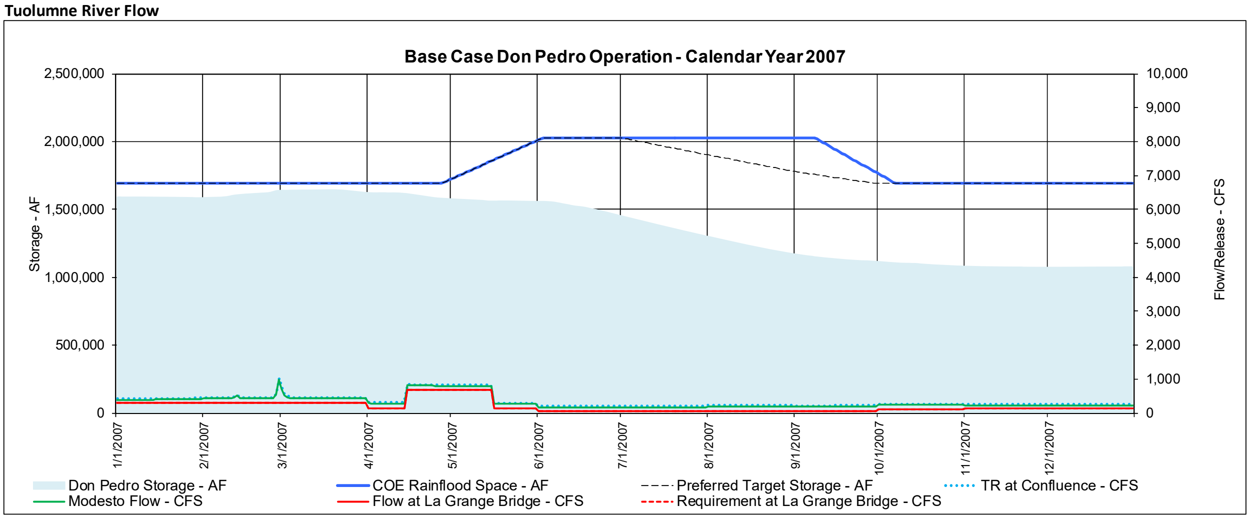


Figure B-36. Base Case conditions – calendar year 2006 (Source: Version 3.00 of the Tuolumne River Operations Model).

Don Pedro Reservoir Inflow, Release and Storage Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

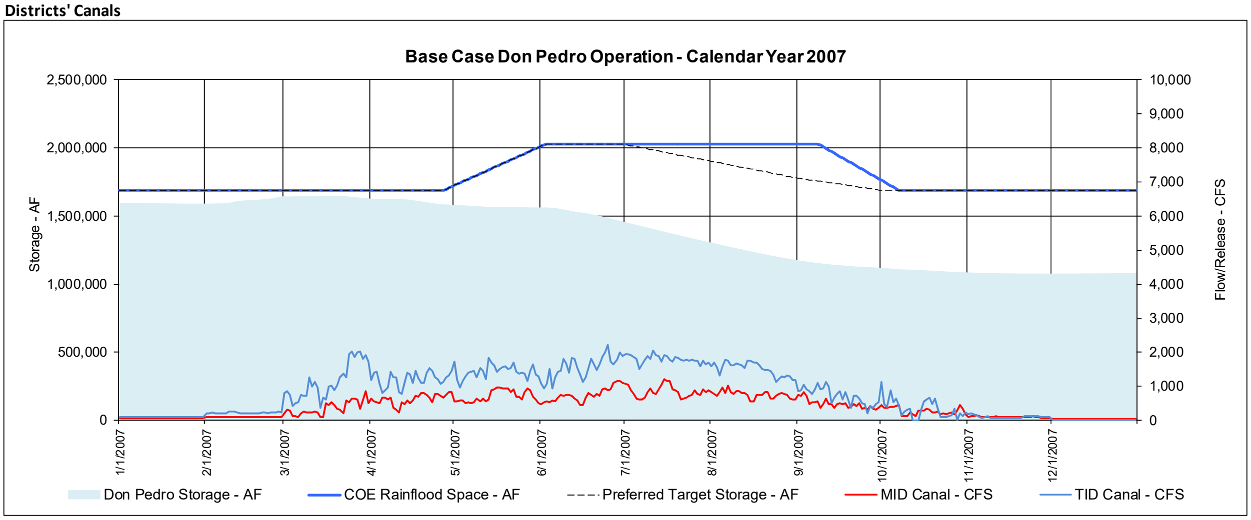
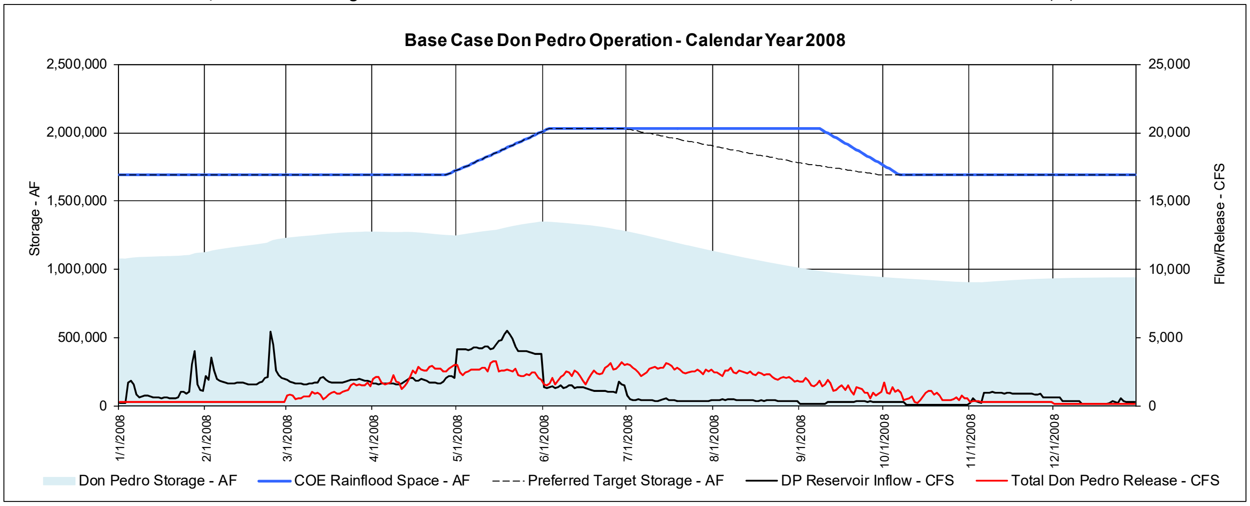


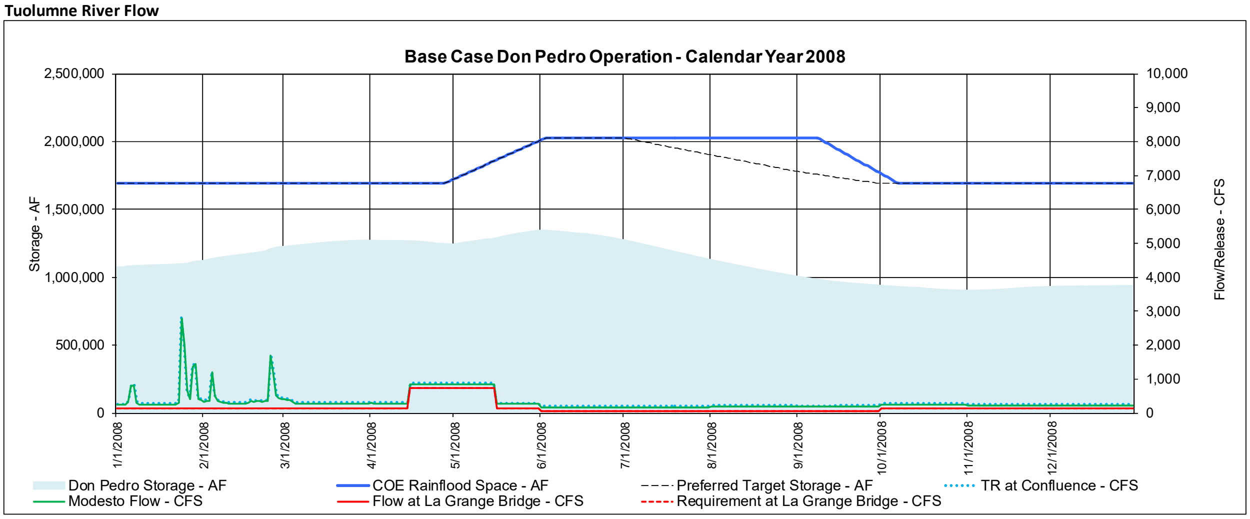
Figure B-37. Base Case conditions – calendar year 2007 (Source: Version 3.00 of the Tuolumne River Operations Model).

Don Pedro Reservoir Inflow, Release and Storage

Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

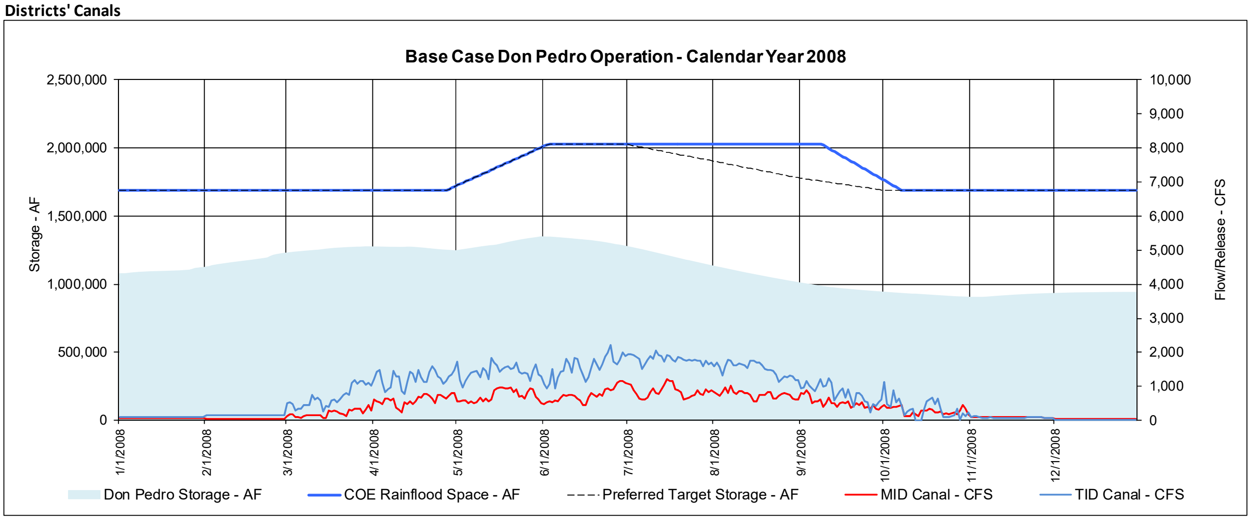
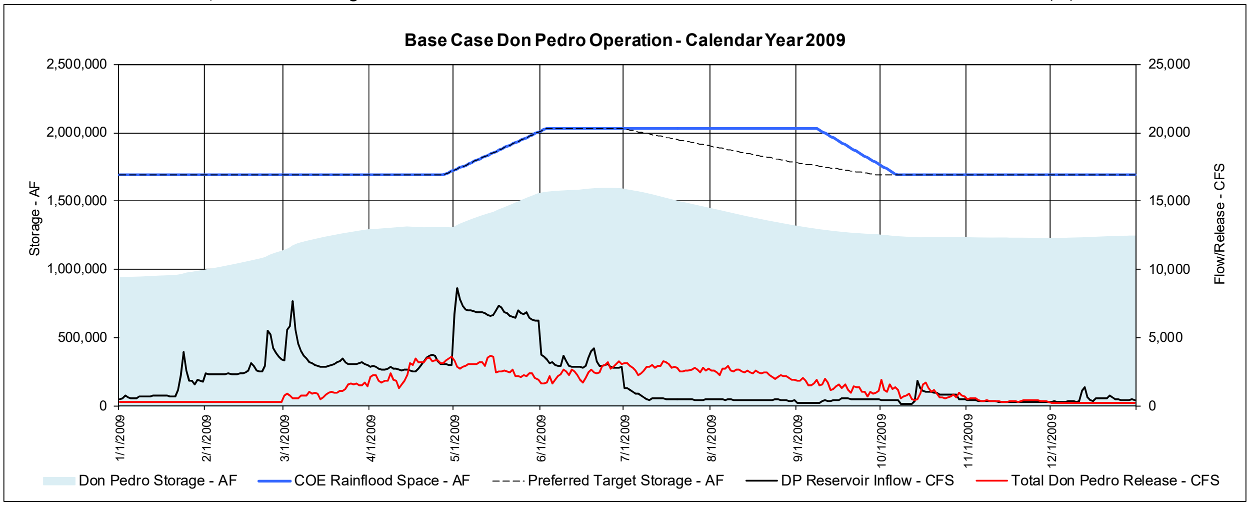


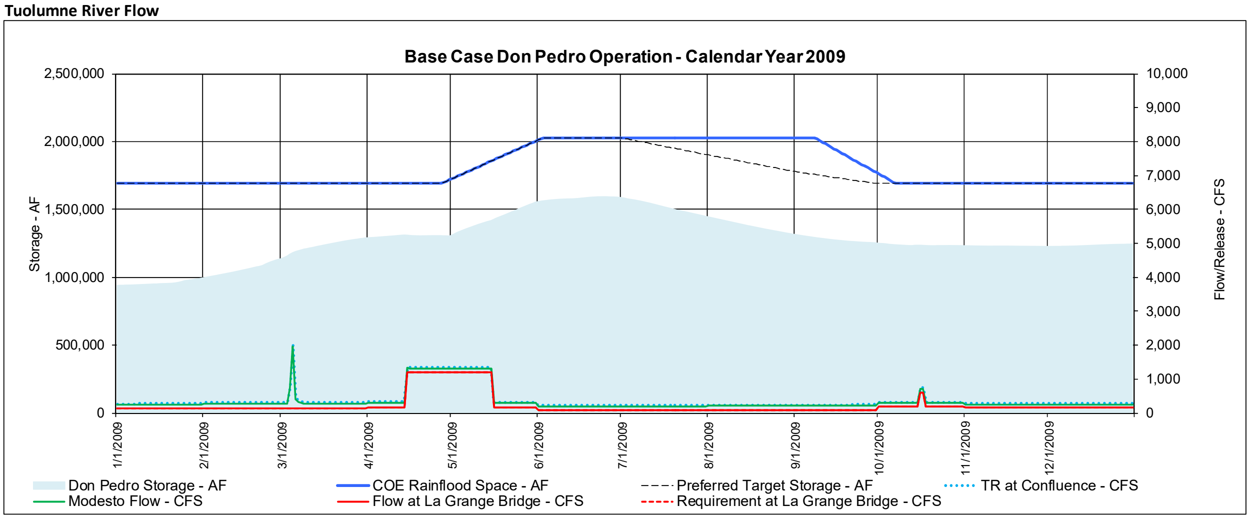
Figure B-38. Base Case conditions – calendar year 2008 (Source: Version 3.00 of the Tuolumne River Operations Model).

Don Pedro Reservoir Inflow, Release and Storage

Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

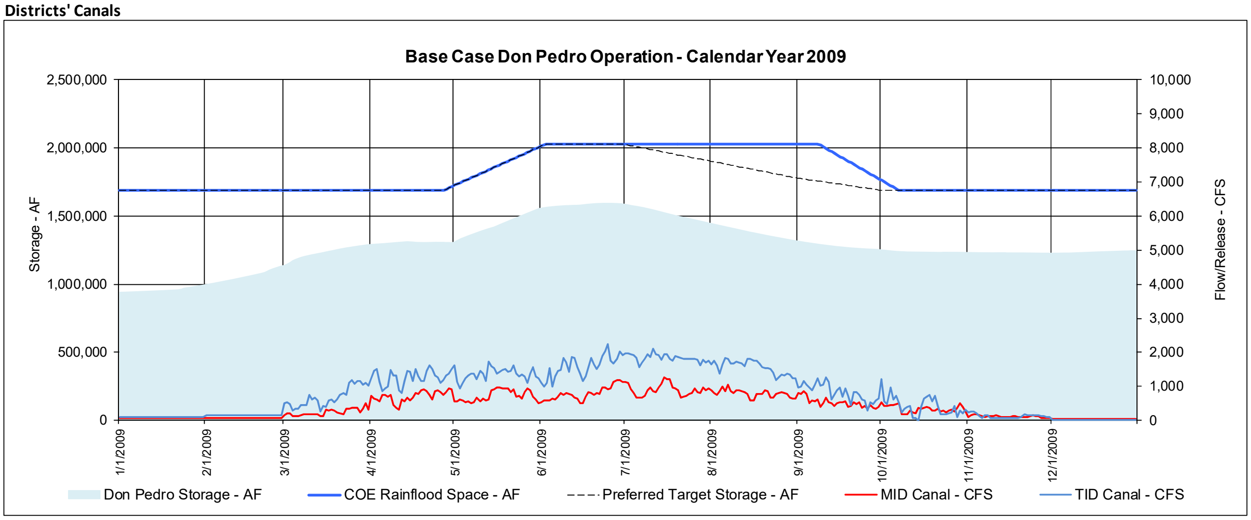
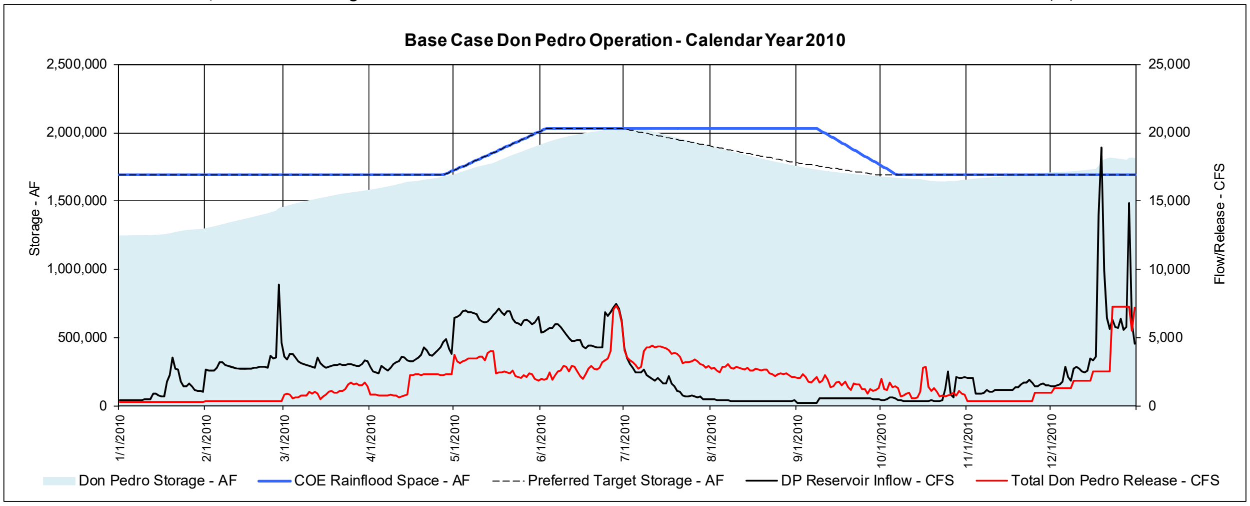
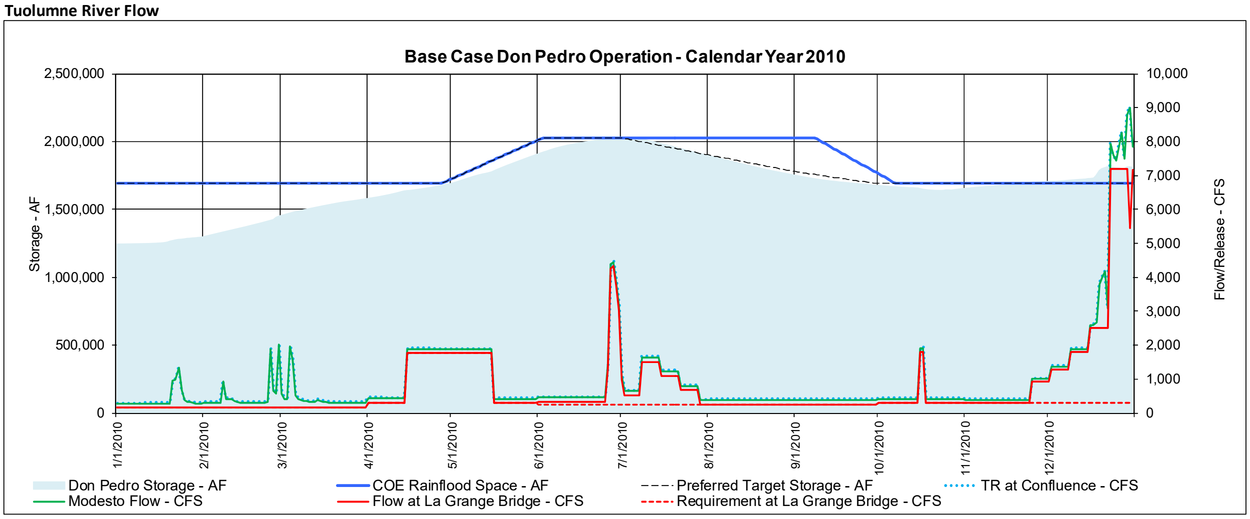


Figure B-39. Base Case conditions – calendar year 2009 (Source: Version 3.00 of the Tuolumne River Operations Model).

Don Pedro Reservoir Inflow, Release and Storage Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

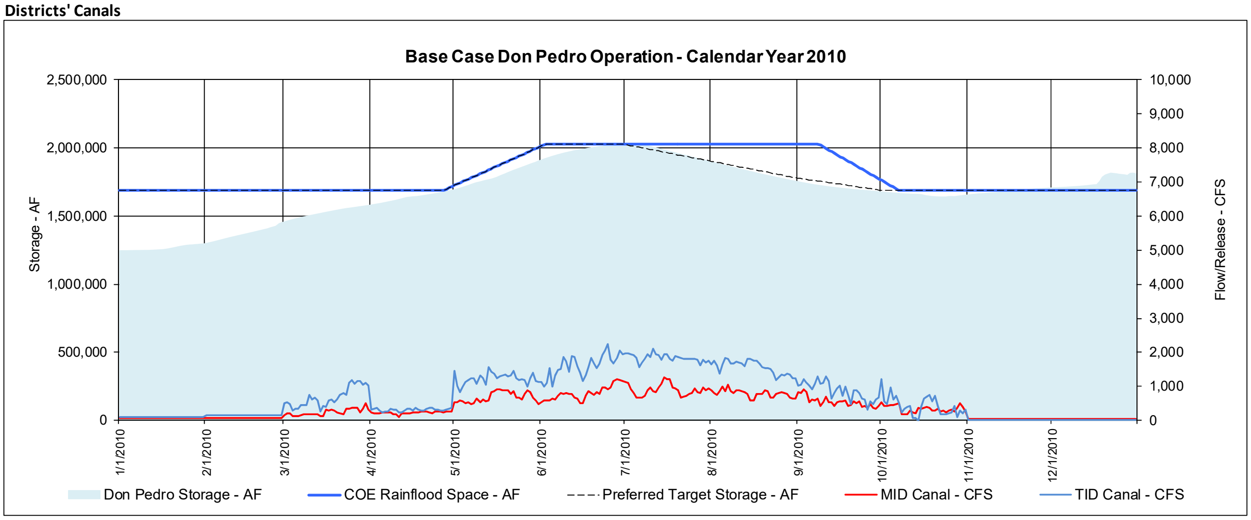
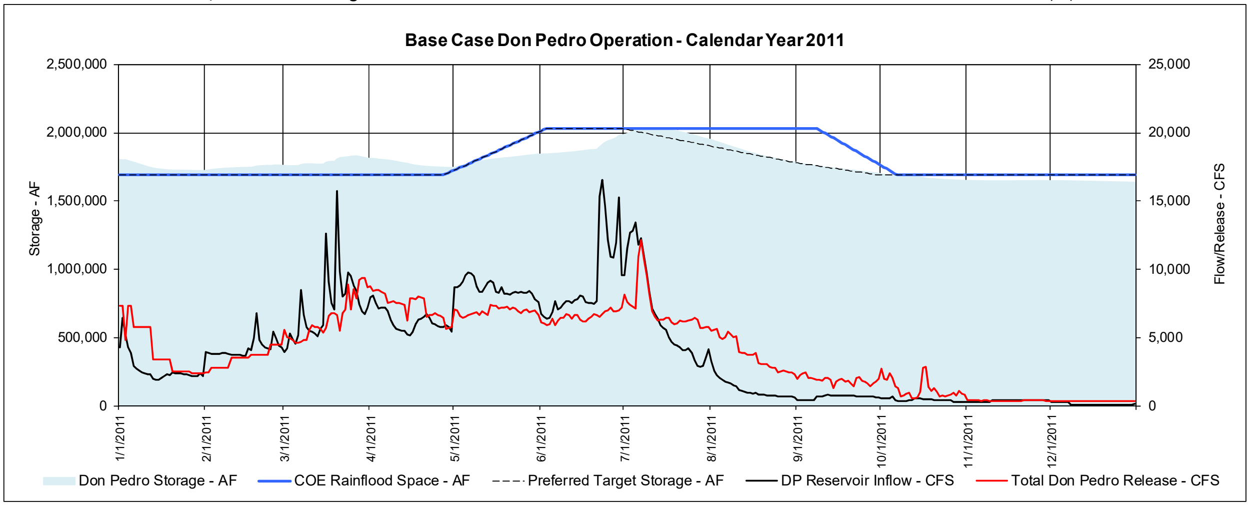


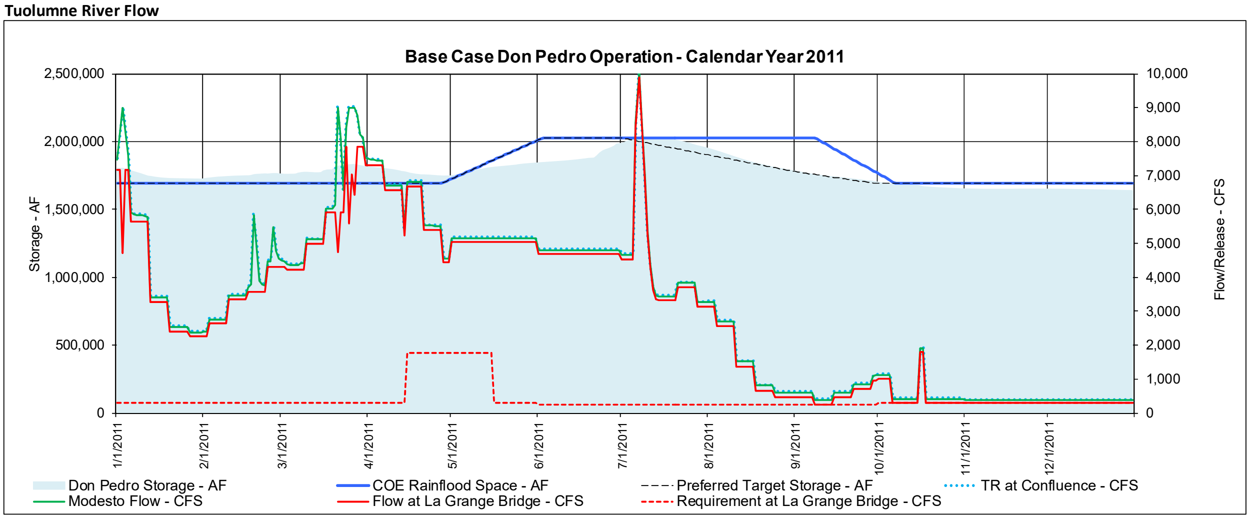
Figure B-40. **Base Case conditions – calendar year 2010 (Source: Version 3.00 of the Tuolumne River Operations Model).**

Don Pedro Reservoir Inflow, Release and Storage

Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

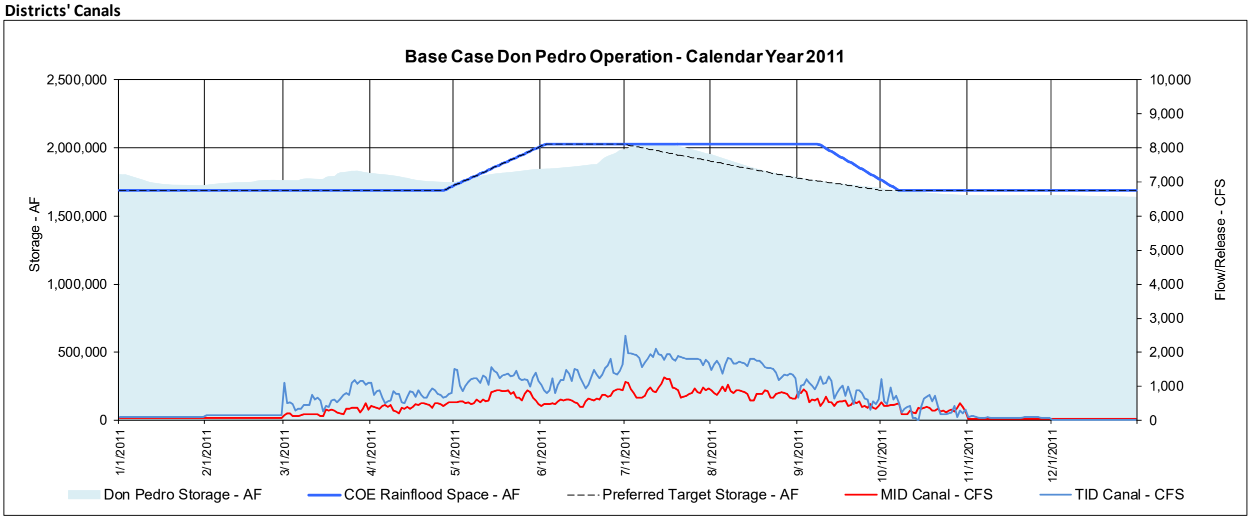
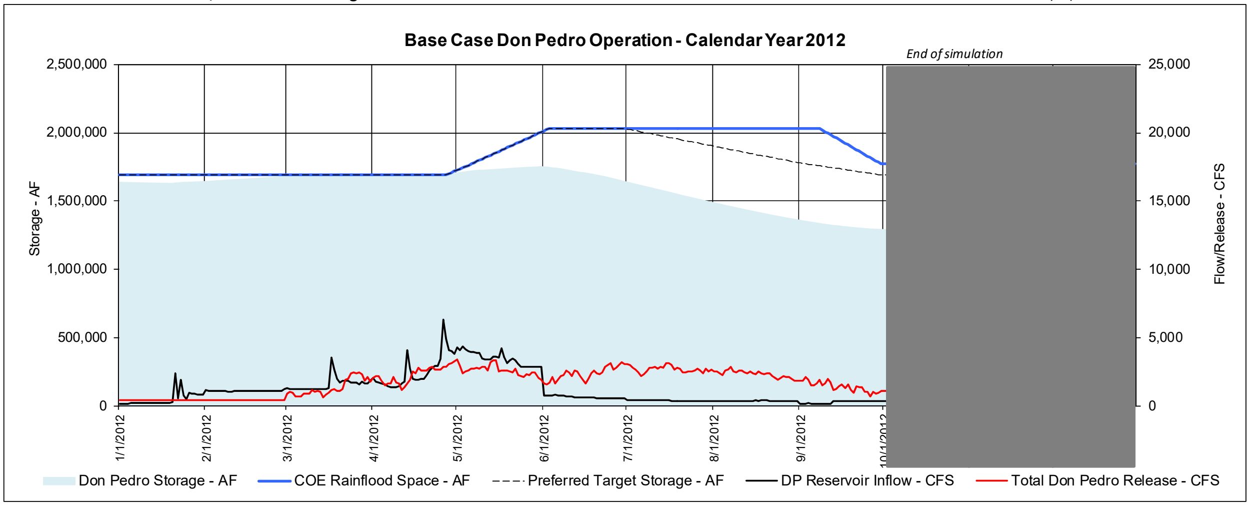


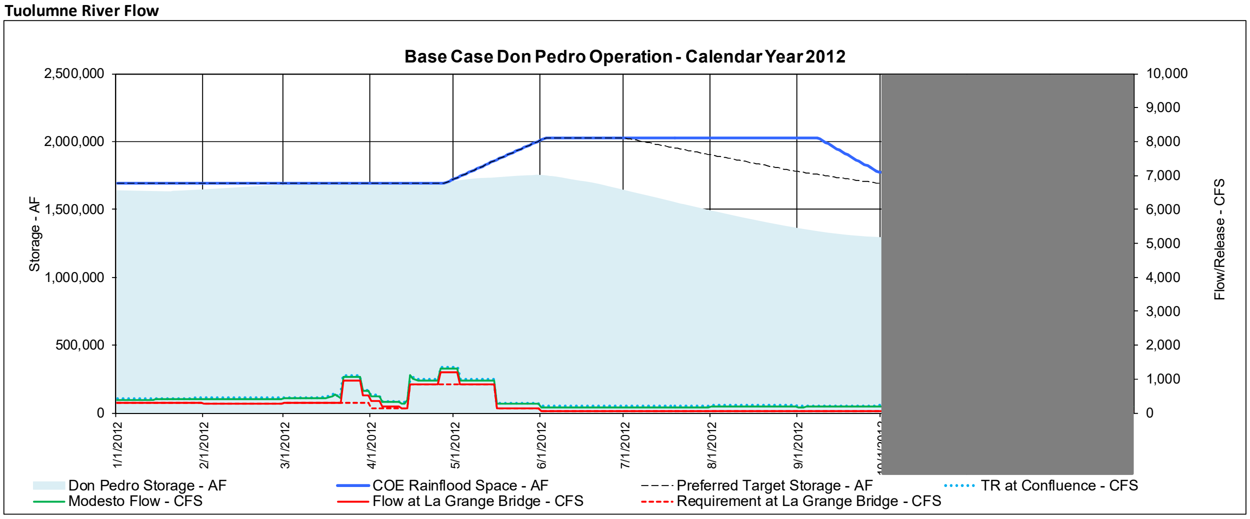
Figure B-41. Base Case conditions – calendar year 2011 (Source: Version 3.00 of the Tuolumne River Operations Model).

Don Pedro Reservoir Inflow, Release and Storage

Tuolumne River Daily Operations Model Version 3.00



Tuolumne River Flow



Districts' Canals

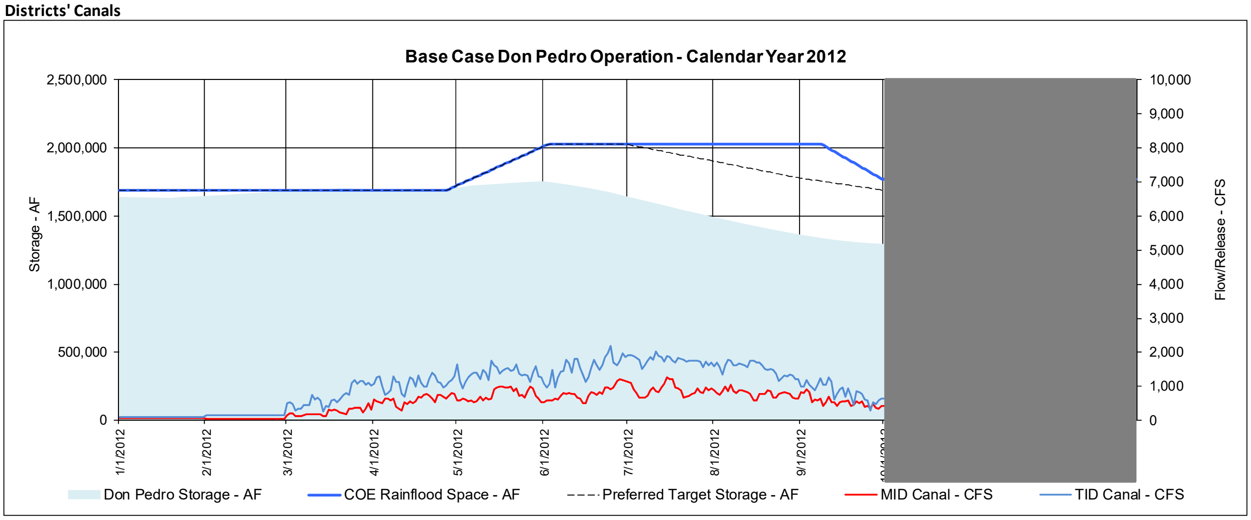


Figure B-42. Base Case conditions – calendar year 2012 (Source: Version 3.00 of the Tuolumne River Operations Model).