



**Sacramento
and
San Joaquin
River Basins**

Comprehensive Study

TECHNICAL STUDIES DOCUMENTATION

APPENDIX C

RESERVOIR OPERATIONS MODELING

Existing Design Operations and Reoperation Analyses



**US Army Corps
of Engineers**
Sacramento District

Expectations of Use

Reservoir Operation Models

Developed Specifically for the Comprehensive Study

Purpose of Models: The Sacramento and San Joaquin River Basins Comprehensive Study models are excellent representations of the existing flood control system and were developed specifically for use in regional, broad concept studies, such as the Comprehensive Study. As developed, they are capable of facilitating the technical needs of other studies; however, their level of detail offers only enough detail for pre-feasibility applications and hence may or may not completely fulfill those needs. In most applications, more detailed models will need to be developed for site-specific applications.

The Hydrologic Engineering Center's HEC-5 software (Simulation of Flood Control and Conservation Systems) used for the models is designed to perform sequential reservoir operation based on specified project demands and constraints. It can simulate any dendritic reservoir system configuration of streams, weirs, bypasses, and storage areas within the dimension limits of the version being used. HEC-5 version 8.0 (May 2000), which includes the executable modifications added in January 2002, was used as the operating platform to conduct the reservoir operation modeling. HEC-5 provides a means both for understanding and representing the flood management systems for the Sacramento and San Joaquin river systems.

Four separate HEC-5 models were developed: two for the Sacramento River system and two for the San Joaquin River system. In each set, one of the models represents the headwater reservoirs and the second represents the lower basin flood control facilities. The HEC-5 models were constructed to allow modeling of flood flow conditions and were used to develop tributary contributions to the mainstems of both the Sacramento and San Joaquin rivers. Output from them was then used for subsequent analyses of floodplain and channel hydraulics using the Sacramento and San Joaquin River Basins Comprehensive Study UNET models.

For more information about the capabilities of the HEC-5 simulation program, refer to the October 1998 User's Manual and the December 2002 Comprehensive Study Reservoir Operation Models User's Guide.

Responsibility of Users:

- 1) Users may provide comments and feedback regarding model construction, coding errors, etc. to the Water Management Section of the Corps of Engineers. The point of contact is:

Mr. Robert Collins, District Hydrologist
U.S. Army Corps of Engineers
Sacramento District
(916) 557-7132

- 2) These complex and intricate models require application by qualified hydrologic/hydraulic engineers and scientists familiar with the HEC-5 simulation program. Professional judgment and expertise should be exercised for all analyses conducted using them. The U.S. Army Corps of Engineers and the California State Department of Water Resources do not provide technical support for these models.

Basic Assumptions and Limitations: The HEC-5 program is used to simulate the sequential operation of a system of reservoirs for short-interval historical or synthetic floods, for long duration non-flood periods, or combinations of the two. The models developed for the Comprehensive Study analysis were created with the following assumptions and limitations:

- They were created for use only with the synthetic 30-day hourly hydrographs developed specifically for the Comprehensive Study. To simulate other time steps or series, adjustments may need to be made.
- FEMA requires the starting storage of any headwater reservoir be established as that reservoir's gross pool; however, the Comprehensive Study simulations establish starting storages of the headwater reservoirs as an average of their storages during the '97, '95, and '86 storm events. If the average storage was greater than gross pool, then gross pool was used as the starting storage. Starting storage of the lower basin flood control reservoirs is the top of conservation.
- Top of conservation of lower basin reservoirs assumes a maximum basin wetness to assure the maximum available flood space.
- Guidelines established within each reservoir's water control manual were strictly observed.
- Some reservoirs with stepped release schedules rely on both the percentage of required flood control space used and peak inflow in determining flood releases. For these reservoirs, fixed percentages of required flood control space used were assumed.
- Muskingum routing parameters are fixed for all simulated exceedence frequencies.
- Local flows were either produced through procedures outlined in *Appendix B Synthetic Hydrology Technical Documentation* or assumed to be a ratio of the short duration maxima of a nearby natural flow hydrograph. These ratios are not scaled for each simulated exceedence frequency.
- Calibration and verification were accomplished using the '95 and '97 flood events and by comparing these to manual routings published in water control manuals.

- There are no losses simulated within the model: no evaporation, no groundwater infiltration or seepage, and no levee breaks. The models assume an infinite channel capacity.
- There was difficulty in concisely integrating some of the operating criteria of specific reservoirs. The multi-parameter “Release Schedules” of Black Butte and Oroville had to be written into the model by assuming one of the variable parameters to be constant. Similar difficulties required that an operational point for Black Butte Dam (Ord Ferry) be excluded from the simulations. Complications in utilizing the forecast capabilities of HEC-5 required that one of the operating points of Friant Dam be located outside of the program’s forecast window.
- The simulation program assumes near certainty in flow contributions from downstream tributaries when operating facilities for flows at that location or downstream of that location.

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RESERVOIR OPERATIONS MODELING
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CHAPTER I

INTRODUCTION

AUTHORITY

In response to extensive flooding and damages experienced in 1997, the United States Congress authorized the U.S. Army Corps of Engineers, Sacramento District (USACE) to provide a comprehensive analysis of the Sacramento and San Joaquin river basin flood management systems and to partner with the State of California to develop master plans for flood damage reduction. The USACE and the State Reclamation Board of California are leading this Comprehensive Study to improve flood management and integrate ecosystem restoration in the Sacramento and San Joaquin river basins.

The authorization for the Comprehensive Study directed the development of hydrologic and hydraulic models for both river basins that will allow systematic evaluation. These models incorporate reservoir operations and flow along the major river systems to evaluate the performance of the flood management systems. The models can be used to assess the performance of the current systems or modified systems under a wide range of hydrologic conditions.

PURPOSE OF DOCUMENTATION

This report documents the work conducted for the Sacramento and San Joaquin River Basins Comprehensive Study to develop reservoir operation models, specifically Phase II – Model Refinement and Simulation of both existing operational conditions and evaluation of flood management alternatives. The main product components of this effort include: HEC-5 Reservoir Operation Models for the Sacramento and San Joaquin River basins, which will include headwater and major flood management reservoirs.

The first part of this document is limited to the use of reservoir models to identify and describe baseline conditions. It does not include the formulation or evaluation of flood management alternatives. The performance of modified flood management strategies is addressed within subsequent sections of this document. Future work will continue to use these models in the analysis of alternatives for reducing flood damages in California's Central Valley.

STUDY AREA

The study area encompasses the watersheds of the two major river systems of California's Central Valley, the Sacramento River in the north and the San Joaquin River in the south. These river systems comprise a combined drainage area of over 43,000 square miles, an area nearly as large as the state of Florida.

Note: Prior to use and application, reference the "Expectations of Use" preface.

Due to its climate and geography, flooding is a frequent and natural event in the Central Valley. Historically, the Sacramento River Basin has been subject to floods that result from winter and spring rainfall as well as rainfall combined with snowmelt. The San Joaquin River Basin has been subject to floods that result from both rainfall that occurs during the late fall and winter months, and melting of the winter snowpack during the spring and early summer months.

Note: Prior to use and application, reference the "Expectations of Use" preface.

CHAPTER II

RESERVOIR MODELING BACKGROUND

GENERAL

The technical process for the hydrologic and hydraulic investigations of the Sacramento and San Joaquin River Basins Comprehensive Study is comprised of three interrelated parts: 1) Development of Synthetic Hydrology (Appendix B); 2) Reservoir Operations Modeling (Appendix C); and 3) Hydraulic Modeling of Floodplain Areas (Appendix D), as shown in Figure II-1. This report documents Phase II reservoir modeling efforts and presents the results of system-wide reservoir simulations and evaluation of proposed flood management operation alternatives.

Phase I modeling began in 1998, immediately after the Comprehensive Study was authorized. The reservoir simulation model selected for use was *HEC-5: Simulation of Flood Control and Conservation Systems*. HEC-5, a computer program first developed and distributed in 1973, was designed by the Hydrologic Engineering Center (HEC) to offer guidance in real-time reservoir release decisions and to aid in planning studies for proposed reservoirs, operation alternatives, and flood space allocation (HEC-5 Users Manual Version 8.0, 1998).

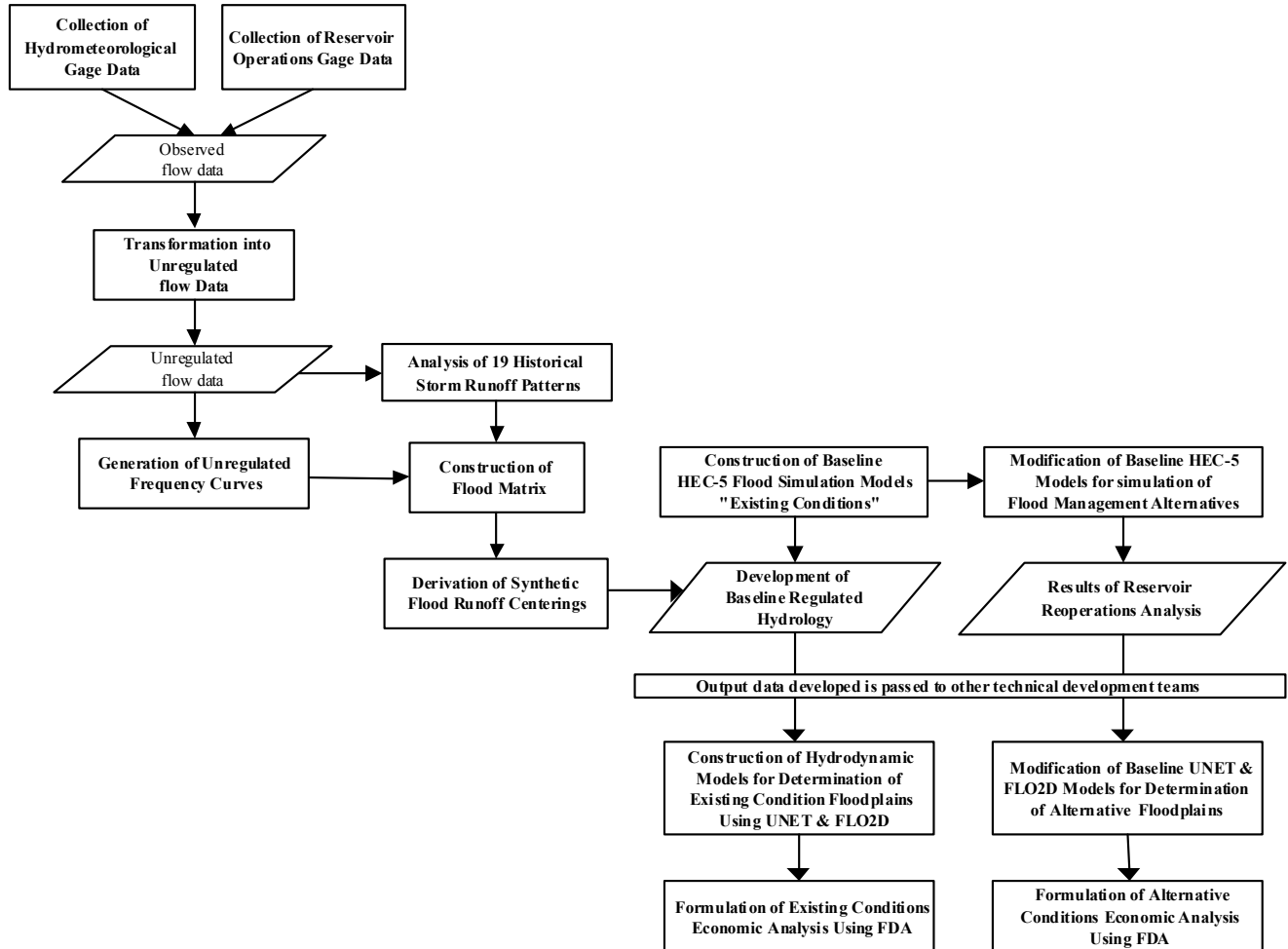
An HEC-5 model is constructed using operational criteria input by the modeler. The program is designed to accept criteria related to flood operations, hydropower generation, river routings, diversions, and low-flow operations. Simulations can be performed using any time step. HEC-5 is the U.S. Army Corps of Engineers' (USACE) standard tool in reservoir analyses.

In support of the Water Management Section of the Sacramento District, USACE, HEC undertook Phase I development of HEC-5 models for flood damage reduction reservoirs within the Central Valley. At the conclusion of Phase I, HEC provided the Water Management Section with a report documenting the development of working models for the Sacramento Basin, which then included five flood damage reduction reservoirs, and for the San Joaquin Basin, which then included thirteen flood damage reduction reservoirs (Reservoir System Analysis, 1999).

Phase II reservoir modeling began in July 1999 and was performed by the Water Management Section. Efforts focused on refining and expanding the working models provided by HEC into calibrated models capable of performing reservoir simulations for the entire watershed. Fundamental changes to the Phase I models included the addition of spillway gate operations; detailed modeling of local flows; a philosophical shift from modeling verification using past events, to verification using established operational criteria found in each reservoir's Water Control Manual; and an overall expansion of the models from the original 18 reservoirs to a final tally of 73.

Note: Prior to use and application, reference the "Expectations of Use" preface.

FIGURE II-1 HYDROLOGY AND MODELING DEVELOPMENT PROCESS SCHEMATIC



Note: Prior to use and application, reference the "Expectations of Use" preface.

In support of the Comprehensive Study, Water Management performed reservoir simulations for the 50-, 10-, 4-, 2-, 1-, 0.5-, and 0.2-percent chance exceedence flood events. The seven synthetic exceedence frequency inflows to the reservoirs were computed in the Synthetic Hydrology Analysis (Appendix B – Synthetic Hydrology). Results from the HEC-5 simulations have been used in the hydraulic modeling and delineation of composite floodplain areas for each basin (Appendix D - Hydraulics). Results of the floodplain analyses have been fed into the stage-frequency relationships that drive the model estimating economic damages incurred during each of the seven synthetic exceedence flood runoff events. This entire process, from hydrology to economics, defines the “without-project conditions” needed for Comprehensive Study plan formulation.

Preparation of the reservoir models was undertaken with two goals in mind. The first goal was to accurately depict without-project conditions, thereby providing a solid frame of reference for analyses of potential improvements to the current flood damage reduction system. The second goal was to assure that the models used to define the baseline have the ability to analyze alternatives efficiently. In other words, the reservoir models were to be developed to have value beyond the definition of baseline conditions.

SACRAMENTO AND SAN JOAQUIN RIVER BASIN RESERVOIRS

All reservoirs with gross pool storage greater than 10,000 acre-feet located in the Sacramento River Basin are shown in Plate 1. All reservoirs with gross storage greater than 10,000 acre-feet in the San Joaquin River Basin are shown in Plate 2. A tabular listing of all reservoirs in the Sacramento and San Joaquin River Basin is shown in Table II-1 (note: Identification numbers for each reservoir shown in Plates corresponds to identification numbers listed in tables for each reservoir).

Note: Prior to use and application, reference the “Expectations of Use” preface.

TABLE II-1
INVENTORY OF RESERVOIRS IN THE SACRAMENTO AND SAN JOAQUIN
RIVER BASINS

#	Reservoir	Drainage	Owner	Gross Pool Storage (ac-ft)	DA ¹ (mi ²)	DOB ²	Purpose
1	Antelope	Indian Creek	DWR	22,566	71	1946	Water Supply
2	Beardsley	Mfk Stanislaus River	Oakdale So San Joaquin ID	77,600	308.5	1957	Hydropower
3	Big Dry Creek	Big Dry Crk & Dog Crk	Fresno Metropolitan Fc Dist	30,200	82	1948	
4	Big Sage Reservoir	Rattlesnake Crk	Hot Spring Valley Irrigation Dist.	77,000	107	1921	
5	Black Butte	Stony Creek	USACE	143,700	741	1963	Flood Management
6	Bowman	Canyon Creek	Nevada Irrigation District	64,000	28.91	1927	Water Supply, Hydropower
7	Box Canyon	Sacramento River	Siskiyou County FCWCD	26,000	126	1969	Water Supply
8	Buchanan	Chowchilla River	USACE	150,000	235	1975	Flood Management
9	Bucks Storage	Bucks Creek	Pac Gas And Electric Co	103,000	29.5	1928	
10	Buena Vista	Offstream	J Boswell Co & Tenneco West	205,000	373	1890	
11	Burns	Burns Creek	USACE	6,800	74	1950	
12	Butt Valley	Butt Creek	Pac Gas And Electric Co	49,800	86.2	1924	
13	Camanche	Mokelumne River	East Bay Municipal District	417,124	619	1963	Flood Management
14	Camp Far West	Bear River	South Sutter Water Dist	103,000	285	1963	
15	Caples Lake	Tr Silver Fork	Pac Gas And Electric Co	21,581	13	1922	
16	Cherry Valley	Cherry Creek	City County San Francisco	273,500	114	1956	Water Supply, Hydropower
17	Clear Lake Imp	Cache Creek	Yolo County FCWC District	315,000	514	1914	
18	Courtright	Helms Creek	Pac Gas And Electric Co	123,300	39.2	1958	Water Supply, Hydropower
19	Crane Val Stor/Bass Lake	Nfk San Joaquin River	Pac Gas And Electric Co	45,410	51.4	1910	Water Supply, Hydropower
20	Don Pedro	Tuolumne River	Turlock Irrigation District	2,030,000	1542	1971	Flood Management
21	Donnells	Mfk Stanislaus River	Oakdale So San Joaquin ID	56,893	229	1958	Hydropower
22	East Park	Little Stony Creek	US Bureau Of Reclamation	51,000	102	1910	Water Supply
23	Englebright	Yuba River	USACE	70,000	1100	1941	
24	Farmington	Littlejohn Creek	USACE	52,000	212	1951	Flood Management
25	Florence Lake	Sfk San Joaquin River	Southern California Edison Co	64,406	171	1926	Water Supply, Hydropower
26	Folsom	American River	US Bureau Of Reclamation	1,010,000	1885	1956	Flood Management
27	French Lake	Canyon Creek	Nevada Irrigation District	12,500	5.3	1859	
28	Frenchman	Last Chance Creek	DWR	55,477	82	1961	Water Supply
29	Friant	San Joaquin River	US Bureau Of Reclamation	520,500	1675	1942	Flood Management
30	Grizzly Valley/Lake Davis	Big Grizzly Creek	DWR	83,000	44	1966	Water Supply
31	Hidden	Fresno River	USACE	90,000	234	1975	Flood Management
32	Homestake Tails	Tr Hunting Crk	Homestake Mining Company	20,160	1.56	1990	
33	Huntington Lake 1	Big Creek	Southern California Edison Co	88,834	80.4	1917	Water Supply, Hydropower
34	Ice House	Sfk Silver Creek	Sacramento Muni Utility Dist	37,120	28.4	1959	Water Supply, Hydropower
35	Indian Ole (Mtn Meadows)	Hamilton Creek	Pac Gas And Electric Co	24,800	158	1924	

Notes:

1. Drainage area (DA) in square miles
2. Completion date of dam and beginning of operation (DOB)

Note: Prior to use and application, reference the "Expectations of Use" preface.

TABLE II-1
INVENTORY OF RESERVOIRS IN THE SACRAMENTO AND SAN JOAQUIN RIVER BASINS

#	Reservoir	Drainage	Owner	Gross Pool Storage (ac-ft)	DA ¹ (mi ²)	DOB ²	Purpose
36	Indian Valley	Nfk Cache Creek	Yolo County FCWC District	300,000	122	1976	Flood Management
37	Iron Canyon Reservoir	Iron Canyon Creek	Pac Gas And Electric Co	24,300	11.2	1965	
38	Isabella	Kern River	USACE	568,000	2074	1953	Flood Management
39	Jackson Creek	Jackson Creek	Jackson Valley Irrigation Dist	22,000	58	1965	
40	Jackson Meadows	Mfk Yuba River	Nevada Irrigation District	52,500	37.11	1965	Surcharge Storage
41	Jamestown Mines T	Tr Woods Creek	Sonora Mining Corporation	12,100	0.37	1991	
42	Keswick	Sacramento River	US Bureau Of Reclamation	23,772	1950	1950	
43	Lake Almanor	Nfk Feather Creek	Pac Gas And Electric Co	1,308,000	503	1959	
44	Lake Eleanor	Eleanor Creek	City County San Francisco	27,800	79	1918	Water Supply, Hydropower
45	Lake Fordyce	Fordyce Creek	Pac Gas And Electric Co	48,900	30.15	1926	Water Supply, Hydropower
46	Lake Kaweah/Terminus	Kaweah River	USACE	143,000	561	1962	Flood Management
47	Lake Spaulding	Sfk Jackson Creek	Pac Gas And Electric Co	74,773	118	1901	Water Supply, Hydropower
48	Little Grass Valley	Sfk Feather River	Oroville Wyandotte ID	93,010	27.3	1961	Water Supply
49	Ll Anderson/French Meadows	Mfk American River	Placer County Water Agency	136,405	47.2	1965	Water Supply, Hydropower
50	Loon Lake	Gerle Creek	Sacramento Muni Utility Dist	76,500	8.1	1963	Water Supply, Hydropower
51	Los Banos Detention	Los Banos Creek	US Bureau Of Reclamation	34,600	160	1965	Flood Management
52	Lower Bear River	Bear River	Pac Gas And Electric Co	52,025	37	1952	
53	Lower Hell Hole	Rubicon River	Placer County Water Agency	208,400	114	1966	Water Supply, Hydropower
54	Main Strawberry	Sk Stanislaus River	Pac Gas And Electric Co	16,590	26.6	1916	
55	Mammoth Pool	San Joaquin River	Southern California Edison Co	123,000	998	1960	Water Supply, Hydropower
56	Mariposa	Mariposa Creek	USACE	15,000	107	1948	
57	Mark Edson/Stumpy Meadows	Pilot Creek	Georgetown Divide Pud	20,000	15.6	1962	
58	McCloud	McCloud River	Pac Gas And Electric Co	35,300	380	1965	
59	Modesto Res	Tr Tuolumne River	Modesto Irrigation Dist	29,000	10	1911	
60	Monticello	Putah Creek	US Bureau Of Reclamation	1,602,000	576	1957	
61	New Bullards Bar	No. Yuba River	Yuba County Water Agency	969,600	481	1970	Flood Management
62	New Exchequer	Merced River	Merced Irrigation District	1,032,000	1041	1967	Flood Management
63	New Hogan	Calaveras River	USACE	317,000	363	1963	Flood Management
64	New Melones	Stanislaus River	US Bureau Of Reclamation	2,400,000	900	1979	Flood Management
65	New Spicer Meadow	Highland Creek	Calaveras Co Water District	189,000	46.63	1989	Hydropower
66	North Fork	Nfk Amerien River	USACE	14,700	343	1939	
67	H. Hetchy /O Shaughnessy	Tuolumne Creek	City County San Francisco	360,000	459	1923	Water Supply, Hydropower
68	O'Neill	San Luis Creek	US Bureau Of Reclamation	56,400	18	1967	
69	Oroville	Feather River	DWR	3,537,577	3607	1968	Flood Management
70	Paradise	Little Butte Creek	Paradise Irrigation Dist	11,500	8.66	1957	

Notes:

1. Drainage area (DA) in square miles
2. Completion date of dam and beginning of operation (DOB)

Note: Prior to use and application, reference the "Expectations of Use" preface.

TABLE II-1
INVENTORY OF RESERVOIRS IN THE SACRAMENTO AND SAN JOAQUIN
RIVER BASINS

#	Reservoir	Drainage	Owner	Gross Pool Storage (ac-ft)	DA ¹ (mi ²)	DOB ²	Purpose
71	Pardee	Mokelumne River	East Bay Municipal District	210,000	575	1929	Flood Management
72	Pine Flat	Kings River	USACE	1,000,000	1545	1954	Flood Management
73	Pit No 3 (Lake Britton)	Pit River	Pac Gas And Electric Co	34,600	4700	1925	Water Supply, Hydropower
74	Pit No 6	Pit River	Pac Gas And Electric Co	15,700	5020	1965	Water Supply, Hydropower
75	Pit No 7	Pit River	Pac Gas And Electric Co	34,000	5170	1965	Water Supply, Hydropower
76	Red Rock No 1	Red Rock Creek	John Jay Casey	10,000	43.3	1893	
77	Redinger	San Joaquin River	Southern California Edison Co	35,000	1392	1951	Water Supply, Hydropower
78	Relief	Summit Creek	Pac Gas And Electric Co	15,122	24.51	1910	
79	Rollins	Bear River	Nevada Irrigation District	66,000	104	1965	
80	Salt Springs	Nfk Mokelumne River	Pac Gas And Electric Co	141,900	169	1931	
81	Salt Springs Valley	Rock Creek	Rock Creek Water District	10,900	20.03	1882	
83	San Luis	San Luis Creek	US Bureau Of Reclamation	2,041,000	84.6	1967	
84	Scotts Flat	Deer Creek	Nevada Irrigation District	49,000	20	1948	Water Supply, Hydropower
85	Shasta	Sacramento River	US Bureau Of Reclamation	4,552,000	6665	1945	Flood Management
86	Shaver Lake	Stevenson Creek	Southern California Edison Co	135,283	29.3	1927	Water Supply, Hydropower
87	Slab Creek	Sfk American River	Sacramento Muni Utility Dist	16,600	497	1967	Water Supply, Hydropower
88	Sly Creek	Lost Creek	Oroville Wyandottie ID	65,050	23.9	1924	Water Supply, Hydropower
89	Sly Park	Sly Park Creek	US Bureau Of Reclamation	41,000	47	1955	
90	Stony Gorge	Stoney Creek	US Bureau Of Reclamation	50,350	735	1928	Water Supply
91	Success	Tule River	USACE	82,300	393	1961	Flood Management
92	Thermalito Ab	Tr Feather River	DWR	57,041	13.3	1967	
93	Thermalito Div	Feather River	DWR	13,328	3640	1967	
94	Thermalito Fb	Tr Cottonwood Creek	DWR	11,768	3.6	1967	
95	Thomas Edison/Vermilion Valley	Mono Creek	Southern California Edison Co	125,000	90.9	1954	Water Supply, Hydropower
96	Tule Lake	Cedar Creek	Lyneta Ranches	39,500	82	1904	
97	Tulloch	Stanislaus River	Oakdale So San Joaquin ID	68,400	971	1958	Hydropower, Flood Management
98	Turlock Lake	Tr Tuolumne River	Turlock Irrigation District	45,600	10.4	1915	
99	Union Valley	Silver Creek	Sacramento Muni Utility Dist	230,000	84	1963	Water Supply, Hydropower
100	Virginia Ranch	Dry Creek	Browns Valley Irrigation Dist	57,000	72.3	1963	
101	West Valley Reservoir	West Valley Creek	S Fork Irrigation District	23,000	134.8	1936	
102	Whiskeytown	Clear Creek	US Bureau Of Reclamation	241,100	201	1963	
103	Wishon	Nfk Kings River	Pac Gas And Electric Co	118,000	177	1958	Water Supply, Hydropower
104	Woodward	Simmons Creek	South San Joaquin ID	18,441	12	1918	Water Supply, Hydropower

Notes:

1. Drainage area (DA) in square miles
2. Completion date of dam and beginning of operation (DOB)

Note: Prior to use and application, reference the "Expectations of Use" preface.

TERMINOLOGY AND BACKGROUND

“Flood damage reduction” is an important water resource function performed by the USACE. The goal of flood damage reduction is to minimize detrimental impacts caused by flows in excess of conveyance capacities of existing drainage systems. This can be accomplished through a variety of structural (i.e., reservoirs and levees) and non-structural measures (i.e., floodplain management policies, early warning systems, and wetland attenuation areas).

The USACE used to refer to flood damage reduction as “flood control.” This term was discarded, because extreme floods tend to surpass the design capabilities of management systems and are therefore uncontrollable. Essentially a misnomer, flood control misrepresented the true nature of floods and of the management systems established to cope with flood impacts.

Reservoirs are a key tool in reducing flood damages. The Flood Control Act of 1944 authorized the USACE to prescribe regulations for the use of reservoir storage dedicated to flood damage reduction for all facilities constructed wholly or in part with federal funds (Public Law 534, December 22, 1944, 78th Congress, 2d Session). In the Central Valley, most reservoirs with flood storage space are classified as “Section 7” projects. These are reservoirs owned and operated by agencies other than the USACE. In accordance with the Flood Control Act, the USACE has established operational criteria for the flood space in these projects and is responsible for providing guidance to the reservoir owners and operators regarding proper operational decisions (i.e., flood flow releases) when reservoir storage encroaches space allocated for flood storage. Owners are legally obligated to follow the USACE guidelines. In not doing so, they would incur liability for any resulting damages.

The amount of reservoir space dedicated to flood damage reduction is established in coordination with local concerns (i.e., municipalities, water associations, and irrigation districts). These agencies weigh recreation, environmental, and water supply issues with flood risk, potential damages, and levels of protection. The USACE can recommend options, but the locals make the final decision.

The “level of protection” for a reservoir is defined as the most severe flood inflow that the project can store and pass without violating downstream operation constraints. Each flood damage reduction project has a unique level of protection that is tied to basin-specific operation criteria (i.e., channel capacity below the dam and amount of flood space), flood inflows, flows from downstream tributaries (often referred to as local flows), and regulating effects of upstream reservoirs.

The level of protection (as a function of inflow) is related to the hydrologic record used to characterize the flood frequencies of that basin. Therefore, with each passing year, more information becomes available regarding basin flood dynamics, and the level of protection is continuously redefined. Most years do not significantly affect the level, but large flood years (i.e., 1997) can be very influential, as they provide the most information regarding extreme floods.

The amount of flood space chosen establishes an operational zone within the reservoir. A simplified water control diagram is shown in Plate 3. Flood space is always the top zone, it is kept vacant at all possible times to provide consistent protection for downstream areas and includes all storage available above the “top of conservation.” The bottom of the flood pool is typically referred to as the top of conservation. Below this level, the reservoir is in the

Note: Prior to use and application, reference the “Expectations of Use” preface.

conservation pool and the reservoir owners and operators determine releases based on storage constraints, release capabilities, and downstream uses including municipal, environmental, hydropower, and agriculture demands. At pool elevations above the top of conservation, the flood space is encroached and the USACE has authority to recommend flood releases. Flood space will continue to fill until outflow from the reservoir exceeds inflow. If all flood space becomes filled, the reservoir reaches “gross pool” and subsequently becomes surcharged. Gross pool usually coincides with the crest of a spillway or the point at which the reservoir must begin to release water in excess of downstream operational limits.

In some cases, part of the required flood space may be offset by available storage at upstream reservoirs. These headwater facilities do not have specific flood damage reduction functions, but still capture a portion of the natural flood flows of the basin. In this sense, the space available upstream acts as flood space and the top of conservation at the downstream flood damage reduction reservoir can be increased (decreasing the flood space) proportionally. These scenarios can provide water supply benefits without lowering the level of protection for downstream areas and are typically referred to as “credit space” agreements.

CHAPTER III

BASELINE HEC-5 METHODOLOGY

GENERAL

Reservoirs were selected for inclusion in the study based on two criteria: 1) their existing flood damage reduction functions; or 2) they maintain an active storage greater than 10,000 acre-feet and regulate a significant natural drainage area. All reservoirs over 10,000 acre-feet are shown for the Sacramento and San Joaquin river basins in Plates 1 and 2, respectively. The majority of facilities modeled do not have formal flood damage reduction responsibilities, but still alter the form and timing of flood hydrographs. The influence of non-flood damage reduction reservoirs is significant and cannot be ignored in a holistic watershed study.

Simulation models were developed for both the Sacramento and San Joaquin river basins. Due to the number of facilities and control points, these models were further split into headwater models and lower basin models leading to a total of 4 separate HEC-5 models: 1) Sacramento headwaters; 2) Sacramento lower basin; 3) San Joaquin headwaters; and 4) San Joaquin lower basin. The headwater model for each basin generally contains reservoirs located upstream of flood damage reduction projects. Lower basin models contain those flood projects as well as a few water supply, recreation, and hydropower facilities.

HEC-5 routes flows through reservoirs based on operational criteria provided by the modeler. Although HEC-5 is capable of performing period of record simulations, criteria currently focus on operations for flood damage reduction reservoirs that are encroached and general winter operations for water supply and hydropower reservoirs.

All models perform hourly flood simulations using the 30-day hourly hydrographs, detailed within Appendix B – Synthetic Hydrology, as source data for all seven reservoir inflow synthetic exceedence frequencies. The synthetic hydrology investigated flood frequencies at mainstem and tributary locations. Storm centerings were then formulated and analyzed. For each centering, synthetic natural flow hydrographs were computed at locations throughout the Central Valley as tabulated in Attachment B.4 – Synthetic Flood Centerings. Typically, each tributary basin contained one hydrograph location. Many of these sites were inflow points to major flood management projects (i.e., Feather River at Oroville Dam). These natural flow hydrographs represent flood time series produced by a wholly unimpaired drainage area; hydrographs do not reflect the influence of headwater reservoirs.

A 3-step process was required to analyze each storm centering as shown in Plate 6. To begin the sequence, the headwaters models were simulated. Then, using the resulting storage time series for select headwater facilities, top of conservation storage for those flood damage reduction projects with established credit space agreements were computed. Next, using the results of the headwater simulations and the computed top of conservation series, the lower basin models were simulated, thereby completing the procedure.

Full basin simulations were run for each centering regardless of storm location or intensity.

Note: Prior to use and application, reference the "Expectations of Use" preface.

HEADWATER RESERVOIRS

Headwater reservoirs are typically located in the watersheds above flood damage reduction projects. Primarily used for water supply and hydropower generation, these facilities do not have any type of formalized flood operations. A total of 44 headwater reservoirs (27 in the Sacramento and 17 in the San Joaquin) were modeled. Selected headwater reservoirs are shown in Table III-1.

Operational Criteria

Headwater reservoirs do not have published criteria to guide modelers. In this study, criteria were developed through conference calls with facility owners and operators as shown in Table III-1, and analysis of gage data collected and processed by the Water Management Section in Phase I and II of the Comprehensive Study. Whenever possible, operations discussed during the phone interviews were confirmed with gage data. When discrepancies were discovered, follow-up calls were made to clarify historic operations, and final criteria were established in accordance with both the expert commentary and historic records.

Operations were generally less complex than those required to model flood damage reduction projects. Most focused on some type of constant release philosophy. Water supply reservoirs often released only the minimum flows required to satisfy instream requirements for fish and wildlife. These reservoirs are referred to as “fill and spill,” because pools are operated to capture as much water as possible, usually filling up to and above spillway crest during a strong rainfall event. Hydropower facilities typically began to release flows to generate maximum power whenever a spill was imminent. To these facilities, any flow over the spillway represents lost revenue because it has not been routed through power generation penstocks.

Physical Characteristics

Elevation-capacity tables, outlet and spillway ratings, and facility schematics were obtained from the California State Division of Safety of Dams (DSOD). When data were not available at DSOD, reservoir owners were contacted. All agencies responded to the data requests. A few of the agencies that deserve special recognition for providing large amounts information are Pacific Gas and Electric, Southern California Edison, and U.S. Bureau of Reclamation.

Preparing Model Input

Prior to simulation of headwater reservoirs, flows needed to be split from the single natural flow series at the frequency curve location into inflow hydrographs at all upstream reservoirs as shown in Table III-2. This was performed on a tributary specific basis. For example, the natural hydrograph for Feather River at Oroville Dam was split into 10 parts (8 hydrographs to reflect natural inflows to headwater reservoirs and 2 hydrographs to reflect the contribution of unregulated watershed area between reservoirs in series).

Note: Prior to use and application, reference the “Expectations of Use” preface.

**TABLE III-1
HEADWATER RESERVOIR OPERATIONS**

Reservoir, Owner^a	Data	Operations Information^b	HEC-5 Modeling
<i>Sacramento River Basin</i>			
Antelope Owner: DWR (Feather River)	Min flow = 5 cfs Max outlet flow = 150 cfs (30" pipeline)	Fill and spill reservoir. Reservoir will release minimum flow until spill. Spills during a normal year.	Release minimum flow till and during spill.
Butt Valley Owner: Pacific Gas and Electric (Feather River)	Max (combined) flow to the powerhouses = 2,500 cfs	In addition to natural inflows, Butt Valley receives power releases from Lake Almanor. Butt Valley has a minimum winter pool of 34,000 to 35,000 ac-ft. Butt Valley generates power through two plants, which have a combined power flow of 2,500 cfs.	Release half of the maximum power flow between minimum pool and 39,000 ac-ft. Above this storage, release full maximum power flow.
Bucks Storage Owner: Pacific Gas and Electric (Feather River)	Min flow = 1 cfs Max power flow = 395 cfs	Bucks Storage has a target pool of 45,000 ac-ft that PGE tries to reach by December 31. Generally, Bucks is shut down during rainfall events and downstream generation is supplied by natural flows from Grizzly Creek. If the pool gets high, power releases will be made to the Grizzly powerhouse and flows will be spilled from Grizzly Forebay and out of the generation system.	Release maximum power and minimum flows till and during spill.
Bowman Owner: Nevada Irrigation District (Yuba River)	Min flow = 3.5 cfs Max outlet flow = 375 cfs (2 outlets, one powerhouse penstock, one canal outlet)	Operated first for water supply. Gated spillway used to capture additional storage near the end of the wet season (gate operations are related to snowpack runoff). During flood season, gates remain full open.	Gage record indicates outlet releases in excess of minimum flow prior to spill in 1997 and 1986. Ramp up to max outlet as pool rises. Divert first 250 cfs in excess of minimum flow to Spaulding Reservoir.
Camp Far West Owner: South Sutter Irrigation District (Bear River)		Low flow gage record indicates fish flow releases of between 12 and 18 cfs in December 1996.	Release 15 cfs (typical winter release) till and during spill.
East Park Owner: USBR (Stony Creek)	Max flow = 750 cfs Min pool = 5,000 ac-ft Min flow = 5 cfs	Fill and spill reservoir. Reservoir used only for water supply. No hydropower. In winter months, reservoir will release minimum flow until spill.	Release minimum flow till and during spill.

- a) Tributary basin is indicated in parentheses below owner.
- b) Operations information was obtained through communications between the Water Management Section, Sacramento District, USACE, and the owners and operators of the headwater reservoirs. While some information is based in fact (i.e., minimum flow and pool restrictions), the operation policies are intended to be generic and may not reflect operations during actual floods. Owners and operators manage reservoirs continuously and, to an extent, the character of an individual flood will dictate releases.

**TABLE III-1 (CONT.)
HEADWATER RESERVOIR OPERATIONS**

Reservoir, Owner ^a	Data	Operations Information ^b	HEC-5 Modeling
Fordyce Owner: Pacific Gas and Electric (Yuba River)	Min flow = 5 cfs (Fordyce)	Fordyce is higher in elevation and has a smaller drainage area than Spaulding and therefore tends to spill less often and with smaller magnitude. Fordyce has a target pool of 4,000 to 5,000 ac-ft that is usually reached by January 1. After this, it is mainly in a storage mode. If the pool gets high, Fordyce will feed waters to Spaulding to support generation once Spaulding inflows have receded and the pool comes under control.	Release minimum flow until spill.
French Meadows - LL Anderson Owner: Placer County Water Agency (American River)	Min flow = 8 cfs Max power flow = 400 cfs	French Meadows generates power via the French Meadows Powerhouse. Power generation is unimpaired by spill at either reservoir. Spill from French Meadows creates sedimentation problems at downstream structures, but pre-releases from French Meadows are usually not made. Releases typically hold at max power in hopes that inflows will recede.	Release maximum power and minimum flow (408 cfs) till and during spill. Divert first 400 cfs in excess of minimum flow to Hell Hole Reservoir.
Frenchman Owner: DWR (Feather River)	Min flow = 2 cfs Max outlet flow = 160 cfs (36" pipeline)	Will release flows through the outlet works to minimize spill from the dam, which is potentially damaging to downstream distribution systems. Outlet works are head dependent. 160 cfs can be released at full lake (5,588-ft). Spills during a normal year.	Release maximum outlet when filled higher than 90 percent of capacity.
Hell Hole Owner: Placer County Water Agency (American River)	Min flows = 10 cfs (December 15 – May 14) Max power flow = 1,000 cfs	In the fall and early winter months, PCWA reduces storage in Hell Hole and French Meadows to 140,000 to 150,000 ac-ft. Of this total, 90,000 to 100,000 ac-ft is typically stored in Hell Hole. Pools are further lowered preceding the snowmelt, which usually tops off the pools in June. Hell Hole generates power via the Middle Fork Powerhouse and will do so while spilling.	Release maximum power and minimum flow (1,010 cfs) till and during spill.
<p>a) Tributary basin is indicated in parentheses below owner.</p> <p>b) Operations information was obtained through communications between the Water Management Section, Sacramento District, USACE, and the owners and operators of the headwater reservoirs. While some information is based in fact (i.e., minimum flow and pool restrictions), the operation policies are intended to be generic and may not reflect operations during actual floods. Owners and operators manage reservoirs continuously and, to an extent, the character of an individual flood will dictate releases.</p>			

**TABLE III-1 (CONT.)
HEADWATER RESERVOIR OPERATIONS**

Reservoir, Owner ^a	Data	Operations Information ^b	HEC-5 Modeling
Ice House Owner: Sacramento Municipal Utility District (American River)	Min flow = 3 cfs (January 1 – April 30) Max power flow = 285 cfs (via Jones Fork Powerhouse to Union Valley) Max outlet flow = 700 cfs (hollow cone valve)	During wet periods, reservoir will release maximum power flows through Jones Fork Powerhouse into Union Valley Reservoir till and during spill.	Release maximum power and minimum flows (288 cfs). Divert first 285 cfs in excess of minimum flow to Union Valley Reservoir.
Jackson Meadows Owner: Nevada Irrigation District (Yuba River)	Min flow = 5 cfs Max outlet flow = 400 cfs (flow to a canal could add an additional 20 cfs)	Operated first for water supply. Gated spillway used to capture additional storage near the end of the wet season (gate operations are related to snowpack runoff). During flood season, gates remain full open.	Gage record does not indicate high outflows during flood periods. Release 35 cfs (typical release during 1997 and 1986 floods) until and during spill.
Lake Almanor Owner: Pacific Gas and Electric (Feather River)	Min flow = 35 cfs Max power flow = 2,118 cfs Max outlet flow = 2,200 cfs	Generally, Almanor tends to store inflows until basin flows recede. This allows both the basin flows and then the Almanor releases to be routed through system powerhouses. However, if the reservoir fills high enough, power releases will be made through powerhouses high in the basin and sacrificed in the lower system where flows are already more than sufficient to satisfy power generation requirements. Almanor has a maximum pool of 1,100,000 ac-ft. Almanor will go to full outlet in addition to max power to stay below maximum pool (as seen in 1997). If the outlet is opened to maintain storage below maximum pool, it is opened fully.	Release minimum flow throughout simulations. In addition, ramp up to and hold maximum power releases until storage exceeds 943,000 ac-ft. Above this storage, release maximum outlet and maximum power flows.
Lake Davis - Grizzly Valley Owner: DWR (Feather River)	Min flow = 10 cfs Max outlet flow = 210 cfs (two outlets: 10" and 30" pipelines)	Will try to avoid spilling by pre-releasing through the outlet works. Outlet works are head dependent. 210 cfs can be released at full lake (5,775-ft).	Release max outlet when filled higher than 70 percent of capacity.

- a) Tributary basin is indicated in parentheses below owner.
 b) Operations information was obtained through communications between the Water Management Section, Sacramento District, USACE, and the owners and operators of the headwater reservoirs. While some information is based in fact (i.e., minimum flow and pool restrictions), the operation policies are intended to be generic and may not reflect operations during actual floods. Owners and operators manage reservoirs continuously and, to an extent, the character of an individual flood will dictate releases.

**TABLE III-1 (CONT.)
HEADWATER RESERVOIR OPERATIONS**

Reservoir, Owner ^a	Data	Operations Information ^b	HEC-5 Modeling
Little Grass Valley Owner: Oroville Wyandotte Irrigation District (Feather River)	Max outlet flow = 600 cfs Min flow = 5 cfs (November 1 – April 30)	Reservoir is water supply only, no hydropower. In the winter months, reservoir will release minimum flow until spill.	Release 5 cfs (minimum flow) till and during spill. Divert first 225 cfs in excess of minimum flow to Sly Creek Reservoir.
Loon Lake Owner: Sacramento Municipal Utility District (American River)	Min flow = 8 cfs Max power flow = 700 cfs (approximate value based on gauge records)	Loon Lake releases can be routed to Union Valley through a diversion on the South Fork of the Rubicon River. Power flows are usually lowered when flows on the South Fork are high. Average power flows during flood periods in 1995 and 1997 were well below maximum capacity.	Release typical power flows (150 cfs; as recorded during the 1995 and 1997 flood events) and minimum flow till and during spill.
McCloud Owner: Pacific Gas and Electric (Sacramento River above Shasta)	Min flow = 40 cfs (December 1 – April 30) Diversion flow = 1,000 cfs to 1,400 cfs (related to the head differential between McCloud and Iron Canyon)	During the winter months in wet years, McCloud is pulled down to 18,000 ac-ft. As McCloud fills, water is diverted to Black Powerhouse (through Iron Canyon Reservoir). This water enters the Pit River above Pit #6.	Release maximum average flow directly to Black Powerhouse (1,200 cfs) and minimum flow to McCloud River (40 cfs). Neglect influence of Iron Canyon Reservoir.
Merle Collins Owner: Browns Valley Irrigation District (Dry Creek – Yuba Drainage)	Min flow = 2.5 cfs (at Smith Diversion) Max power flow = 100 cfs	Operated first for water supply. Hydropower will be generated at high pool elevations and while spilling. Typical water supply operations pull the pool to about 5,000 to 6,000 ac-ft after the irrigation season. Reservoir usually fills by mid-January in average to above average water year.	Release minimum flow until storage exceeds 55,000 ac-ft. Then begin to release maximum power flows.
Mountain Meadows Owner: Pacific Gas and Electric (Feather River)	Max power flow = 200 cfs	Mountain Meadows has a wintertime maximum storage of less than 5,000 ac-ft. PGE maintains an operational storage of 3,000 to 5,000 ac-ft and will empty additional storage as quickly as possible. Max power is 200 cfs and is unaffected by spillway flows.	Release maximum power till and during spill.
Pit #3 (Lake Britton) Owner: Pacific Gas and Electric (Sacramento River above Shasta)	Min flow = 150 cfs Min pool = 26,852 ac-ft Max pool = 40,626 ac-ft Max power flow = 3,315 cfs Max outlet flow = 7,500 cfs	Whenever possible, reservoir storage is maintained below 40,626 ac-ft to prevent erosion at a recreational beach. Based on a wet forecast, Lake Britton may increase power releases and reduce storage to around 33,000 to 35,000 ac-ft.	Release maximum power and minimum flows until storage 39,200 ac-ft. Above this level, transition to maximum power and full outlet releases (10,815 cfs).
<p>a) Tributary basin is indicated in parentheses below owner.</p> <p>b) Operations information was obtained through communications between the Water Management Section, Sacramento District, USACE, and the owners and operators of the headwater reservoirs. While some information is based in fact (i.e., minimum flow and pool restrictions), the operation policies are intended to be generic and may not reflect operations during actual floods. Owners and operators manage reservoirs continuously and, to an extent, the character of an individual flood will dictate releases.</p>			

**TABLE III-1 (CONT.)
HEADWATER RESERVOIR OPERATIONS**

Reservoir, Owner ^a	Data	Operations Information ^b	HEC-5 Modeling
Pit #6 and Pit #7 Owner: Pacific Gas and Electric (Sacramento River above Shasta)	Min flow = 150 cfs (Pit #7) Max power flow = 6,470 cfs (Pit #6) Max power flow = 7,440 cfs (Pit #7)	Pit #6 and #7 are operated near full year round. Based on a wet forecast, reservoirs may be pulled down to minimum pools of 30,000 ac-ft at Pit #7 and 13,000 ac-ft at Pit #6. Both facilities release either maximum power or minimum flow and have no problems with generation while spilling.	Release maximum power from Pit #6 till and during spill. Release maximum power and minimum flow from Pit #7 till and during spill.
Rollins Owner: Nevada Irrigation District (Bear River)	Min flow = 20 cfs Max outlet flow = 900 cfs (2 outlets, Bear River Canal and one to the Bear River)	Flows released from Rollins can be diverted to the American River Basin through the Bear River Canal, which feeds multiple power generation facilities. Rollins typically spills in above average water years.	Release maximum outlet flow till and during spill. Divert first 310 cfs in excess of minimum flow to American River Basin.
Scotts Flat Owner: Nevada Irrigation District (Deer Creek – Yuba Drainage)	Min flow = none Max outlet flow = 180 cfs (92 cfs via power conduit and 88 cfs via power bypass)	Operations are driven by water supply with a goal of reaching full lake by April 1 of each year. Lake typically fills in February or March in average to above average years. During wet times and while reservoir is spilling, max power will be released, but power will always be sacrificed to protect or ensure water supply.	Release maximum power flow till and during spill when filled higher than 85 percent of capacity.
Sly Creek Owner: Oroville Wyandotte Irrigation District (Feather River)	Min flow = none Max power = 850 cfs	During wet years, Sly Creek will release maximum power regardless of spill. There is a downstream minimum flow requirement at Lost Creek Diversion Dam, but this is met by natural flows from Lost Creek.	Release 850 cfs (maximum power release) till and during spill.
Spaulding Owner: Pacific Gas and Electric (Yuba River)	Min flow = 5 cfs (Spaulding)	In addition to natural inflows, Spaulding receives Fordyce releases and diversion flows through the Bowman-Spaulding Canal. Spaulding has a target pool of 20,000 to 25,000 ac-ft. The pool may be pulled below this based on a large snowmelt runoff. Spaulding generates power via canals that carry water primarily to the Bear River drainage.	Release approximate historic (1986, 1995 and 1997 flood events) power releases and minimum flow until storage exceeds 50,000 ac-ft. Above this level, increase river outlet flows to 100 cfs. Divert first 600 cfs in excess of minimum flow to Bear drainage above Rollins.

a) Tributary basin is indicated in parentheses below owner.
 b) Operations information was obtained through communications between the Water Management Section, Sacramento District, USACE, and the owners and operators of the headwater reservoirs. While some information is based in fact (i.e., minimum flow and pool restrictions), the operation policies are intended to be generic and may not reflect operations during actual floods. Owners and operators manage reservoirs continuously and, to an extent, the character of an individual flood will dictate releases.

**TABLE III-1 (CONT.)
HEADWATER RESERVOIR OPERATIONS**

Reservoir, Owner ^a	Data	Operations Information ^b	HEC-5 Modeling
Stony Gorge Owner: USBR (Stony Creek)	Min pool = 7,500 ac-ft Min flow = 5 cfs (Seepage roughly 15 cfs)	Fill and spill reservoir. Reservoir used only for water supply. No hydropower. In winter months, reservoir will release minimum flow until spill. Seepage at the dam exceeds minimum flow requirements.	Release 15 cfs (seepage) till and during spill.
Union Valley Owner: Sacramento Municipal Utility District (American River)	Min flow = 0 cfs Max power flow = 1,500 cfs (approximate value)	In addition to natural inflows, Union Valley receives flows from Ice House reservoir (via Jones Fork Powerhouse) and the Rubicon River (via the diversion to Robbs Peak Powerhouse). During wet periods, Union Valley will release maximum power flows through Union Valley Powerhouse till and during spill.	According to gage records, average power releases during the 1995 and 1997 flood events did not maintain maximum release levels throughout the flood period. Model with a 1,000 cfs power release.
SAN JOAQUIN RIVER BASIN			
Bass Lake/Crane Valley Owner: Pacific Gas and Electric (San Joaquin above Friant)	Min flow = none Max power flow = 140 cfs (reduced from 160 cfs for channel integrity)	Usually kept close to full after snowmelt during the spring and summer (within 3,000 ac-ft of capacity). After the summer months, the pool is drawn down slightly. Storage usually hovers near 25,000 to 26,000 ac-ft throughout the winter. Max power releases are limited by downstream channel integrity concerns.	Release maximum power flow (140 cfs) at storage above 25,000 ac-ft till and during spill.
Beardsley and Donnells Owner: Oakdale South San Joaquin Irrigation District (Stanislas River)	Donnells: Min flow = 16 cfs Max power flow = 750 cfs Min pool = 5,000 ac-ft Beardsley: Min flow = 50 cfs Max power flow = 600 cfs Min pool = 20,000 ac-ft	Both reservoirs generally release maximum power flows up to and above the spillway crest. Pools are lowered in the fall and winter months. Minimum pool limits are usually reached in February or March.	Release maximum power and minimum flows from both facilities (766 cfs from Beardsley and 650 cfs from Donnells).
<p>a) Tributary basin is indicated in parentheses below owner.</p> <p>b) Operations information was obtained through communications between the Water Management Section, Sacramento District, USACE, and the owners and operators of the headwater reservoirs. While some information is based in fact (i.e., minimum flow and pool restrictions), the operation policies are intended to be generic and may not reflect operations during actual floods. Owners and operators manage reservoirs continuously and, to an extent, the character of an individual flood will dictate releases.</p>			

**TABLE III-1 (CONT.)
HEADWATER RESERVOIR OPERATIONS**

Reservoir, Owner ^a	Data	Operations Information ^b	HEC-5 Modeling
Cherry Valley Owner: City and County of San Francisco (CCSF) (Tuolumne River)	Min flow = 5 cfs (October 1 – June 30) Max power flow = 950 cfs	All of these CCSF reservoirs are operated first for water supply. In addition to natural inflows, Cherry Valley receives flow from Lake Eleanor via the Cherry-Eleanor Tunnel. Cherry Valley has three operational flow levels above minimum flow. The first is maximum power releases to Holm Powerhouse. The second is the highest release that does not effect power generation efficiency (6,000 cfs) and the final level is the highest flow that can pass through downstream areas without causing damages (28,000 cfs). CCSF will make releases to keep potential flows within these levels.	Operate Cherry Valley for conditions at Holm Powerhouse. When flows are below 5,000 cfs release maximum power and minimum flow (955 cfs) until storage exceeds 90 percent of capacity. Above this storage, ramp up releases as much as possible while maintaining flows below 6,000 cfs at Holm Powerhouse.
Courtright Owner: Pacific Gas and Electric (PG&E) (Kings River)	Min flow = 2.5 cfs (December 1 – May 31)	Courtright and Wishon are located in series, high in the Kings River watershed (higher than 6,500-ft above sea level). Supply is derived primarily from snowmelt. Reservoirs are pulled down in the winter to make space for the melt. The normal minimum combined pool is 60,000 ac-ft (the actual minimum operational storage at Courtright is 5,000 ac-ft)..	Model Courtright and Wishon as a single reservoir. Combine storage and inflows. Use the outlet works of Wishon as those of the composite reservoir. Refer to Wishon HEC-5 modeling for more information.
Edison Owner: Southern California Edison Company (SCE) (San Joaquin River above Friant)	Min flows = 7.5 cfs (November 1 – April 30)	SCE reduces storage in the fall to a minimum pool that is based on snowpack forecasts. SCE releases to meet minimum pool by early spring and will go as low as 6,000 ac-ft during wet years. Storage is reduced at a rate of up to 450 cfs per day. Most of this water is diverted to the Bear-Mono Conduit and onto the Ward Tunnel, which transports flow to Huntington Reservoir. During high waters, diversions to the Bear-Mono Conduit may be shut off. If Edison is high and cannot offset inflow with a 450 cfs release, outflows may be increased. Any releases above 450 cfs flow past the diversion works and on to Mammoth Pool.	Release minimum flow until storage exceeds 120,000 ac-ft. Above this storage, increase releases to full outlet (1,700 cfs).
a) Tributary basin is indicated in parentheses below owner. b) Operations information was obtained through communications between the Water Management Section, Sacramento District, USACE, and the owners and operators of the headwater reservoirs. While some information is based in fact (i.e., minimum flow and pool restrictions), the operation policies are intended to be generic and may not reflect operations during actual floods. Owners and operators manage reservoirs continuously and, to an extent, the character of an individual flood will dictate releases.			

**TABLE III-1 (CONT.)
HEADWATER RESERVOIR OPERATIONS**

Reservoir, Owner ^a	Data	Operations Information ^b	HEC-5 Modeling
Florence Owner: Southern California Edison Company (San Joaquin River above Friant)	Min flow = 15 cfs (November 1 – April 30)	Florence is almost entirely emptied by November 1 of each year; SCE usually pulls the pool down to 1,200 ac-ft. Storage accumulated in Florence from rain events is routed through Ward Tunnel to Huntington and Shaver as soon as there is sufficient space in those pools. SCE tries to keep flows below the dam less than 3,000 cfs. Florence has a gated spillway with no seasonal restrictions and uses the final 11,000 ac-ft of available storage to minimize spill, but water has never been this high during the winter. Gaged maximum flow to Ward Tunnel is 1,770 cfs, but winter flows rarely exceed 1,000 cfs and are usually held below 200 cfs.	Release minimum flow until storage exceeds 60,000 ac-ft. At this level, increase flows to 3,000 cfs.
Hetch Hetchy Owner: City and County of San Francisco (Tuolumne River)	Min flows = 50 cfs (January 1 – January 31; while drafting more than 920 cfs, min flow required is increased by 64 cfs) Max power flow = 1,350 cfs	Hetch Hetchy is an important water source for the City of San Francisco. Water is delivered to the City through the Hetch Hetchy Aqueduct. During periods of high flows, waters become turbid and CCSF limits flows through the aqueduct to approximately 110 cfs. Hetch Hetchy has three operational flow levels above minimum flow. The first is maximum power (1,350 cfs). The second is the highest release that does not effect power generation efficiency (7,000 cfs) and the final level is the highest flow that can pass through downstream areas without causing damages (18,000 cfs). CCSF will make releases to keep potential spills within these levels.	Release maximum power and minimum flow (approximately 1,500 cfs) until storage exceeds 90 percent of capacity. Above this storage, ramp up releases and hold at 7,000 cfs. If storage exceeds 95 percent of capacity, increase releases to maximum outlet (approximately 15,000 cfs). Aqueduct diversion is held constant at 110 cfs.
<p>a) Tributary basin is indicated in parentheses below owner.</p> <p>b) Operations information was obtained through communications between the Water Management Section, Sacramento District, USACE, and the owners and operators of the headwater reservoirs. While some information is based in fact (i.e., minimum flow and pool restrictions), the operation policies are intended to be generic and may not reflect operations during actual floods. Owners and operators manage reservoirs continuously and, to an extent, the character of an individual flood will dictate releases.</p>			

**TABLE III-1 (CONT.)
HEADWATER RESERVOIR OPERATIONS**

Reservoir, Owner ^a	Data	Operations Information ^b	HEC-5 Modeling
Huntington Owner: Southern California Edison Company (San Joaquin River above Friant)	Min flow = 2 cfs	Maintained consistently at a high pool (1,000 ac-ft below capacity) during summer months. After Labor Day, storage is reduced to 30,000 ac-ft by early spring. During this drawdown, a power flow (300 cfs) is typically routed through Big Creek Powerhouse #1 and on to Redinger. An additional 200 cfs is normally diverted from Huntington to Shaver through Balsam Forebay. This 500 cfs pull is usually half offset by natural inflow and diversion flows through the Ward Tunnel. A large percentage of Huntington inflow is diverted from Florence and Edison Reservoirs through the Ward Tunnel. SCE prevents any spill from Huntington Reservoir. If the pool gets high, Ward Tunnel flows will be reduced or shut off. Huntington has gated spillways with SCE self-imposed restrictions because of downstream domestic water contamination concerns.	Release 500 cfs. Ward Tunnel is not modeled based on information that indicated flows can be cut back when Huntington inflows and storage are high.
Lake Eleanor Owner: City and County of San Francisco (Tuolumne River)	Min flow = 5 cfs (November 1 – February 28 and while diverting to Cherry Valley)	Lake Eleanor is the smallest of the three CCSF reservoirs in the Tuolumne headwaters. Eleanor is connected to Cherry Valley Reservoir via the Cherry-Eleanor Tunnel. The tunnel has a maximum conveyance of 500 cfs obtainable at variable pool elevations through stage or pump driven flows. Flows will not be diverted while Cherry Valley is spilling, but may be used when Eleanor is closer to full capacity than Cherry Valley.	Release maximum flow to the tunnel and minimum flow (505 cfs) till and during spill. Divert first 500 cfs in excess of minimum flow to Cherry Valley Reservoir.
Lower Bear Owner: Pacific Gas and Electric (Mokelumne River)	Min flow = 2 cfs (November 1 – April 30) Max power flow = 218 cfs	Lower Bear generates power via Salt Springs Powerhouse #2. Flows to the powerhouse can be diverted from Cole Creek or released from Lower Bear. Lower Bear usually tops off during the spring runoff and will begin to make power releases when Cole Creek recedes. Power generation is unaffected by spillway flows.	Release maximum power and minimum flow (220 cfs) till and during spill.
a) Tributary basin is indicated in parentheses below owner. b) Operations information was obtained through communications between the Water Management Section, Sacramento District, USACE, and the owners and operators of the headwater reservoirs. While some information is based in fact (i.e., minimum flow and pool restrictions), the operation policies are intended to be generic and may not reflect operations during actual floods. Owners and operators manage reservoirs continuously and, to an extent, the character of an individual flood will dictate releases.			

**TABLE III-1 (CONT.)
HEADWATER RESERVOIR OPERATIONS**

Reservoir, Owner ^a	Data	Operations Information ^b	HEC-5 Modeling
Mammoth Owner: Southern California Edison Company (San Joaquin River above Friant)	Min flow = 10 cfs (November 1 – April 15)	Mammoth storage is reduced from its summer pool to general targets of 35,000 ac-ft by January 1 and 10,000 ac-ft by March 1. Mammoth has an ungated spillway and will release max power (2,420 cfs) to lower storage and during spilling.	Release maximum power and minimum flow when storage is in excess of 11,000 ac-ft. Maintain maximum power flow during spill.
New Spicer Meadows Owner: Calaveras County Water District (Stanislas River)	Min flow = 16.5 cfs Max outlet flow = 2,000 cfs	Power generation at New Spicer Meadows (NSM) is typically shut down during the winter months. NSM has enough capacity to store most natural inflow. Generation at downstream projects is primarily fed by natural flow (runoff below NSM) during winter months. Releases pick up in May or June when downstream facilities can utilize released flows. Maximum power release is 350 to 400 cfs.	In accordance with gage records for the 1997, 1986, and 1995 flood seasons, release maximum power flow (350 cfs) at storage above 55 percent of capacity.
Redinger Owner: Southern California Edison Company (San Joaquin River above Friant)	Min flow = 3 cfs (below dam) Min flow = 20 cfs (below Willow Creek)	Maintained near full pool throughout the year. Maximum power through Big Creek Powerhouse #4 is 3,600 cfs and generation is head-dependent. The spillway at Redinger has 4 radial gates that can be operated year-round.	Release maximum power and minimum flow (3,620 cfs) when storage is in excess of 20,000 ac-ft. Model spillway without gates with a gross pool of 25,000 ac-ft. Develop rating curve based on gate releases made during the 1997 flood event.
Salt Springs Owner: Pacific Gas and Electric (Mokelumne River)	Min flow = 20 cfs (November 1 – April 30) Max power flow = 600 cfs	The reservoir typically fills and spills by the end of May and can continue to spill into July during wet years. Max power flow is 600 cfs and generation is unaffected by spill. Both Salt Springs and Lower Bear tend to spill in average to above average years.	Release maximum power till and during spill.
<p>a) Tributary basin is indicated in parentheses below owner.</p> <p>b) Operations information was obtained through communications between the Water Management Section, Sacramento District, USACE, and the owners and operators of the headwater reservoirs. While some information is based in fact (i.e., minimum flow and pool restrictions), the operation policies are intended to be generic and may not reflect operations during actual floods. Owners and operators manage reservoirs continuously and, to an extent, the character of an individual flood will dictate releases.</p>			

**TABLE III-1 (CONT.)
HEADWATER RESERVOIR OPERATIONS**

Reservoir, Owner ^a	Data	Operations Information ^b	HEC-5 Modeling
Mammoth Owner: Southern California Edison Company (San Joaquin River above Friant)	Min flow = 10 cfs (November 1 – April 15)	Mammoth storage is reduced from its summer pool to general targets of 35,000 ac-ft by January 1 and 10,000 ac-ft by March 1. Mammoth has an ungated spillway and will release max power (2,420 cfs) to lower storage and during spilling.	Release maximum power and minimum flow when storage is in excess of 11,000 ac-ft. Maintain maximum power flow during spill.
New Spicer Meadows Owner: Calaveras County Water District (Stanislas River)	Min flow = 16.5 cfs Max outlet flow = 2,000 cfs	Power generation at New Spicer Meadows (NSM) is typically shut down during the winter months. NSM has enough capacity to store most natural inflow. Generation at downstream projects is primarily fed by natural flow (runoff below NSM) during winter months. Releases pick up in May or June when downstream facilities can utilize released flows. Maximum power release is 350 to 400 cfs.	In accordance with gage records for the 1997, 1986, and 1995 flood seasons, release maximum power flow (350 cfs) at storage above 55 percent of capacity.
Redinger Owner: Southern California Edison Company (San Joaquin River above Friant)	Min flow = 3 cfs (below dam) Min flow = 20 cfs (below Willow Creek)	Maintained near full pool throughout the year. Maximum power through Big Creek Powerhouse #4 is 3,600 cfs and generation is head-dependent. The spillway at Redinger has 4 radial gates that can be operated year-round.	Release maximum power and minimum flow (3,620 cfs) when storage is in excess of 20,000 ac-ft. Model spillway without gates with a gross pool of 25,000 ac-ft. Develop rating curve based on gate releases made during the 1997 flood event.
Salt Springs Owner: Pacific Gas and Electric (Mokelumne River)	Min flow = 20 cfs (November 1 – April 30) Max power flow = 600 cfs	The reservoir typically fills and spills by the end of May and can continue to spill into July during wet years. Max power flow is 600 cfs and generation is unaffected by spill. Both Salt Springs and Lower Bear tend to spill in average to above average years.	Release maximum power till and during spill.
<p>a) Tributary basin is indicated in parentheses below owner.</p> <p>b) Operations information was obtained through communications between the Water Management Section, Sacramento District, USACE, and the owners and operators of the headwater reservoirs. While some information is based in fact (i.e., minimum flow and pool restrictions), the operation policies are intended to be generic and may not reflect operations during actual floods. Owners and operators manage reservoirs continuously and, to an extent, the character of an individual flood will dictate releases.</p>			

**TABLE III-1 (CONT.)
HEADWATER RESERVOIR OPERATIONS**

Reservoir, Owner ^a	Data	Operations Information ^b	HEC-5 Modeling
Sly Park - Jenkinson Lake Owner: U.S. Bureau of Reclamation (Cosumnes River)	Min flow = 1 cfs Max outlet flow = 125 cfs	Reservoir supplies flow to a water treatment plant, which provides drinking water to the Eastern Slope of Eldorado County. Typical flows are approximately 10 to 15 cfs during winter months. Sly Park spills in nearly all water years. Treatment plant releases are maintained during times of spill.	Release minimum and typical treatment plant flows (total of 15 cfs) till and during spill.
Shaver Owner: Southern California Edison Company (San Joaquin River above Friant)	Min flow = 3 cfs	During wet years, the minimum summer pool (June 15 - September 1) in Shaver is 90,000 ac-ft. Storage is reduced in the fall and winter to a general target of 76,000 ac-ft by February 1. During this pull down, typically Shaver releases 300 cfs to Big Creek Powerhouse #2a, which then flows on to Redinger. As with Huntington, SCE does not spill Shaver. Shaver has a small natural watershed and a high percentage of inflow is delivered through diversions. SCE operates Shaver to prevent any possibility of spill.	To simplify simulations, the Huntington to Shaver diversion was not modeled. Instead, model releases were reduced from SCE's typical power release of 300 cfs to 100 cfs. This adjusted for the 200 cfs flow that would have been delivered by the diversion. Release 100 cfs flow throughout simulation.
Wishon Owner: Pacific Gas and Electric (Kings River)	Min flow = 33 cfs (65 ac-ft per day) Max power flow = 850 cfs	The minimum operation pool at Wishon is 33,000 ac-ft. There is a pump-back system between Wishon and Courtright capable of sending high flows upslope. During rainfloods, most likely would pump from Wishon to Courtright to avoid spilling at Wishon.	Release Wishon maximum power and minimum flow from composite reservoir (883 cfs).
<p>a) Tributary basin is indicated in parentheses below owner.</p> <p>b) Operations information was obtained through communications between the Water Management Section, Sacramento District, USACE, and the owners and operators of the headwater reservoirs. While some information is based in fact (i.e., minimum flow and pool restrictions), the operation policies are intended to be generic and may not reflect operations during actual floods. Owners and operators manage reservoirs continuously and, to an extent, the character of an individual flood will dictate releases.</p>			

**TABLE III-2
HEADWATERS MODELING INFORMATION TABLE**

Sacramento River Basin					
River	Destination	Flow Locations	Starting Storage (ac-ft)	Travel Time (hours)	% Split
American River	Folsom Lake	French Meadows Reservoir	67,100	5 ^a	3 ^b
		Hell Hole Reservoir	130,900	6	4
		Loon Lake	41,100	6	1
		Union Valley Reservoir	199,300	5	5
		Ice House Reservoir	25,400	6	1
		Folsom Lake	530,000		86
Bear River	Near Wheatland	Camp Far West Reservoir	100,000	2	62
		Rollins Reservoir	65,500	7	36
		Near Wheatland			2
Deer Creek	Near Smartsville	Scotts Flat Reservoir	48,000	2	30
		Near Smartsville			70
Dry Creek	Near Yuba	Merle Collins Reservoir	51,300	1	85
		Near Yuba			15
Feather River	Lake Oroville	Little Grass	70,000	2	2
		Sly Creek Reservoir	50,000	1	2
		Frenchman Lake	40,000	6	1
		Lake Davis	55,000	4	1
		Mountain Meadows Reservoir	4,465	5	1
		Lake Almanor	850,000	4	8
		Antelope Lake	20,000	7	1
		Butt Valley Reservoir	39,500	4	2
		Bucks Lake	60,000	2	2
		Lake Oroville	2,788,000		80
Sacramento River	Lake Shasta	Lake Britton	32,000	6	42
		Pit No. 6	14,500	2	10
		Pit No. 7	30,000	1	5
		McCloud Reservoir	24,000	3	13
		Lake Shasta	3,252,100		30
Stony Creek	Black Butte	East Park Reservoir	48,210	6	15
		Stony Gorge Reservoir	31,940	4	30
		Black Butte Reservoir	6,702		55
Yuba River	Middle Fork-South Fork	Jackson Meadows Reservoir	38,000	3	5
		Bowman Lake	40,000	3	5
		Fordyce Creek	16,000	3	5
		Spaulding Lake	40,000	2	25
		Middle South Fork			60

^a The travel time between French Meadows Reservoir and Folsom Lake is 5 hours.
^b The percent split of Folsom Lake's full natural flow attributed to French Meadows Reservoir is 3%.

Note: Prior to use and application, reference the "Expectations of Use" preface.

TABLE III-2 (CONT.)
HEADWATERS MODELING INFORMATION TABLE

San Joaquin River Basin					
River	Destination	Flow Locations	Starting Storage (ac-ft)	Travel Time (hours)	% Split
Cosumnes River	At Michigan Bar	Sly Park (Jenkinson Lake)	34,000	6	9
		At Michigan Bar			91
Kings River	Pine Flat Reservoir	Courtright-Wishon Reservoir	100,000	2	10
		Pine Flat Reservoir	525,000		90
Mokelumne River	Camanche Reservoir	Lower Bear River Reservoir	20,000	6	5
		Salt Springs Reservoir	40,000	6	27
		Pardee Reservoir	200,000		61
		Camanche Reservoir	230,900		7
San Joaquin River	Friant/Millerton Lake	Thomas A. Edison Lake	70,000	5	3
		Florence Lake	1,200	6	7
		Huntington Lake	50,000	2	5
		Shaver Lake	90,000	1	3
		Redinger Lake	20,000	1	16
		Mammoth Pool Reservoir	24,000	3	38
		Bass Lake	25,000	3	3
		Friant/Millerton Lake	350,500		25
Stanislaus River	New Melones Reservoir	Beardsley Lake	50,000	6	11
		Donnells Reservoir	20,000	7	14
		New Spicer Meadows Reservoir	80,000	7	05
		New Melones Reservoir	1,969,504		70
Tuolumne River	Don Pedro Reservoir	Hetch Hetchy Reservoir	280,000	4	20
		Cherry Valley Lake	180,000	4	12
		Lake Eleanor	15,000	4	8
		Don Pedro Reservoir	1,690,000		60

^a The travel time between French Meadows Reservoir and Folsom Lake is 5 hours.
^b The percent split of Folsom Lake's full natural flow attributed to French Meadows Reservoir is 3%.

These flow splits were performed by multiplying the full natural hydrograph by a constant percentage based on drainage area ratios, normal annual precipitation (NAP) distribution within the tributary basin, and volume comparisons of flood volume yields at the headwater reservoir and at the full natural flow location. In some instances, the volume comparison was not possible due to a lack of data and the ratio was based solely on NAP distribution and drainage areas.

River Routings

As the pattern of each full natural hydrograph is an actual flood wave that has occurred in the past, the shape and timing of the hydrograph reflects basin alignment, drainage area, time of concentration, and a multitude of other hydrologic and geomorphic characteristics of the basin. Since the pattern is a function of the basin, headwater simulations must take care not to introduce undue influences. For instance, the shape of the full natural flow hydrograph already contains

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travel times and routing effects of individual forks of the river as each travels its course. If attenuation of natural flows through river routings were modeled, the routing effects of that stretch of river would be twice performed (once by nature, the other via the model) and peak flows would be reduced in error.

In order to add the influence of headwater reservoirs properly, flows were rated in the headwater models with lag functions before and during simulations. Inflow hydrographs, computed with the split ratios, were reverse lagged by the total travel time between the designated headwater location and the interface with the lower basin model. Model simulations then introduced headwater reservoir influence and lagged the outflows without attenuation by identical travel times.

Starting Storage – Headwater Reservoirs

Starting storages of the headwater reservoirs were based on the average reservoir storages prior to the December-January 1997, March 1995, and February 1986 flood events. These events were chosen for the analysis because they provided variations in spatially distributed rainfall that best represented extreme storm runoff impacts to these basins. Thus, it was determined that these events exhibited conservative conditions of the starting storages of each of the headwater reservoirs. Storage values that appeared anomalous were discarded or discussed with the operating agency. If the average storage was greater than gross pool, then gross pool was used as the starting storage. Starting storages chosen for each headwater reservoir is presented in Table III-2.

Headwater Simulation Product

HEC-5 computes the regulated and unregulated flows at all node locations within the model. A comparison of these two time series at the original full-basin hydrograph locations provides an excellent visual of the combined influence of all headwater reservoirs within individual watersheds. These relationships are discussed on a tributary specific basis in the results section of this report.

The products that continue on in the modeling process are the regulated hydrographs computed at the interface with the lower basin model. These time series are output by the headwater model and become the inflow data for the lower basin simulation model.

TOP OF CONSERVATION STORAGE – FLOOD CONTROL RESERVOIRS

The required top of conservation is specified on the water control diagram for each flood damage reduction project. Typically, the top of conservation varies seasonally, as a function of a basin wetness parameter, and in some cases as a function of the concurrent storage of reservoirs upstream of the project.

The basin wetness parameter is a function of the total precipitation that has fallen to date over the watershed above the flood damage reduction project in the rainy season. To use an analogy, if one thinks of the watershed as a sponge, the basin wetness parameter would measure how much water the sponge has already absorbed. In this way, the parameter measures the antecedent moisture conditions of the watershed existing above the reservoir. The wetter the sponge, the

Note: Prior to use and application, reference the "Expectations of Use" preface.

higher the runoff and subsequent inflows to the project if a rainfall event were to occur. This parameter is often used as a variable in computing the top of conservation according to the logic that if the sponge is dry (low basin wetness), the top of conservation can be increased to provide water supply benefits without lowering the level of protection for downstream areas. However, most major rainfall events occur in wet years, which tend to have high basin wetness.

Since reservoir models were prepared to simulate specific exceedence events, computation of the top of conservation assumed that the basin wetness parameter would be high enough to reduce the top of conservation to the minimum level in all seven synthetic exceedence frequency floods; the model assumed that the sponge was wet enough to lower the top of conservation storage to its minimum level (i.e., maximum available flood space). Any seasonal variations along this minimum were included in the model input.

Top of conservation for projects with established credit space scenarios were computed as an interim process between simulations of the headwater and lower basin models.

LOWER BASINS

Twenty-four of the 27 lower basin reservoirs have storage dedicated to flood damage reduction. Eighteen of these reservoirs, all with flood storage, are located in the San Joaquin and Tulare Basins. Major flood management reservoirs are presented in Table III-3. The largest of all Central Valley flood damage reduction projects are Shasta and Oroville Lakes, both in the Sacramento Basin. Again, model development focused on flood simulations where flood damage reduction reservoirs are encroached. The rest of this section discusses key modeling aspects for the flood damage reduction reservoirs.

Operational Criteria

In accordance with the Flood Control Act of 1944, the USACE has established flood damage reduction criteria for all reservoirs with allocated flood space. These procedures are described in Water Control Manuals. Criteria were interpreted from published procedures and input into the model.

Key criteria included objective flow rates and locations, reservoir outflow constraints (including rate of release changes), top of conservation storage (discussed above), and Emergency Spillway Release Diagram (ESRD) operations.

ESRD Simulation

Emergency Spillway Release Diagrams (ESRD) are formulated for reservoirs with gated spillways. Gated spillways offer the ability to store water above the spillway crest and release high flows before storage rises to the maximum allowable level. Release diagrams are developed based on the principle that if inflow is going to force releases that exceed downstream limits, emergency releases (above downstream limits) may be made before the available flood space is exhausted, designed freeboard limits are encroached, and the dam is overtopped. By increasing releases earlier in the flood event, the peak outflow required to pass the severe inflows is lowered and downstream damages are usually reduced.

Note: Prior to use and application, reference the "Expectations of Use" preface.

TABLE III-3
LOWER BASIN RESEVOIRS
(MAJOR FLOOD MANAGEMENT RESERVOIRS)

Reservoir	Owner	Objective Flow (cfs)	Objective Flow Location	Gross Pool Storage (ac-ft)	Max Flood Space (ac-ft)	Credit Space Agreement
Sacramento River Basin						
Black Butte	USACE	15,000 130,000	Below dam Ord Ferry	143,700	136,000	Up to 40,000 acre-feet of storage can be transferred based on storage in East Park and Stony Gorge
Folsom	USBR	115,000	Below dam	977,000	600,000 ¹	Up to 200,000 acre-feet of storage can be transferred based on storage in French Meadows, Hell Hole, and Union Valley
Indian Valley	Yolo Cnty FCWC Dist	20,000 10,000	Below dam At Rumsey	300,600	40,000	
New Bullards Bar	Yuba Cnty WA	50,000 180,000	Below dam Marysville At Yuba Riv	960,000	170,000	
Oroville	DWR	150,000 150,000 180,000 300,000 320,000	Below dam Gridley Yuba City Marysville Nicolaus	3,538,000	750,000	
Shasta	USBR	79,000 100,000	Below dam Bend Bridge	4,552,000	1,300,000	
San Joaquin River Basin						
Big Dry Creek	FMFCD	700	Wasteway	30,200	30,200	
Buchanan	USACE	7,400 7,000	Below dam Chowchilla River at Madera Canal	150,000	45,000	
Camanche	EBMUD	5,000	Below dam	430,900	200,000	Up to 70,000 acre-feet of storage can be transferred based on storage in Salt Springs and Lower Bear
Don Pedro	Turlock ID	9,000	Modesto	2,030,000	340,000	
Farmington	USACE	2,000	At the town of Farmington	52,000	52,000	
Friant	USBR	8,000 6,500	Little Dry Creek Mendota Gage	520,500	170,000	Up to 85,000 acre-feet of storage can be transferred based on storage in Mammoth Pool
Hidden	USACE	5,000	Fresno River at Madera Canal	90,000	65,000	
Los Banos	USBR	1,000	Los Banos	34,600	14,000	
New Exchequer	Merced ID	6,000	Cressey	1,024,600	350,000	
New Hogan	USACE	12,500	Mormon Slough	317,100	165,000	
New Melones	USBR	8,000	Orange Blossom	2,400,000	450,000	
Tulare Lake Basin						
Isabella	USACE	4,600	Kern River at Pioneer Turnout	568,000	398,000	
Pine Flat	USACE	4,750 3,200	Kings River North Kings River South	1,000,000	475,000	Up to 162,000 acre-feet of storage can be transferred based on storage in Courtright and Wishon
Success	USACE	3,200	Tule River	82,300	75,000	
Terminus	USACE	5,500	Kaweah River at McKays Point	143,000	142,000	

1. Assumed from the authorized Folsom Dam modifications, designed as part of the American River Project

Note: Prior to use and application, reference the "Expectations of Use" preface.

Each reservoir's ESRD is unique. Some ESRD's base emergency releases on the rate the pool is rising, others as a function of the inflow. Diagrams often have ranges of pool elevations that specify the use of different sets of release criteria.

As a tool designed to have widespread application in planning studies, HEC-5 models ESRD operations generically based on pool elevation and rate of rise in the pool (HEC-5 Users Manual Version 8.0, 1998). The model can be calibrated to better reflect site-specific criteria, but will always tend towards a standard operation.

A key parameter in gated model simulations is the Recession Constant. This parameter is defined as the hours it takes for an extreme flood hydrograph to recede to approximately 40 percent of its peak flow. The Recession Constant allows HEC-5 to anticipate the total volume contained in the flood wave. Releases are then guided to pass that volume.

In this study, gated releases were modeled by entering certain input parameters directly (spillway width and pool elevations for spillway crest and surcharge levels) and adjusting the recession variable until modeled results reflected ESRD operations as closely as possible.

Ramping up to Channel Capacity

As a default, HEC-5 tries to evacuate occupied flood space as quickly as possible (i.e., full channel capacity release when encroached 1 acre-foot). During actual operations, there is usually no immediate danger when reservoirs are at these levels and flood releases are held well below channel capacity.

Several flood damage reduction facilities had schedules relating release rate to encroachment and inflow specified in the Water Control Manual. These were incorporated directly. For most projects, variables needed to be derived to guide release decisions near the bottom of the flood space. The percent of flood space encroached was used as a variable to ramp up releases to channel capacity. All projects without specified criteria reached capacity releases at or below 50 percent encroachment.

Physical Characteristics

All required data (elevation-capacity tables, outlet and spillway ratings, and facility schematics) are available in the Water Control Manuals.

River Routings

Muskingum routings, procedures that delay and attenuate flows as hydrographs travel downstream, were used for all river reaches in the lower basin models. Travel times and attenuation factors (Muskingum X), as shown in Table III-4 for the Sacramento River Basin and Table III-5 for the San Joaquin River Basin, were obtained from past studies, through communication with local water agencies, or through comparisons of historic flood data. If no information was available from these sources, parameters were estimated based on length of reach, average slope, and channel characteristics.

Note: Prior to use and application, reference the "Expectations of Use" preface.

TABLE III-4
HEC-5 LOWER BASIN ROUTING PARAMETERS FOR THE SACRAMENTO RIVER
BASIN

From Node	To Node	Routing Type	Number of Sub-reaches	Muskingum X	Travel Time per Subreach (hrs)	Total Travel Time (hrs)
311 Shasta Dam	302 Keswick Dam	Muskingum	2	0.4	1.05	2.1
302 Keswick Dam	289 Confluence of Clear Creek and Sacramento River	Muskingum	3	0.4	1	3
299 Whiskeytown Reservoir	292 Clear Creek at Igo	Straddle/Stagger	1	–	1	1
299 Whiskeytown Reservoir	302 Keswick Dam	Straddle/Stagger	–	–	1	1
292 Clear Creek at Igo	289 Confluence of Clear Creek and Sacramento River	No Routing	–	–	–	–
289 Confluence of Clear Creek and Sacramento River	280 Confluence of Sacramento River and Cow Creek	Muskingum	2	0.1	1.1	2.2
286 Dummy Reservoir to receive Cow Creek	280 Confluence of Sacramento River and Cow Creek	Muskingum	1	0.2	1	1
280 Confluence of Sacramento River and Cow Creek	276 Confluence of Sacramento River and Cottonwood Creek	Muskingum	2	0.1	1	2
278 Dummy Reservoir to receive Cottonwood Creek	276 Confluence of Sacramento River and Cottonwood Creek	Muskingum	1	0.2	1	1
276 Confluence of Sacramento River and Cottonwood Creek	272 Confluence of Sacramento River and Battle Creek	No Routing	–	–	–	–
274 Dummy Reservoir to receive Battle Creek	272 Confluence of Sacramento River and Battle Creek	Muskingum	1	0.2	1	1
272 Confluence of Sacramento River and Battle Creek	258 Sacramento River at Bend Bridge	Muskingum	3	0.1	1	3
258 Sacramento River at Bend Bridge	234 Confluence of Sacramento River and Elder Creek	Muskingum	6	0.2	1.15	6.9
240 Dummy Reservoir to receive Elder Creek	234 Confluence of Sacramento River and Elder Creek	Muskingum	9	0.2	1	9
234 Confluence of Sacramento River and Elder Creek	230 Confluence of Sacramento River and Mill Creek	No Routing	–	–	–	–
232 Dummy Reservoir to receive Mill Creek	230 Confluence of Sacramento River and Mill Creek	Muskingum	3	0.2	1	3
230 Confluence of Sacramento River and Mill Creek	225 Confluence of Sacramento River and Thomas Creek	Muskingum	1	0.2	1.3	1.3
228 Dummy Reservoir to receive Thomas Creek	225 Confluence of Sacramento River and Thomas Creek	Muskingum	11	0.2	1	11
225 Confluence of Sacramento River and Thomas Creek	220 Confluence of Sacramento River and Deer Creek	Muskingum	1	0.2	1.4	1.4
223 Dummy Reservoir to receive Deer Creek	220 Confluence of Sacramento River and Deer Creek	Muskingum	5	0.2	1	5
220 Confluence of Sacramento River and Deer Creek	218 UNET Handoff point on Sacramento River at Vina-Woodson Bridge	No Routing	–	–	–	–

Note: Prior to use and application, reference the "Expectations of Use" preface.

TABLE III-4 (CONT.)
HEC-5 LOWER BASIN ROUTING PARAMETERS FOR THE SACRAMENTO RIVER
BASIN

From Node	To Node	Routing Type	Number of Sub-reaches	Muskingum X	Travel Time per Subreach (hrs)	Total Travel Time (hrs)
218 UNET handoff point on Sacramento River at Vina-Woodson Bridge	193 Confluence of Sacramento River and Big Chico Creek	Muskingum	6	0.3	1	6
210 Dummy Reservoir to receive Big Chico Creek	205 UNET handoff point on Big Chico Creek	No Routing	–	–	–	–
205 UNET handoff point on Big Chico Creek	193 Confluence of Sacramento River and Big Chico Creek	Muskingum	6	0.2	1	6
193 Confluence of Sacramento River and Big Chico Creek	190 Confluence of Sacramento River and Stony Creek	Muskingum	1	0.2	0.7	0.7
499 Black Butte Reservoir	420 Black Butte outflow	No Routing	–	–	–	–
420 Black Butte outflow	400 UNET handoff point on Stony Creek	Muskingum	5	0.2	2	10
400 UNET handoff point on Stony Creek	190 Confluence of Sacramento River and Stony Creek	No Routing	–	–	–	–
190 Confluence of Sacramento River and Stony Creek	184 Sacramento River at Ord Ferry	No Routing	–	–	–	–
190 Confluence of Sacramento River and Stony Creek	Out of System	Diversion Routing on DR, QS, and QD cards	–	–	–	–
184 Sacramento River at Ord Ferry	169 Sacramento River at Butte City	No Routing	–	–	–	–
184 Sacramento River at Ord Ferry	1184 Dummy Reservoir to route Sacramento River at Ord Ferry overflow to Butte Basin subdivision	Diversion Routing on DR, QS, and QD cards	–	–	–	–
1184 Dummy Reservoir to route Sacramento River at Ord Ferry overflow to Butte Basin subdivision	2184 Ord-end	Muskingum	10	0.1	4	40
169 Sacramento River at Butte City	158 Moulton Weir	Muskingum	4	0.2	2	8
158 Moulton Weir	146 Colusa Weir	No Routing	–	–	–	–
158 Moulton Weir	1158 Dummy Reservoir to receive Moulton Weir diversion	Diversion Routing on DR, QS, and QD cards	–	–	–	–
1158 Dummy Reservoir to receive Moulton Weir diversion	2158 Weir-end	Muskingum	5	0.1	4	20
146 Colusa Weir	143 UNET handoff point on Colusa Weir	No Routing	–	–	–	–
146 Colusa Weir	1146 Dummy Reservoir to receive diversions to Colusa Weir	No Routing	–	–	–	–
1146 Dummy Reservoir to receive diversions to Colusa Weir	2146 Weir-end	Muskingum	4	0.1	4	16
143 UNET handoff point on Colusa Weir	119 Tisdale Weir	Muskingum	4	0.25	2	8
119 Tisdale Weir	83 Confluence of Sacramento River and Feather River	No Routing	–	–	–	–

Note: Prior to use and application, reference the "Expectations of Use" preface.

TABLE III-4 (CONT.)
HEC-5 LOWER BASIN ROUTING PARAMETERS FOR THE SACRAMENTO RIVER
BASIN

From Node	To Node	Routing Type	Number of Sub-reaches	Muskingum X	Travel Time per Subreach (hrs)	Total Travel Time (hrs)
119 Tisdale Weir	1119 Dummy Reservoir to receive diversions to Tisdale Weir	Diversion Routing on DR, QS, and QD cards	–	–	–	–
1119 Dummy Reservoir to receive diversions to Tisdale Weir	2119 End of Tisdale Weir	Muskingum	6	0.2	2	12
2119 End of Tisdale Weir	1500 Sutter Bypass	No Routing	–	–	–	–
2184 Ord-end	2222 Dummy Reservoir to receive flows from Moulton and Colusa Weirs and Ord Ferry overflow	No Routing	–	–	–	–
2158 Weir-end	2222 Dummy Reservoir to receive flows from Moulton and Colusa Weirs and Ord Ferry overflow	No Routing	–	–	–	–
2146 Weir-end	2222 Dummy Reservoir to receive flows from Moulton and Colusa Weirs and Ord Ferry overflow	No Routing	–	–	–	–
2222 Dummy Reservoir to receive flows from Moulton and Colusa Weirs and Ord Ferry overflow	2000 Butte Slough near Meridian	No Routing	–	–	–	–
2111 Dummy Reservoir to receive Butte Creek near Chico	2100 UNET handoff point on Butte Creek	No Routing	–	–	–	–
2100 UNET handoff point on Butte Creek	2000 Butte Slough near Meridian	Muskingum	21	0.2	1	21
2000 Butte Slough near Meridian	1500 Sutter Bypass	Muskingum	8	0.2	2	16
1500 Sutter Bypass	83 Confluence of Sacramento River and Feather River	Muskingum	2	0.2	2	4
599 Oroville Dam	560 UNET handoff point for Feather River at Thermalito	No Routing	–	–	–	–
560 UNET handoff point for Feather River at Thermalito	551 Feather River at Gridley	No Routing	–	–	–	–
551 Feather River at Gridley	550 UNET handoff point for Feather River at Gridley	Muskingum	3	0.2	1	3
550 UNET handoff point for Feather River at Gridley	540 Confluence of Feather River and Honcut Creek	Muskingum	1	0.17	1	1
545 Dummy Reservoir to receive Feather River local	543 UNET handoff point for Feather River local	No Routing	–	–	–	–
543 UNET handoff point for Feather River local	540 Confluence of Feather River and Honcut Creek	No Routing	–	–	–	–
540 Confluence of Feather River and Honcut Creek	528 Feather River at Yuba City	Muskingum	2	0.17	2	4
528 Feather River at Yuba City	527 Confluence of Feather River and Yuba River	No Routing	–	–	–	–
699 Bullards Bar Reservoir (North Fork Yuba River)	690 Confluence of North Fork Yuba River and Middle Fork Yuba River	Muskingum	1	0.15	1	1

Note: Prior to use and application, reference the “Expectations of Use” preface.

TABLE III-4 (CONT.)
HEC-5 LOWER BASIN ROUTING PARAMETERS FOR THE SACRAMENTO RIVER BASIN

From Node	To Node	Routing Type	Number of Sub-reaches	Muskingum X	Travel Time per Subreach (hrs)	Total Travel Time (hrs)
690 Confluence of North Fork Yuba River and Middle Fork Yuba River	680 Confluence of Middle Fork Yuba River and South Fork Yuba River	Muskingum	3	0.15	1	3
680 Confluence of Middle Fork Yuba River and South Fork Yuba River	675 Englebright Dam	No Routing	–	–	–	–
675 Englebright Dam	673 UNET handoff point at Englebright Dam	Muskingum	1	0.15	1	1
673 UNET handoff point at Englebright Dam	665 Confluence of Yuba River and Deer Creek	No Routing	–	–	–	–
670 Dummy Reservoir to receive Deer Creek	668 UNET handoff point for Deer Creek	No Routing	–	–	–	–
668 UNET handoff point for Deer Creek	665 Confluence of Yuba River and Deer Creek	No Routing	–	–	–	–
665 Confluence of Yuba River and Deer Creek	660 Yuba River below Deer Creek	No Routing	–	–	–	–
660 Yuba River below Deer Creek	650 Confluence of Yuba River and Dry Creek	Muskingum	2	0.15	1	2
655 Dummy Reservoir to receive Dry Creek	652 UNET handoff point for Dry Creek near Yuba	No Routing	–	–	–	–
652 UNET handoff point for Dry Creek near Yuba	650 Confluence of Yuba River and Dry Creek	No Routing	–	–	–	–
650 Confluence of Yuba River and Dry Creek	601 Gage at Yuba River near Marysville	Muskingum	2	0.15	0.75	1.5
601 Gage at Yuba River near Marysville	527 Confluence of Feather River and Yuba River	Muskingum	1	0.15	1	1
527 Confluence of Feather River and Yuba River	512 Confluence of Bear Creek and Feather River	Muskingum	8	0.35	1	8
520 Dummy Reservoir to receive Bear Creek	518 UNET handoff point for Bear Creek	No Routing	–	–	–	–
518 UNET handoff point for Bear Creek	514 Confluence of Bear Creek and Dry Creek	Muskingum	2	0.2	1	2
516 Dummy Reservoir to receive Dry Creek near Wheatland	515 UNET handoff point for Dry Bear	No Routing	–	–	–	–
515 UNET handoff point for Dry Bear	514 Confluence of Dry and Bear Creeks	Muskingum	2	0.2	1	2
514 Confluence of Dry and Bear Creeks	512 Confluence of Bear Creek and Feather River	Muskingum	2	0.2	1	2
512 Confluence of Bear Creek and Feather River	510 Feather River near Nicolaus	Muskingum	2	0.35	1	2
510 Feather River near Nicolaus	83 Confluence of Sacramento River and Feather River	Muskingum	2	0.2	2	4

Note: Prior to use and application, reference the "Expectations of Use" preface.

TABLE III-4 (CONT.)
HEC-5 LOWER BASIN ROUTING PARAMETERS FOR THE SACRAMENTO RIVER
BASIN

From Node	To Node	Routing Type	Number of Sub-reaches	Muskingum X	Travel Time per Subreach (hrs)	Total Travel Time (hrs)
83 Confluence of Sacramento River and Feather River	82 Fremont Weir	No Routing	–	–	–	–
82 Fremont Weir	64 Confluence of Sacramento River and American River	Muskingum	4	0.2	2	8
82 Fremont Weir	1082 Weir-rout	No Routing	–	–	–	–
1082 Weir-rout	3333 Dummy Reservoir for start of Yolo Bypass	Muskingum	3	0.2	2	6
799 Folsom Dam	780 American River at Fair Oaks	Muskingum	2	0.4	1	2
780 American River at Fair Oaks	775 UNET handoff point for American River at Fair Oaks	No Routing	–	–	–	–
775 UNET handoff point for American River at Fair Oaks	770 American River at H Street Gage	Muskingum	2	0.2	2	4
770 American River at H Street Gage	64 Confluence of Sacramento River and American River	Muskingum	1	0.2	2	2
64 Confluence of Sacramento River and American River	63 Sacramento Weir on Sacramento River	No Routing	–	–	–	–
63 Sacramento Weir on Sacramento River	60 Sacramento River at I Street Gage	Muskingum	2	0.2	2.5	5
63 Sacramento Weir on Sacramento River	3080 Yolo Bypass at I-80 Causeway	No Routing	–	–	–	–
60 Sacramento River at I Street Gage	48 Sacramento River at Freeport	Muskingum	4	0.2	2	8
48 Sacramento River at Freeport	12 Confluence of Sacramento River and Yolo Bypass at Rio Vista Gage	Muskingum	4	0.2	2	8
3333 Dummy Reservoir for start of Yolo Bypass	3300 Confluence of Colusa Drain and Fremont Weir	No Routing	–	–	–	–
3300 Confluence of Colusa Drain and Fremont Weir	3200 Yolo Bypass near Woodland	Muskingum	1	0.2	2	2
398 Clear Lake Reservoir	397 Cache Creek near Lower Lake	No Routing	–	–	–	–
397 Cache Creek near Lower Lake	396 Cache Creek at Rumsey	Muskingum	8	0.28	1	8
399 Indian Valley Reservoir	396 Cache Creek at Rumsey	Muskingum	7	0.2	1	7
396 Cache Creek at Rumsey	3955 Cache Creek at Capay	Muskingum	3	0.3	1	3
3955 Cache Creek at Capay	395 Cache Creek at Yolo	Muskingum	7	0.2	1	7
395 Cache Creek at Yolo	394 UNET handoff point at Cache Creek Settling Basin	No Routing	–	–	–	–
394 UNET handoff point at Cache Creek Settling Basin	3200 Yolo Bypass near Woodland	No Routing	–	–	–	–
3200 Yolo Bypass near Woodland	3080 Yolo Bypass at I-80 Causeway	Muskingum	1	0.2	1	1
3080 Yolo Bypass at I-80 Causeway	3020 Confluence of Yolo Bypass and Putah Creek	Muskingum	3	0.2	2	6
099 Lake Berryessa and Monticello Dam	80 Putah Diversion Dam	Muskingum	1	0	3	3

Note: Prior to use and application, reference the "Expectations of Use" preface.

**TABLE III-4 (CONT.)
HEC-5 LOWER BASIN ROUTING PARAMETERS FOR THE SACRAMENTO RIVER
BASIN**

From Node	To Node	Routing Type	Number of Sub-reaches	Muskingum X	Travel Time per Subreach (hrs)	Total Travel Time (hrs)
80 Putah Diversion Dam	075 Putah Creek near Winters	Muskingum	1	0	24	24
80 Putah Diversion Dam	Out of System	Diversion Routing on DR, QS, and QD cards	-	-	-	-
075 Putah Creek near Winters	65 UNET handoff point for Putah Creek southeast of Davis	No Routing	-	-	-	-
65 UNET handoff point for Putah Creek southeast of Davis	3020 Confluence of Yolo Bypass and Putah Creek	No Routing	-	-	-	-
3020 Confluence of Yolo Bypass and Putah Creek	3012 Yolo Bypass at Lisbon	No Routing	-	-	-	-
3012 Yolo Bypass at Lisbon	12 Confluence of Sacramento River and Yolo Bypass at Rio Vista Gage	Muskingum	8	0.2	2	16
12 Confluence of Sacramento River and Yolo Bypass at Rio Vista Gage	999 End of Project	No Routing	-	-	-	-

Note: Prior to use and application, reference the "Expectations of Use" preface.

TABLE III-5
HEC-5 LOWER BASIN ROUTING PARAMETERS FOR THE SAN JOAQUIN RIVER
BASIN

From Node	To Node	Routing Type	Number of Sub-reaches	Muskingum X	Travel Time per Subreach (hrs)	Total Travel Time (hrs)
369 Pine Flat Reservoir	360 Intersection of Kings River and Friant Kern Canal	Muskingum	1	0.2	2	2
360 Intersection of Kings River and Friant Kern Canal	3350 Information point Inflow to Army Weir	Muskingum	4	0.1	5	20
3350 Information point Inflow to Army Weir	350 Army Weir	No Routing	–	–	–	0
350 Army Weir	3340 Information point Inflow to Crecent Weir	Muskingum	2	0.1	4	8
3340 Information point Inflow to Crecent Weir	340 Crescent Weir	No Routing	–	–	–	0
340 Crescent Weir	330 James Bypass	Muskingum	30	0.15	1	30
330 James Bypass	333 UNET handoff point for James Bypass	Muskingum	2	0.2	1.5	3
333 UNET handoff point for James Bypass	205 Mendota Gage	Muskingum	10	0.2	1	10
497 Big Dry Creek Dam and Diversion	496 Little Dry Creek at Wasteway	Muskingum	1	0.25	1	1
496 Little Dry Creek at Wasteway	216 UNET handoff point on Little Dry Creek	Muskingum	1	0.25	1	1
216 UNET handoff point on Little Dry Creek	250 Confluence of San Joaquin River and Little Dry Creek	No Routing	–	–	–	–
270 Friant Dam	260 UNET point Confluence of Friant Releases and Cottonwood Creek	No Routing	–	–	–	–
260 UNET point Confluence of Friant Releases and Cottonwood Creek	250 Confluence of San Joaquin River and Little Dry Creek	Muskingum	3	0.25	1	3
250 Confluence of San Joaquin River and Little Dry Creek	215 San Joaquin River at Gravelly Ford	Muskingum	32	0.2	1	32
215 San Joaquin River at Gravelly Ford	445 Information Point for Inflow to Chowchilla Bypass junction	Muskingum	14	0.15	1	14
445 Information Point for Inflow to Chowchilla Bypass junction	452 Junction of Chowchilla Bypass and San Joaquin River	No Routing	–	–	–	–
452 Junction of Chowchilla Bypass and San Joaquin River	1452 Dummy Reservoir to receive Diversions from San Joaquin River to Chowchilla Bypass	No Routing	–	–	–	–
452 Junction of Chowchilla Bypass and San Joaquin River	450 San Joaquin below Diversion	No Routing	–	–	–	–
450 San Joaquin below Diversion	205 Mendota Gage	Muskingum	14	0.15	1	14

Note: Prior to use and application, reference the “Expectations of Use” preface.

TABLE III-5 (CONT.)
HEC-5 LOWER BASIN ROUTING PARAMETERS FOR THE SAN JOAQUIN RIVER
BASIN

From Node	To Node	Routing Type	Number of Sub-reaches	Muskingum X	Travel Time per Subreach (hrs)	Total Travel Time (hrs)
1452 Dummy Reservoir to receive Diversions from San Joaquin River to Chowchilla Bypass	436 Intersection of Chowchilla Bypass with Fresno River	Muskingum	6	0.1	2	12
205 Mendota Gage	433 El Nido	Muskingum	22	0.17	2	44
499 Hidden Dam Hensley Lake (Fresno River)	416 Fresno River at Madera Canal	Muskingum	4	0.2	1	4
416 Fresno River at Madera Canal	426 UNET handoff point on the Fresno River	Muskingum	7	0.2	2	14
426 UNET handoff point on the Fresno River	436 Fresno River at Chowchilla Bypass	Muskingum	4	0.2	2	8
436 Fresno River at Chowchilla Bypass	435 Intersection of Chowchilla River and Chowchilla Bypass	Muskingum	3	0.25	2	6
498 Buchanan Dam (Chowchilla River)	418 Chowchilla River at Madera Canal	Muskingum	2	0.2	2	4
418 Chowchilla River at Madera Canal	1418 Bifurcation to Ash and Brenda Sloughs	No Routing	–	–	–	–
1418 Bifurcation to Ash and Brenda Sloughs	1419 Dummy Reservoir to receive diversions to Ash Slough	No Routing	–	–	–	–
1418 Bifurcation to Ash and Brenda Sloughs	428 UNET handoff point on Brenda Slough	Muskingum	5	0.2	2	10
1419 Dummy Reservoir to receive diversions to Ash Slough	1428 UNET handoff point on Ash Slough	Muskingum	7	0.2	2	14
428 UNET handoff point on Brenda Slough	435 Chowchilla River at Chowchilla Bypass	Muskingum	3	0.2	2	6
1428 UNET handoff point on Ash Slough	435 Chowchilla River at Chowchilla Bypass	Muskingum	3	0.2	2	6
435 Chowchilla River at Chowchilla Bypass	433 El Nido	Muskingum	4	0.2	2	8
433 El Nido	422 Eastside Bypass/Mariposa Bypass Confluence	Muskingum	10	0.2	2	20
422 Eastside Bypass/Mariposa Bypass Confluence	1422 Diversion from Eastside Bypass to Mariposa Bypass	No Routing	–	–	–	–
422 Eastside Bypass/Mariposa Bypass Confluence	402 Eastside Bypass minus Mariposa Bypass plus Mariposa Bypass plus Owens	Muskingum	1	0.3	1	1
1422 Diversion from Eastside Bypass to Mariposa Bypass	147 Confluence of Mariposa Bypass with San Joaquin River	Muskingum	2	0.2	1	2
147 Confluence of Mariposa Bypass with San Joaquin River	136 San Joaquin River near Stevinson	Muskingum	3	0.2	2	6
66 Owens Reservoir	166 Owens Diversion	Muskingum	4	0.3	1	4
88 Mariposa Reservoir	188 Confluence of Mariposa Releases with Owens Diversion flow	Muskingum	6	0.3	1	6
44 Dummy Reservoir to receive Miles Creek	144 Confluence with Miles Creek	Muskingum	10	0.2	1	10

Note: Prior to use and application, reference the "Expectations of Use" preface.

TABLE III-5 (CONT.)
HEC-5 LOWER BASIN ROUTING PARAMETERS FOR THE SAN JOAQUIN RIVER
BASIN

From Node	To Node	Routing Type	Number of Sub-reaches	Muskingum X	Travel Time per Subreach (hrs)	Total Travel Time (hrs)
22 Burns Reservoir	123 Confluence of Burns with Black Rascal Diversion Inflow	Muskingum	8	0.3	1	8
33 Bear Reservoir	123 Confluence of Burns with Black Rascal Diversion Inflow	Muskingum	8	0.3	1	8
166 Owens Diversion	188 Confluence with Owens Diversion	Muskingum	1	0.2	1	1
188 Confluence of Owens Diversion	195 Confluence with Deadman	Muskingum	12	0.2	1	12
195 Confluence with Deadman	198 UNET handoff point on Mariposa Creek	Muskingum	14	0.2	1	14
198 UNET handoff point on Mariposa Creek	402 Eastside Bypass minus Mariposa Bypass plus Mariposa Bypass plus Owens	No Routing	–	–	–	0
144 Confluence of Miles Creek	154 UNET handoff point on Owens Creek	Muskingum	10	0.2	1	10
154 UNET handoff point on Owens Creek	402 Confluence of Eastside Bypass with Mariposa and Owens	No Routing	–	–	–	0
402 Confluence of Eastside Bypass with Mariposa and Owens	401 Confluence of Eastside Bypass with Bear and Burns	Muskingum	3	0.2	1	3
123 Confluence of Burns with Black Rascal Diversion Inflow	133 Bear Creek at Mckee Road	Muskingum	3	0.3	1	3
133 Bear Creek at Mckee Road	143 UNET handoff point on Bear Creek	Muskingum	9	0.2	2	18
143 UNET handoff point on Bear Creek	401 Confluence of Eastside Bypass with Bear and Burns	Muskingum	3	0.2	2	6
401 Confluence of Eastside Bypass with Bear and Burns	136 San Joaquin River near Stevinson	Muskingum	2	0.2	1	2
136 San Joaquin River near Stevinson	121 San Joaquin River near Newman	Muskingum	16	0.2	2	32
599 Los Banos Reservoir	590 Los Banos Creek at SFG	Muskingum	4	0.2	2.5	10
590 Los Banos Creek at SFG	585 Los Banos Creek below SFG	No Routing				0
585 Los Banos Creek below SFG	580 UNET handoff point on Los Banos Creek	Muskingum	5	0.2	2.5	12.5
580 UNET handoff point on Los Banos Creek	121 San Joaquin River near Newman	No Routing	–	–	–	0
699 New Exchequer Dam/Lake McClure	690 Merced River at Cressey	Muskingum	10	0.2	2	20
690 Merced River at Cressey	685 UNET handoff point on Merced River below Cressey	Muskingum	2	0.2	1.75	3.5
685 UNET handoff point on Merced River below Cressey	680 UNET handoff point on Merced River near Stevinson	Muskingum	4	0.2	2	8

Note: Prior to use and application, reference the "Expectations of Use" preface.

TABLE III-5 (CONT.)
HEC-5 LOWER BASIN ROUTING PARAMETERS FOR THE SAN JOAQUIN RIVER
BASIN

From Node	To Node	Routing Type	Number of Sub-reaches	Muskingum X	Travel Time per Subreach (hrs)	Total Travel Time (hrs)
680 UNET handoff point on Merced River near Stevinson	121 San Joaquin River near Newman	Muskingum	11	0.2	1	11
121 San Joaquin River near Newman	1211 Confluence with Orestimba Creek	Muskingum	5	0.15	1	5
1214 Dummy Reservoir to receive Orestimba Creek	1213 UNET handoff point on Orestimba Creek	Muskingum	10	0.1	1	10
1213 UNET handoff point on Orestimba Creek	1211 Confluence with Orestimba Creek	No Routing	–	–	–	0
1211 Confluence with Orestimba Creek	1212 Confluence with Del Puerto Creek	Muskingum	5	0.15	1	5
1222 Dummy Reservoir to receive Del Puerto Creek	1221 UNET handoff point on Del Puerto Creek	Muskingum	5	0.2	1.1	5.5
1221 UNET handoff point on Del Puerto Creek	1212 Confluence with Del Puerto Creek	No Routing	–	–	–	0
1212 Confluence with Del Puerto Creek	120 San Joaquin River at Maze Road Bridge	Muskingum	5	0.15	2	10
799 Don Pedro Dam on Tuolumne River	795 UNET handoff point on Tuolumne River at Santa Fe Avenue	Muskingum	9	0.1	2	18
792 Dummy Reservoir to receive Dry Creek near Modesto	791 UNET handoff point on Dry Creek near Modesto	No Routing	–	–	–	0
791 UNET handoff point on Dry Creek near Modesto	790 Tuolumne River at Modesto	Muskingum	2	0.2	1	2
795 UNET handoff point on Tuolumne River at Santa Fe Avenue	790 Tuolumne River at Modesto	Muskingum	2	0.15	1	2
790 Tuolumne River at Modesto	780 UNET handoff point on Tuolumne River at Modesto	No Routing	–	–	–	0
780 UNET handoff point on Tuolumne River at Modesto	120 San Joaquin River at Maze Road Bridge	Muskingum	4	0.15	2	8
120 San Joaquin River at Maze Road Bridge	119 San Joaquin River near Vernalis	Muskingum	4	0.15	2	8
899 New Melones Reservoir on Stanislaus River	8998 Intermediate point between Melones and Tulloch (local flow input point)	No Routing	–	–	–	0
8998 Intermediate point between Melones and Tulloch (local flow input point)	898 Tulloch Reservoir on Stanislaus River downstream from Melones	No Routing	–	–	–	0
898 Tulloch Reservoir on Stanislaus River downstream from Melones	890 Stanislaus River at Orange Blossom Bridge	Muskingum	2	0.2	2	4
890 Stanislaus River at Orange Blossom Bridge	889 UNET handoff point on Stanislaus River at Orange Blossom Bridge	No Routing	–	–	–	0
889 UNET handoff point on Stanislaus River at Orange Blossom Bridge	880 Stanislaus River at Ripon	Muskingum	5	0.1	3	15

Note: Prior to use and application, reference the "Expectations of Use" preface.

TABLE III-5 (CONT.)
HEC-5 LOWER BASIN ROUTING PARAMETERS FOR THE SAN JOAQUIN RIVER BASIN

From Node	To Node	Routing Type	Number of Sub-reaches	Muskingum X	Travel Time per Subreach (hrs)	Total Travel Time (hrs)
880 Stanislaus River at Ripon	879 UNET handoff point on Stanislaus River at Ripon	No Routing	–	–	–	0
879 UNET handoff point on Stanislaus River at Ripon	119 San Joaquin River near Vernalis	Muskingum	8	0.2	2	16
119 San Joaquin River near Vernalis	115 San Joaquin River at I-5	Muskingum	6	0.2	2	12
115 San Joaquin River at I-5	110 San Joaquin River at Stockton	Muskingum	7	0.2	2	14
99 Dummy Reservoir to bring in Duck Creek flow	996 Intermediate point	No Routing	–	–	–	0
996 Intermediate point	65 Duck Creek Diversion	No Routing	–	–	–	0
65 Duck Creek Diversion	23 UNET handoff point FCS	Muskingum	6	0.2	1	6
65 Duck Creek Diversion	665 Duck Creek Diversion to Littlejohn Creek at Farmington	No Routing	–	–	–	0
665 Duck Creek Diversion to Littlejohn Creek at Farmington	25 Littlejohn Creek at Farmington Reservoir	Muskingum	1	0.2	1	1
10 Farmington Reservoir	25 Littlejohn Creek at Farmington Reservoir	Muskingum	1	0.3	1.6	1.67
25 Littlejohn Creek at Farmington Reservoir	24 Lone Tree	Muskingum	6	0.2	1	6
24 Lone Tree	23 UNET handoff point FCS	Muskingum	1	0.2	1	1
23 UNET handoff point FCS	110 San Joaquin River at Stockton	No Routing	–	–	–	0
110 San Joaquin River at Stockton	105 Terminus	Muskingum	5	0.2	1	5
105 Terminus	999 Nirvana	No Routing	–	–	–	0

Local Flows

Local flows are unregulated tributaries that join with larger tributaries between reservoirs in series or between a flood damage reduction reservoir and its objective flow location. In this study, local flows were modeled in one of two ways. Hydrographs for local flows were either produced through procedures outlined in Attachment B - Synthetic Hydrology or local flows were estimated as a percentage or ratio of a nearby natural flow hydrograph. Percentages were estimated based on comparisons of short duration maxima (peak, 1-, and 3-day) for the local and nearby natural hydrographs.

These local flows were input into the HEC-5 model and influenced reservoir outflows by filling some or all of the downstream channel capacity.

The natural flow hydrographs to which these ratios were applied are provided in the column titled ‘Source’ in Tables III-6 and III-7.

Note: Prior to use and application, reference the “Expectations of Use” preface.

Starting Storage

During model simulations the initial starting storages are set at the top of conservation for all flood damage reduction projects. Top of conservation values for projects with established credit space scenarios are computed as an interim process between simulations of the headwater and lower basin models. The top of conservation parameter is therefore variable with each iterative time-step simulation of the lower basin reservoirs that operate with formal credit space agreements.

Simulation Product

The lower basin simulation is the final step in translating the seven synthetic exceedence frequency natural-flow hydrographs, produced in the Synthetic Hydrology Study (Appendix B), to seven simulated regulated outflow hydrographs. In the Comprehensive Study modeling procedure, these results provide the hydrologic input for hydraulic models, which perform detailed routing of the flows through floodplain areas. Floodplains are delineated and stage-frequency information is passed to economic modelers for use in determining damages associated with the occurrence of each of the seven synthetic exceedence frequency events.

TABLE III-6
LOCAL FLOW ASSUMPTIONS FOR THE SACRAMENTO RIVER BASIN

Location	Ratio	Source
Watershed area below Shasta, Whiskeytown, and gage locations on Cow, Cottonwood, and Battle Creeks and above Bend Bridge	0.47	Combined flows of Cow, Cottonwood, and Battle Creek gages
Watershed area below Bend Bridge, Black Butte Reservoir, and gage locations on Mill, Elder, Thomes, Deer, and Big Chico Creeks and above Ord Ferry	0.55	Combined flows of Mill, Elder, Thomes, Deer, and Big Chico Creek gages
Honcut Creek at Feather River	0.0925	Feather River natural flow at Oroville Dam
Watershed area between New Bullards Bar, the Our House gage, Jones Bar gage, and the Yuba River below Englebright Dam	0.28	New Bullards Bar inflow
Dry Creek near Browns Valley (Yuba River)	1	Deer Creek near Smartsville
Dry Creek at the Bear River near Wheatland	0.15	Bear River natural flow near Wheatland
Watershed area between the Grigsby Riffles and Cache Creek near Lower Lake gage	0.13	Indian Valley inflow
Watershed area between Cache Creek near Lower Lake gage, Indian Valley Reservoir, and Cache Creek at Rumsey	1.65	Indian Valley inflow
Watershed area between Cache Creek at Rumsey and Cache Creek at Capay	0.4	Indian Valley inflow
Note: The following local flow streams were investigated in the Synthetic Hydrology. Therefore, no local flow ratios were needed for Cow Creek, Cottonwood Creek, Battle Creek, Mill Creek, Elder Creek, Thomes Creek, Deer Creek (near Vina), Big Chico Creek, and Deer Creek (near Smartsville).		

Note: Prior to use and application, reference the "Expectations of Use" preface.

TABLE III-7
LOCAL FLOW ASSUMPTIONS FOR THE SAN JOAQUIN RIVER BASIN

Location	Ratio	Source
Mill and Hughes Creeks, Kings River Basin	0.1	Kings River natural flow at Pine Flat Dam
Little Dry Creek at confluence with San Joaquin River	0.95	Big Dry Creek reservoir inflow
Cottonwood Creek at confluence with San Joaquin River	0.25	Big Dry Creek reservoir inflow
Watershed area between Hidden Dam (Hensley Lake) and Madera Canal	0.1	Hensley Lake inflow
Watershed area between Buchanan Dam (H.V. Eastman Lake) and Madera Canal	0.1	Eastman Lake inflow
Miles Creek at confluence with Owens Creek	0.7	Owens inflow
Watershed area between Owens and Mariposa Dams and the confluence of Owens Diversion	0.28	Owens inflow
Deadman and Dutchman Creeks and watershed area between Owens Diversion and Deadman confluence	2.2	Owens inflow
Watershed area between Owens Creek at the Miles confluence and the Eastside Bypass	0.25	Owens inflow
Black Rascal Creek at Diversion	0.53	Burns inflow
Watershed area between Burns and Bear Dams and McKee Road	0.3	Bear inflow
Watershed area between McKee Road and Bear Creek near the Eastside Bypass	0.2	Bear inflow
Watershed area between Los Banos Reservoir and Los Banos Creek below the Santa Fe Grade	0.2	Los Banos inflow
Dry Creek at the Merced River	0.07	New Exchequer inflow
Watershed area between New Melones and Tulloch Reservoirs on the Stanislaus River	0.07	Stanislaus River natural flow at New Melones Dam
Watershed area between Tulloch Dam and the Stanislaus River at Orange Blossom Bridge	0.01	Stanislaus River natural flow at New Melones Dam
Watershed area between Duck Creek near Farmington Gage and the Duck Creek Diversion	2.4	Duck Creek near Farmington gage site
Watershed area between Farmington Dam and the confluence of Littlejohn Creek and the Duck Creek Diversion	0.04	Farmington inflow
Lone Tree Creek at Littlejohn Creek	0.68	Duck Creek near Farmington gage site
Deer Creek at the confluence with the Cosumnes River	0.07	Natural flow for the Cosumnes River at Michigan Bar
Dry Creek near Galt	0.4	Natural flow for the Cosumnes River at Michigan Bar
Note: Dry Creek (near Modesto) was analyzed in the Synthetic Hydrology. Therefore, no local flow ratio was needed for this stream.		

Note: Prior to use and application, reference the "Expectations of Use" preface.

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CHAPTER IV

MODEL CALIBRATION AND VERIFICATION

GENERAL

Models for flood damage reduction projects were calibrated individually using the 1997 and 1995 flood events. The key calibration variable was related to gate operations, specifically the Recession Constant. For additional verification, HEC-5 flood simulations were performed through the routing of historic or design events published in each reservoir's Water Control Manual. The results were then compared with manual routings based on the emergency spillway release diagram (ESRD). The Recession Constant was adjusted iteratively until results reflected ESRD operations as closely as possible.

Verification and calibration of these models was unique in that the modeling goal was not to reflect recorded history. Instead, modeling sought to portray "by the book" operations. As severe floods dictate event-specific operations, an ideal verification data set does not exist. Modelers inspected simulation results to confirm agreement with operations under existing conditions for headwater and flood damage reduction projects.

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CHAPTER V

BASELINE MODELING RESULTS AND DISCUSSION

OVERVIEW

Generally, model output is in good agreement on by the book operations (see Figures C.1-1a to C.2-9). Reservoir operations for downstream local flow at the first operational point are excellent. Models did experience some difficulty simulating systems with multiple operational points where one or more points were located a long distance from the reservoir (i.e., Black Butte operating for Ord Ferry or Friant Dam operating for flows at Mendota).

For some reservoirs, the design structure and capabilities of HEC-5 limited the accuracy of model simulations. This was true in the modeling of gated spillway operations. HEC-5 was not designed to reflect all details of complicated ESRD's, but the model did perform acceptably for all facilities and often produced results in excellent agreement with manual routings.

The focus on by the book operations was needed to reflect baseline conditions, but could actually mask existing problems. For example, flood releases on Stony Creek and the Mokelumne River create erosion and conveyance problems below design levels of channel capacity. As simulations are performed with the full design capacity as a variable, HEC-5 results (by design) will not illustrate these problems. In the Comprehensive Study, reservoir simulation results provide input data for hydraulic models that execute detailed routings of river reaches downstream of the reservoirs. The hydraulic models may draw attention to the problems, but the efforts of the Comprehensive Study must consider the potential masking of problems through modeling procedures.

The remainder of this section is formatted as a series of short discussions for each major tributary in a north to south progression. Tables V-1 and V-2 provide data detailing the simulated influence of headwater reservoirs. Simulation results for all tributaries are available in Attachment C.1 - Controlling Reservoirs and Attachment C.2 – Downstream Control Points.

Note: Prior to use and application, reference the "Expectations of Use" preface.

TABLE V-1
EFFECTS OF HEADWATER REGULATIONS - SACRAMENTO BASIN

Sacramento Basin					
Annual Percent Chance Exceedence		Reservoir			
		Shasta	Black Butte	Oroville	Folsom
50%	% Peak Reduced	2.8	20.3	11.1	9.5
	Total Volume Captured (ac-ft)	5,086	616	-43,804	-47,274
10%	% Peak Reduced	1.8	20.3	15.4	12.6
	Total Volume Captured (ac-ft)	11,038	616	113,360	53,230
4%	% Peak Reduced	1.9	15.7	15.0	11.5
	Total Volume Captured (ac-ft)	12,325	900	183,292	98,391
2%	% Peak Reduced	1.8	11.0	13.6	11.0
	Total Volume Captured (ac-ft)	13,156	1,788	214,465	133,284
1%	% Peak Reduced	1.8	8.6	12.6	10.8
	Total Volume Captured (ac-ft)	13,876	2,370	264,970	160,276
0.5%	% Peak Reduced	-0.2	8.4	12.3	10.6
	Total Volume Captured (ac-ft)	14,532	2,913	314,175	170,907
0.2%	% Peak Reduced	0.9	8.3	12.3	9.8
	Total Volume Captured (ac-ft)	14,842	3,528	369,800	172,366

Notes:

a) % Peak Reduced = ((Maximum Unregulated Inflow)-(Maximum Regulated Inflow))/(Maximum Unregulated Inflow) X 100%

b) Total Volume Captured = (Total Unregulated Inflow - Total Regulated Inflow)*30 days *(1.98 ac-ft/day/cfs)

Note: Prior to use and application, reference the "Expectations of Use" preface.

TABLE V-2
EFFECTS OF HEADWATER REGULATIONS - SAN JOAQUIN BASIN

San Joaquin Basin					
Annual Percent Chance Exceedence		Reservoir			
		Pine Flat	Friant	Don Pedro	New Melones
50%	% Peak Reduced	3.9	45.4	33.4	25.7
	Total Volume Captured (ac-ft)	-35,326	-20,011	1,649	-2,158
10%	% Peak Reduced	8.1	60.8	37.2	28.5
	Total Volume Captured (ac-ft)	-23,858	21,710	65,537	46,283
4%	% Peak Reduced	8.9	51.7	28.5	26.6
	Total Volume Captured (ac-ft)	-12,600	92,259	87,224	71,355
2%	% Peak Reduced	9.1	52.8	27.0	22.9
	Total Volume Captured (ac-ft)	-2,836	129,133	97,058	81,439
1%	% Peak Reduced	9.3	49.3	24.5	22.2
	Total Volume Captured (ac-ft)	7,996	147,839	97,547	87,947
0.5%	% Peak Reduced	9.5	40.0	24.5	21.9
	Total Volume Captured (ac-ft)	20,191	166,735	97,634	94,493
0.2%	% Peak Reduced	9.6	39.3	21.2	20.7
	Total Volume Captured (ac-ft)	38,397	189,870	94,455	103,012

Notes:

a) % Peak Reduced = ((Maximum Unregulated Inflow)-(Maximum Regulated Inflow))/(Maximum Unregulated Inflow) X 100%

b) Total Volume Captured = (Total Unregulated Inflow - Total Regulated Inflow)*30 days *(1.98 ac-ft/day/cfs)

Note: Prior to use and application, reference the "Expectations of Use" preface.

SACRAMENTO BASIN RESULTS

Sacramento River at Shasta Dam

Headwaters

Four headwater reservoirs were modeled above Shasta (Lake Britton, Pit #6, Pit #7, and McCloud Reservoir). The starting storage for each of these reservoirs began near gross pool and all spilled heavily during simulations of each of the seven synthetic exceedence frequency events. The combined influence of these reservoirs on attenuating flood volumes was negligible.

Lower Basin

Shasta has 1.3 million acre-feet of flood control space and operates for the Sacramento River at Keswick (79,000 cfs) and Bend Bridge (100,000 cfs). Between Keswick and Bend Bridge there are several unregulated tributaries that generate significant inflows to the Sacramento mainstem. The influence of these tributaries is reflected in Shasta operations when Shasta is forced to lower releases while storage and inflow are increasing and flows are exceeding downstream operational limits. According to model simulations, Shasta offers protection to downstream areas for events occurring slightly more frequent than a 1-percent chance exceedence event.

Feather River at Oroville Dam

Headwaters

The reservoir system modeled above Oroville included 9 headwater reservoirs (Mountain Meadows, Almanor, Butt Valley, Antelope, Bucks Storage, Lake Davis, Frenchman, Little Grass Valley, and Sly Creek) with a combined gross pool storage of 1.8 million acre-feet. Nearly 400,000 acre-feet of this storage is vacant and active at the start of the flood simulations. The effects of the headwaters, while significant for all seven synthetic exceedence frequency events, were limited by the amount of natural flow regulated. Though only 20 percent of the full-basin natural flow hydrograph for the Feather River at Oroville Dam was routed through headwater reservoirs, average peak inflows to Oroville were reduced by 12.4 percent and 310,000 acre-feet (average) was captured by the headwater facilities during the simulation of 1-, 0.5-, and 0.2-percent chance exceedence events.

Lower Basin

Oroville Dam has a maximum flood control space of 750,000 acre-feet and operates for several locations within the Feather River basin, including points below the confluence of the Yuba and Bear rivers. Due to the release schedule, the presence of gated spillways on Oroville and New Bullards Bar (Yuba River), and the number of points and related tributaries, the Feather River system was among the most complex tributaries to model.

In the model, emergency releases (gated releases based on modeled ESRD criteria) at Oroville Dam tended to begin several hours prior to those computed during manual routings. Through the

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course of the routings, HEC-5 simulations tended to increase releases more slowly than rates observed in manual computations. However, peak outflows ended in good agreement.

Model results show that Oroville Dam is capable of routing the 1-percent chance exceedence event with a maximum storage of 3.4 million acre-feet (150,000 acre-feet below gross pool).

Yuba River above Marysville

The Yuba River system is unique in that the headwater reservoirs do not regulate watershed area above a flood damage reduction project. There are seven reservoirs above the City of Marysville. Six are included in the headwaters model (4 on the Middle and South Forks of the Yuba and 1 each on Deer and Dry Creeks). The only lower basin reservoir is New Bullards Bar, which is also the only reservoir above Marysville with flood control space. New Bullards Bar regulates the North Fork of the Yuba, which is otherwise unregulated. Its releases are influenced by the 6 headwater reservoirs through operational points located below the confluence of the regulated headwater sources.

Headwaters

The 6 headwater reservoirs above Marysville (Jackson Meadows, Bowman, Fordyce, Spaulding, Scotts Flat, and Merle Collins) have a combined gross pool storage of approximately 320,000 acre-feet. According to the starting storages, 90,000 acre-feet are vacant at the start of the simulations. Most of this storage is available in the 4 reservoirs that regulate the Middle and South Forks of the Yuba River.

Lower Basin

New Bullards Bar has 170,000 acre-feet of flood space and operates for several locations within the Yuba and Feather river basins. In accordance with the Water Control Manual, New Bullards Bar cuts back on releases when flows in the Feather River are high to assure that flows at the Yuba River's confluence with the Feather River do not exceed 300,000 cfs. This operation is performed despite the lower level of protection provided by New Bullards Bar (in comparison to Oroville), which, according to model results, is just below the 1-percent chance exceedence level.

New Bullards Bar also has a gated spillway. There were a few hours of releases above the objective flow at the dam (50,000 cfs) during simulations of the 2-percent chance exceedence event. These are not supported by manual routings, but are minor considering the complexities of the Feather -Yuba system.

American River above Folsom Dam

Headwaters

Five headwater reservoirs were modeled (French Meadows, Hell Hole, Loon Lake, Union Valley, and Ice House). These reservoirs have a combined gross pool storage of 660,000 acre-feet, of which 200,000 acre-feet remains vacant at the start of the flood simulations. Unlike many of the other basins, vacant storage was distributed proportionally amongst the American

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River headwater reservoirs. Facilities were all filled to between 54 and 85 percent of capacity. This balanced situation is reflected in simulations where only Union Valley reservoir, which receives a higher percentage of natural flow than the other four, spilled prior to the onset of the 1-percent chance exceedence event (and even while spilling, Union Valley reservoir significantly altered the flood hydrograph through surcharge storage). The combined effects of the headwater reservoirs, despite regulating only 14 percent of the full natural flow into Folsom Dam, reduced the peak inflow by an average of 10.4 percent and captured an average of 165,000 acre-feet during the critical 1-, 0.5-, and 0.2-percent chance exceedence simulations.

Lower Basin

According to the Water Control Diagram used in real-time operations, Folsom Reservoir has a maximum flood pool of 670,000 acre-feet. Folsom Dam does have a credit space agreement where up to 200,000 acre-feet of flood storage can be provided by a combination of available space in French Meadows, Hell Hole, and Union Valley reservoirs. All simulations of Folsom Dam were performed using outlet ratings that have been designed, but not yet implemented, by the Folsom Modifications portion of the ongoing American River Project. This aspect of the project has been authorized and is part of the future without-project conditions of the Comprehensive Study.

Gate operations at Folsom Dam were simulated with maximum releases capped at 160,000 cfs until a pool elevation of 470 feet was reached. Transitions from the design channel capacity of 115,000 cfs to 160,000 cfs were controlled by standard gate criteria of HEC-5. During the annual 1-percent chance exceedence event, these criteria briefly activated transitional flows before required by the ESRD. Although this led to a peak outflow slightly larger than 115,000 cfs, manual routings confirmed that Folsom Dam offers downstream areas a level of protection for the occurrence of events between a 1- and 0.5-percent chance exceedence. Comparisons of Comprehensive Study simulations and routings performed for the Folsom Modifications Study show simulated outflow hydrographs are consistent in magnitude and form. HEC-5 results display slightly lower peak outflows for the 0.5- and 0.2-percent chance exceedence events. This may be due to the detailed modeling of headwater reservoirs performed in this study.

SAN JOAQUIN BASIN RESULTS

Stanislaus River above Tulloch Dam

Headwaters

Three headwater reservoirs were modeled in the upper Stanislaus basin (New Spicer Meadows, Beardsley, and Donnell). The combined gross pool storage of these facilities is 320,000 acre-feet and, according to the starting storages, most of this space (170,000 acre-feet) is available in the rain flood season. New Spicer Meadows is a high elevation reservoir that regulates a small fraction of the natural flows in the Stanislaus watershed. This reservoir is primarily operated to fill during the snowmelt runoff and is relatively inactive during the winter months. New Spicer

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Meadows did not spill during simulations of any of the seven synthetic exceedence frequency events.

Beardsley and Donnell's regulate the Middle Fork of the Stanislaus River. Donnell's is located upstream of Beardsley and regulates 11 percent of the total natural flow. Beardsley further regulates that 11 percent and an additional 14 percent, which enters the Middle Fork between the two reservoirs. Due to this substantial portion of total natural flow, reservoir size, operations, and available storage, Beardsley spills in all events occurring less frequently than the 50-percent chance exceedence event. Donnell's closely follows suit, spilling in all events more severe than the 4-percent chance exceedence event. The combined effects of these reservoirs reduced the peak inflow by an average of 21.6 percent and captured an average of 95,000 acre-feet during simulations of the critical 1-, 0.5-, and 0.2-percent chance exceedence events.

Lower Basin

New Melones Reservoir has 450,000 acre-feet of flood space and an ungated spillway. Tulloch Reservoir, located just downstream of New Melones, contains only 10,000 acre-feet of flood space. The size discrepancy between the two reservoirs was evident in initial basin simulations. Releases from New Melones tended to quickly fill the smaller flood space at Tulloch reservoir. HEC-5 interpreted this as a danger and adjusted releases at both facilities to allow Tulloch reservoir to vacate the space. When Tulloch returned to the bottom of the flood pool, the cycle was repeated. To stabilize release, Tulloch was modeled as a flow-through reservoir. In this case, New Melones essentially looked past Tulloch to operate for downstream channel capacity. This helped to smooth out the operations, but even with the flow-through reservoir option, Tulloch and New Melones simulations have difficulties operating for local flows. During simulations, New Melones reservoir does not exceed downstream criteria until the simulation of a 0.5-percent chance exceedence event. Due mainly to significant local inflow between New Melones and Tulloch and in part to model dynamics, channel capacity below Tulloch Reservoir is exceeded during simulation of the 1-percent chance exceedence event.

Tuolumne River above Don Pedro Dam

Headwaters

The 3 headwater reservoirs modeled above Don Pedro Reservoir are Hetch Hetchy, Cherry Valley, and Lake Eleanor. These reservoirs are an important source of water for the City of San Francisco; they are operated first for water supply and then for hydropower. Releases are also made to evacuate water while maintaining downstream flows below levels that could impair power generation and damage infrastructure located within the river channel. In this sense, these reservoirs follow operation criteria that mimic flood damage reduction criteria. Their combined gross pool storage is 630,000 acre-feet, of which 160,000 acre-feet are vacant at the start of the model simulations. Hetch Hetchy and Cherry Valley contain most of these capacities; each is over 10 times as large as Lake Eleanor.

These reservoirs regulate 40 percent of the Tuolumne River's natural flow at Don Pedro. Cherry Valley is a relatively large reservoir with respect to the percentage of natural flow it regulates (12 percent) and maintained low release levels throughout the simulations. Hetch Hetchy is similar in size to Cherry Valley, but experiences larger inflows (20 percent of Don Pedro natural flow).

Note: Prior to use and application, reference the "Expectations of Use" preface.

Hetch Hetchy spilled during the simulation of the 1-percent chance exceedence event and all less frequently occurring events. Diversions into the Hetch Hetchy aqueduct were set at a constant rate of 110 cfs for simulation of all seven synthetic exceedence frequencies. The combined effects of these reservoirs reduced the peak inflow by an average of 23.9 percent and captured an average of 80,000 acre-feet during simulations of the more critical 4-, 2-, and 1-percent chance exceedence events.

Lower Basin

Don Pedro Reservoir has 340,000 acre-feet of flood space and provides flood protection to downstream areas including the City of Modesto. At Modesto, Dry Creek, which provides unregulated local flow, joins the Tuolumne River. Don Pedro Dam releases are operated to keep flows below the Dry Creek confluence within channel capacity limits of 9,000 cfs.

Don Pedro has a gated spillway. In accordance with the ESRD, maximum releases were capped at 9,000 cfs until pool elevation exceeded 830 feet during all simulations. Simulation results showed good agreement with manual routings and indicated that Don Pedro will spill in all events more severe than the simulated annual 4-percent chance exceedence event.

Merced River above New Exchequer Dam

Headwaters

The upper Merced River Basin is unregulated; no reservoirs were modeled.

Lower Basin

New Exchequer Dam has 350,000 acre-feet of flood space, a gated spillway, and operates for one downstream point, the Merced River at Cressey. Dry Creek joins with Merced flows just above this location. Modeling this reservoir was straightforward. The ESRD for the project closely paralleled the general case HEC-5 was designed to model. New Exchequer Dam spilled in all simulations occurring less frequently than the simulated annual 4-percent chance exceedence event.

San Joaquin River above Friant Dam

Headwaters

The Upper San Joaquin is among one the most heavily regulated basins within the study area. Seven headwater reservoirs, which regulate 75 percent of the natural flow at Friant, were included in the model (Edison, Florence, Mammoth Pool, Huntington, Shaver, Bass Lake, and Redinger). The combined gross pool storage is 590,000 acre-feet, of which 310,000 acre-feet are vacant at the start of model simulations.

The combination of number of facilities, available storage, methods of operation, and percentage of regulated natural flow proved to be very influential in reshaping the natural flood hydrograph at Friant Dam. In fact, the hydrology in the Upper San Joaquin River was effected more than that of any other headwater basin. Peak inflows were reduced by an average of 51.3 percent for

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all events and an average of 123,000 acre-feet was captured during simulation of the more critical 4-, 2-, and 1-percent chance exceedence events.

Lower Basin

Friant Dam has 170,000 acre-feet of flood space. There is a credit space agreement established that relates the top of conservation at Friant Dam to concurrent storages in Mammoth Pool. As much as 85,000 acre-feet of required flood space may be transferred. Friant operates for downstream locations below the Little Dry Creek confluence and at Mendota. Simulations perform very well for criteria below Little Dry Creek. This accuracy is not apparent for the Mendota location, which is located further downstream, below a large diversion and the confluence of another significant tributary. Discussion of Friant Dam's operations for Mendota is speculative, but difficulties are likely created by the distance and travel time of the site from Friant Dam and the model's simulation of the Chowchilla Diversion structure.

Like New Exchequer Dam, Friant Dam has a gated spillway with operational criteria that closely parallel the general case HEC-5 was designed to model. Simulation results were stable and accurate. The reservoir spilled in all simulations occurring less frequently than the 4-percent chance exceedence event.

Kings River above Pine Flat Dam

Headwaters

There are two headwater reservoirs of significant size above Pine Flat Dam (Courtright and Wishon). Their combined gross pool storage is roughly 250,000 acre-feet, of which 150,000 acre-feet are vacant at the start of model simulations. Courtright and Wishon occur in series high on the North Fork of the Upper Kings River and regulate only 10 percent of the natural basin flows. These facilities are unique in that there is a pump system capable of sending large flows from Wishon upslope to Courtright. This pump system is typically operated in times of low power demand so water can be rerun through power generation facilities during times of high demand. As operations try to avoid spilling water from Wishon when there is space available in Courtright (this would represent lost generation potential), the pump-back system essentially balances the pools. Instead of modeling this relationship in HEC-5, the storages and inflows of Courtright and Wishon were consolidated into a single reservoir. The outlet and spillway works of Wishon, the lower reservoir, were applied to the combined reservoir because outlet capabilities, in conjunction with operational decisions, determine flow releases to downstream areas. Therefore, any combined reservoir should reflect release capabilities of the individual reservoir furthest downstream in order to model realistic downstream conditions.

The effects of the combined reservoir were noticeable, but tempered by the low percentage of regulation. Peak inflows were reduced by an average of 9.5 percent and an average of 22,000 acre-feet of flood volume was captured during simulation of the more critical 1-, 0.5-, and 0.2-percent chance exceedence events. The combined reservoir did not spill during any of the events.

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Lower Basin

Pine Flat Dam has 475,000 acre-feet of flood control space. There is a credit space agreement that can raise the top of conservation at Pine Flat Dam by the concurrent storage available in Courtright and Wishon reservoirs to less than 20,000 acre-feet. Pine Flat has one operational location, Kings River at the Friant-Kern Canal. Between the dam site and the canal, Mill and Hughes creeks, two local tributaries, join the Kings River. These flows were properly accounted for in the HEC-5 model simulations.

Below the Friant-Kern Canal, the Kings River enters into a system of distributaries that split flood flows to the San Joaquin Basin through Kings River North, and to the Tulare Basin through Kings River South. In accordance with the Water Control Manual, the first 4,750 cfs of simulated flood releases are sent North and the next 3,200 are diverted South. Within the model, any flood flows in excess of 7,950 cfs are divided equally between the North and South.

Pine Flat Dam has a gated spillway and simulations did not calibrate with the ESRD as well as those for most other reservoirs. In the model, emergency releases tended to begin several hours prior to those computed through manual routings. In spite of this, simulated releases during events that require gated spillway flows (0.5- and 0.2-percent chance exceedence events) were close to manual routings. The reservoir spilled in all simulations higher than the annual 1-percent chance exceedence event.

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CHAPTER VI

LOWER BASIN RESERVOIR RE-OPERATIONS

OVERVIEW

Re-operation of lower basin flood damage reduction reservoirs were performed as an analysis of existing flood operations in both the Sacramento and San Joaquin river basins. Reservoir re-operations were modeled using the existing baseline HEC-5 architecture developed and presented in Chapter III. In order to gain a better understanding of the study area and answer questions posed by the team, local and regional interests and agencies, the models were used to perform a number of evaluations. While countless evaluations are possible, those that have been conducted to date were designed to illustrate a broad range of potential re-operational changes. Within this document these evaluations are referred to as “alternatives.” The re-operation alternative scenarios were executed using HEC-5, by modifying parameter values of available flood control space and objective flow values. Three lower basin reservoir re-operation analyses are discussed herein: storage and objective release grid analysis, reservoir reoperation alternative scenarios, and transitory floodplain storage analysis. Tables and figures summarizing the simulation results from these analyses are presented within this chapter and in Attachments C.3 and C.4.

The grid analysis provides information on how incremental changes to an individual reservoir’s flood control storage and/or objective release affect the ability to manage various frequencies various flood events. The alternative scenarios were developed for use as planning tools in assessing the performance of various basin-wide conceptual plans. Parameters of available flood control space and objective flow values were varied, models executed, and output tabulated for events of 50-, 10-, 4-, 2-, 1-, 0.5-, and 0.2-percent chance exceedences. Unlike the grid analysis, these alternatives provide a system-wide perspective and analysis at multiple index locations on both the mainstems of the Sacramento and San Joaquin rivers and their tributaries. Performance of flood damage reduction reservoirs were simulated with their respective tributary specific, synthetic flood centerings developed in the *Synthetic Hydrology Technical Documentation*. Index locations were used as a point of reference in comparison of attenuated flow volumes. Last, the floodplain storage analysis evaluates the effectiveness of combinations of several representative off-stream storage areas in reducing peak flows in the mainstem of the San Joaquin River.

GRID ANALYSIS

Alternatives analysis is a learning phase in the planning process. Systems are assessed from different viewpoints and new management concepts are tested. One of the first investigations tested how changes in objective release (maximum flow rate below reservoirs as established in current operational guidelines) and amount of reservoir storage dedicated to flood reduction would influence levels of protection and outflows in accordance with existing reservoir operating

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criteria. Both variables were changed incrementally (individually and in combination) for a range of values and simulated with the baseline HEC-5 models constructed during the without project phase. All other system constraints were held consistent with baseline (without project) conditions.

Results were tabulated with the incremental objective flows in columns and the flood space in rows, creating a matrix format and leading to the title “Grid Analysis.” Grid analyses were performed for Shasta, Black Butte, Oroville, New Bullard’s Bar, New Melones, Don Pedro, New Exchequer, Buchanan, Hidden, Friant, and Pine Flat reservoirs. The rest of this section details the methodology, a sample grid analysis, and summary results for all analyses.

Methodology

Setting the Grids

Ranges were chosen based on the following criteria: 1) Assess a wide range without violating other system constraints (i.e., minimum pool restrictions, downstream channel and operational limitations); 2) Increase and decrease both variables; 3) When no constraints are identified, use twice the flood storage and objective flow as upper bounds for variable increase; and 4) Test values that have been mentioned by local and/or regional interests, agencies, and other studies as constraints or possible alternatives.

Hydrologic Input to the Simulations

Grid analyses focused on reservoir operations and all simulations were performed with tributary specific centerings (see Appendix B, Chapter III). System perspectives, including study of changes in available flood space and objective flows on mainstem areas, are discussed later in this chapter.

Maintaining Consistency with the Baseline

Care was taken to assure that alternative simulations reflected only the changes made to flood storage and objective release. Two key parameters held consistent with the baseline were ramp up scenarios and gate operations. There were two primary types of ramp up scenarios (see Chapter III) for studied reservoirs. The first increased releases to maximum objective flows as a function of percent encroachment (percent of dedicated flood space filled with water). Here, relations of percent objective release to percent encroachment were held constant. Therefore, during simulations with increased flood storage, releases ramped up more conservatively than the baseline because it took more flood volume to encroach the pool to any specific percentage. While this reduced the efficiency of added storage, it was consistent with the baseline and logical from an operation perspective. The second ramp up scenario increased releases to objective flow limits as a function of the magnitude of flood inflows to the reservoir and percent encroachment. For these facilities, relationships between specified releases and reservoir inflow were held identical to the baseline until inflow rates triggered the maximum flood release, which was changed to match the alternative maximum objective flow from the grid. As in the first ramp up scenario, relations involving percent encroachment were held constant.

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Gated operations required minor changes to incorporate alternative maximum objective releases. For example, emergency releases from spillway gates at Don Pedro Reservoir do not begin under baseline conditions until the water surface elevation within the reservoir exceeds a reservoir elevation of 830 feet above mean sea level. Until this elevation, releases never exceed 9,000 cfs, which is the maximum objective flow under baseline conditions. This relation was scripted into baseline gate operations and adjusted whenever an alternative objective flow was investigated. Changes in flood storage had no effect on gate operations, which began near the top of the flood storage regardless of flood pool size.

Results and Discussion

Grid results for all frequencies and reservoirs are presented in Attachment C.3, Figures C.3-1 through C.3-11. This section discusses 1) the construction, simulation, and use of a sample analysis; and 2) review and use of all results in general.

Sample Grid

Don Pedro Reservoir on the Tuolumne River has a baseline objective flow of 9,000 cfs and a maximum storage capacity of 2,030 thousand acre-feet (TAF) (340 TAF of which is dedicated control flood storage). Baseline simulations indicated that Don Pedro Reservoir exceeded objective flows in all events occurring less frequently than the 4-percent chance exceedence event (see Chapter V).

Since modeling results indicate Don Pedro Reservoir offers a relatively low level of protection to downstream areas, alternatives focused on increases to available flood storage and objective flows. The maximum increase in flood storage was 340 TAF (no minimum pool restrictions were violated). Channel capacities are restrictive in the lower Tuolumne River and flows greater than 15,000 cfs inundate infrastructure around the City of Modesto. The 15,000 cfs flow rate is also mentioned by other studies (*Tuolumne River Feasibility Study, USACE*) as the highest plausible increase to objective flows and was incorporated into the analysis as the maximum alternative flow.

To produce Don Pedro Reservoirs grid, simulations were performed for all seven synthetic exceedence frequency events (50-, 10-, 4-, 2-, 1-, 0.5-, and 0.2-percent chance exceedence events) using the Tuolumne River centering. This tributary centering was originally prepared in the Synthetic Hydrology (see Appendix B) and routed through the HEC-5 headwater reservoirs model during baseline analyses. Results of the simulated 2-percent chance exceedence event are presented in Figure VI-1.

Simulations where peak reservoir releases did not exceed the maximum objective flow are shaded. Generally, flood releases less than or equal to the objective flow threshold cause minimal damage to downstream areas and the interface between shaded and non-shaded cells reflect combinations of flood storage and objective flows that safely pass the annual 2-percent chance exceedence event while exhausting the reservoir's capacity to reduce floods.

Theoretically, this relation between operating parameters and the start of damaging flows is a smooth function that would pass near or through points on the grid interface of shaded and non-shaded cells. The optimal combination of change in available flood storage and change in

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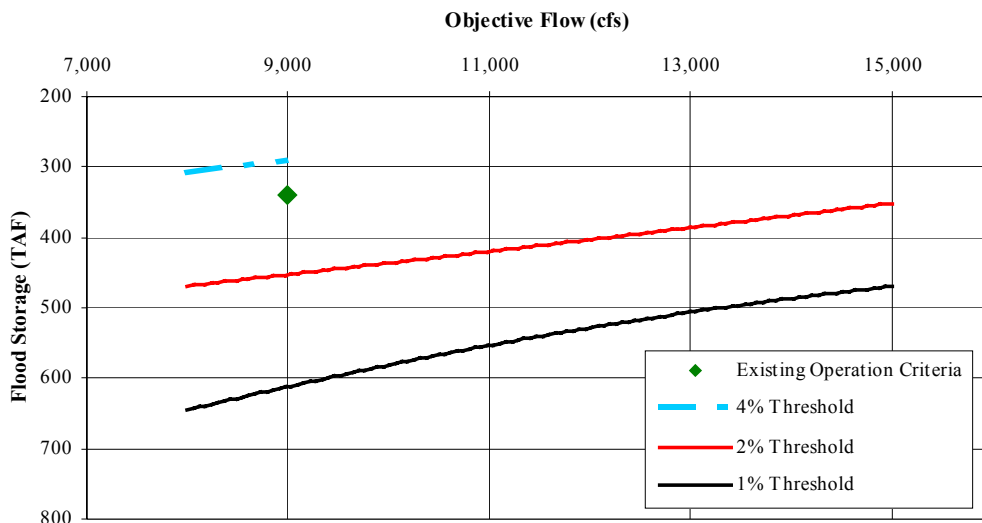
objective flow can be estimated from the grid results as exemplified in Figure VI-1 or from graphical representations as shown in Figure VI-2, and presented in Attachment C.3.

**FIGURE VI-1 DON PEDRO RESERVOIR – TUOLUMNE RIVER,
ANNUAL 2% CHANCE EXCEEDENCE EVENT**

		Model Simulation					
		Peak flow - objective flow Percent encroached					
		Objective flow is not exceeded					
		Change in Objective Flow (cfs)					
		-1,000	0	1,000	2,000	4,000	6,000
Change in Flood Storage (TAF)	-50	TUO-E01A 47,651 107%	TUO-E02A 42,587 106%	TUO-E03A 38,445 106%	TUO-E04A 35,403 105%	TUO-E05A 27,743 104%	TUO-E06A 19,932 103%
	0	TUO-E07A 35,396 104%	BASELINE 30,600 104%	TUO-E08A 25,951 103%	TUO-E09A 22,115 103%	TUO-E10A 11,660 101%	TUO-E11A 1,611 100%
	50	TUO-E12A 21,973 102%	TUO-E13A 16,438 101%	TUO-E14A 12,383 101%	TUO-E15A 10,792 101%	TUO-E16A 0 100%	TUO-E17A 0 91%
	100	TUO-E18A 14,578 101%	TUO-E19A 13,569 101%	TUO-E20A 10,540 100%	TUO-E21A 0 99%	TUO-E22A 0 90%	TUO-E23A 0 82%
	200	TUO-E24A 0 95%	TUO-E25A 0 91%	TUO-E26A 0 87%	TUO-E27A -175 83%	TUO-E28A 0 76%	TUO-E29A 0 69%
	340	TUO-E30A 0 78%	TUO-E31A 0 74%	TUO-E32A 0 71%	TUO-E33A -171 68%	TUO-E34A -302 62%	TUO-E35A -252 57%

Amount of flow above objective at peak reservoir release and the percent encroached at peak storage for the annual 2-percent chance exceedence flood event. Don Pedro is currently operated to maintain flows below 9,000 cfs at Modesto and has a maximum flood pool of 340 TAF.

FIGURE VI-2 SAMPLE GRID ANALYSIS



Curves delineate combinations of flood storage and objective flows that would pass a specified frequency event while exhausting the capabilities of the flood damage reduction reservoir. These curves are estimated through visual inspection of the grid results. Use of these values in plan preparation should be verified through simulations and manual routings.

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Review of Results

The grids developed for Shasta, Oroville, New Bullards Bar, and Friant dam revealed simulated releases in excess of objective flow criteria, prior to those that would be required by standard operating procedures outlined within the respective Water Control Manuals. These releases were associated with the start of emergency gate releases during HEC-5 simulations; similar release dynamics were noted during baseline modeling (see Chapter V). In these cases, definition of the damage – non-damage interface was verified manually for all grid points. Grid cells were shaded where releases in excess of established objective flow criteria were above and beyond those that would occur according to actual operational mechanisms. All other grids displayed consistent results in agreement with baseline simulations and standard operations set forth in Water Control Manuals.

RESERVOIR RE-OPERATION WITHIN THE SACRAMENTO AND SAN JOAQUIN RIVER BASINS

The grid analysis previously described provides an assessment of how changes to a reservoir's objective flow releases and flood control storage influence the level of flood protection along tributaries of both the Sacramento and San Joaquin rivers. Using the grids as a guide, a variety of specific alternative scenarios were modeled using the Sacramento and San Joaquin river HEC-5 flood control simulation models (Tables VI-1 and VI-2).

The primary purpose of the lower basin alternative scenarios was to examine the effects that changes to selected reservoir re-operation criteria would have on peak flows and volumes in both the tributaries and mainstem of the Sacramento and San Joaquin rivers. Unlike the grids, many of the alternative scenarios evaluate changes in objective flow and available flood control space for more than one reservoir at a time and simulate these analyses with a variety of storm runoff centering patterns. The majority of the alternative scenarios include changes to both a reservoir's objective releases and allocated flood control storage. However, a few alternatives examine other more detailed and difficult modifications. For example, forecast-based operations and increased dam height, as adopted from the American River Long Term Study, were modeled in the alternative scenario SAC-B04A.

Results from HEC-5 alternative scenarios were taken as input into the Sacramento and San Joaquin Basin UNET models to determine hydraulic impacts along the mainstem.

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TABLE VI-1
ALTERNATIVE SCENARIO MODIFICATIONS
SACRAMENTO RIVER BASIN

		SAC-B01A	SAC-B02A	SAC-B03A	SAC-B04A
<i>Shasta Dam and Reservoir</i>	Flood Reservation	1,300 TAF			
	Objective Release				
<i>Cottonwood Creek</i>	Flood Reservation				
	Objective Release		15,000 cfs		
<i>Oroville Dam and Reservoir</i>	Flood Reservation	750 TAF		Incremental changes made to available storage and objective flow	Incremental changes made to available storage and objective flow
	Objective Release				
<i>New Bullards Bar Dam and Reservoir</i>	Flood Reservation			Incremental changes made to available storage and objective flow	
	Objective Release				

TABLE VI-2
ALTERNATIVE SCENARIO MODIFICATIONS
JOAQUIN RIVER BASIN

		SJQ-B01A	SJQ-B02A	SJQ-B03A	SJQ-B04A	SJQ-B05A	SJQ-B06A	SJQ-B07A
<i>Friant Dam and Reservoir</i>	Flood Reservation	170 TAF	100 TAF		50 TAF	100 TAF		
	Objective Release				4,000 cfs		8,000 cfs	
<i>New Exchequer Dam</i>	Flood Reservation		50 TAF			50 TAF		
	Objective Release				1,000 cfs			2,000 cfs
<i>Don Pedro Dam and Reservoir</i>	Flood Reservation	340 TAF	100 TAF			200 TAF		
	Objective Release		2,000 cfs	6,000 cfs	6,000 cfs			

Note: Values represent increases to existing criteria.

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Alternative Scenario SAC-B01A

Comparison of the baseline and alternative simulation results indicate little to no attenuation of the peak flow maxima and peak volume within northern portions of the Sacramento River, with the exception of those occurring during the simulated 0.5- and 0.2-percent chance exceedence events. The maximum attenuation of peak volumes occurs during the simulation of an annual 0.2-percent chance exceedence event. The effects of additional storage in Shasta Reservoir is noticed along the Sacramento River for the more extreme events because of Shasta's capability to cutback on large release volumes. For more frequent events (those occurring more frequently than the simulated 1-percent chance exceedence), the lack of attenuated flow volume is due to the large contributions of unregulated local flow generated upstream of Ord Ferry.

Some irregularities may be observed within the tables. For example, at Bend Bridge during the simulation of an annual 4-percent chance exceedence event centered at Oroville Dam, there is no indicated reduction in peak flow maxima, but results indicate an attenuated peak volume of 179,463 acre-feet. Inconsistencies such as this are attributed to hydrograph shape. Both the resultant baseline and alternative hydrographs maintain nearly similar peak flow values, but exhibit a calculated peak flow reduction with the hydrograph shapes indicating different associated volumes.

Index locations situated along the southern reach of the Sacramento River (i.e., Verona and Sacramento) are located downstream of the Feather River confluence. Peak flows and volumes are subsequently affected by storage increases at both Oroville and Shasta reservoirs. Since simulations of this alternative indicate minimal attenuation along the Sacramento River upstream of its confluence with the Feather River for events occurring more frequently than a 1-percent chance exceedence event, it can be concluded that Oroville is responsible for attenuating the majority of peak flow at Verona and Sacramento for these events. However, for the larger events (i.e., 0.5- and 0.2-percent chance exceedence events) both Shasta and Oroville contribute substantially to the attenuated flows at Verona and Sacramento.

Alternative Scenario SAC-B02A

Alternative SAC-B02A simulates the effect of restricting the contribution of Cottonwood Creek flows into the Sacramento River to a maximum of 15,000 cfs. The purpose of this alternative is to observe the effect that a hypothetical dam on Cottonwood Creek might have on downstream peak flow maxima and flood volumes. Cottonwood Creek was chosen because it remains one of the largest, generally unregulated tributaries to the Sacramento River. The flow adjustments of this alternative were made to the existing HEC-5 DSS input file through mathematical manipulations using the USACE's DSSMATH utility program. Modeling a hypothetical dam within HEC-5 may provide a more accurate approach, however this method demands a much more detailed modeling effort in that specific physical design characteristics of the dam itself need to be known. Through the chosen method, the simulated effect of regulated flow contributions of Cottonwood Creek on downstream locations can still be observed.

Because there were no flood management reoperations associated with Oroville Dam in this alternative, all values representative of the index location "Oroville" are zero (Table C.4-2). This reservoir will continue to operate as it had within the baseline simulation results. Reduction in peak maxima at index locations along the northern reach of the Sacramento River, occur

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during events greater in magnitude than the 1-percent chance exceedence event for all storm-runoff centerings. Locations lower in the basin, such as Verona and Sacramento, experience maximum percent peak reductions during events generally less than or equal to the 4-percent chance exceedence event, though all percent peak reductions are only within a few percentage points of one another at these southerly locations. Percent peak reductions in the northerly reaches of the Sacramento River are much higher and more variable. In the most northern reaches of the Sacramento River, simulated peak reductions range from 15 to 35 percent, but only 0.4 to 3.5 percent in the southern reaches. It can be surmised that restricting the flow contributions of Cottonwood Creek to 15,000 cfs has a significant impact on peak flow attenuation for locations above Ord Ferry. However, benefits may be minimal at downstream locations such as Verona and Sacramento.

Alternative Scenario SAC-B03A

The purpose of alternative SAC-B03A was to restrict flows in the Feather River downstream of its confluence with the Yuba River (at Shanghi Bend) to 230,000 cfs for all seven synthetic exceedence frequencies up to and including the annual 1-percent chance exceedence event. Because there was no specific requirement for additional flood control space specified for any particular reservoir in the SAC-B03A problem definition, the analysis approach was somewhat different from the other alternatives: it involved increasing flood storage space incrementally in Oroville and New Bullards Bar reservoirs (the contributing lower basin reservoirs) and reducing index gage operating criteria. Both the Feather River and Yuba River storm runoff centerings were analyzed for this alternative, since they generated the most extreme stream flow conditions in the upper Feather and Yuba river system.

Two main adjustments had to be made to the baseline HEC-5 models for this alternative: adjusting release operating criteria and increasing available flood control storage space. The first parameter adjusted was the reservoir's downstream release operating criteria. Both New Bullards Bar and Oroville reservoirs operate for several independent and common index gages. This makes the Feather/Yuba river system unique in that its operations are more comparable to a true systematic or coordinated effort, and provide a complexity of operation beyond that of other systems, which typically operate independently for a single index location. Current operational requirements for Oroville Reservoir are to keep flows at or below the following values along the Feather River: 150,000 cfs at Gridley, 180,000 cfs upstream of its confluence with the Yuba River (at Yuba City), 300,000 cfs downstream of its confluence with the Yuba River (at Shanghi Bend), and 320,000 cfs at Nicolaus. Operations at New Bullards Bar Reservoir are dependent on flow conditions both in the Yuba and Feather rivers. When flows in the Feather River upstream of its confluence with the Yuba are at or above 180,000 cfs, New Bullards Bar Reservoir must operate so that flows are kept at or below 120,000 cfs on the Yuba River at the City of Marysville. However, if flows in the Feather River upstream of its confluence with the Yuba River are lower than 180,000 cfs, New Bullards Bar releases may be increased, provided that flows at Marysville do not exceed 180,000 cfs. Since this alternative posed a reduction in flows at Shanghi Bend from 300,000 cfs to 230,000 cfs, all other index gage operational points had to be adjusted. These adjustments are shown below in Table C.4-3.

The second parameter that was adjusted in the HEC-5 models was the available flood control space. It was increased incrementally within the HEC-5 input files by lowering the top of

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conservation values of both reservoirs. Increases in available flood storage in each reservoir were modeled both independently and in conjunction with one another, since the operational procedures of New Bullards Bar Reservoir are affected by flow rates in the Feather River (at Yuba City). After initial simulations, it was evident that increases to the available flood control space in New Bullards Bar Reservoir had little effect on attenuating downstream peak flows in the Feather River. This is because New Bullards Bar Reservoir regulates less than 40 percent of the Yuba River drainage basin. For this reason, the primary focus of this alternative was changes in the amount of available flood control space in Oroville Reservoir. Table C.4-3 exhibits the resultant peak flow maxima that the models generated at various operating locations along the Feather and Yuba rivers for five increases to flood storage in Oroville Reservoir.

Peak flows at Shanghi Bend exceeded the alternative's operational criteria of 230,000 cfs, for the 1-percent chance exceedence event, for all model simulations. Peak flows are shown to generally decrease at Shanghi Bend as flood storage in Oroville Reservoir is increased. The largest reduction in peak maxima occurs when flood control space is increased by 200,000 acre-feet when an annual 1-percent chance exceedence runoff event is centered at Oroville Dam. This percent peak reduction diminishes with increasing flood storage.

Alternative Scenario SAC-B04A

In this alternative, two major changes to the Sacramento lower basin HEC-5 baseline model were made in order to incorporate: 1) some of the changes being proposed by the American River Watershed Investigation (ARWI) to Folsom Dam, and 2) the results of alternative run SAC-B03A that added 200 TAF of flood space to Oroville Reservoir. The Folsom Dam changes that were incorporated into the HEC-5 model came from two of the three major components stemming from the ARWI: The American River Long-Term Study and the Folsom Dam Modifications Project. The main components of the Folsom Dam Modifications Project include modified outlets and ramp-up criteria, increased surcharge storage, and advanced release operations based on precipitation and runoff forecasts. The American River Long-Term Study is examining how to increase flood protection along the American River by means of enlarging Folsom Dam. All of the main components of the Folsom Dam Modifications Project, as well as raising the dam to an elevation of 482 feet (an alternative being examined by the American River Long-Term Study), were included in this modeling effort.

The ARWI is using two models to perform Folsom Reservoir routings: the Reservoir Release Forecast Model (RRFM) developed by Utah State University and an accompanying Excel spreadsheet model. Some of the operating criteria proposed by the Folsom Dam projects are not programmed into RRFM; hence, reservoir outflows had to be hard-coded by hand prior to simulation of the model. The spreadsheet model, however, includes some of the modified operating rules that the RRFM does not, such as pre-release operations and the 60-percent rule (Table VI-3). For these reasons, the spreadsheet model was selected to simulate operations of Folsom Dam in this application of the Comprehensive Study hydrology.

Four of the Sacramento Basin synthetic storm runoff centerings (Ord Ferry, Sacramento, Feather River, and American River) were routed through the reservoir model. The Ord Ferry and Sacramento centerings were chosen because they are mainstem centerings, which stress the entire basin. The Feather River and American River tributary centerings stress individual tributary systems, but are not widespread enough to produce runoff volumes typical of a basin-

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wide event. Since this alternative includes the re-operation of both Folsom and Oroville dams, their associated tributary centerings were chosen to simulate extreme flood events along the Feather and American Rivers.

The ARWI has examined many scenarios with different assumptions and operating criteria. This study involved modeling operating criteria that are being examined by the ARWI, but were executed to remain consistent with assumptions developed by the Comprehensive Study. The similarities and differences between two ARWI scenarios and the modeling efforts associated with this study are described in Table VI-3.

**TABLE VI-3
ASSUMPTIONS AND OPERATIONAL CONDITIONS FOR FOLSOM DAM**

Factor	American River Watershed Investigation (Base Case)	American River Watershed Investigation (Min Case)	Comprehensive Study
<i>Flood waves modeled</i>	1 (main wave only)		6 (entire 30 day storm)
<i>Synthetic hydrograph wave shape</i>	Based on 1980 PMF		Based on 1997 event
<i>Starting storage</i>	277,000 ac-ft	337,000 ac-ft	377,000 ac-ft
<i>Initial upstream reservoir space</i>	0 ac-ft	150,000 ac-ft	167,000 ac-ft
<i>Initial top of conservation with credit space adjustments</i>	377,000 ac-ft	527,000 ac-ft	544,000 ac-ft
<i>Headwater routing effects</i>	None	Reduce unregulated volume by 14% of the 3-day volume (peak flow reductions range from 0-14%)	Use regulated inflow to Folsom from HEC-5 headwaters model (peak flow reductions range from 9-13%)
<i>Outlet works operation</i>	100%		
<i>Minimum flow</i>	8,000 cfs (max power)		1,500 cfs (minimum release)
<i>Rate of change of release on rising limb of flood wave</i>	5,000 cfs/hr to 25,000 cfs inflow 10,000 cfs/hr above 25,000 cfs inflow		
<i>Outflows from Folsom when inflows are < 25,000 cfs</i>	4-hour response time matching outflow to inflow		
<i>Outflow from Folsom when inflows are > 25,000 cfs</i>	60% Rule: Outflow is limited to 60% of inflow until the actual inflow exceeds 150,000 cfs		
<i>Rate of change of release on falling limb of flood wave</i>	5,000 cfs/hr until outflow reaches 20,000 cfs Use USBR criteria when outflows are less than 20,000 cfs		
<i>Pre-release operation</i>	Assume additional 100,000 ac-ft of flood control storage in Folsom at beginning of main wave (assumption based on previously modeled pre-release operation scenarios)	Assume additional 190,000 ac-ft of flood control storage in Folsom at beginning of main wave (assumption based on previously modeled pre-release operation scenarios)	Begin ramping up at a rate of 20,000 cfs/hr to 115,000 cfs 72 hrs prior to first forecasted inflow of 300,000 cfs or more

Note: Prior to use and application, reference the "Expectations of Use" preface.

The main differences between the ARWI scenarios and the Comprehensive Study are the assumptions associated with the influence of headwater reservoirs in providing flood protection. Modeling of SAC-B04A used output from the HEC-5 headwaters model developed for the Comprehensive Study. The Folsom credit space computations were generated by hourly storage values of all five headwater reservoirs modeled. Peak flow attenuation of Folsom inflow is also a product of the HEC-5 headwater model output. Peak reductions of inflow into Folsom range from 9 to 13 percent, depending on the event (Table VI-4). The ARWI baseline case assumes no attenuation due to headwater regulation and therefore no credit space adjustments for potential upstream storage allocations. However, the ARWI Minimum Case does assume a 14-percent, 3-day volume reduction and 150,000 acre-feet of upstream credit space. This equates to peak flow reduction of 0 to 14 percent, depending on the exceedence event being simulated. Therefore, the ARWI Minimum Case is more representative of the Comprehensive Study information. Other differences between the Comprehensive Study and the ARWI modeling parameters that affect the output results include: hydrograph shape, storm duration, and pre-release operating assumptions. Keeping these differences in mind, comparison of peak outflows between the ARWI minimum case and SAC-B04A are in good agreement (Table VI-4).

TABLE VI-4
PEAK FLOW COMPARISONS FOR FOLSOM DAM

Percent Chance Exceedence	Peak Inflows (cfs)			Percent Differences	
	ARWI Base Case	ARWI Min Case	Comp Study	Base vs. Comp Study	Min vs. Comp Study
4%	207,410	178,370	196,408	5.6%	-9.2%
2%	274,860	236,380	258,555	6.3%	-8.6%
1%	353,540	304,040	329,258	7.4%	-7.7%
0.5%	444,570	408,320	409,934	8.4%	-0.4%
0.2%	585,930	585,930	536,703	9.2%	9.2%

Percent Chance Exceedence	Peak Inflows (cfs)			Percent Differences	
	ARWI Base Case	ARWI Min Case	Comp Study	Base vs. Comp Study	Min vs. Comp Study
4%	115,000	115,000	115,000	0.0%	0.0%
2%	115,000	115,000	115,000	0.0%	0.0%
1%	115,000	115,000	116,814	-1.6%	-1.6%
0.5%	122,570	115,000	119,689	2.4%	-3.9%
0.2%	528,380	498,860	485,040	8.9%	2.8%

Note: Prior to use and application, reference the "Expectations of Use" preface.

Alternative Scenario SJQ-B01A

The results of scenario SJQ-B01A are presented in Table C.4-5. Comparison of the baseline peak flow maxima versus those generated through the simulation of this alternative show the largest percent peak flow reductions at each storm runoff centering generally occur at or nearest the two facilities modified in the simulation of this alternative (Friant and Don Pedro dams). During every flood runoff centering, with the exception of the one at Friant Dam, the largest percent peak flow reduction occurred at Don Pedro Dam during simulation of the 2-, 1-, 0.5-, and 0.2-percent chance annual exceedence events. This is due mostly to the large increase in available flood space in this facility suggested by this alternative. The largest reduction in peak flow maxima that occurred during the Friant Dam flood runoff centering occurred at Friant Dam. Reduction in peak discharges are noticeably smaller at mainstem locations, compared to the reduced peak regulated outflows of the flood control facilities themselves. This is attributed to the different conveyance capacities between the mainstem and its tributaries. Maximum releases from the flood damage reduction reservoirs were calculated at each facility with data obtained from simulating each synthetic flood runoff centering. Operations of both Friant and Don Pedro dams are affected by objective flow criteria at downstream index gage locations. Friant releases are operated to keep flows at or below 8,000 cfs downstream of its confluence with Little Dry Creek and a maximum of 6,500 cfs at a control point below Mendota Dam. Operational releases at Don Pedro Dam are to be kept at or below 9,000 cfs just downstream of the Dry Creek confluence with the Tuolumne River. As can be observed in the reservoir simulation hydrographs in Attachment C.4, objective flows were exceeded by the 1-percent chance exceedence storm runoff event centered at Friant and a 0.5-percent chance exceedence storm runoff event centered at Don Pedro (Figures C.4-5c and C.4-5g). By comparison, objective flows modeled at baseline conditions were exceeded at Friant by an annual 4-percent chance exceedence event and at Don Pedro by an annual 2-percent chance exceedence event (Attachment C.1, Figures C.1-8c and C.1-12d).

Alternative SJQ-B01A did not involve the modeling of variations to the available flood storage, objective flow parameters, or any other operational changes at the New Exchequer flood control reservoir. This results in two effects observed during the analysis. First, the percent peak reduction and volume attenuated for all return periods at each synthetic storm centering at New Exchequer are zero. Second, the percent reductions in peak maxima during the more frequent synthetic exceedence frequencies are little to none for the Exchequer flood runoff centering at all other gage locations. Several calculated peak reduction values at Don Pedro Reservoir for several of the synthetic exceedence frequencies within the centering groups are also found to be zero. Peak reductions of zero values are appropriate in these instances only because the maximum peak flows for both the baseline and alternative are the same. Volumes attenuated, however, may be significant in magnitude and clearly present flood damage reduction benefits.

As previously mentioned, this alternative resulted in large percent peak reduction at the locations of the Friant and Don Pedro reservoirs, where the alternative modifications were applied. In contrast, this alternative analysis has less effect in peak flow reductions on the mainstem, especially when the flood centering is targeted over that mainstem basin. This can be observed during the Newman flood centering. During this centering, gage locations at Modesto, Maze Rd., and Vernalis experienced flow increases for all synthetic exceedence frequencies up to and including the simulated 4-percent chance exceedence runoff event.

Note: Prior to use and application, reference the "Expectations of Use" preface.

Alternative Scenario SJQ-B02A

The results of scenario SJQ-B02A are presented in Tables C.4-6a and C.4-6b. For each synthetic flood runoff centering, the maximum reduction in the resultant peak flow occurs between simulation of the annual 2-, 1-, 0.5-, and 0.2-percent chance exceedence events at each index gage location, depending on which storm runoff centering is analyzed. Effects of changes in peak discharges are generally smaller at mainstem locations, downstream of tributary contributions, compared to the reduced, peak regulated outflows of the flood control facilities. This is attributed, in part, to the different conveyance capacities between the mainstem and its tributaries. Volumes attenuated at each location, however, are incrementally higher within the mainstem, as would be expected. Flood control operations at Friant, New Exchequer, and Don Pedro dams are affected by objective flow criteria at downstream index gage locations. Friant releases are operated to keep flows at or below 8,000 cfs downstream of its confluence with Little Dry Creek, and a maximum of 6,500 cfs at a control point below Mendota Dam. Flows from New Exchequer must be adjusted to allow for local flow contributions below the dam to avoid exceeding the channel capacity of 6,000 cfs downstream at Cressey, on the Merced River. Likewise, the modified Don Pedro releases for this alternative are operated to keep flows at or below 11,000 cfs (an increase of 2,000) just downstream of Dry Creek's confluence to the Tuolumne River. Because of the change in objective flow releases within the Tuolumne River, output data cannot be directly compared to the baseline modeling results. Direct benefits are noticed though, and can be observed in the reservoir simulation hydrographs in Appendix C.4. The simulated releases at Friant Dam for this alternative were maintained with the occurrence of an annual 4-percent chance exceedence storm runoff centering at Friant Dam, and an annual 1-percent chance exceedence event centered at New Exchequer and Don Pedro dams (Figures C.4-6b, C.4-6g, and C.4-6k). By comparison, objective flows modeled at baseline conditions were maintained at Friant Dam with a simulated annual 10-percent chance exceedence event, and at New Exchequer and Don Pedro by an annual 4-percent chance exceedence event (Figures C.1-8b, C.1-11c, and C.1-12c), in effect increasing the simulated level of flood protection provided by each flood damage reduction facility. Friant Dam outflows, representative of a simulated 4-percent chance exceedence event generated by SJQ-B02A, result in a reduction in peak maxima (from baseline) of 11 percent. Likewise, peak maxima at New Exchequer and Don Pedro (with runoff centerings directed at them) resulted in a 73- and 72-percent reduction, respectively.

Calculated peak reduction values at several of the index gage locations, for several synthetic frequency frequencies within the centering groups, are found to be zero. Peak reductions of zero values are appropriate in these instances only because the maximum peak flows for both the baseline and alternative are the same. Their difference is simply zero. Parallels are noticed in the response of both Don Pedro and Modesto gages to the increased available storage capacity and objective flow limits. Negative values, indicative of an increase in peak flows associated with the modeled peak reduction values, are attributed to an increase in allowable objective flows downstream of the Don Pedro facility. With the exception of the Friant storm runoff centering, a reduction of peak maxima occurs at each flood control facility when a synthetic annual 2-percent chance exceedence flood runoff centering is targeted at its basin. Maximum peak reduction benefits at the mainstem index gage locations, however, were at or near the 1-percent chance exceedence event.

Note: Prior to use and application, reference the "Expectations of Use" preface.

Alternative Scenario SJQ-B03A

The results of scenario SJQ-B03A are presented in Attachment C.4, Tables C.4-7a and C.4-7b. Examination of this alternative proves to be conceptually different from others presented herein. Because comparison of peak discharge and peak volume for this modeled alternative are designed to permit the passage of greater volumes, a direct comparison of baseline data to alternative data is inadequate. Direct observation of the output data generated by this alternative does, however, reveal that simply increasing downstream objective flow limits allows the flood damage reduction facilities to increase their outflows sooner. The direct result is to allow the flood control facility to pass the inflow volumes associated with the first flood wave volumes as described in *Appendix B – Synthetic Hydrology Documentation*. The indirect result is that the flood control pool is allowed to stay lower longer, allowing the facility to better attenuate the incoming peak flood wave. This alternative of increasing downstream objective flows provided a greater benefit for the more frequent synthetic exceedence frequencies with the increased objective flow criteria, allowing manageable releases to be made sooner.

Reduction in peak discharges are noticeably smaller at mainstem locations downstream of tributary contributions, compared to the reduced peak regulated outflows of the flood control facilities for all seven synthetic exceedence frequencies. This is attributed, in part, to the significantly different conveyance capacities between the mainstem, its tributaries, and the added effect of various local, unregulated inflows. Operations at the Don Pedro flood damage reduction facility, for example, are effected by objective flow criteria at downstream index gage locations. The modified releases at Don Pedro for this alternative are operated to keep flows at or below 15,000 cfs (an increase of 6,000 cfs) just downstream of Dry Creek's confluence to the Tuolumne River. As can be observed in the alternative reservoir simulation hydrographs in Attachment C.4, simulated objective flow criteria at Don Pedro Dam were maintained by all events occurring more frequently than and including an annual 4-percent chance exceedence storm runoff centering focused at Don Pedro Dam (Figures C.4-7a through C.4-7d). Similarly, objective flows modeled at baseline conditions were also maintained at Don Pedro by the occurrence of an annual 4-percent chance exceedence event or greater (Figure C.1-12c).

Volumes attenuated through the modeling of Alternative SJQ-B03 are significant in quantity, clearly exhibiting flood damage reduction benefits for less frequent events, such as the 2-, 1-, 0.5-, and 0.2-percent exceedence intervals. Reductions in peak volume at Don Pedro remain consistent with the occurrence of a 2-percent chance exceedence flood runoff event centered at or downstream of the Newman index gage location, changing to a 1-percent exceedence as the centerings are focused further upstream. Parallels are noticed in the response of both Don Pedro and Modesto index gage locations to the increased objective flow limits. Negative values, indicative of a net increase in peak flow maxima and volume associated with the modeled alternative, are attributed to an increase in the simulated objective flows at the Don Pedro facility. Noticeably, both gages react in unison as would be expected.

As exemplified in Table C.4-7a, simulations of alternative SJQ-B03A indicate no benefit in the projected level of flood protection at Don Pedro Dam. Existing results indicate that releases from Don Pedro Dam provide protection for the occurrence of a 4-percent chance exceedence event in both the baseline and simulation of alternative scenario SJQ-B03A.

Note: Prior to use and application, reference the "Expectations of Use" preface.

Alternative Scenario SJQ-B04A

The results of scenario SJQ-B04A are presented in Attachment C.4, Tables C.4-8a and C.4-8b. As in the examination of SJQ-B03A, analysis of this alternative proves different conceptually than others presented herein. Because the design of this alternative permits the passage of greater volumes through increases to objective release criteria on the upper reach of the San Joaquin, Merced, and Tuolumne rivers, a direct comparison of baseline data to alternative data is inadequate. Direct observation of the output data generated by this alternative does however, expose that simply increasing downstream objective flow limits allows the flood damage reduction facilities to increase their outflows sooner. The direct result is that the flood control facility is allowed to pass the inflow volumes associated with the first three flood wave volumes as described in *Appendix B – Synthetic Hydrology Documentation*. The indirect result is that the flood control pool is allowed to stay lower longer, in some instances allowing the facility to better attenuate the incoming peak flood wave. This alternative of increasing downstream objective flows provided a greater benefit for the more frequently occurring exceedence events.

Reduction in peak discharge maxima are noticeably smaller at mainstem locations, downstream of tributary contributions, in comparison to the reduced peak regulated outflows of the flood control facilities for all seven synthetic exceedence frequencies being simulated. This is attributed, in part, to the largely different conveyance capacities between the mainstem, its tributaries and the added cumulative effect of various local inflows. Operations at each of the flood damage reduction facilities are effected by objective flow criteria at downstream index gage locations. The modified releases at Friant Dam for this alternative are operated to keep flows at or below 12,000 cfs (up from a baseline of 8,000 cfs) just downstream of Little Dry Creek's confluence with the San Joaquin River. At New Exchequer Dam, objective flow criteria have been increased to maintain flows at or below 7,000 cfs (up from a baseline of 6,000 cfs) in the Merced River at Stevinson and at Don Pedro Dam, 15,000 cfs (up from a baseline of 9,000 cfs) within the Tuolumne River below its confluence with Dry Creek.

As can be observed in the resultant simulation hydrographs presented for this alternative in Attachment C.4, increased flood protection benefits are achieved at Friant Dam for simulated runoff centerings targeted at Friant, New Exchequer, and Don Pedro flood damage reduction facilities. The ability for Friant Dam to maintain operational downstream release criteria at or below required limits changes from a 10-percent to a 4-percent, from a 4-percent to a 1-percent, and from a 2-percent to a 1-percent annual chance exceedence, for targeted centerings at Friant, New Exchequer, and Don Pedro, respectively (Table C.4-8a). With the exception of a change in the ability of New Exchequer Dam to provide an increase in flood protection from that of a 2-percent to a 1-percent chance annual exceedence event at New Exchequer Dam, as a runoff centering was targeted at it; no other benefits are observed with in simulations of this alternative.

Volumes attenuated by the Friant Dam facility, through the modeling of Alternative SJQ-B04A are significant in capacity and clearly exhibit flood damage reduction benefits. Parallels are noticed in the response of both Don Pedro and Modesto gages to the increased objective flow limits. Negative values, indicative of a net increase in peak flow maxima associated with the modeled alternative, are attributed to an increase in objective release criteria at the Don Pedro facility. Noticeably, both gages react in unison as would be expected.

Note: Prior to use and application, reference the "Expectations of Use" preface.

Alternative Scenario SJQ-B05A

The results of scenario SJQ-B05A are presented in Attachment C.4, Tables C.4-9a and C.4-9b. During every flood runoff centering, with the exception of the one centered at Newman, the largest percent reduction in peak flow maxima occurred at Don Pedro Dam during the 2-, 1-, and 0.2-percent chance exceedence events. This is due mostly to the large increase in available flood space in this facility imposed by this alternative. Reduction in peak discharges are noticeably smaller at mainstem locations, compared to the reduced peak regulated outflows of the flood control facilities themselves. This is attributed to the different conveyance capacities between the mainstem and its tributaries, and the immediate local effects of increasing available flood storage at the reservoirs on each tributary (Friant, New Exchequer, and Don Pedro). Operations of Friant, New Exchequer, and Don Pedro dams are affected by objective flow criteria at downstream index gage locations. Friant Dam releases are operated to keep flows at or below 8,000 cfs downstream of its confluence with Little Dry Creek and a maximum of 6,500 cfs at a control point below Mendota Dam. Operational releases at New Exchequer Dam are to be maintained at or below 6,000 cfs and at Don Pedro Dam, at or below 9,000 cfs just downstream of the Dry Creek confluence with the Tuolumne River. As can be observed in the alternative reservoir simulation hydrographs in Attachment C.4, objective flows simulated by this alternative were maintained at Friant Dam with an annual 4-percent chance exceedence event centered at Friant; at New Exchequer Dam with an annual 2-percent chance exceedence event centered at New Exchequer; and at Don Pedro Dam with an annual 2-percent chance exceedence event centered at Don Pedro (Figures C.4-9a, C.4-9f, and C.4-9j). By comparison, objective flows modeled at baseline conditions were maintained at Friant with the occurrence of an annual 10-percent chance exceedence event, and at New Exchequer and Don Pedro with an annual 4-percent chance exceedence event centered over those facilities (Figures C.1-8b, C.1-11c, and C.1-12c).

Alternative Scenario SJQ-B06A

The results of scenario SJQ-B06A are presented in Attachment C.4, Tables C.4-10a and C.4-10b. As previously explained, comparison of peak discharge maxima and peak volume, for this modeled alternative, are designed to permit the passage of greater volumes. A direct comparison of baseline data to alternative data is inadequate. Direct observation of the output data generated by this alternative does, however, expose that simply increasing downstream objective flow limits allows the flood damage reduction facilities to increase their outflows sooner. The direct result is allowing the flood control facility to pass the inflow volumes associated with the first flood wave volumes as described in *Appendix B – Synthetic Hydrology Documentation*. The indirect result is that the flood control pool is allowed to stay lower, longer, allowing the facility to better attenuate the incoming peak flood wave. This alternative of increasing downstream objective flows typically provides a greater benefit for more frequent exceedence frequencies, with the increased objective flow criteria allowing manageable releases to be made sooner.

Reductions in peak discharges are noticeably smaller at mainstem locations, downstream of tributary contributions, compared to the reduced peak regulated outflows at Friant Dam for all seven synthetic exceedence frequencies. This is attributed, in part, to the largely different conveyance capacities between the mainstem, its tributaries, and the added effect of various unregulated local inflows. Operations at the Friant flood damage reduction facility are effected by objective flow criteria at a downstream index gage location. The modified releases at Friant

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Dam for this alternative are operated to keep flows at or below 16,000 cfs (up from an existing baseline of 8,000 cfs) just downstream of Little Dry Creek's confluence with the San Joaquin River. As can be observed in the alternative's reservoir simulation hydrographs representative of Friant Dam, simulated objective flows were maintained by all events including and occurring more frequently than an annual 4-percent chance exceedence storm runoff centered at Friant Dam (Figures C.4-10a through C.4-10d). By comparison, the objective flows representing simulated baseline conditions were exceeded at Friant Dam by events more frequent than and including a 10-percent chance exceedence event (Figure C.1-8b). Volumes attenuated through the modeling of Alternative SJQ-B06 are significant in capacity and clearly exhibit flood damage reduction benefits. Reductions in peak maxima and volume remains consistent with the occurrence of 1- and 0.5-percent chance exceedence events for flood centerings at or immediately downstream (El Nido) of the Friant Dam index gage location. Negative values, indicative of a net increase in peak flow maxima and volume associated with the modeled alternative, are attributed to an increase in the simulated objective flows at the Don Pedro facility.

As exemplified in Table C.4-10a, the simulation of alternative SJQ-B06A provides an immediate beneficial increase in the projects ability to manage simulated floods of greater magnitude. The existing baseline results indicate that though the peak maxima increase in the simulation of the 50-, 10-, and 4-percent chance exceedence events, increasing the operational objective flow value allows Friant Dam to increase its ability to maintain downstream objective flow criteria from that of a 10-percent chance exceedence event during baseline simulations to that which occurs during the simulation of an annual 4-percent chance exceedence event. Allowing Friant Dam to increase its downstream objective flow yields a net reduction in the peak maxima of the simulated 2-percent chance exceedence event of 24.5 percent.

Alternative Scenario SJQ-B07A

The results of scenario SJQ-B07A are presented in Tables C.4-11a and C.4-11b. Because comparison of peak discharge maxima and peak volume, for this modeled alternative, are designed to permit the passage of greater volumes, a direct comparison of baseline data to the alternative data is inadequate. Direct observation of the output data generated by this alternative does however, expose that simply increasing downstream objective flow limits allows the flood damage reduction facilities to increase their outflows sooner. The direct result is allowing the flood control facility to pass the inflow volumes associated with the first flood wave volumes as described in *Appendix B – Synthetic Hydrology Documentation*. The indirect result is that the flood control pool is allowed to stay lower, longer, allowing the facility to better attenuate the incoming peak flood wave. This alternative of increasing downstream objective flows typically provides a greater benefit for events of a more frequent exceedence probability, with the increased objective flow criteria allowing manageable releases to be made sooner.

Reductions in peak discharges are noticeably smaller at mainstem locations, downstream of tributary contributions, in comparison to the reduced peak regulated outflows of New Exchequer Dam for all seven synthetic exceedence frequencies being simulated. This is attributed, in part, to the significantly different conveyance capacities between the mainstem and its tributaries and the added effect of various unregulated local inflows. Operations at the New Exchequer flood damage reduction facility are effected by objective flow criteria at a downstream index gage location. The modified releases at New Exchequer for this alternative are operated to keep flows

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at or below 8,000 cfs (an increase of 2,000 cfs) in the Merced River at Stevinson. As can be observed in the alternative reservoir simulated hydrographs in Attachment C.4, the simulated objective flows were maintained by all simulated events more frequent than, and including the simulated annual 2-percent chance exceedence storm runoff centering, focused at New Exchequer Dam (Figures C.4-11a through C.4-11d). By comparison, objective flows simulating baseline conditions were exceeded at New Exchequer (with a centering at New Exchequer) by events occurring in greater frequency than the simulated 4-percent chance exceedence event (Figures C.1-11c through C.1-11g). Volumes attenuated through the modeling of Alternative SJQ-B07 are significant in quantity and clearly exhibit flood damage reduction benefits. Negative values, indicative of a net increase in peak flow maxima and volume associated with the modeled alternative, are attributed to an increase in the simulated objective flows at the Don Pedro facility.

As exemplified in Table C.4-11a, simulations of alternative SJQ-B07A provide an immediate beneficial increase in the projected level of flood protection at New Exchequer Dam. Existing baseline results indicate that simulated releases from New Exchequer Dam provide roughly a 4-percent chance exceedence level of protection while the simulated alternative provides just over an annual 2-percent chance exceedence level of protection, resulting in a reduction of the peak maxima by 63.8 percent.

MAINSTEM FLOOD REDUCTION ALTERNATIVES INCORPORATING FLOODPLAIN STORAGE BASINS AND RESERVOIR REOPERATIONS

Introduction

An approach to solving the problem of not having adequate water control alternatives in flood management operations is to find areas to which peak flood volumes can be temporarily diverted and detained. Taking advantage of one of the basic benefits of using simulation models, modifications were made to the original baseline HEC-5 flood control simulation model to do just that. Off-stream storage areas were coded into a copy of the simulation model input file. This alteration allowed for a “modified baseline” to be established, representing how the existing flood management system would function with additional flood storage areas. The result is a set of “with-additional-storage” hydrographs to use in comparison with the “without-additional-storage” (baseline) hydrology. Comparison of the “modified baseline” and the “original baseline” hydrology allow planners and managers to make quantitative assessments of the effect an off-stream storage site has on attenuating in-stream peaks and flow volumes. Additionally, this modified baseline model allowed for further changes and combinations of changes to the model’s representation of individual reservoir’s flood operating criteria, such as increasing its available flood conservation space.

Selection of Floodplain Storage Areas

In order to evaluate the potential effectiveness of floodplain storage in terms of reducing peak flows, several representative storage areas were evaluated using the HEC-5 model. Five locations along the San Joaquin River were identified as having hydraulic characteristics suited for diverting and temporarily storing flood runoff (Table VI-5). The representative floodplain

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storage areas that were chosen for evaluation were determined by using the following considerations:

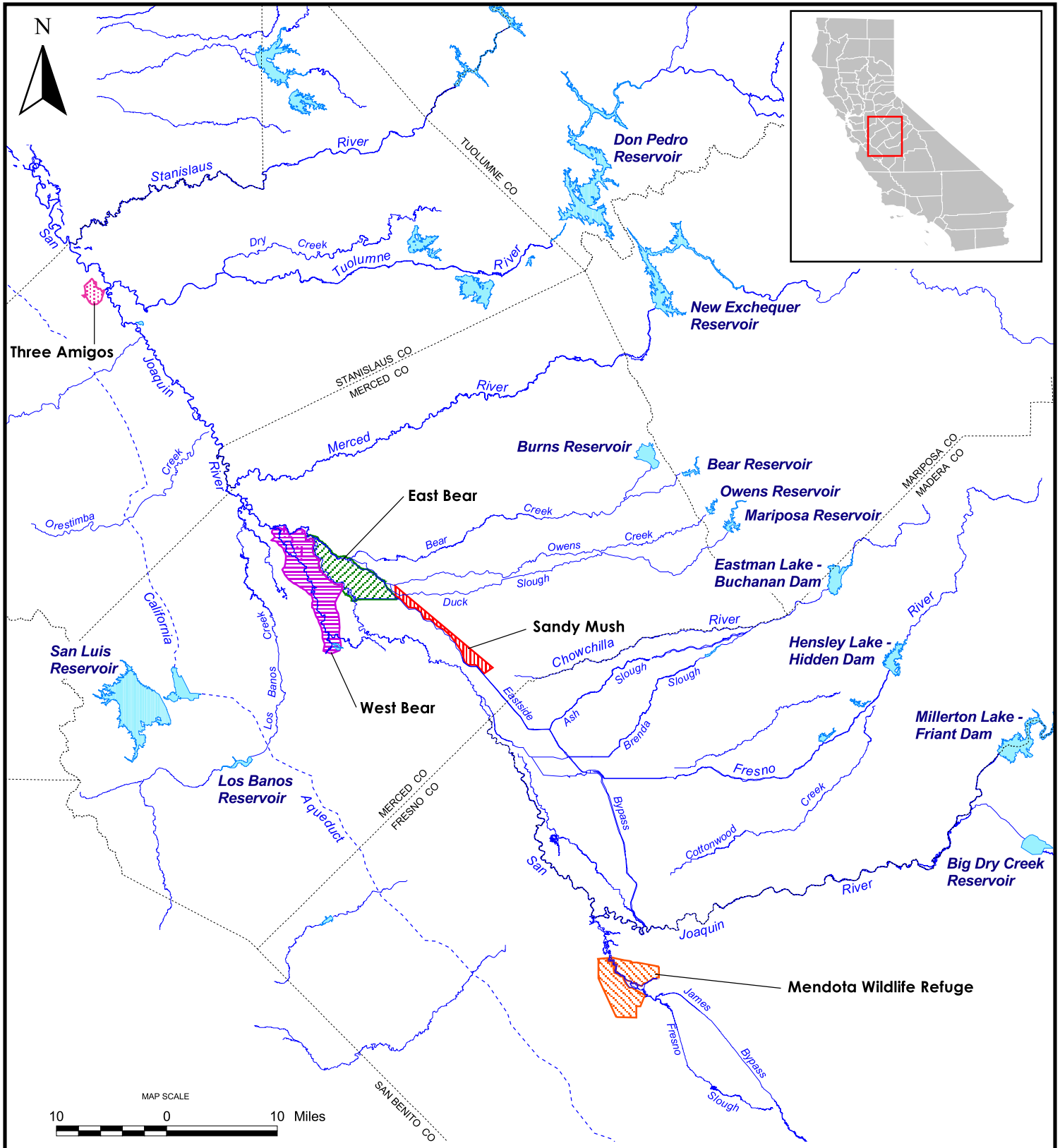
- Public lands currently in or planned for wetland restoration.
- Areas that have flooded in the past, as recorded in the Sacramento and San Joaquin River Basins, Post-Flood Assessment (March 1999), which included the flood events of 1983, 1986, 1995, and 1997.
- Inundation maps prepared for the Comprehensive Study, placing special emphasis on areas that flooded more frequently.
- Topographic suitability (ability to contain and drain flows using existing terrain).

The baseline HEC-5 San Joaquin lower basin reservoir operations model was then modified to include these five storage areas. Figure VI-3 exhibits the proposed location and extent of each storage basin as they were modeled along the San Joaquin River. The physical constraints of each storage area, such as their rate of inflow and maximum storage capacities, were based on the topographical characteristics of each area of inundation and their average flood depth determined through parallel hydraulic modeling efforts (*Technical Appendix D – Hydraulic Technical Documentation*).

**TABLE VI-5
FLOODPLAIN STORAGE AREAS**

Floodplain Storage	Diversion Location	Maximum Storage Capacity (acre-feet)
Mendota Wildlife Area	Along Fresno Slough upstream of Mendota	21,676
Sandy Mush	Eastside/Mariposa Bypass upstream of El Nido	20,500
West Bear	San Joaquin River upstream of Bear River confluence	35,600
East Bear (Bravel Slough)	Eastside Bypass upstream of Owens Creek confluence	35,000
Three Amigos	San Joaquin River immediately downstream of Tuolumne River confluence	14,650

Note: Prior to use and application, reference the "Expectations of Use" preface.



MAP LEGEND

- Transitory Storage Basins
- Lake or Reservoir
- River or Stream
- County Boundary

SACRAMENTO & SAN JOAQUIN RIVER BASINS
COMPREHENSIVE STUDY

**TRANSITORY STORAGE
BASIN LOCATIONS**

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Reservoir Selection and Reoperation

Three flood damage reduction reservoirs, each tributary to the San Joaquin River, were chosen for these alternatives analysis based on their current levels of flood protection. It was anticipated that flood damage reduction benefits would be attained by allocating additional flood storage at these facilities. Those chosen were Friant Dam, New Exchequer Dam, and Don Pedro Dam, each of which barely provide protection against the occurrence of a storm equivalent to that of a 2-percent chance exceedence event. This alternatives analysis set forth to analyze the effects of adding various storage combinations of additional flood control space in these reservoirs and the influence those additional volumes have on the diverted flood volumes and the peak flow and volumes within the mainstem of the San Joaquin River. Table VI-6 presents the myriad of possible combinations and permutations of additional flood control space modeled in this analysis, as well as the total flood control space incorporated into San Joaquin drainage basin. These volumes were chosen based on: 1) the practicality of attaining additional flood control space within each reservoir; 2) preliminary benefits analysis of previous investigations (Grid Analysis); and 3) existing system constraints. At Friant Dam, flood control storage increases of 100 and 170 TAF were analyzed, at New Exchequer 50 and 100 TAF, and at Don Pedro 100 and 200 TAF.

HEC-5 Modeling Approach

The floodplain storage areas were treated as storage basins or reservoirs and modeled with the baseline HEC-5 model such that excess flows from the San Joaquin River were diverted directly into the storage basins. Diversions were coded within the model input file to begin when flows in the mainstem of the San Joaquin River were near the maximum channel capacity at that location. The rate at which diverted flows enter each floodplain storage area were defined through parallel modeling efforts of the San Joaquin UNET model developed for the Comprehensive Study (Appendix D). Output from the simulated annual 0.2-percent chance exceedence event was used to generate best-fit curves of total in-stream flow versus diverted flow for each floodplain storage area. The annual 0.2-percent chance exceedence event was chosen as a conservative estimator ensuring that the maximum conveyance capacity and diversion rates are represented. Total and diverted flow values entered into the HEC-5 model were selected from these curves.

Note: Prior to use and application, reference the "Expectations of Use" preface.

TABLE VI-6
FLOOD CONTROL STORAGE INCREASES

Alternative Scenario	Flood Control Storage Combinations (TAF)			
	Friant	New Exchequer	Don Pedro	Total
Modified Baseline	0	0	0	0
*SJQ-T01A	100	0	0	100
*SJQ-T02A	170	0	0	170
SJQ-T03A	0	50	0	50
*SJQ-T04A	100	50	0	150
*SJQ-T05A	170	50	0	220
SJQ-T06A	0	100	0	100
*SJQ-T07A	100	100	0	200
*SJQ-T08A	170	100	0	270
SJQ-T09A	0	0	100	100
*SJQ-T10A	100	0	100	200
*SJQ-T11A	170	0	100	270
SJQ-T12A	0	50	100	150
*SJQ-T13A	100	50	100	250
*SJQ-T14A	170	50	100	320
SJQ-T15A	0	100	100	200
*SJQ-T16A	100	100	100	300
*SJQ-T17A	170	100	100	370
SJQ-T18A	0	0	200	200
*SJQ-T19A	100	0	200	300
*SJQ-T20A	170	0	200	370
SJQ-T21A	0	50	200	250
*SJQ-T22A	100	50	200	350
*SJQ-T23A	170	50	200	420
SJQ-T24A	0	100	200	300
*SJQ-T25A	100	100	200	400
*SJQ-T26A	170	100	200	470

* Alternative scenarios presented in Figure VI-18.

Figures VI-4 through VI-7 depict the timing of inflow into each basin as the model passes the synthetic 4-, 2-, and 1-percent chance exceedence events through the system. Once these storage areas reach their maximum capacities, excess flows are redirected back into the main channel. This was accomplished by modeling the floodplain storage areas as “dummy” reservoirs that “fill and spill.” Outflow from each dummy reservoir is held at zero while maintaining channel capacity within the mainstem of the San Joaquin River, until its storage capacity is exceeded. At this point: outflows equal inflows, returning outflows in excess of each floodplain storage basin’s retaining capacity back into the main channel immediately downstream of the diversion point with a zero routing time. In essence, Figures VI-4 through VI-7 exhibit the total flows diverted through each floodplain storage basin. Figures VI-8 through VI-11 however, reveal the functionality of each basin as each of the seven synthetic exceedence frequency events is processed through the model. Noticeably, in Figures VI-8 through VI-11, the West Bear storage floodplain area is the first of the five basins to begin receiving inflows and fills to its maximum capacity with any event occurring more frequently than an annual 50-percent chance exceedence event. The intent of each diversion is to provide a mechanism for lowering peak stage and

Note: Prior to use and application, reference the “Expectations of Use” preface.

volume within the mainstem of the San Joaquin River. Figures VI-12 through VI-17 exhibit regulated, in-stream hydrographs representative of the original baseline (without-project) and modified baseline (with-project) flow conditions on the mainstem of the San Joaquin River.

A total of 27 different scenarios of flood control storage combinations between the three selected reservoirs were examined (Table VI-6). The total amount of increased flood control space ranged from 0 to 470 TAF, and was written into the HEC-5 model by decreasing each reservoir's respective conservation volume; thereby effectively lowering its top of conservation elevation. Increasing a reservoir's available flood control space through lowering their individual top of conservation elevations provided a simple mechanistic approach in the application of these alternatives without having to arduously re-design the input structure with respect to the physical and operational characteristics of each reservoir and recalibrate each reservoir.

The modified baseline (AAB) and alternative scenario (SJQ-T01A through SJQ-T26A) models were each analyzed with four previously developed centerings (*Appendix B Synthetic Hydrology Technical Documentation*): three of them mainstem storm centerings (El Nido, Newman, and Vernalis) and one tributary centering (San Joaquin River at Friant). These mainstem centerings were selected because of their ability to impact the entire basin, that being the mainstem of the San Joaquin River and its tributaries. Unlike mainstem centerings, the tributary centerings stress individual tributary systems but are not widespread enough to generate the large runoff volumes typical of a basin wide storm. The Friant storm centering was chosen to simulate flood events along the upper San Joaquin River downstream of which the majority of the floodplain storage areas are located.

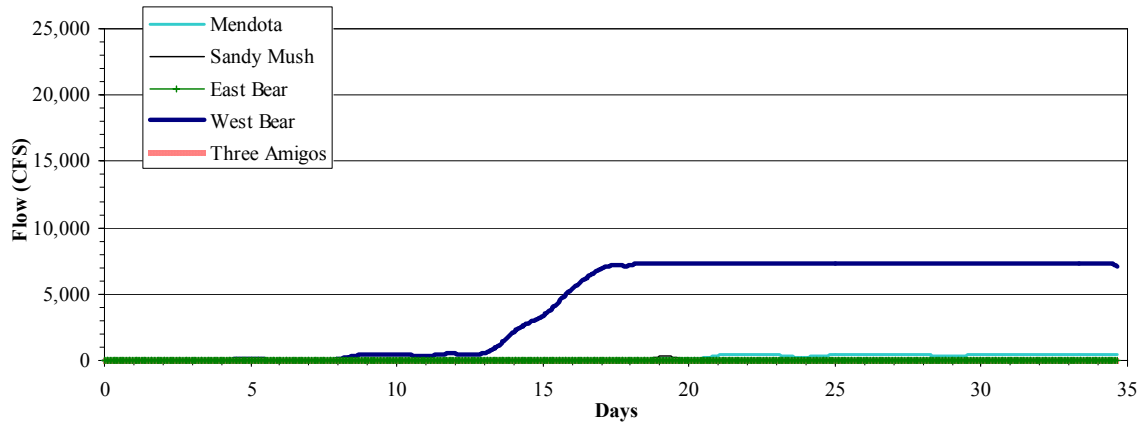
The effectiveness that increased flood control storage has on reducing floodplain storage volume was analyzed for the occurrence of 4-, 2-, and 1-percent chance exceedence events (Figure VI-18). The influence that increased reservoir flood control space has on floodplain storage volumes is strongly dependent on the location of the floodplain storage area. Increases to flood control storage within Friant, New Exchequer, and Don Pedro have no effect on floodplain storage volumes within the Mendota Wildlife Area, which receives diverted flow from Fresno Slough, upstream of the Friant, New Exchequer, and Don Pedro flood damage reduction facilities.

CONCLUSIONS

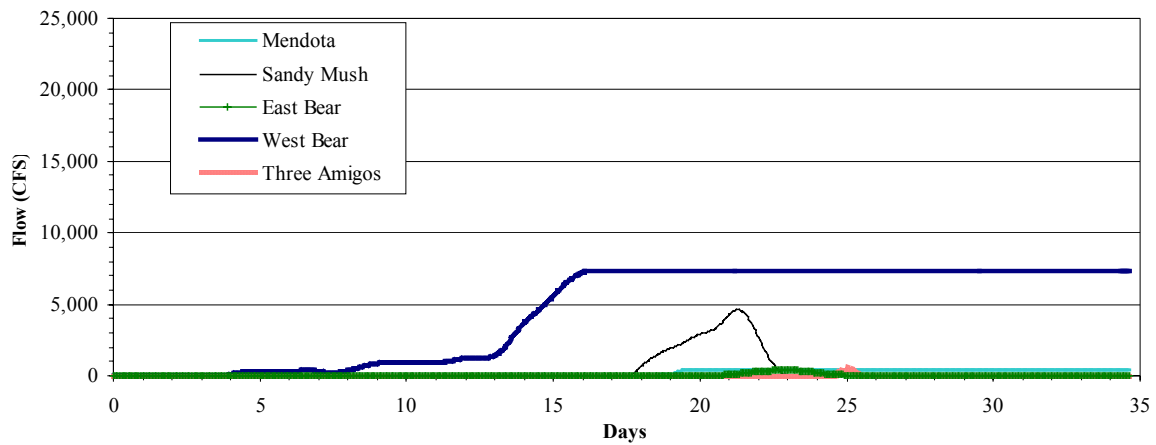
These analyses were not designed to recommend specific re-operations, but to serve as valuable references for investigating and communicating the effects of changes in objective releases and available flood storage. It is important to remember that increases in flood storage allocation do not necessarily come at the expense of water supply. Actions like conjunctive use and off-stream storage can bank water for future consumption while freeing space in reservoirs that would be effective in both reducing flood damage and capturing additional water resources seasonally. Likewise, increases in objective flows do not necessarily entail downstream channel alterations. In some cases, existing distribution systems may be used to route floodwater, thereby increasing effective objective releases.

Note: Prior to use and application, reference the "Expectations of Use" preface.

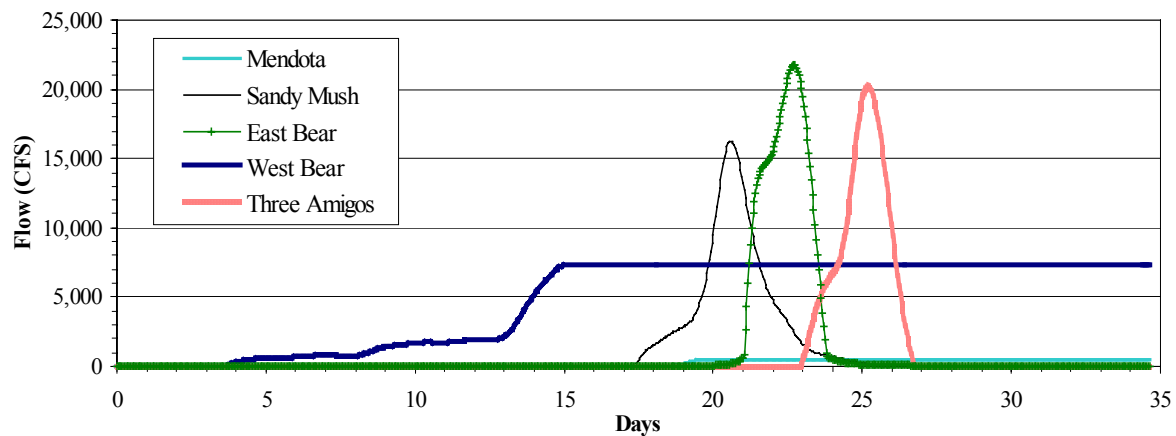
**FIGURE VI-4 FLOW DIVERTED TO FLOODPLAIN STORAGE
Friant Centering (4% Chance Exceedence Event)**



Friant Centering (2% Chance Exceedence Event)

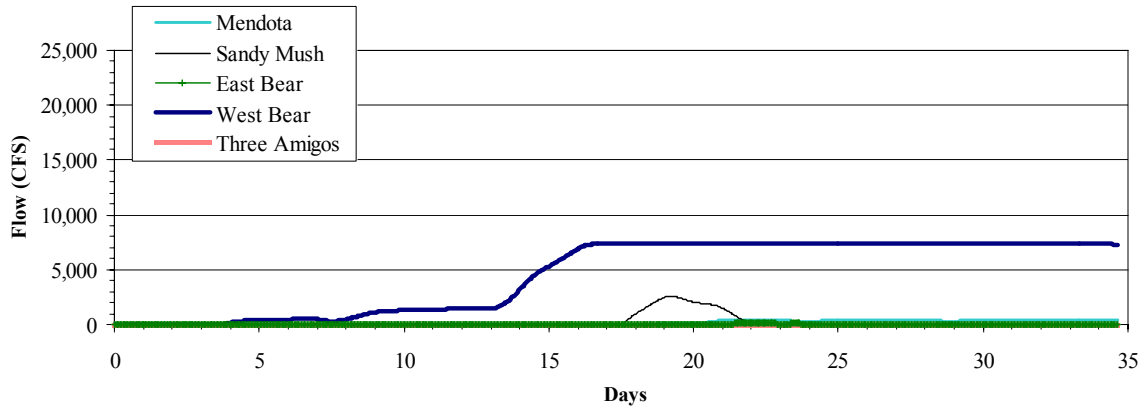


Friant Centering (1% Chance Exceedence Event)

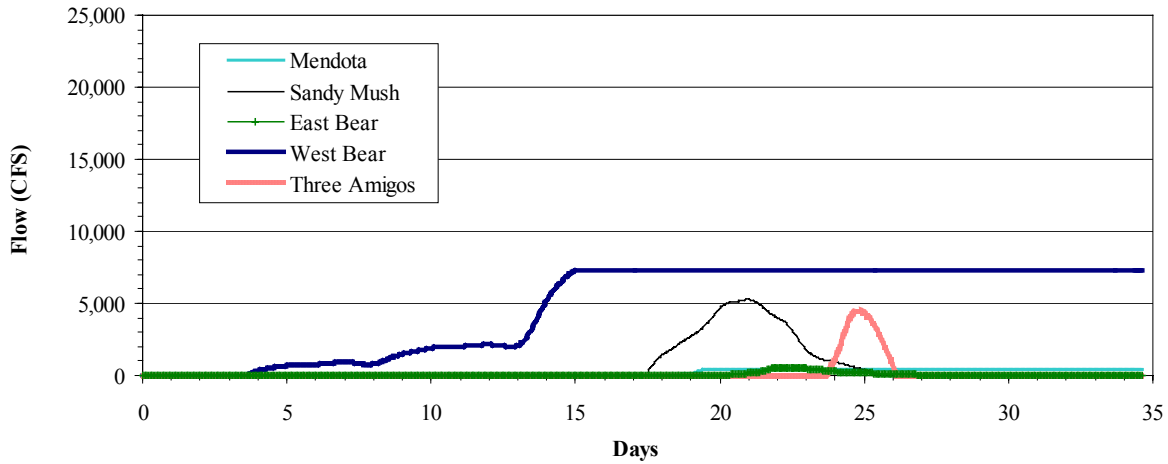


Note: Prior to use and application, reference the "Expectations of Use" preface.

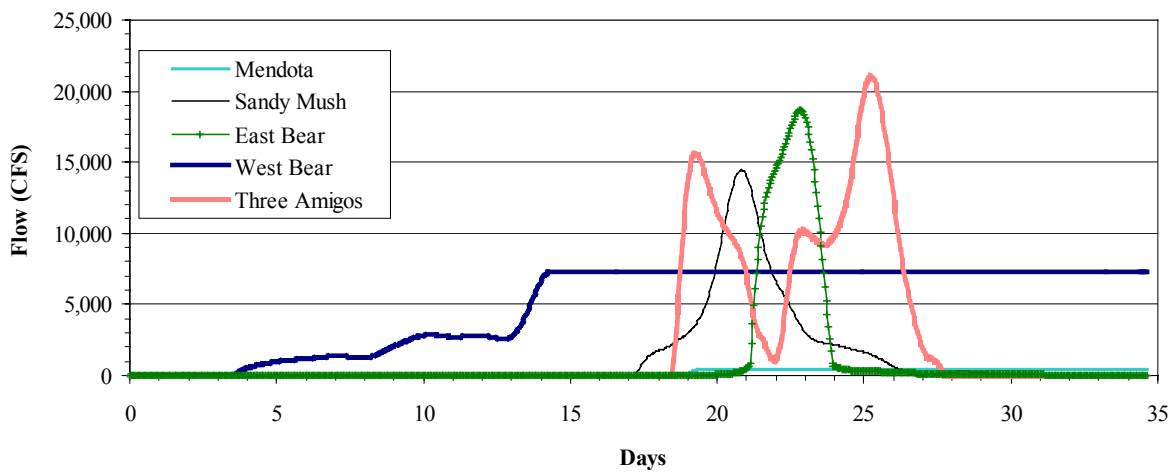
**FIGURE VI-5 FLOW DIVERTED TO FLOODPLAIN STORAGE
El Nido Centering (4% Chance Exceedence Event)**



El Nido Centering (2% Chance Exceedence Event)

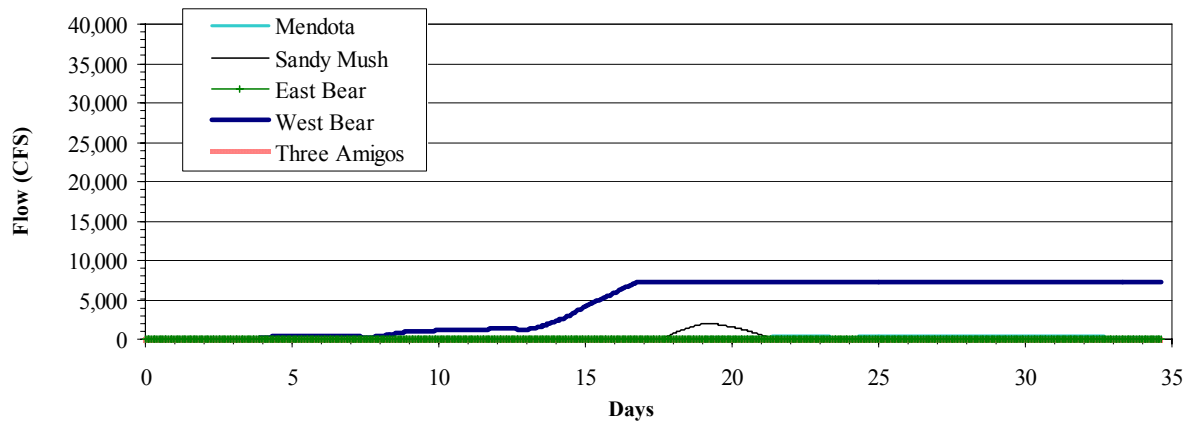


El Nido Centering (1% Chance Exceedence Event)

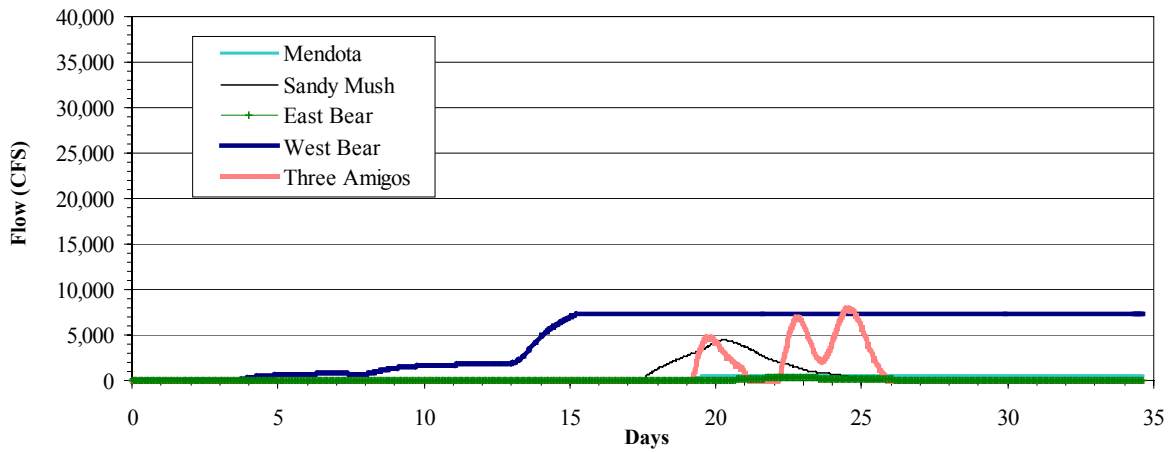


Note: Prior to use and application, reference the "Expectations of Use" preface.

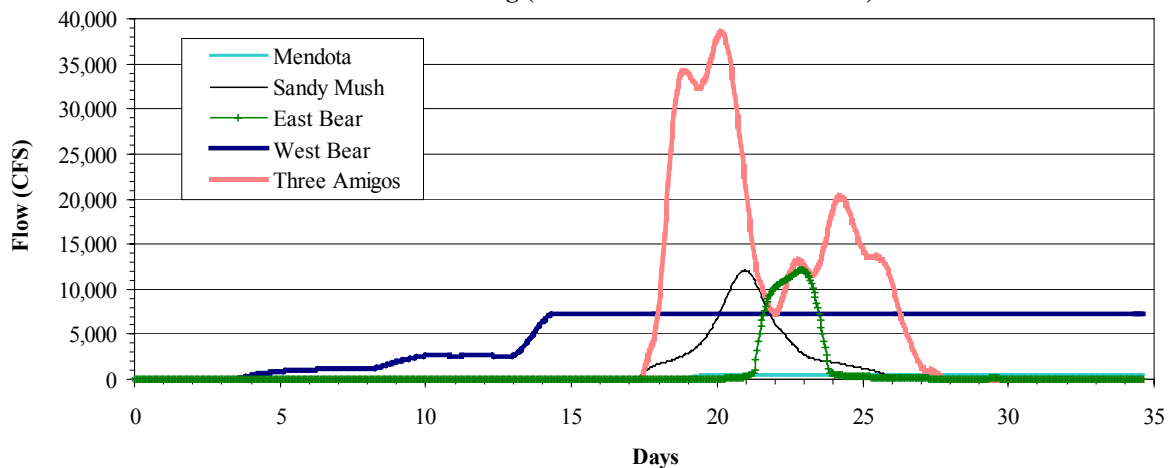
FIGURE VI-6 FLOW DIVERTED TO FLOODPLAIN STORAGE
Newman Centering (4% Chance Exceedence Event)



Newman Centering (2% Chance Exceedence Event)

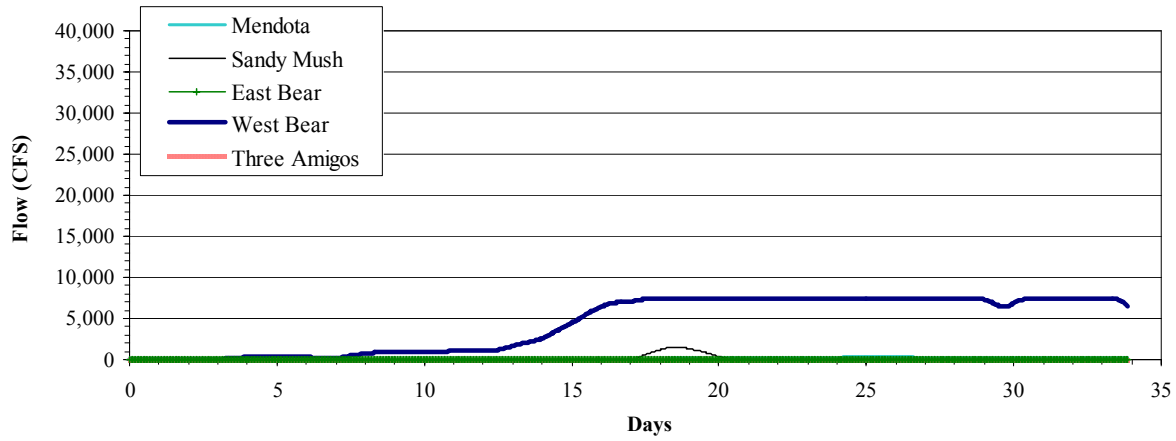


Newman Centering (1% Chance Exceedence Event)

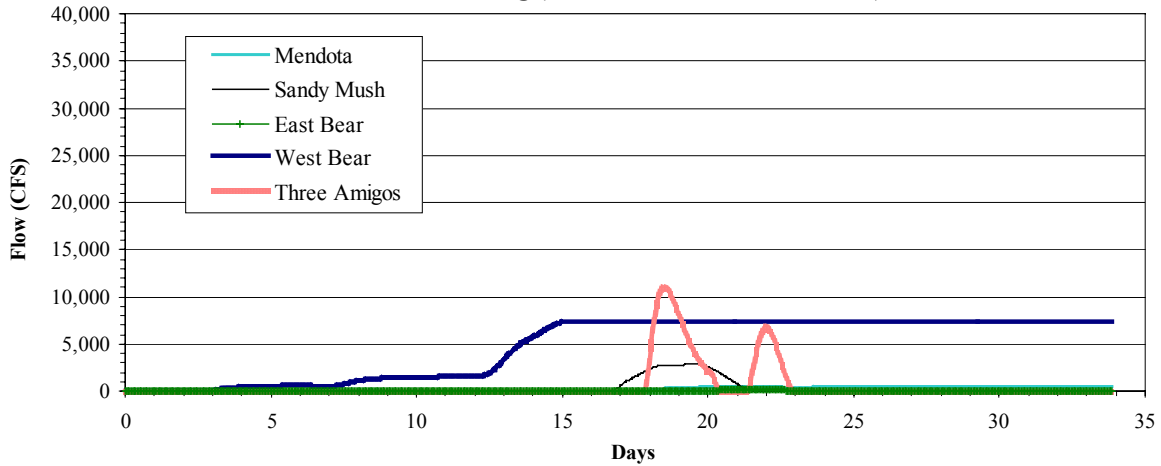


Note: Prior to use and application, reference the "Expectations of Use" preface.

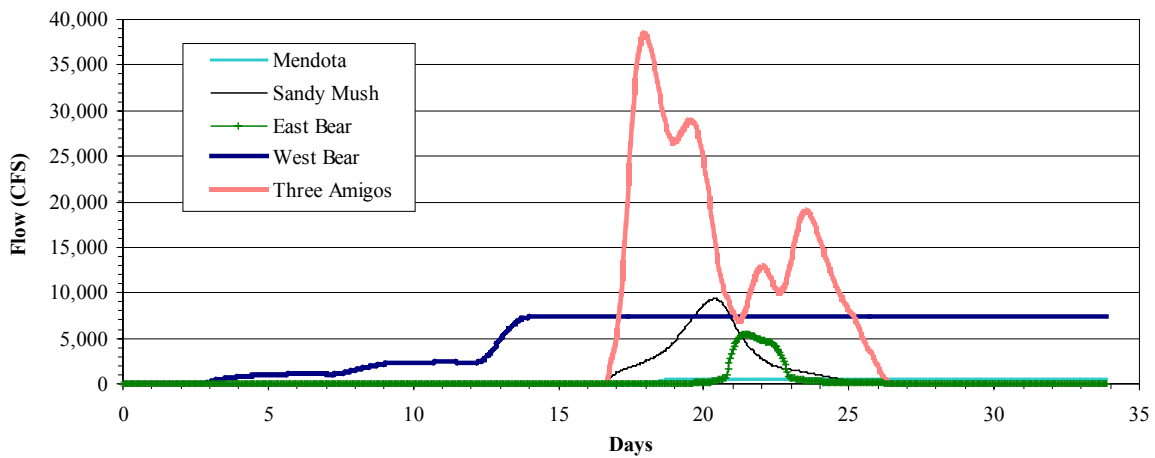
**FIGURE VI-7 FLOW DIVERTED TO FLOODPLAIN STORAGE
Vernalis Centering (4% Chance Exceedence Event)**



Vernalis Centering (2% Chance Exceedence Event)



Vernalis Centering (1% Chance Exceedence Event)



Note: Prior to use and application, reference the "Expectations of Use" preface.

FIGURE VI-8 TOTAL FLOW DIVERTED TO STORAGE - MODIFIED BASELINE, FRIANT CENTERING

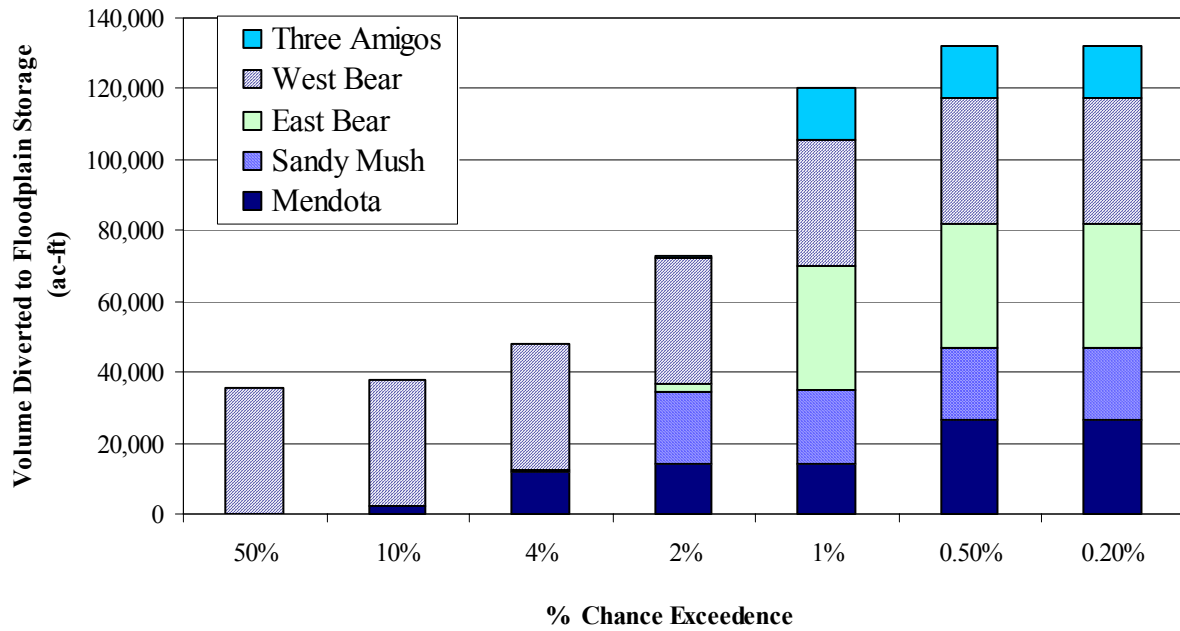
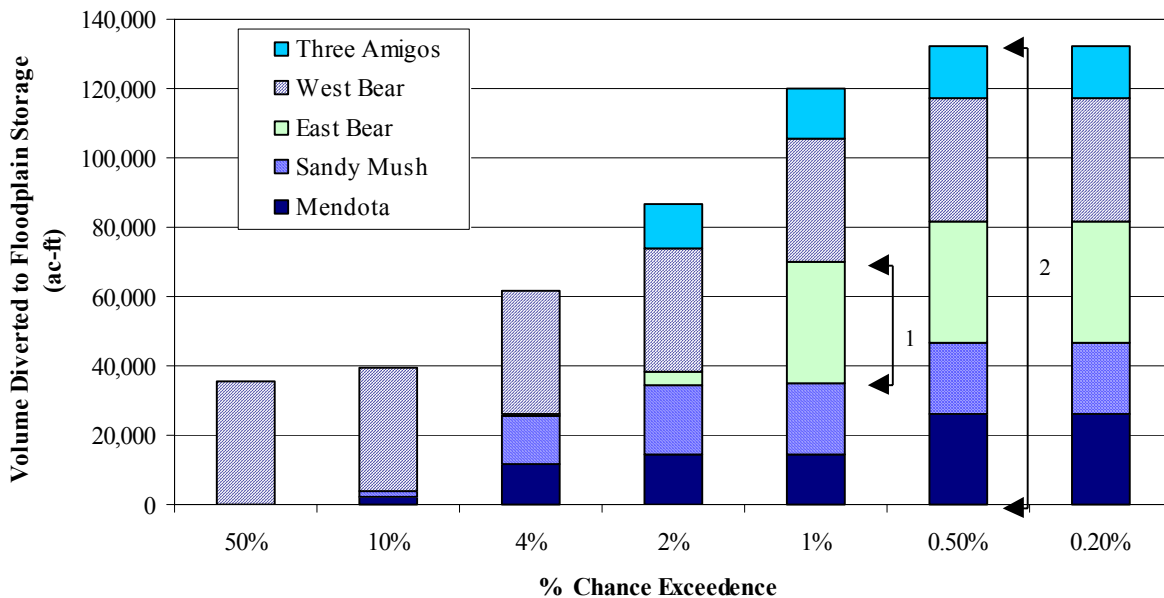


FIGURE VI-9 TOTAL FLOW DIVERTED TO STORAGE - MODIFIED BASELINE, EL NIDO CENTERING



Notes:

1. Column lengths, representative of individual floodplain storage basins, represent the total volume captured by that basin, independent of column heights representing the other basins.
2. Total column heights represent the average total volume diverted into all floodplain storage basins modeled.

Note: Prior to use and application, reference the "Expectations of Use" preface.

FIGURE VI-10 TOTAL FLOW DIVERTED TO STORAGE - MODIFIED BASELINE, NEWMAN CENTERING

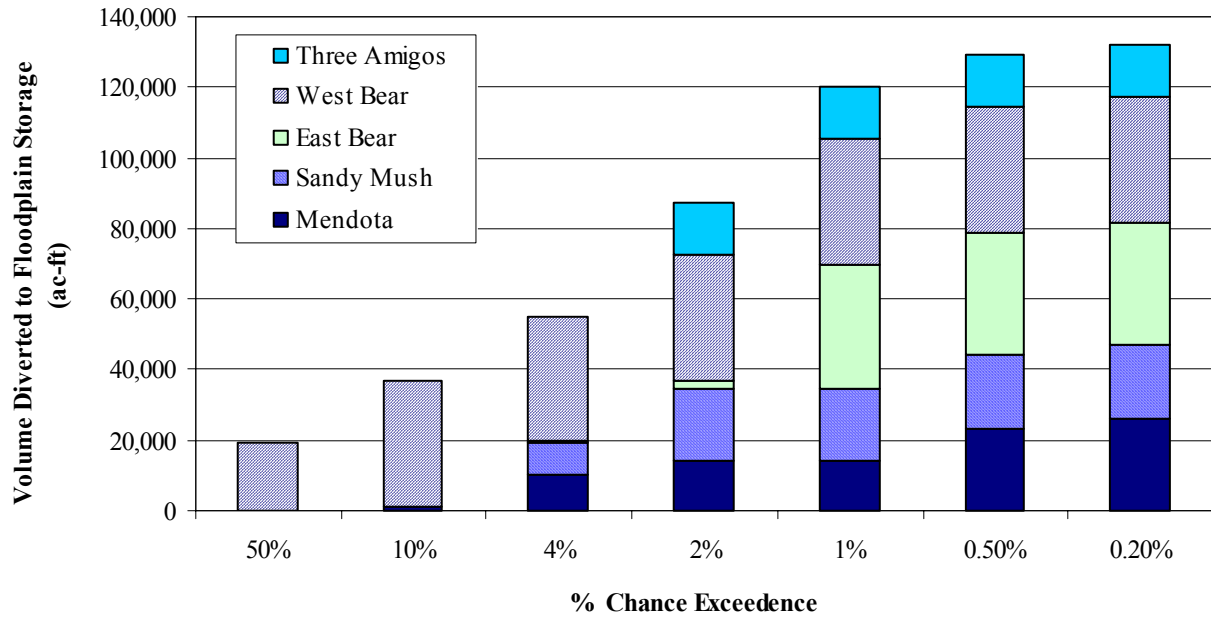
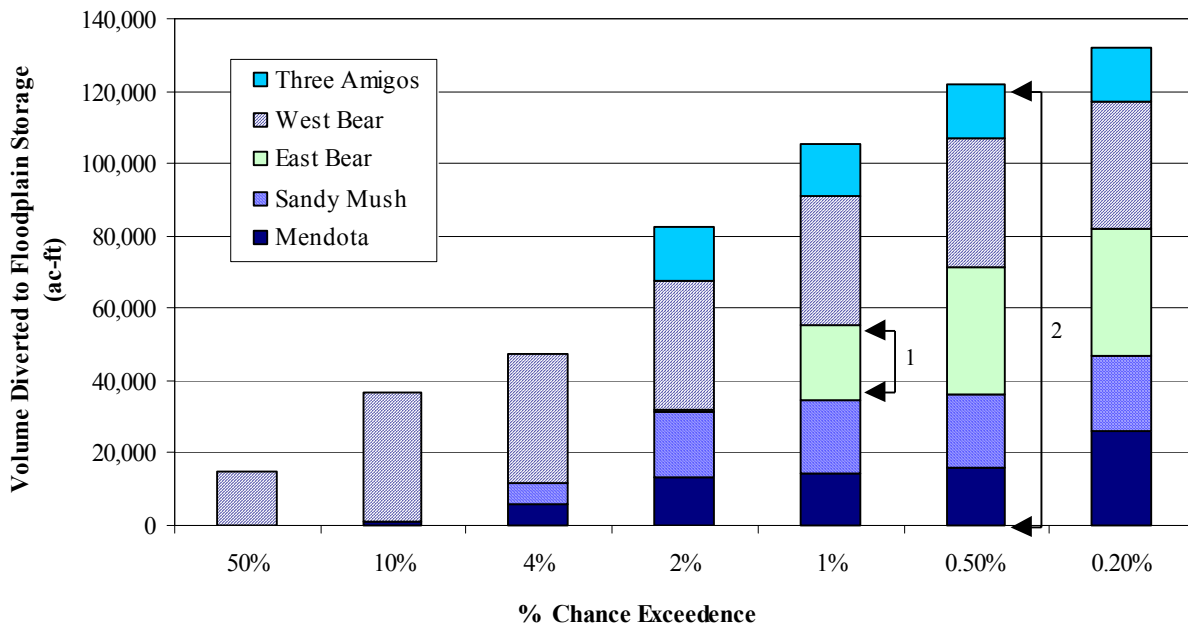


FIGURE VI-11 TOTAL FLOW DIVERTED TO STORAGE - MODIFIED BASELINE, VERNALIS CENTERING



Notes:

1. Column lengths, representative of individual floodplain storage basins, represent the total volume captured by that basin, independent of column heights representing the other basins.
2. Total column heights represent the average total volume diverted into all floodplain storage basins modeled.

Note: Prior to use and application, reference the "Expectations of Use" preface.

COMPARISON OF BASELINE AND MODIFIED BASELINE (WITH-FLOODPLAIN STORAGE) FLOW HYDROGRAPHS

SAN JOAQUIN RIVER FLOW AT EL NIDO (EL NIDO STORM CENTERING)

FIGURE VI-12

Hypothetical Baseline

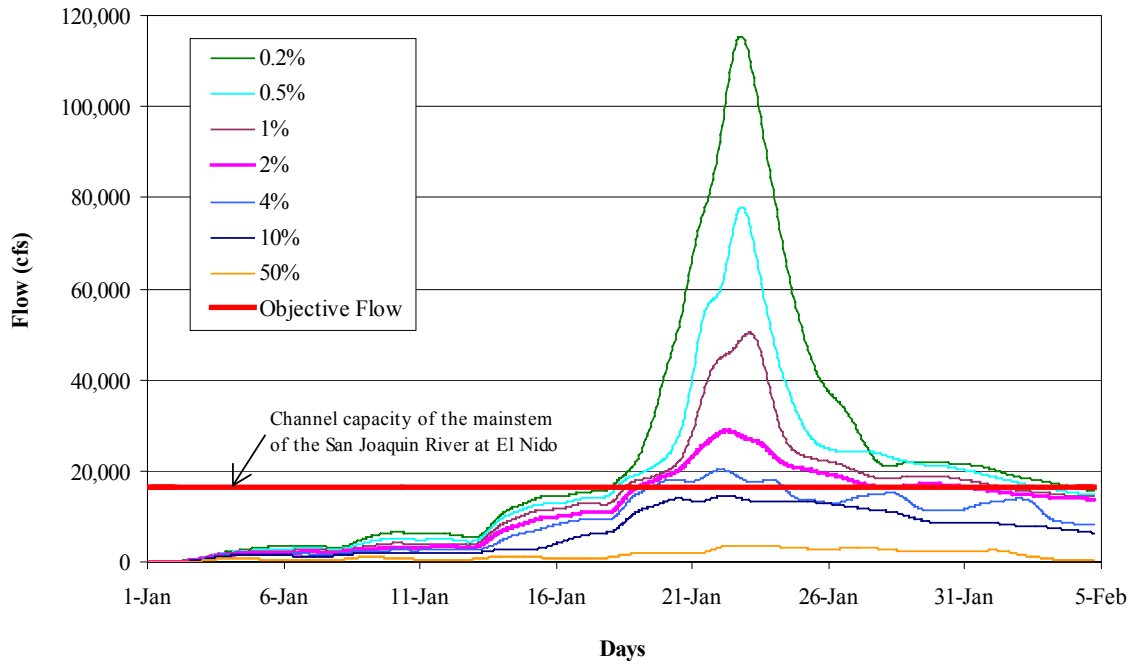
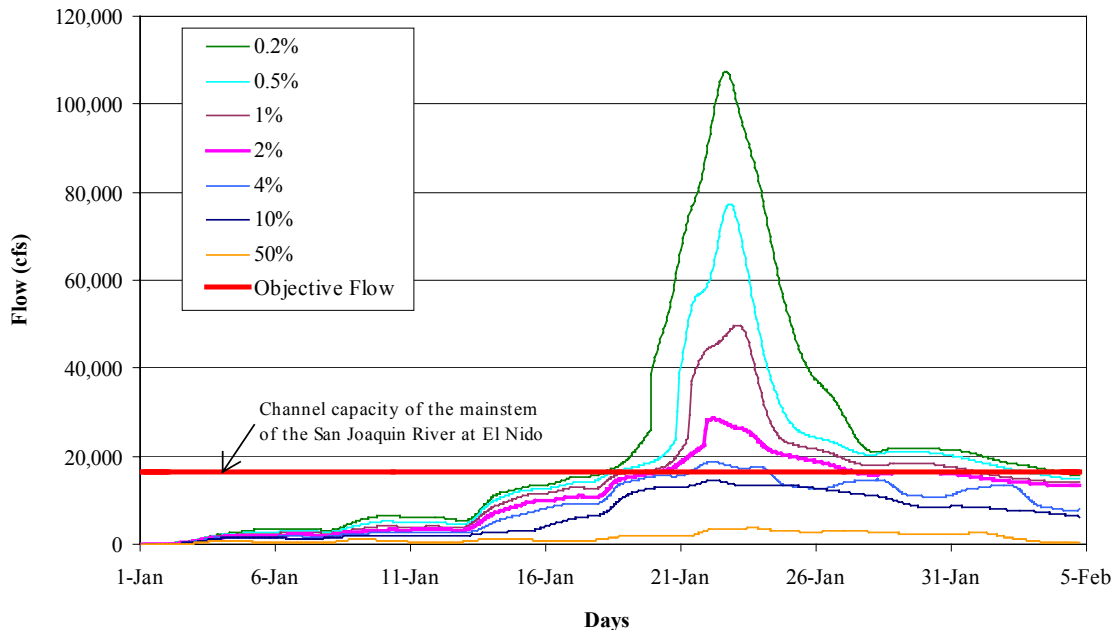


FIGURE VI-13

Modified Hypothetical Baseline



Note: Prior to use and application, reference the "Expectations of Use" preface.

COMPARISON OF BASELINE AND MODIFIED BASELINE (WITH-FLOODPLAIN STORAGE) FLOW HYDROGRAPHS

SAN JOAQUIN RIVER FLOW AT NEWMAN (NEWMAN STORM CENTERING)

FIGURE VI-14

Hypothetical Baseline

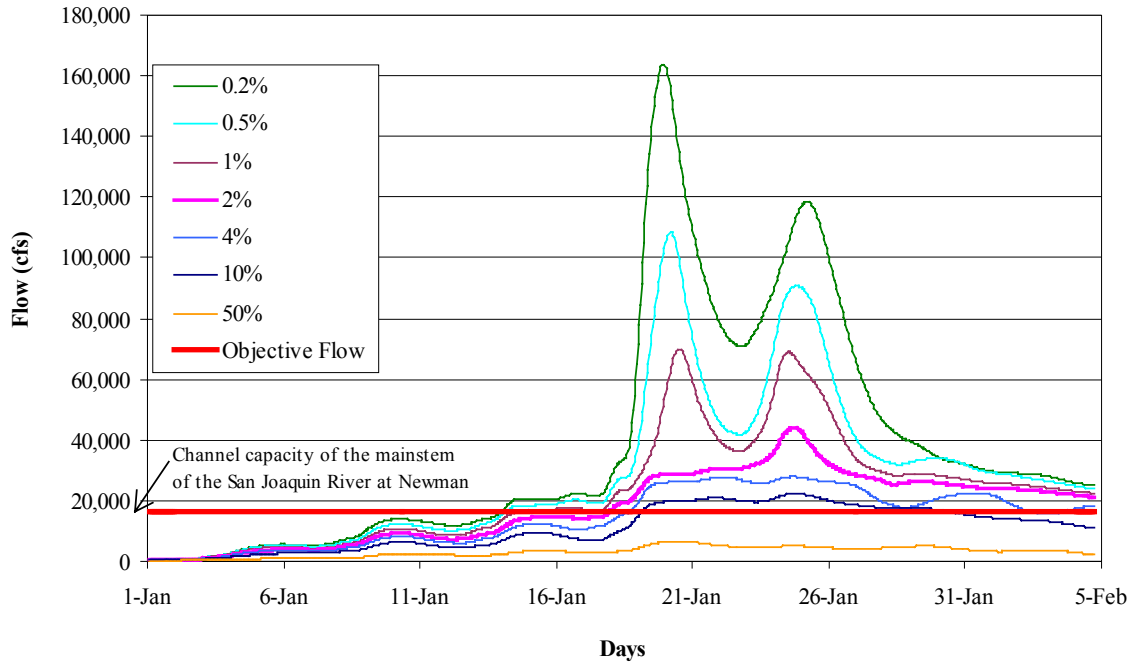
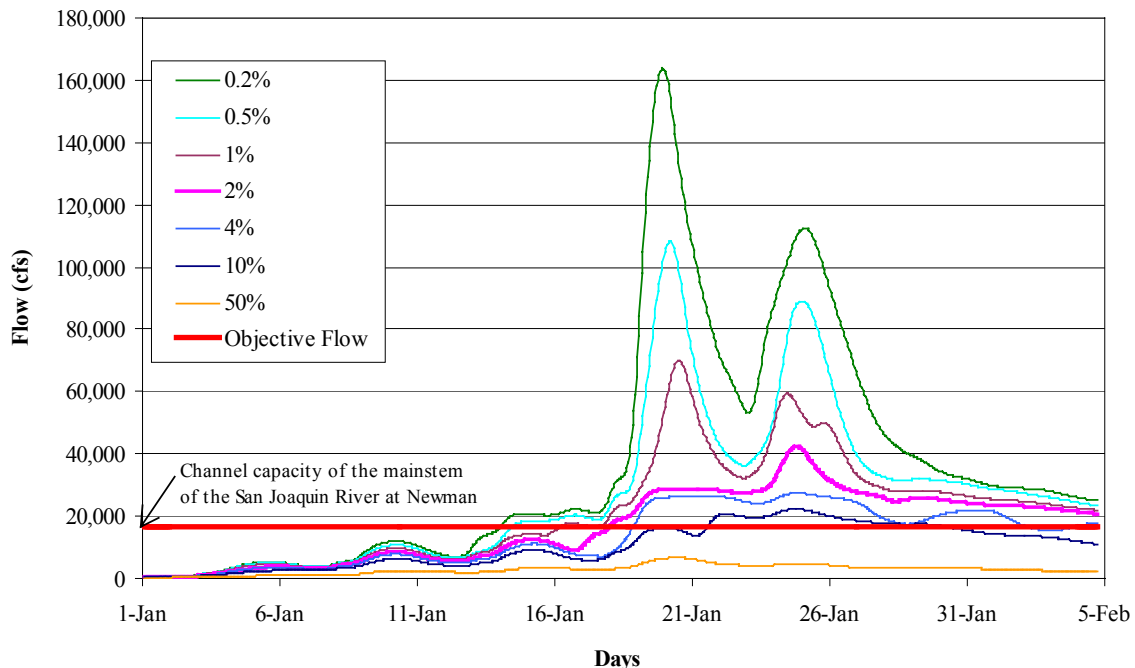


FIGURE VI-15

Modified Hypothetical Baseline



Note: Prior to use and application, reference the "Expectations of Use" preface.

COMPARISON OF BASELINE AND MODIFIED BASELINE (WITH-FLOODPLAIN STORAGE) FLOW HYDROGRAPHS

SAN JOAQUIN RIVER FLOW AT VERNALIS (VERNALIS STORM CENTERING)

FIGURE VI-16

Hypothetical Baseline

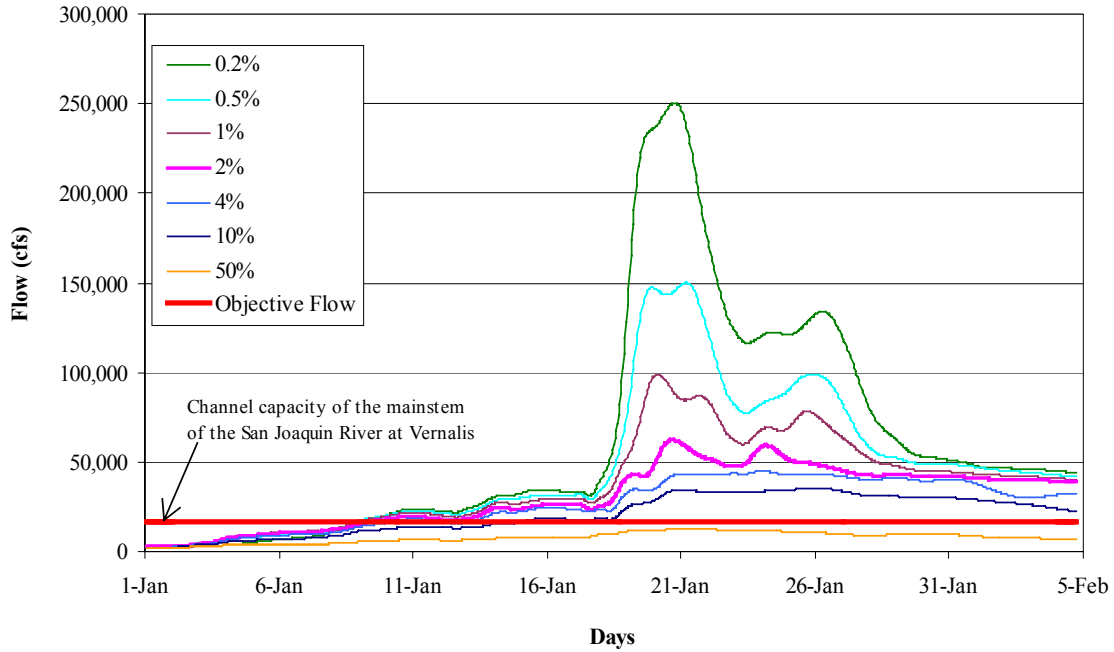
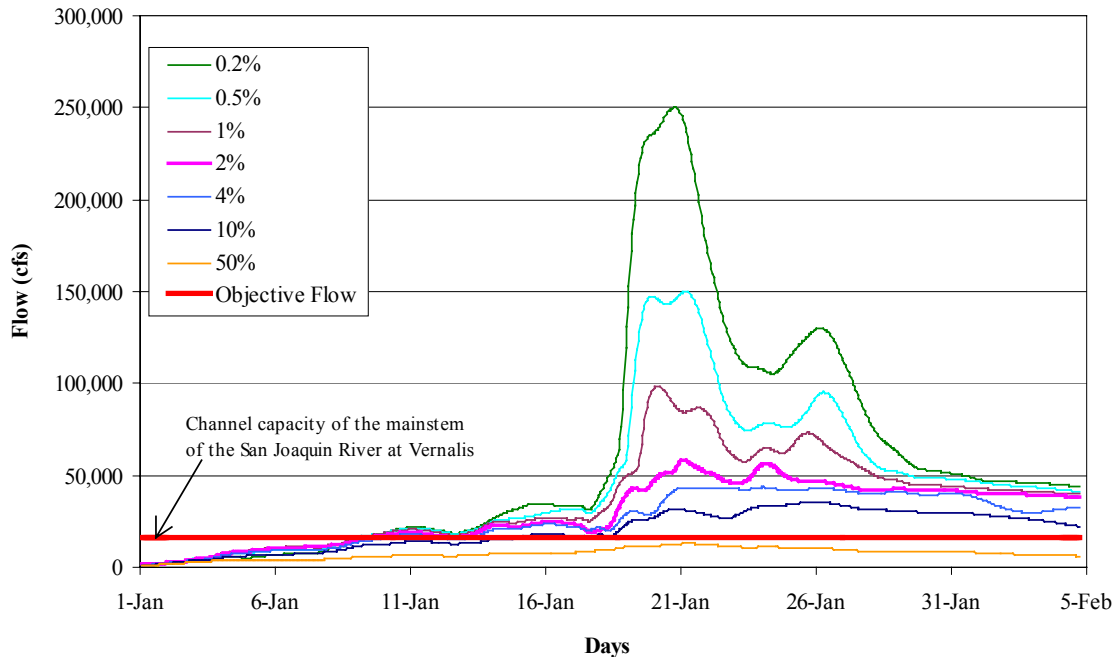


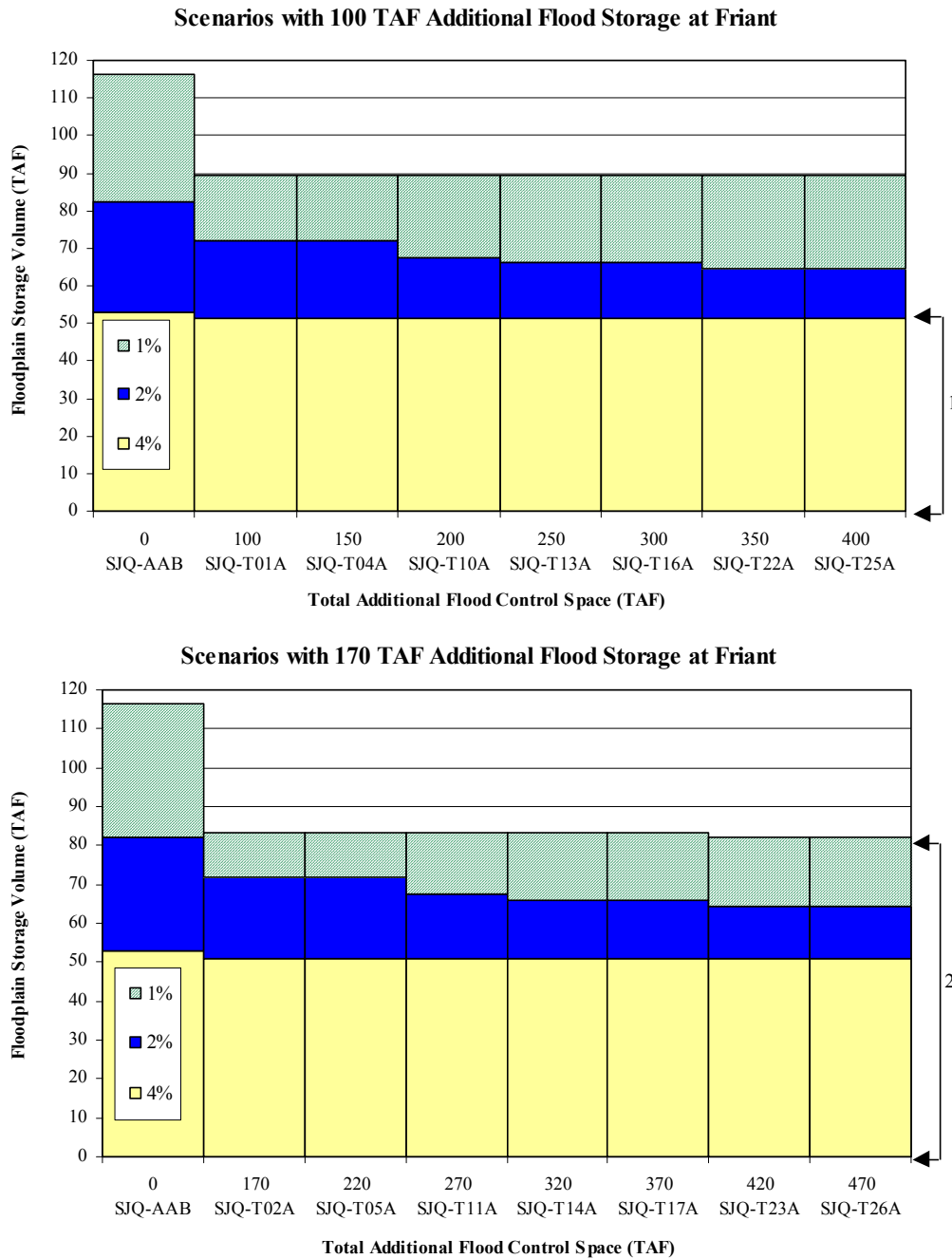
FIGURE VI-17

Modified Hypothetical Baseline



Note: Prior to use and application, reference the "Expectations of Use" preface.

FIGURE VI-18 - TOTAL FLOODPLAIN STORAGE VOLUMES FOR FRIANT STORAGE SCENARIOS



Notes:

1. Individual column segments, representative of each alternative scenario, represent the average volume captured by all the floodplain storage basins in all four event centerings, for each of the seven exceedence frequency events.
2. Total column heights are not cumulative and are stacked in front of one another (i.e. the average volume associated with the annual 1-percent chance exceedence event is that of the total bar height).
3. The Total Additional Flood Control Space (TAF) values are the total additional flood space at Friant, New Don Pedro, and New Exchequer (combined) as modeled in each scenario (see Table VI-6).

Note: Prior to use and application, reference the "Expectations of Use" preface.

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CHAPTER VII

OPERATIONS OF HEADWATER RESERVOIRS

INTRODUCTION

Forty-six headwater reservoirs were included in Comprehensive Study models. Baseline investigations showed that, despite having no formal flood damage reduction functions (operated primarily for water supply and hydropower generation), these reservoirs significantly reduce peak inflows to lower basin reservoirs (see Chapter V). As important elements in system-wide flood hydrology, headwater reservoirs offer opportunities to further reduce potentially damaging flows through reservoir reoperation. This chapter discusses a screening procedure used to highlight opportunities and preliminary alternatives that may provide additional flood damage reduction benefits.

SCREENING OF HEADWATER RESERVOIRS

Early in the alternatives analysis process, selection criteria were developed to screen headwater reservoirs with promise to reduce flood flows. Reservoirs that did not spill during baseline simulations of the 0.2-percent chance exceedence event, or that are located in series above such reservoirs, were omitted from consideration.

Criteria

The following criteria were used for all headwater reservoirs:

- 1) Size. The total storage capacity of a reservoir is proportional to how much flood volume can be stored. Reservoir gross pool storage ranged from 4.5 TAF at Mountain Meadows Reservoir to 1,308 TAF at Lake Almanor with a median of 64 TAF. Almanor was by far the largest; Hetch Hetchy Reservoir followed at 360 TAF. Gross pool storages are tabulated in Chapter II, Table II-1. Reservoirs were assigned values ranging linearly from 0 to 10 according to gross pool storage between 0 TAF and 360 TAF (i.e., gross pool storage of 180 TAF would receive a 5). Lake Almanor did not spill during simulation of the 0.2-percent chance exceedence event and is therefore eliminated from this list.
- 2) Percent natural runoff regulated. The percent regulation is proportional to the opportunity for reduction of flood flows downstream. Values ranged from 1 to 98 percent (see Chapter III). Reservoirs were assigned values linearly from 0 to 10 according to percent regulation between 0 and 100 percent.
- 3) Percent capacity at start of simulation. This measure was proportional to the opportunity for reduction of flood flows because reservoirs that tend to maintain near full pools are likely to be more receptive to operations with seasonally reduced storage. Percent capacities ranged from 2 to 100 percent and reservoirs were assigned values between 0 and 10 (i.e., 100 percent capacity would receive a 10).

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- 4) Level of protection of the lower basin. This measure was inversely proportional to the opportunity to reduce flood flows. In other words, if the lower basin protection is already high, there is less of a need to improve or further reduce flood flows. Baseline levels of protection ranged from 5 percent to approximately 0.58 percent chance exceedences. Values for each reservoir were interpolated along a step-linear scale with the following ordinate pairs (50 percent = 10, 10 percent = 8, 2 percent = 6, 1 percent = 3, 0.5 percent = 1, and 0.2 percent = 0).
- 5) Level of protection of the headwater reservoir. This measure was also inversely proportional to the opportunity to reduce flood flows; the greater the baseline level of protection, the smaller the opportunity to further reduce flood flows. Baseline levels ranged from less than a 50- to 0.2-percent chance exceedences and values for each reservoir were interpolated based on the scale listed for criterion 4.

Ranking

In order to focus alternatives analysis on facilities with potential to improve the flood damage reduction system in the Central Valley, criteria values were weighted, summed, and ranked for the headwater reservoirs. Ranked sets were prepared to address: 1) the overall potential of individual facilities to reduce valley flood damages; 2) potential to reduce flood flows; and 3) potential to change operations and the need for that change.

Potential Reduction of Valley Flood Damages (Criteria No. 1, 2, 3, 4, & 5)

This list included all criteria using the most complete perspective while highlighting promising reservoirs (Table VII-1). Criteria values were weighted prior to aggregation and ranking. Size, % regulation, and the lower basin level of protection were emphasized.

Potential to Reduce Flood Flows (Criteria No. 1 & 2)

This list ranked only the physical capabilities of the headwater reservoirs to reduce flows. No attention was given to the need for reductions or for the potential for reoperation to significantly change flood flows. Only size and % regulation criteria, with size weighted twice as heavily as % regulation, were summed and ranked (Table VII-2).

Potential to Change Operations and the Need for that Change (Criteria No. 3, 4, & 5)

This list included % capacity and the level of protection criteria for both headwaters and lower basins (Table VII-3). Of the three, the % capacity at start of simulation received the highest weighting because it most closely reflected the potential to change. Headwater level of protection, which indirectly reflects this same potential, received the lowest rating in order to maintain a balance between the potential for change and the need for that change.

Viewing the Lists

Rankings provide direction for modelers and planners and can be instructive for people becoming familiar with the operation and function of headwater reservoirs. This exercise is not

Note: Prior to use and application, reference the "Expectations of Use" preface.

intended to focus attention and resources on only the highest-ranking facilities and should, therefore, only be used as a rough guide in the formulation of final decisions.

Each list presents a different aspect for consideration during plan formulation and tracking facilities from list to list can be informative. Consider Hetch Hetchy Reservoir, located in the upper Tuolumne River Basin. Hetch Hetchy tops Tables VII-1 and VII-2 and ranks well in Table VII-3. This reservoir places highly across the board indicating that it is strong and well rounded in all criteria. Sly Park Reservoir, which tops the third list, is also an interesting case. Sly Park is located in the Cosumnes River Basin, operated primarily for water supply, and maintained near full (and spills commonly) during wet periods. The Cosumnes River is one of the only Central Valley rivers without a major impoundment on its mainstem and downstream levee systems offering protection against event lesser in magnitude than a 5-percent chance exceedence event. All of these factors suggest that there is need and potential for change in Sly Park operations, which leads to a high rating in Table VII-3. However, Table VII-2 reveals that Sly Park is not likely to be an effective contributor in flood damage reduction due to a low potential to reduce flood flows. Therefore, despite need and potential for change, Sly Park lacks the physical ability to improve flood damage reduction and is a poor candidate for study.

Again, care should be taken to avoid using these lists too explicitly. Rankings are best viewed in terms of fuzzy ranges such as good, borderline, and unlikely candidates.

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TABLE VII-1
WEIGHTED MEASURE OF HEADWATER RESERVOIRS POTENTIAL
TO REDUCE VALLEY FLOOD DAMAGES

Rank	Aggregate Measure	Reservoir	Basin	Tributary	Owner
1	72.9	Hetch Hetchy	Tuolumne River	Tuolumne Creek	CCSF
2	62.5	Camp Far West	Bear River	Bear River	SSWD
3	55.5	Almanor	Feather River	Nfk Feather Creek	PGE
4	54.8	Cherry Valley	Tuolumne River	Cherry Creek	CCSF
5	47.2	Union Valley	American River	Silver Creek	SMUD
6	44.5	Mammoth Pool	SJQ above Friant	San Joaquin River	SCE
7	44.4	Redinger	SJQ above Friant	San Joaquin River	SCE
8	43.6	Rollins	Bear River	Bear River	NID
9	41.4	Salt Springs	Mokelumne River	Nfk Mokelumne River	PGE
10	41.0	Courtright and Wishon	Kings River	Nfk Kings River	PGE
11	39.6	Stony Gorge	Stony Creek	Stony Creek	USBR
12	38.0	Hell Hole	American River	Rubicon River	PCWA
13	36.8	Sly Park Reservoir	Cosumnes River	Sly Park Creek	USBR
14	35.6	Pit7	Sac above Shasta	Pit River	PGE
15	35.2	East Park	Stony Creek	Little Stony Creek	USBR
16	33.9	Shaver	SJQ above Friant	Stevenson Creek	SCE
17	33.6	Britton (Pit3)	Sac above Shasta	Pit River	PGE
18	32.9	New Spicer Meadows	Stanislaus River	Highland Creek	CCWD
19	32.9	Pit6	Sac above Shasta	Pit River	PGE
20	31.8	Edison	SJQ above Friant	Mono Creek	SCE
21	31.5	Beardsley	Stanislaus River	Mfk Stanislaus River	Oakdale - Tri-dams
22	30.8	Spaulding	Yuba River	Sfk Jackson Creek	PGE
23	29.5	French Meadows	American River	Mfk American River	PCWA
24	28.2	Little Grass Valley	Feather River	Sfk Feather River	OWID
25	27.8	Huntington	SJQ above Friant	Big Creek	SCE
26	27.5	Lake Eleanor	Tuolumne River	Eleanor Creek	CCSF
27	27.1	Merle Collins	Yuba River	Dry Creek	Browns Valley ID
28	26.5	Bass Lake	SJQ above Friant	Nfk San Joaquin River	PGE
29	26.0	McCloud	Sac above Shasta	McCloud River	PGE
30	25.3	Scotts Flat	Yuba River	Deer Creek	NID
31	23.2	Bucks Lake	Feather River	Bucks Creek	PGE
32	22.9	Sly Creek	Feather River	Lost Creek	OWID
33	22.5	Donnells	Stanislaus River	Mfk Stanislaus River	Oakdale - Tri-dams
34	22.3	Florence	SJQ above Friant	Sfk San Joaquin River	SCE
35	22.3	Frenchman	Feather River	Last Chance Creek	DWR

Notes:

Weighting is an aggregate of gross pool storage (six), % flood volume regulated (three), level of basin protection (two), level of headwater protection (one), and percent filled at start of flood (one).

Ranking of headwater reservoirs is based on potential to reduce valley flood damages. Shaded rows indicate facilities that have, or occur above reservoirs that offer protection against events > 0.2-percent chance exceedence.

Note: Prior to use and application, reference the "Expectations of Use" preface.

TABLE VII-1 (CONT.)
WEIGHTED MEASURE OF HEADWATER RESERVOIRS POTENTIAL
TO REDUCE VALLEY FLOOD DAMAGES

Rank	Aggregate Measure	Reservoir	Basin	Tributary	Owner
36	21.8	Butt Valley	Feather River	Butt Creek	PGE
37	21.6	Lower Bear	Mokelumne River	Bear River	PGE
38	21.5	Jackson Meadows	Yuba River	Mfk Yuba River	NID
39	20.6	Lake Davis	Feather River	Big Grizzly Creek	DWR
40	19.9	Antelope	Feather River	Indian Creek	DWR
41	18.3	Mountain Meadows	Feather River	Hamilton Creek	PGE
42	17.6	Loon Lake	American River	Gerle Creek	SMUD
43	17.2	Bowman	Yuba River	Canyon Creek	NID
44	15.6	Ice House	American River	Sfk Silver Creek	SMUD
45	13.8	Fordyce	Yuba River	Fordyce Creek	PGE

Notes:

Weighting is an aggregate of gross pool storage (six), % flood volume regulated (three), level of basin protection (two), level of headwater protection (one), and percent filled at start of flood (one).

Ranking of headwater reservoirs is based on potential to reduce valley flood damages. Shaded rows indicate facilities that have, or occur above reservoirs that offer protection against events > 0.2-percent chance exceedence.

TABLE VII-2
MEASURE OF HEADWATER RESERVOIRS POTENTIAL
TO REDUCE FLOOD FLOWS

Rank	Poser 1 Measure	Reservoir	Basin	Tributary	Owner
1	73.3	Hetch Hetchy	Tuolumne River	Tuolumne Creek	CCSF
2	69.7	Almanor	Feather River	Nfk Feather Creek	PGE
3	54.6	Cherry Valley	Tuolumne River	Cherry Creek	CCSF
4	51.7	Camp Far West	Bear River	Bear River	SSWD
5	48.0	Courtright and Wishon	Kings River	Nfk Kings River	PGE
6	44.3	Union Valley	American River	Silver Creek	SMUD
7	39.9	Hell Hole	American River	Rubicon River	PCWA
8	38.8	Mammoth Pool	SJQ above Friant	San Joaquin River	SCE
9	36.7	New Spicer Meadows	Stanislaus River	Highland Creek	CCWD
10	35.3	Salt Springs	Mokelumne River	Nfk Mokelumne River	PGE
11	26.6	Redinger	SJQ above Friant	San Joaquin River	SCE
12	26.3	French Meadows	American River	Mfk American River	PCWA
13	26.1	Shaver	SJQ above Friant	Stevenson Creek	SCE
14	24.2	Rollins	Bear River	Bear River	NID
15	24.1	Edison	SJQ above Friant	Mono Creek	SCE
16	23.8	Spaulding	Yuba River	Sfk Jackson Creek	PGE
17	22.7	Beardsley	Stanislaus River	Mfk Stanislaus River	Oakdale - Tri-dams
18	22.5	Pit7	Sac above Shasta	Pit River	PGE
19	20.4	Britton (Pit3)	Sac above Shasta	Pit River	PGE
20	20.3	Stony Gorge	Stony Creek	Stony Creek	USBR
21	19.7	Bucks Lake	Feather River	Bucks Creek	PGE
22	18.7	Pit6	Sac above Shasta	Pit River	PGE
23	18.1	Huntington	SJQ above Friant	Big Creek	SCE
24	17.9	Little Grass Valley	Feather River	Sfk Feather River	OWID
25	15.7	Lake Davis	Feather River	Big Grizzly Creek	DWR
26	15.2	Donnells	Stanislaus River	Mfk Stanislaus River	Oakdale - Tri-dams
27	14.5	Loon Lake	American River	Gerle Creek	SMUD
28	14.3	Florence	SJQ above Friant	Sfk San Joaquin River	SCE
29	13.9	East Park	Stony Creek	Little Stony Creek	USBR
30	13.6	Merle Collins	Yuba River	Dry Creek	Browns Valley Irr Dist
31	13.5	Bowman	Yuba River	Canyon Creek	NID
32	12.7	Sly Creek	Feather River	Lost Creek	OWID
33	11.4	Jackson Meadows	Yuba River	Mfk Yuba River	NID
34	11.3	Lower Bear	Mokelumne River	Bear River	PGE
35	10.7	Fordyce	Yuba River	Fordyce Creek	PGE

Notes:

Measure based on gross pool storage and percent of basin volume regulated.

Ranking of individual headwater reservoirs is based on potential to reduce flood flows. Shaded rows indicate facilities that have, or occur above reservoirs that offer protection against events > 0.2-percent chance exceedence.

Note: Prior to use and application, reference the "Expectations of Use" preface.

TABLE VII-2 (CONT.)
MEASURE OF HEADWATER RESERVOIRS POTENTIAL
TO REDUCE FLOOD FLOWS

Rank	Poser 1 Measure	Reservoir	Basin	Tributary	Owner
36	10.6	Frenchman	Feather River	Last Chance Creek	DWR
37	10.6	Sly Park Reservoir	Cosumnes River	Sly Park Creek	USBR
38	10.1	Scotts Flat	Yuba River	Deer Creek	NID
39	9.9	Butt Valley	Feather River	Butt Creek	PGE
40	9.4	Bass Lake	SJQ above Friant	Nfk San Joaquin River	PGE
41	8.9	McCloud	Sac above Shasta	McCloud River	PGE
42	7.2	Ice House	American River	Sfk Silver Creek	SMUD
43	7.0	Lake Eleanor	Tuolumne River	Eleanor Creek	CCSF
44	4.5	Antelope	Feather River	Indian Creek	DWR
45	1.2	Mountain Meadows	Feather River	Hamilton Creek	PGE

Notes:

Measure based on gross pool storage and percent of basin volume regulated.

Ranking of individual headwater reservoirs is based on potential to reduce flood flows. Shaded rows indicate facilities that have, or occur above reservoirs that offer protection against events > 0.2-percent chance exceedence.

Note: Prior to use and application, reference the "Expectations of Use" preface.

TABLE VII-3
MEASURE OF HEADWATER RESERVOIRS POTENTIAL
TO CHANGE OPERATIONS AND NEED FOR THAT CHANGE

Rank	Posers 2-3 Measure	Reservoir	Basin	Tributary	Owner
1	91.5	Sly Park Reservoir	Cosumnes River	Sly Park Creek	USBR
2	91.3	Rollins	Bear River	Bear River	NID
3	90.2	Camp Far West	Bear River	Bear River	SSWD
4	89.6	Redinger	SJQ above Friant	San Joaquin River	SCE
5	88.8	Stony Gorge	Stony Creek	Stony Creek	USBR
6	88.8	East Park	Stony Creek	Little Stony Creek	USBR
7	76.7	Pit6	Sac above Shasta	Pit River	PGE
8	76.7	Pit7	Sac above Shasta	Pit River	PGE
9	75.6	McCloud	Sac above Shasta	McCloud River	PGE
10	73.9	Hetch Hetchy	Tuolumne River	Tuolumne Creek	CCSF
11	72.9	Britton (Pit3)	Sac above Shasta	Pit River	PGE
12	72.3	Scotts Flat	Yuba River	Deer Creek	NID
13	71.2	Mountain Meadows	Feather River	Hamilton Creek	PGE
14	70.4	Lake Eleanor	Tuolumne River	Eleanor Creek	CCSF
15	68.3	Merle Collins	Yuba River	Dry Creek	Browns Valley ID
16	66.0	Antelope	Feather River	Indian Creek	DWR
17	64.8	Union Valley	American River	Silver Creek	SMUD
18	61.7	Bass Lake	SJQ above Friant	Nfk San Joaquin River	PGE
19	59.3	Little Grass Valley	Feather River	Sfk Feather River	OWID
20	58.8	Butt Valley	Feather River	Butt Creek	PGE
21	58.7	Cherry Valley	Tuolumne River	Cherry Creek	CCSF
22	56.6	Shaver	SJQ above Friant	Stevenson Creek	SCE
23	56.5	Frenchman	Feather River	Last Chance Creek	DWR
24	56.1	Sly Creek	Feather River	Lost Creek	OWID
25	55.7	Beardsley	Stanislaus River	Mfk Stanislaus River	Oakdale - Tri-dams
26	53.7	Jackson Meadows	Yuba River	Mfk Yuba River	NID
27	51.8	Huntington	SJQ above Friant	Big Creek	SCE
28	51.3	Edison	SJQ above Friant	Mono Creek	SCE
29	48.8	Spaulding	Yuba River	Sfk Jackson Creek	PGE
30	46.2	Salt Springs	Mokelumne River	Nfk Mokelumne River	PGE
31	45.9	Ice House	American River	Sfk Silver Creek	SMUD
32	44.8	Mammoth Pool	SJQ above Friant	San Joaquin River	SCE
33	43.4	Hell Hole	American River	Rubicon River	PCWA
34	43.1	Lake Davis	Feather River	Big Grizzly Creek	DWR
35	42.6	Lower Bear	Mokelumne River	Bear River	PGE

Notes:

Measure based on level of protection for the basin, level of protection for the reservoir, and percent filled at start of flood.

Ranking of individual headwater reservoirs based on potential to change operations and need for that change. Shaded rows indicate facilities that offer protection against events > 0.2-percent chance exceedence.

Note: Prior to use and application, reference the "Expectations of Use" preface.

**TABLE VII-3 (CONT.)
MEASURE OF HEADWATER RESERVOIRS POTENTIAL TO CHANGE
OPERATIONS AND NEED FOR THAT CHANGE**

Rank	Posers 2-3 Measure	Reservoir	Basin	Tributary	Owner
36	40.9	French Meadows	American River	Mfk American River	PCWA
37	40.1	Bucks Lake	Feather River	Bucks Creek	PGE
38	37.9	Bowman	Yuba River	Canyon Creek	NID
39	37.7	Donnells	Stanislaus River	Mfk Stanislaus River	Oakdale - Tri-dams
40	37.5	Almanor	Feather River	Nfk Feather Creek	PGE
41	34.2	Loon Lake	American River	Gerle Creek	SMUD
42	30.7	Courtright and Wishon	Kings River	Nfk Kings River	PGE
43	30.5	New Spicer Meadows	Stanislaus River	Highland Creek	CCWD
44	27.6	Florence	SJQ above Friant	Sfk San Joaquin River	SCE
45	24.7	Fordyce	Yuba River	Fordyce Creek	PGE

Notes:

Measure based on level of protection for the basin, level of protection for the reservoir, and percent filled at start of flood.

Ranking of individual headwater reservoirs based on potential to change operations and need for that change. Shaded rows indicate facilities that offer protection against events > 0.2-percent chance exceedence.

Note: Prior to use and application, reference the "Expectations of Use" preface.

ALTERNATIVES ANALYSIS FOR HEADWATER SPILLWAYS

The majority of headwater reservoirs are owned and operated by private agencies for hydropower generation and water supply. Preferred alternatives increase flood reduction without impinging on existing operations. Plan formulation should begin by identifying such alternatives, as these are most likely to receive support from local and regional interests. In the headwater drainage basins, a promising group of alternatives involves using spillway regulation to further attenuate peak flood flows.

Spillway Analysis

Gated operations at flood damage reduction reservoirs are typically guided by Emergency Spillway Release Diagrams (ESRD). These diagrams script reservoir releases as a function of inflow (or rate of water surface elevation rise) and pool elevation. ESRD operations activate only when flood conditions threaten to surpass the existing flood management capabilities of a reservoir. This occurs only near the top of the reservoir and in no way impacts operations in the water conservation pool.

Headwater reservoirs outfitted with gates and ESRD criteria would further attenuate flood volumes during extreme events, which could, in turn, reduce inflows to lower basin reservoirs during critical flood times.

Current Spillway Operations

Spillway operations of all studied headwater reservoirs can be sorted into three groups: 1) unimpaired; 2) impaired with seasonal restrictions; and 3) impaired without seasonal restrictions (Table VII-4). Spillways are impaired with a variety of devices, including flashboards and radial, tainter, and drum gates. At some reservoirs, the California State Division of Safety of Dams (DSOD) restricts the use of impairments during the rain flood season due to safety and accessibility concerns. When spillways are impaired and unrestricted, owners and operators largely determine how the gates are used.

Division of Safety of Dams restrictions are implemented in the Fall and terminate in early Spring (April 1 through May 1). In some cases, restrictions may be disengaged earlier pending low snowmelt forecasts and DSOD approval.

Alternative Operations

There are different strategies for using spillway regulation to reduce flood flows (i.e., implementation of ESRD criteria for headwater reservoirs for all storage in excess of gross pool or hold gates open until operations are triggered by dangerous conditions at the downstream flood damage reduction reservoir). The primary danger in all cases is exhaustion of available surcharge storage prior to the flood peak, which would lead to releases in excess of the peak reservoir outflows that would have occurred with an unimpaired spillway. Emergency spillway release criteria can be scripted to minimize this danger, but it is a risk.

Note: Prior to use and application, reference the "Expectations of Use" preface.

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TABLE VII-4
SUMMARY OF STUDIED HEADWATER RESERVOIRS

Reservoir	Tributary	Owner	Type ^a	Impaired Spillway	Seasonal Restrictions	Gate Type	# Gates	Gate Width (feet)	Gate Height (feet)	Induced Storage Potential ^c	What To Do
Sacramento River above Shasta											
<i>Britton (Pit3)</i>	Pit River	PGE	2	Yes	Yes	Inflatable	3	84.6	6	Overtop < 4 %	Omit
<i>Pit6</i>	Pit River	PGE	3	Yes	No	Radial	2	49	40	overtop < 50%	Omit
<i>Pit7</i>	Pit River	PGE	3	Yes	No	Radial	2	49	40	overtop < 10%	Omit
<i>McCloud</i>	McCloud River	PGE	3	Yes	No	Radial	3	27	24.5	good, but gates in use	Consider
Stony Creek above Black Butte											
<i>East Park</i>	Little Stony Creek	USBR	2	Yes	Yes	F.boards	9	46	1.5	overtop < 2%	Omit
<i>Stony Gorge</i>	Stony Creek	USBR	2 ^b	Yes	Yes	Slide Gates	3	30	30	good	Consider
Feather River above Oroville											
<i>Mountain Meadows</i>	Hamilton Creek	PGE	2	Yes	Yes	F.boards	22	8	4.54	Not important	Omit
<i>Almanor</i>	Nfk Feather Creek	PGE	1	No	--	--	--	--	--	Not important	Omit
<i>Butt Valley</i>	Butte Creek	PGE	1	No	--	--	--	--	--	good	Consider
<i>Antelope</i>	Indian Creek	DWR	1	No	--	--	--	--	--	good	Consider
<i>Bucks Lake</i>	Bucks Creek	PGE	1	No	--	--	--	--	--	good	Consider
<i>Frenchman</i>	Last Chance Creek	DWR	1	No	--	--	--	--	--	good	Consider
<i>Lake Davis</i>	Big Grizzly Creek	DWR	1	No	--	--	--	--	--	good	Consider
<i>Little Grass Valley</i>	Sfk Feather River	OWID	2	Yes	Yes	Radial	2	40	15	good	Consider
<i>Sly Creek</i>	Lost Creek	OWID	2	Yes	Yes	Radial	1	54	16	good	Consider

a: Type: 1) unimpaired; 2) Impaired with seasonal restrictions; and 3) impaired without seasonal restrictions.

b: Stony Gorge gates are in operation during winter months but storage is restricted to 38,311 acre-feet.

c: Value represents that event occurring less in frequency than the stated percent chance exceedence event.

Note: Prior to use and application, reference the "Expectations of Use" preface.

TABLE VII-4 (CONT.)
SUMMARY OF STUDIED HEADWATER RESERVOIRS

Reservoir	Tributary	Owner	Type ^a	Impaired Spillway	Seasonal Restrictions	Gate Type	# Gates	Gate Width (feet)	Gate Height (feet)	Induced Storage Potential ^c	What To Do
Yuba above Marysville											
<i>Jackson Meadows</i>	Mfk Yuba River	NID	2	Yes	Yes	Radial	3	30	15	good	Consider
<i>Bowman</i>	Canyon Creek	NID	2	Yes	Yes	Radial	7	12	5.8	good	Omit
<i>Fordyce</i>	Fordyce Creek	PGE	2	Yes	Yes	Radial	2	14	15	do not exceed	Consider
<i>Spaulding</i>	Sfk Jackson Creek	PGE	2	Yes	Yes	Radial	3	14	20	do not exceed	Consider
<i>Scotts Flat</i>	Deer Creek	NID	1	No	--	--	--	--	--	good	Consider
<i>Merle Collins</i>	Dry Creek	BVID	1	No	--	--	--	--	--	good	Consider
Bear											
<i>Rollins</i>	Bear River	NID	1	No	--	--	--	--	--	good	Consider
<i>Camp Far West</i>	Bear River	SSWD	1	No	--	--	--	--	--	good	Consider
American											
<i>French Meadows</i>	Mfk American River	PCWA	2	Yes	Yes	Radial	2	20	18.5	good	Consider
<i>Hell Hole</i>	Rubicon River	PCWA	1	No	--	--	--	--	--	good	Consider
<i>Loon Lake</i>	Gerle Creek	SMUD	1	No	--	--	--	--	--	good	Omit
<i>Union Valley</i>	Silver Creek	SMUD	2	Yes	Yes	Radial	2	40	15	good	Consider
<i>Ice House</i>	Sfk Silver Creek	SMUD	2	Yes	Yes	Radial	2	40	14	good	Consider
Cosumnes above Michigan Bar											
<i>Sly Park Reservoir</i>	Sly Park Creek	USBR	1	No	--	--	--	--	--	good	Consider
Mokelumne above Pardee											
<i>Salt Springs</i>	Nfk Mokelumne River	PGE	2	Yes	Yes	Radial	11	40	11	good	Consider
<i>Lower Bear</i>	Bear River	PGE	2	Yes	Yes	Radial	1	8	14	good	Consider
<p>a: Type: 1) unimpaired; 2) Impaired with seasonal restrictions; and 3) impaired without seasonal restrictions.</p> <p>b: Stony Gorge gates are in operation during winter months but storage is restricted to 38,311 acre-feet.</p> <p>c: Value represents that event occurring less in frequency than the stated percent chance exceedence event.</p>											

Note: Prior to use and application, reference the "Expectations of Use" preface.

TABLE VII-4 (CONT.)
SUMMARY OF STUDIED HEADWATER RESERVOIRS

Reservoir	Tributary	Owner	Type ^a	Impaired Spillway	Seasonal Restrictions	Gate Type	# Gates	Gate Width (feet)	Gate Height (feet)	Induced Storage Potential ^c	What To Do
Stanislaus above New Melones											
<i>New Spicer Meadows</i>	Highland Creek	CCWD	1	No	--	--	--	--	--	good	Omit
<i>Donnells</i>	Mfk Stanislaus River	Oakdale - Tri-dams	2	Yes	Yes	Radial	5	35	19	good	Consider
<i>Beardsley</i>	Mfk Stanislaus River	Oakdale - Tri-dams	2	Yes	Yes	Radial	4	40	30	good	Consider
Tuolumne above Don Pedro											
<i>Hetch Hetchy</i>	Tuolumne Creek	CCSF	2	Yes	Yes	Drum	3	66	10	good	Consider
<i>Lake Eleanor</i>	Eleanor Creek	CCSF	2	Yes	Yes	F.boards	25	8	4	overtop > 10%	Omit
<i>Cherry Valley</i>	Cherry Creek	CCSF	2	Yes	Yes	F.boards	--	--	--	good	Consider
San Joaquin above Friant											
<i>Florence</i>	Sfk San Joaquin River	SCE	3	Yes	No	Drum	2	51	12	good, but gates in use	Consider
<i>Edison</i>	Mono Creek	SCE	3	Yes	No	Radial	1	15	8	good, but gates in use	Omit
<i>Mammoth Pool</i>	San Joaquin River	SCE	1	No	--	--	--	--	--	good	Consider
<i>Huntington</i>	Big Creek	SCE	3	Yes	No	Radial	15	12	5	good, but gates in use	Consider
<i>Shaver</i>	Stevenson Creek	SCE	1	No	--	--	--	--	--	good	Omit
<i>Redinger</i>	San Joaquin River	SCE	3	Yes	No	Radial	4	40	30	good, but gates in use	Consider
<i>Bass Lake</i>	Nfk San Joaquin River	PGE	2	Yes	Yes	Radial	2	17.58	10.75	good	Consider
Kings River above Pine Flat											
<i>Wishon</i>	Nfk Kings River	PGE	2	Yes	Yes	Radial	6	40	11.5	good	Consider
<p>a: Type: 1) unimpaired; 2) Impaired with seasonal restrictions; and 3) impaired without seasonal restrictions.</p> <p>b: Stony Gorge gates are in operation during winter months but storage is restricted to 38,311 acre-feet.</p> <p>c: Value represents that event occurring less in frequency than the stated percent chance exceedence event.</p>											

Note: Prior to use and application, reference the "Expectations of Use" preface.

In all cases, maximum design pool elevations must be restricted below top of dam to allow for wind and wave run-up. For the purposes of this feasibility study, a limit of 3 feet below top of dam was assumed during site selection.

Division of Safety of Dams restrictions are due in part to the isolation and inaccessibility of certain dam sites during inclement weather in winter months. Spillway regulation would require remote or automated operations capability. The Water Management Section of the Sacramento District, USACE, has completed dam and computer system retrofitting for remote operations at Farmington and Warm Springs Dams. Water Management estimates that site implementation would require as little as 1 year and \$300,000, pending no significant structural modifications.

Site Selection

Baseline investigations based on simulation of the seven synthetic exceedence frequency flood events showed that many of the reservoirs filled beyond safe levels (3' below top of dam) without gated spillway operations. Since gated operations tend to store more water, reservoirs without sufficient capacity to route flows (with unimpaired spillways) are unlikely to further reduce floods through spillway regulation.

Baseline simulations were summarized and peak storages were compared to the maximum storages that would be allowed after spillway regulation (Table VII-5). According to the space available, many facilities did not look like promising candidates. Spillway regulation at some of these sites may become more effective if included as part of a reoperation strategy.

According to space available, volume of spill, and peak outflow, 13 headwater reservoirs were highlighted as candidates (from north to south): 1) Butt Valley; 2) Antelope; 3) Frenchman; 4) Little Grass Valley; 5) Rollins; 6) Camp Far West; 7) French Meadows; 8) Union Valley; 9) Salt Springs; 10) Beardsley; 11) Hetch Hetchy; 12) Cherry Valley; and 13) Mammoth Pool.

Conclusions

Flood hydrology and reservoir operations will need to be studied for any reservoir targeted for spillway regulation. Additionally, ideas such as allocation of water surcharged during the rainflood season to environmental water purposes (pending spring snowmelt forecasts) should be pursued to identify interested parties and gather a wide support base.

Gating of headwater reservoirs offers benefits beyond flood reduction. Some positive and negative effects of added or modified spillway regulation are anticipated. Overall, there is a strong upside to regulating spillways and it is hoped that this concept will receive local interest.

• Pros

- Increased hydropower production via routing more water through penstocks at higher heads.
- Increased water supply as new spillway gates enlarge storage capacities of existing reservoirs.
- Owners and operators could utilize remote operations to reduce time and resources expended while making release changes.
- Many reservoirs have gated spillways that are required to be held full open during the rain flood season. If operational restrictions can be lifted and remote or automated operations established, flood reduction functions at these facilities could be made operational quickly and economically.

Note: Prior to use and application, reference the "Expectations of Use" preface.

- The Water Management Section of the USACE, in Sacramento, has experience in software and hardware retrofitting for remote operation and could provide expert guidance during implementation.
 - Storage accumulated during the rain flood season could be used for environmental purposes including pulse flows designed to stimulate riparian vegetation, flows routed to slow the recession of water surface elevations, volume to enhance waterfowl and wildlife refuge habitat, and freshets (cues for fish migration).
 - Structural additions and opportunities to remote operate gates may attract private owners and operators willing to act as local sponsors for individual projects.
- **Cons**
 - Significant changes to the operation of headwater reservoirs may reshape the lower basin flood hydrology enough to force existing ESRD criteria to be reviewed.
 - The success of gated operation is sensitive to timing within the basin and will need to be addressed during the study.
 - Additional spillway regulation would be designed to reduce peak flood flows, which may suppress ecosystem dynamics linked to high river flows.
 - May entail structural additions and minor modifications.
 - Must consider the risk of exhausting available surcharge storage prior to the incoming flood volume. This would result in higher outflows than those that would occur under unimpaired spillway operation.

Note: Prior to use and application, reference the "Expectations of Use" preface.

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TABLE VII-5
AVAILABLE STORAGE WITHIN HEADWATER RESERVOIRS

			Annual Percent Chance Exceedences						
Sacramento River above Shasta			50%	10%	4%	2%	1%	0.5%	0.2%
Britton		Peak outflow (cfs)	27,013	59,368	76,043	88,727	101,258	130,172	131,557
		Peak storage (ac-ft)	43,496	53,388	57,812	61,187	64,359	67,333	67,393
Storage at proposed TIS (ac-ft)	54,465	Space available (ac-ft)	10,969	1,077	-3,347	-6,722	-9,894	-12,868	-12,928
Gross pool (ac-ft)	40,626	Percent gross pool	107%	131%	142%	151%	158%	166%	166%
		Volume of spill (ac-ft)	277,906	733,058	956,736	1,118,210	1,275,036	1,427,874	1,624,853
McCloud		Peak outflow (cfs)	8,291	18,293	23,566	27,461	31,686	35,962	40,667
		Peak storage (ac-ft)	27,732	31,393	32,802	33,819	34,669	35,111	35,723
Storage at proposed TIS (ac-ft)	39,000	Space available (ac-ft)	11,268	7,607	6,198	5,181	4,331	3,889	3,277
Gross pool (ac-ft)	24,500	Percent gross pool	113%	128%	134%	138%	142%	143%	146%
		Volume of spill (ac-ft)	77,378	217,796	286,742	336,560	384,945	432,118	492,957
Pit6		Peak outflow (cfs)	34,714	74,914	95,627	111,386	126,393	149,724	164,089
		Peak storage (ac-ft)	16,479	17,141	17,391	17,581	17,998	19,736	20,030
Storage at proposed TIS (ac-ft)	16,924	Space available (ac-ft)	445	-217	-467	-657	-1,074	-2,812	-3,106
Gross pool (ac-ft)	15,700	Percent gross pool	105%	109%	111%	112%	115%	126%	128%
		Volume of spill (ac-ft)	289,981	848,129	1,124,508	1,324,099	1,517,983	1,706,962	1,950,637
Pit7		Peak outflow (cfs)	37,903	81,807	104,526	121,735	138,356	162,816	179,588
		Peak storage (ac-ft)	33,085	35,789	36,931	37,736	38,233	38,924	39,630
Storage at proposed TIS (ac-ft)	36,429	Space available (ac-ft)	3,344	640	-502	-1,307	-1,804	-2,495	-3,201
Gross pool (ac-ft)	19,084	Percent gross pool	173%	188%	194%	198%	200%	204%	208%
		Volume of spill (ac-ft)	281,902	893,572	1,196,374	1,415,226	1,627,700	1,834,765	2,101,760
Combined space available			26,000	9,000	6,000	5,000	4,000	4,000	3,000
Stony Creek above Black Butte			50%	10%	4%	2%	1%	0.5%	0.2%
East Park		Peak outflow (cfs)	1,572	4,978	7,119	8,862	10,762	12,854	15,636
		Peak storage (ac-ft)	50,413	52,362	53,344	54,121	54,886	55,534	56,266
Storage at proposed TIS (ac-ft)	48,517	Space available (ac-ft)	-1,896	-3,845	-4,827	-5,604	-6,369	-7,017	-7,749
Gross pool (ac-ft)	50,899	Percent gross pool	99%	103%	105%	106%	108%	109%	111%
		Volume of spill (ac-ft)	20,704	59,295	83,220	102,289	122,087	142,612	170,711
Stony Gorge		Peak outflow (cfs)	4,440	14,617	20,929	26,100	31,777	37,677	45,958
		Peak storage (ac-ft)	38,930	45,017	47,847	50,102	52,254	54,458	57,247
		Volume of spill (ac-ft)	61,931	177,346	248,812	305,850	365,113	426,550	510,678
Combined space available			15,000	9,000	7,000	4,000	2,000	0	0
Feather River above Oroville			50%	10%	4%	2%	1%	0.5%	0.2%
Mountain Meadows		Peak outflow (cfs)	200	903	1,322	1,726	2,325	2,915	3,453
		Peak storage (ac-ft)	4,451	8,269	10,152	11,573	12,834	13,944	15,930
Storage at proposed TIS (ac-ft)	14,477	Space available (ac-ft)	10,026	6,208	4,325	2,904	1,643	533	-1,453
Gross pool (ac-ft)	4,468	Percent gross pool	100%	185%	227%	259%	287%	312%	357%
		Volume of spill (ac-ft)	0	8,033	14,190	19,013	23,922	28,886	35,520
Note:									
1. The acronym "TIS" refers to "top of induced surcharge". Space Available is equal to Storage at Proposed TIS less Peak Storage.									

Note: Prior to use and application, reference the "Expectations of Use" preface.

TABLE VII-5 (CONT.)
AVAILABLE STORAGE WITHIN HEADWATER RESERVOIRS

Feather River above Oroville (Cont.)			50%	10%	4%	2%	1%	0.5%	0.2%	
Almanor			Peak outflow (cfs)	2,153	2,153	3,077	4,218	4,218	4,218	4,218
			Peak storage (ac-ft)	849,860	908,712	956,800	981,884	1,019,947	1,060,489	1,115,416
Storage at proposed TIS (ac-ft)	1,716,465	Space available (ac-ft)	866,605	807,753	759,665	734,581	696,518	655,976	601,049	
Gross pool (ac-ft)	1,308,000	Percent gross pool	65%	69%	73%	75%	78%	81%	85%	
			Volume of spill (ac-ft)	0	0	0	0	0	0	
Butt Valley			Peak outflow (cfs)	2,578	3,447	5,097	6,778	7,953	9,228	11,408
			Peak storage (ac-ft)	41,265	51,594	55,376	57,041	58,698	60,356	62,029
Storage at proposed TIS (ac-ft)	70,239	Space available (ac-ft)	28,974	18,645	14,863	13,198	11,541	9,883	8,210	
Gross pool (ac-ft)	49,768	Percent gross pool	83%	104%	111%	115%	118%	121%	125%	
			Volume of spill (ac-ft)	0	4,986	16,536	26,196	36,157	46,212	59,638
Antelope			Peak outflow (cfs)	426	1,215	1,694	2,109	2,758	3,501	4,481
			Peak storage (ac-ft)	22,905	24,413	25,554	26,545	27,480	28,253	29,277
Storage at proposed TIS (ac-ft)	43,200	Space available (ac-ft)	20,295	18,787	17,646	16,655	15,720	14,947	13,923	
Gross pool (ac-ft)	22,000	Percent gross pool	104%	111%	116%	121%	125%	128%	133%	
			Volume of spill (ac-ft)	5,964	17,539	24,032	28,993	34,007	39,061	45,810
Bucks Lake			Peak outflow (cfs)	381	396	396	396	747	1,513	3,621
			Peak storage (ac-ft)	63,780	80,250	92,304	101,936	109,742	112,737	117,319
Storage at proposed TIS (ac-ft)	130,400	Space available (ac-ft)	66,620	50,150	38,096	28,464	20,658	17,663	13,081	
Gross pool (ac-ft)	108,400	Percent gross pool	59%	74%	85%	94%	101%	104%	108%	
			Volume of spill (ac-ft)	0	0	0	0	2,643	12,326	25,404
Frenchman			Peak outflow (cfs)	153	482	1,064	1,544	2,052	2,552	3,230
			Peak storage (ac-ft)	45,561	52,005	54,460	56,004	57,635	59,242	61,425
Storage at proposed TIS (ac-ft)	76,400	Space available (ac-ft)	30,839	24,395	21,940	20,396	18,765	17,158	14,975	
Gross pool (ac-ft)	49,500	Percent gross pool	92%	105%	110%	113%	116%	120%	124%	
			Volume of spill (ac-ft)	0	4,532	10,009	14,231	18,843	23,610	30,051
Lake Davis			Peak outflow (cfs)	193	199	203	206	210	292	467
			Peak storage (ac-ft)	60,230	68,187	73,975	78,162	82,845	86,754	90,347
Storage at proposed TIS (ac-ft)	114,000	Space available (ac-ft)	53,770	45,813	40,025	35,838	31,155	27,246	23,653	
Gross pool (ac-ft)	83,000	Percent gross pool	73%	82%	89%	94%	100%	105%	109%	
			Volume of spill (ac-ft)	0	0	0	0	0	1,148	5,059
Little Grass Valley			Peak outflow (cfs)	810	2,349	3,354	4,389	5,904	7,423	9,287
			Peak storage (ac-ft)	76,533	80,020	82,384	84,263	85,670	86,964	88,652
Storage at proposed TIS (ac-ft)	105,000	Space available (ac-ft)	28,467	24,980	22,616	20,737	19,330	18,036	16,348	
Gross pool (ac-ft)	74,730	Percent gross pool	102%	107%	110%	113%	115%	116%	119%	
			Volume of spill (ac-ft)	11,489	34,641	47,604	57,498	67,491	77,560	91,000
Sly Creek			Peak outflow (cfs)	850	850	2,995	5,218	6,883	8,405	10,379
			Peak storage (ac-ft)	49,935	53,521	59,117	60,727	61,714	62,407	63,284
Storage at proposed TIS (ac-ft)	66,275	Space available (ac-ft)	16,340	12,754	7,158	5,548	4,561	3,868	2,991	
Gross pool (ac-ft)	56,220	Percent gross pool	89%	95%	105%	108%	110%	111%	113%	
			Volume of spill (ac-ft)	0	0	9,177	18,608	28,601	38,877	52,489
Combined space available			255,000	202,000	167,000	144,000	123,000	109,000	93,000	
Note:										
1. The acronym "TIS" refers to "top of induced surcharge". Space Available is equal to Storage at Proposed TIS less Peak Storage.										

Note: Prior to use and application, reference the "Expectations of Use" preface.

TABLE VII-5 (CONT.)
AVAILABLE STORAGE WITHIN HEADWATER RESERVOIRS

Yuba and Bear Rivers			50%	10%	4%	2%	1%	0.5%	0.2%	
Jackson Meadows			Peak outflow (cfs)	35	35	35	131	636	1,677	3,523
			Peak storage (ac-ft)	40,718	48,779	51,946	54,531	56,076	57,066	58,593
Storage at proposed TIS (ac-ft)	75,980	Space available (ac-ft)	35,262	27,201	24,034	21,449	19,904	18,914	17,387	
Gross pool (ac-ft)	54,123	Percent gross pool	75%	90%	96%	101%	104%	105%	108%	
			Volume of spill (ac-ft)	0	0	0	522	3,494	6,712	12,351
Bowman			Peak outflow (cfs)	254	254	254	299	304	345	375
			Peak storage (ac-ft)	39,980	41,442	44,993	47,980	51,426	55,349	61,101
Storage at proposed TIS (ac-ft)	68,884	Space available (ac-ft)	28,904	27,442	23,891	20,904	17,458	13,535	7,783	
Gross pool (ac-ft)	60,150	Percent gross pool	66%	69%	75%	80%	85%	92%	102%	
			Volume of spill (ac-ft)	0	0	0	0	0	0	0
Fordyce			Peak outflow (cfs)	5	5	5	5	5	939	3,057
<i>Note: flash restricted</i>			Peak storage (ac-ft)	20,475	28,548	31,424	34,296	37,311	39,242	39,957
Storage at proposed TIS (ac-ft)	47,659	Space available (ac-ft)	27,184	19,111	16,235	13,363	10,348	8,417	7,702	
Gross pool (ac-ft)	39,071	Percent gross pool	52%	73%	80%	88%	95%	100%	102%	
			Volume of spill (ac-ft)	0	0	0	0	0	1,532	7,171
Spaulding			Peak outflow (cfs)	601	5,904	11,055	15,147	19,181	23,504	29,854
<i>Note: flash restricted</i>			Peak storage (ac-ft)	42,471	66,393	68,505	69,440	70,370	71,357	72,316
Storage at proposed TIS (ac-ft)	72,706	Space available (ac-ft)	30,235	6,313	4,201	3,266	2,336	1,349	390	
Gross pool (ac-ft)	61,542	Percent gross pool	69%	108%	111%	113%	114%	116%	118%	
			Volume of spill (ac-ft)	0	22,801	39,675	53,876	69,044	87,683	122,619
Scotts Flat			Peak outflow (cfs)	611	1,260	1,862	2,232	2,584	2,986	3,475
			Peak storage (ac-ft)	48,892	49,226	49,538	49,729	49,910	50,070	50,226
Storage at proposed TIS (ac-ft)	53,413	Space available (ac-ft)	4,521	4,187	3,875	3,684	3,503	3,343	3,187	
Gross pool (ac-ft)	48,402	Percent gross pool	101%	102%	102%	103%	103%	103%	104%	
			Volume of spill (ac-ft)	2,204	10,040	17,476	22,095	26,360	30,448	35,435
Merle Collins			Peak outflow (cfs)	1,698	3,703	5,479	6,569	7,605	8,587	9,801
			Peak storage (ac-ft)	58,024	58,948	59,551	59,921	60,273	60,606	61,018
Storage at proposed TIS (ac-ft)	67,200	Space available (ac-ft)	9,176	8,252	7,649	7,279	6,927	6,594	6,182	
Gross pool (ac-ft)	57,000	Percent gross pool	102%	103%	104%	105%	106%	106%	107%	
			Volume of spill (ac-ft)	12,606	34,533	55,479	68,542	80,602	92,157	106,258
Rollins			Peak outflow (cfs)	4,651	11,317	14,730	17,160	19,425	21,454	24,133
			Peak storage (ac-ft)	67,994	69,654	70,285	70,735	71,173	71,675	72,333
Storage at proposed TIS (ac-ft)	77,438	Space available (ac-ft)	9,444	7,784	7,153	6,703	6,265	5,763	5,105	
Gross pool (ac-ft)	65,998	Percent gross pool	103%	106%	106%	107%	108%	109%	110%	
			Volume of spill (ac-ft)	24,012	77,799	101,133	116,335	129,827	141,614	154,910
Camp Far West			Peak outflow (cfs)	9,466	27,226	36,193	42,649	48,646	54,185	61,136
			Peak storage (ac-ft)	112,285	122,525	127,150	130,116	132,869	135,415	138,607
Storage at proposed TIS (ac-ft)	145,560	Space available (ac-ft)	33,275	23,035	18,410	15,444	12,691	10,145	6,953	
Gross pool (ac-ft)	102,000	Percent gross pool	110%	120%	125%	128%	130%	133%	136%	
			Volume of spill (ac-ft)	127,400	273,278	336,523	377,768	414,389	446,391	482,529
Combined space available			43,000	31,000	26,000	22,000	19,000	16,000	12,000	
Note:										
1. The acronym "TIS" refers to "top of induced surcharge". Space Available is equal to Storage at Proposed TIS less Peak Storage.										

Note: Prior to use and application, reference the "Expectations of Use" preface.

TABLE VII-5 (CONT.)
AVAILABLE STORAGE WITHIN HEADWATER RESERVOIRS

American River			50%	10%	4%	2%	1%	0.5%	0.2%	
French Meadows			Peak outflow (cfs)	408	408	408	408	1,235	3,476	7,908
			Peak storage (ac-ft)	67,072	83,509	97,918	109,357	115,312	120,757	127,653
Storage at proposed TIS (ac-ft)	146,799	Space available (ac-ft)	79,727	63,290	48,881	37,442	31,487	26,042	19,146	
Gross pool (ac-ft)	111,300	Percent gross pool	60%	75%	88%	98%	104%	108%	115%	
			Volume of spill (ac-ft)	0	0	0	0	8,334	20,295	36,677
Hell Hole			Peak outflow (cfs)	1,010	1,010	1,010	1,010	1,010	4,054	16,763
			Peak storage (ac-ft)	130,856	149,687	168,240	183,479	199,182	205,273	208,290
Storage at proposed TIS (ac-ft)	221,952	Space available (ac-ft)	91,096	72,265	53,712	38,473	22,770	16,679	13,662	
Gross pool (ac-ft)	204,000	Percent gross pool	64%	73%	82%	90%	98%	101%	102%	
			Volume of spill (ac-ft)	0	0	0	0	11,209	33,007	
Loon Lake			Peak outflow (cfs)	158	158	158	158	158	158	158
			Peak storage (ac-ft)	41,089	45,537	50,121	53,930	57,856	61,875	67,325
Storage at proposed TIS (ac-ft)	83,275	Space available (ac-ft)	42,186	37,738	33,154	29,345	25,419	21,400	15,950	
Gross pool (ac-ft)	76,168	Percent gross pool	54%	60%	66%	71%	76%	81%	88%	
			Volume of spill (ac-ft)	0	0	0	0	0	0	
Union Valley			Peak outflow (cfs)	1,000	2,125	5,760	8,999	12,499	15,954	21,533
			Peak storage (ac-ft)	209,976	240,813	251,947	259,286	266,166	272,731	281,735
Storage at proposed TIS (ac-ft)	292,772	Space available (ac-ft)	82,796	51,959	40,825	33,486	26,606	20,041	11,037	
Gross pool (ac-ft)	234,989	Percent gross pool	89%	102%	107%	110%	113%	116%	120%	
			Volume of spill (ac-ft)	0	15,732	39,130	57,835	77,469	97,473	124,752
Ice House			Peak outflow (cfs)	288	288	288	288	288	1,027	3,179
			Peak storage (ac-ft)	25,378	25,380	28,707	32,074	35,794	38,328	40,102
Storage at proposed TIS (ac-ft)	46,725	Space available (ac-ft)	21,347	21,345	18,018	14,651	10,931	8,397	6,623	
Gross pool (ac-ft)	37,121	Percent gross pool	68%	68%	77%	86%	96%	103%	108%	
			Volume of spill (ac-ft)	0	0	0	0	2,443	7,891	
Combined space available			317,000	247,000	195,000	153,000	117,000	93,000	66,000	
Cosumnes above Michigan Bar			50%	10%	4%	2%	1%	0.5%	0.2%	
Sly Park Reservoir			Peak outflow (cfs)	250	2,872	4,092	5,088	6,135	6,807	7,055
			Peak storage (ac-ft)	41,224	42,886	43,423	43,825	44,200	44,653	45,904
Storage at proposed TIS (ac-ft)	46,339	Space available (ac-ft)	5,115	3,453	2,916	2,514	2,139	1,686	435	
Gross pool (ac-ft)	41,033	Percent gross pool	100%	105%	106%	107%	108%	109%	112%	
			Volume of spill (ac-ft)	1,391	17,064	26,052	32,900	39,802	46,705	55,802
Combined space available			0	0	0	0	0	0	0	
Mokelumne above Pardee			50%	10%	4%	2%	1%	0.5%	0.2%	
Salt Springs			Peak outflow (cfs)	463	600	600	1,686	6,922	23,858	39,107
			Peak storage (ac-ft)	41,159	80,451	110,815	133,960	136,163	139,655	141,991
Storage at proposed TIS (ac-ft)	147,441	Space available (ac-ft)	106,282	66,990	36,626	13,481	11,278	7,786	5,450	
Gross pool (ac-ft)	133,498	Percent gross pool	31%	60%	83%	100%	102%	105%	106%	
			Volume of spill (ac-ft)	0	0	0	3,236	31,946	63,262	115,422
Note:										
1. The acronym "TIS" refers to "top of induced surcharge". Space Available is equal to Storage at Proposed TIS less Peak Storage.										

Note: Prior to use and application, reference the "Expectations of Use" preface.

TABLE VII-5 (CONT.)
AVAILABLE STORAGE WITHIN HEADWATER RESERVOIRS

Mokelumne above Pardee (Continued)			50%	10%	4%	2%	1%	0.5%	0.2%
Lower Bear			Peak outflow (cfs)	220	220	220	220	220	1,419
			Peak storage (ac-ft)	19,984	21,708	27,272	32,093	37,219	48,083
Storage at proposed TIS (ac-ft)	52,862	Space available (ac-ft)	32,878	31,154	25,590	20,769	15,643	9,980	4,779
Gross pool (ac-ft)	42,936	Percent gross pool	47%	51%	64%	75%	87%	100%	112%
			Volume of spill (ac-ft)	0	0	0	0	0	7,535
Combined space available			139,000	98,000	62,000	34,000	27,000	18,000	10,000
Stanislaus above New Melones			50%	10%	4%	2%	1%	0.5%	0.2%
New Spicer Meadows			Peak outflow (cfs)	17	17	350	350	350	350
			Peak storage (ac-ft)	84,950	96,300	100,631	104,186	111,193	119,157
Storage at proposed TIS (ac-ft)	210,500	Space available (ac-ft)	125,550	114,200	109,869	106,314	99,307	91,343	78,865
Gross pool (ac-ft)	189,000	Percent gross pool	45%	51%	53%	55%	59%	63%	70%
			Volume of spill (ac-ft)	0	0	0	0	0	0
Donnells			Peak outflow (cfs)	766	766	766	4,720	14,010	23,464
			Peak storage (ac-ft)	19,944	29,562	48,927	58,262	59,991	61,470
Storage at proposed TIS (ac-ft)	63,488	Space available (ac-ft)	43,544	33,926	14,561	5,226	3,497	2,018	723
Gross pool (ac-ft)	56,893	Percent gross pool	35%	52%	86%	102%	105%	108%	110%
			Volume of spill (ac-ft)	0	0	0	9,327	29,746	88,335
Beardsley			Peak outflow (cfs)	650	2,569	7,811	11,368	23,202	39,758
			Peak storage (ac-ft)	58,061	79,352	81,698	82,847	85,875	89,459
Storage at proposed TIS (ac-ft)	101,400	Space available (ac-ft)	43,339	22,048	19,702	18,553	15,525	11,941	8,432
Gross pool (ac-ft)	77,838	Percent gross pool	75%	102%	105%	106%	110%	115%	119%
			Volume of spill (ac-ft)	0	16,546	33,926	57,576	93,780	194,576
Combined space available			212,000	170,000	144,000	130,000	118,000	105,000	88,000
Tuolumne above Don Pedro			50%	10%	4%	2%	1%	0.5%	0.2%
Hetch Hetchy			Peak outflow (cfs)	1,500	6,451	8,612	15,087	22,228	32,428
			Peak storage (ac-ft)	287,298	313,245	330,028	338,689	349,718	357,113
Storage at proposed TIS (ac-ft)	366,295	Space available (ac-ft)	78,997	53,050	36,267	27,606	16,577	9,182	-410
Gross pool (ac-ft)	341,000	Percent gross pool	84%	92%	97%	99%	103%	105%	108%
			Volume of spill (ac-ft)	0	0	1,625	21,695	44,718	115,852
Lake Eleanor			Peak outflow (cfs)	505	3,488	8,707	12,171	15,728	19,735
			Peak storage (ac-ft)	14,961	25,884	28,225	29,617	30,902	32,237
Storage at proposed TIS (ac-ft)	24,286	Space available (ac-ft)	9,325	-1,598	-3,939	-5,331	-6,616	-7,951	-9,806
Gross pool (ac-ft)	23,355	Percent gross pool	64%	111%	121%	127%	132%	138%	146%
			Volume of spill (ac-ft)	0	9,713	25,308	37,378	49,445	77,594
Cherry Valley			Peak outflow (cfs)	800	800	2,166	2,887	5,030	8,174
			Peak storage (ac-ft)	190,086	232,243	252,876	254,100	261,648	271,011
Storage at proposed TIS (ac-ft)	289,840	Space available (ac-ft)	99,754	57,597	36,964	35,740	28,192	18,829	12,585
Gross pool (ac-ft)	268,200	Percent gross pool	71%	87%	94%	95%	98%	101%	103%
			Volume of spill (ac-ft)	0	0	0	0	2,911	23,459
Combined space available			188,000	111,000	73,000	63,000	45,000	28,000	13,000
Note:									
1. The acronym "TIS" refers to "top of induced surcharge". Space Available is equal to Storage at Proposed TIS less Peak Storage.									

Note: Prior to use and application, reference the "Expectations of Use" preface.

TABLE VII-5 (CONT.)
AVAILABLE STORAGE WITHIN HEADWATER RESERVOIRS

San Joaquin above Friant			50%	10%	4%	2%	1%	0.5%	0.2%	
Florence			Peak outflow (cfs)	15	15	15	15	15	1,447	3,000
<i>Note: gates in operation</i>			Peak storage (ac-ft)	9,563	25,385	36,089	45,169	55,167	60,000	62,715
Storage at proposed TIS (ac-ft)	62,970	Space available (ac-ft)	53,407	37,585	26,881	17,801	7,803	2,970	255	
Gross pool (ac-ft)	64,400	Percent gross pool	15%	39%	56%	70%	86%	93%	97%	
			Volume of spill (ac-ft)	0	0	0	0	6,165	22,328	
Edison			Peak outflow (cfs)	8	8	8	8	8	8	8
			Peak storage (ac-ft)	73,492	80,273	84,860	88,751	93,035	97,748	104,676
Storage at proposed TIS (ac-ft)	134,000	Space available (ac-ft)	60,508	53,727	49,140	45,249	40,965	36,252	29,324	
Gross pool (ac-ft)	125,000	Percent gross pool	59%	64%	68%	71%	74%	78%	84%	
			Volume of spill (ac-ft)	0	0	0	0	0	0	
Mammoth Pool			Peak outflow (cfs)	1,632	2,430	2,430	12,605	33,829	51,585	70,880
			Peak storage (ac-ft)	23,869	63,244	105,874	126,399	130,087	133,186	137,334
Storage at proposed TIS (ac-ft)	146,800	Space available (ac-ft)	122,931	83,556	40,926	20,401	16,713	13,614	9,466	
Gross pool (ac-ft)	123,000	Percent gross pool	19%	51%	86%	103%	106%	108%	112%	
			Volume of spill (ac-ft)	0	0	0	25,031	75,410	140,291	246,746
Huntington			Peak outflow (cfs)	500	500	500	500	500	500	1,017
			Peak storage (ac-ft)	49,959	49,959	51,195	56,710	63,019	70,493	82,100
Storage at proposed TIS (ac-ft)	89,870	Space available (ac-ft)	39,911	39,911	38,675	33,160	26,851	19,377	7,770	
Gross pool (ac-ft)	82,100	Percent gross pool	61%	61%	62%	69%	77%	86%	100%	
			Volume of spill (ac-ft)	0	0	0	0	0	0	285
Shaver			Peak outflow (cfs)	100	100	100	100	100	100	100
			Peak storage (ac-ft)	90,619	95,142	99,672	103,535	107,801	112,505	119,541
Storage at proposed TIS (ac-ft)	130,874	Space available (ac-ft)	40,255	35,732	31,202	27,339	23,073	18,369	11,333	
Gross pool (ac-ft)	135,300	Percent gross pool	67%	70%	74%	77%	80%	83%	88%	
			Volume of spill (ac-ft)	0	0	0	0	0	0	0
Redinger			Peak outflow (cfs)	3,620	9,186	16,478	21,406	48,732	74,137	101,612
			Peak storage (ac-ft)	20,056	25,000	25,000	25,000	26,272	27,000	27,797
Storage at proposed TIS (ac-ft)	36,170	Space available (ac-ft)	16,114	11,170	11,170	11,170	9,898	9,170	8,373	
Gross pool (ac-ft)	25,000	Percent gross pool	80%	100%	100%	100%	105%	108%	111%	
			Volume of spill (ac-ft)	0	15,990	36,756	83,122	157,179	247,131	392,278
Bass Lake			Peak outflow (cfs)	140	140	140	445	1,226	2,383	4,293
			Peak storage (ac-ft)	25,451	28,781	32,693	34,711	36,233	37,244	38,882
Storage at proposed TIS (ac-ft)	46,252	Space available (ac-ft)	20,801	17,471	13,559	11,541	10,019	9,008	7,370	
Gross pool (ac-ft)	34,200	Percent gross pool	74%	84%	96%	101%	106%	109%	114%	
			Volume of spill (ac-ft)	0	0	0	2,258	6,487	11,263	18,519
Combined space available			354,000	279,000	212,000	167,000	135,000	109,000	74,000	
Kings River above Pine Flat			50%	10%	4%	2%	1%	0.5%	0.2%	
Courtright and Wishon			Peak outflow (cfs)	850	850	850	850	850	850	850
<i>Note: Results are sum of both reservoirs.</i>			Peak storage (ac-ft)	99,930	99,930	99,930	106,536	116,827	129,011	147,213
Storage at proposed TIS (ac-ft)	248,814	Space available (ac-ft)	148,884	148,884	148,884	142,278	131,987	119,803	101,601	
Gross pool (ac-ft)	240,936	Percent gross pool	41%	41%	41%	44%	48%	54%	61%	
			Volume of spill (ac-ft)	0	0	0	0	0	0	
Combined space available			149,000	149,000	149,000	142,000	132,000	120,000	102,000	
Note:										
1. The acronym "TIS" refers to "top of induced surcharge". Space Available is equal to Storage at Proposed TIS less Peak Storage.										

Note: Prior to use and application, reference the "Expectations of Use" preface.

CHAPTER VIII

ON-STREAM AND OFF-STREAM STORAGE

OVERVIEW

This pilot study investigates the potential for flood damage reduction within the Sacramento and San Joaquin River Basins associated with raising existing dams or constructing new on-stream or off-stream storage projects. For the purposes of this study, off-stream storage projects are defined as projects that propose to provide significant storage capacity at a location that is physically separated from major rivers. A substantial number of these three types of projects are being considered by various agencies and organizations in the Sacramento and San Joaquin River Basins, with a focus on increasing or improving water supply. This pilot study is intended to investigate the potential that these projects may also have for flood damage reduction as a component of the Sacramento and San Joaquin River Basins Comprehensive Study.

Raising existing reservoir storage levels and constructing new on-stream storage facilities provides the opportunity to consider allocating or re-allocating dedicated flood storage space or changing operational criteria to meet flood damage reduction objectives.

Off-stream reservoirs are typically very large with respect to their tributary basins. As a result, they provide significant flood reduction for minor streams on which they are located. In addition, they may provide a location for transfer of existing on-stream reservoir conservation storage that allows re-allocation of reservoir space to increase flood control pools. Flood damage reduction benefits may be realized from off-stream storage flow transfers either prior to a flood event, by increasing available flood space, or during an event, by making diversions downstream of the reservoir that reduces peak flows in the river.

This investigation included a review of 67 potential on-stream and off-stream water storage sites within the Sacramento and San Joaquin River Basins. The potential sites were identified from recent studies conducted by CALFED (CALFED, 2000). Through use of a screening process, two pilot scenarios were selected. These scenarios are intended to investigate the potential for flood damage reduction associated with new storage projects in the two river basins. The scenarios and analyses described herein are preliminary and focus on the potential benefits of dam raises, on-stream storage projects, and off-stream storage projects at a conceptual level.

The analysis involved modifications to existing HEC-5 hydrologic models for the basin and comparison of these results to data previously generated by the Water Management Section of the U.S. Army Corps of Engineers (USACE) for existing (baseline) conditions.

PROJECT SELECTION

Two conceptual project scenarios were identified for flood damage reduction analysis through review of existing documentation. The scenarios were selected using the following steps.

Step 1 - Potential Storage Project Identification

Within the Sacramento and San Joaquin River Basins, a total of 67 potential reservoir projects were compiled from the following two documents:

- **Initial Surface Water Storage Screening**, Integrated Storage Investigation, CALFED Bay-Delta Program, August 2000.
- **Technical Memorandum 4, Draft Long List of Alternatives**, Development of Water Supply Alternatives for Use in Habitat Restoration for the San Joaquin River, Friant Water Users Association and National Resource and Natural Resources Defense Council Coalition, Nov 22, 2000.

These documents investigated potential reservoir projects with respect to water supply objectives. As a result, the list does not represent all potential reservoir sites that might provide flood damage reduction in the basins. The initial list of the potential projects is provided in Table VIII-1. After compilation, the list was reviewed. No additional projects were identified for consideration. A map showing the location of each project, indexed to the project numbers shown in Table VIII-1, is provided in Plate 7.

Step 2 - Initial Screening of Projects

Thirty-nine of the projects were recommended to be eliminated from further consideration in this study based on storage size, diversion location, and results of previous studies. All projects that impounded less than 200,000 acre-feet were also eliminated. This value was set as the lower limit for projects that might provide significant regional flood damage reduction benefits. All projects having a point of diversion from the Sacramento and San Joaquin River Delta were also eliminated. Flood damage reduction benefits associated with these projects would be limited to the downstream portion of the basins, and would not address significant flooding problems identified in the remainder of the study area. The Trinity Lake Enlargement project was eliminated because it is located outside of the drainage basin.

Projects upstream of Shasta Reservoir were eliminated because Shasta presently has the capacity to control peak outflows at or below the objective flow up to the flows corresponding to the annual 1-percent chance exceedence event. In addition, several projects were identified that had been extensively studied in the past and did not appear likely to be constructed. These projects were subsequently eliminated from the list. The list of projects recommended for elimination from further consideration in this study is shown in Table VIII-1.

**TABLE VIII-1
COMPOSITE LIST OF POTENTIAL WATER STORAGE PROJECTS**

Project Name	Reference No.	Storage Type	Storage Size	Description	Documentation*	Reason For Preliminary Elimination
Allen Camp Reservoir	29	On-Stream	196,000	Not Provided	CALFED NO. 1	200,000 ac-ft or Smaller
Arroyo Pasajero	66	On-Stream	52,000	Construction of 17,000 ac-ft reservoir on Los Gatos Creek and 35,000 ac-ft reservoir on Warthan Creek.	URS NO. S17	200,000 ac-ft or Smaller
Auburn Reservoir	1	On-Stream	2,300,000	Construct a new dam on the North Fork of the American River near Auburn and store instream flows.	CALFED NO. 2	Previous Extensive Study
Bella Vista	2	On-Stream	146,000	Not Provided	CALFED NO. 3	200,000 ac-ft or Smaller
Big Dry Creek Dam	56	Off-Stream	varies, but <13,500	Utilize excess storage space in the existing Big Dry Creek Reservoir in the spring and summer months. Flows Diverted from the Friant Kern Canal.	URS NO. S5	200,000 ac-ft or Smaller
Chain of Lakes Facility	15	Island Storage	300,000 to 600,000	Conversion of six major Delta Islands to reservoirs connected with siphons and pumps and Diverting water from the Delta.	CALFED NO. 5	Source of Diversion
Clay Station	42	Off-Stream	170,000	The reservoir would be located on Luguna Creek in Sacramento County with Flows diverted from the American River.	CALFED NO. 7	200,000 ac-ft or Smaller
Coloma Reservoir	3	On-Stream	710,000	Reservoir would be located on the South Fork of the American River near Coloma and store instream flows.	CALFED NO. 8	Retained For Further Consideration
Colusa Reservoir Complex	18	Off-Stream	3,300,000	Extension of the proposed Sites Reservoir. Includes two additional large dams where Hunter and Logan Creeks pass through Logan Ridge, and several saddle dams. Flows would be diverted from the Sacramento River.	CALFED NO. 9	Retained For Further Consideration
Cooperstown Reservoir	43	Off-Stream	609,000	The reservoir would be located on Dry Creek between Stanislaus an Tuolumne Rivers Flows would be diverted from New Melones and Don Pedro reservoirs	CALFED NO. 10	Retained For Further Consideration
Cottonwood Creek Reservoir Complex	19	Off-Stream and On-Stream	1,600,000	Construction of two reservoirs 900,000 ac-ft on the main stream of Cottonwood Creek and 700,000 ac-ft on the South Fork of Cottonwood Creek.	CALFED NO. 11	Previous Extensive Study
Dear Creek Meadows	4	On-Stream	200,000	Reservoir would be located on Deer Creek in Tehama County.	CALFED NO. 12	200,000 ac-ft or Smaller
Deer Creek Reservoir	44	Off-Stream	600,000	The reservoir would be located on Deer Creek in Sacramento County. Flow would be diverted from the American River.	CALFED NO. 13	Retained For Further Consideration
Dinkey Creek Dam	60	On-Stream	200,000	Construction of a new dam on Dinkey Creek, a tributary to the North Fork of the Kings River.	URS NO. S9	200,000 ac-ft or Smaller

*** Documentation Refers to:**
Initial Surface Water Storage Screening, Integrated Storage Investigation, CALFED Bay-Delta Program, August 2000.
Technical Memorandum 4, Draft Long List of Alternatives, Development of Water Supply Alternatives for Use in Habitat Restoration for the San Joaquin River, Friant Water Users Association and National Resource and Natural Resources Defense Council Coalition, Nov 22, 2000.

TABLE VIII-1 (CONT.)

COMPOSITE LIST OF POTENTIAL WATER STORAGE PROJECTS

Project Name	Reference No.	Storage Type	Storage Size	Description	Documentation*	Reason For Preliminary Elimination
Dry Creek Dam	63	Off-Stream	444,000	Construction of a new dam on Dry Creek about 7 miles southwest of Terminus Dam. Flow would be diverted from the Kaweah River.	URS NO. S12	Retained For Further Consideration
Duck Creek	45	Off-Stream	100,000	The reservoir would be located in the Calaveras watershed in San Joaquin County. Flow would be diverted from the Mokelumne and Calaveras Rivers	CALFED NO. 15	200,000 ac-ft or Smaller
Farmington Reservoir Enlargement	46	Off-Stream and On-Stream	100,000	Enlargement of the Farmington Reservoir	CALFED NO. 16	200,000 ac-ft or Smaller
Fiddlers Reservoir	20	Off-Stream and On-Stream	310,000 to 545,000	Construction of a new dam on the Middle Fork of Cottonwood Creek. Flow would be diverted from the Middle fork of Cottonwood Creek	CALFED NO. 17	Previous Extensive Study
Fine Gold Creek Dam	55	Off-Stream	350,000	Construction of a dam upstream of the confluence of Fine Gold Creek and Millerton Lake. Flow would be diverted from Millerton Lake.	URS NO. S4	Retained For Further Consideration
Folsom Reservoir	5	On-Stream	365,000	Enlargement of Folsom Reservoir by increasing the height of Folsom Dam by 30 feet	CALFED NO. 18	Retained For Further Consideration
Freemans Crossing Reservoir	6	On-Stream	300,000	A dam would be constructed near Freemans Crossing on the Middle Fork of the Yuba River and divert water from the North Fork.	CALFED NO. 19	Retained For Further Consideration
Galatin Reservoir	21	On-Stream	183,000	Not Provided	CALFED NO. 20	200,000 ac-ft or Smaller
Garden Bar Reservoir	7	On-Stream	245,000	Construction of a 320 foot high dam on the Bear River upstream of Camp Far West Reservoir.	CALFED NO. 21	Retained For Further Consideration
Garzas Reservoir	30	Off-Stream	139,000 to 1,754,000	The reservoir would be located on Ganzas Creek in Stanislaus County	CALFED NO. 22	Retained For Further Consideration
Glenn Reservoir Project	22	Off-Stream	8,206,000	Construction of Rancheria Dam on the main stream of Stony Creek and Newville Dam on the North Fork of Stony Creek. One of the Dams would be 420 feet tall. Would store runoff from Stony and Thomes Creeks and pumped flows from the Sacramento River.	CALFED NO. 23	Retained For Further Consideration
Ground Water Conjunctive Use	52	Off-Stream	500,000 to 1,000,000	Groundwater Storage in Sacramento Valley, San Joaquin Valley, and Southern California	CALFED	Source of Diversion

*** Documentation Refers to:**
Initial Surface Water Storage Screening, Integrated Storage Investigation, CALFED Bay-Delta Program, August 2000.
Technical Memorandum 4, Draft Long List of Alternatives, Development of Water Supply Alternatives for Use in Habitat Restoration for the San Joaquin River, Friant Water Users Association and National Resource and Natural Resources Defense Council Coalition, Nov 22,000.

TABLE VIII-1 (CONT.)

COMPOSITE LIST OF POTENTIAL WATER STORAGE PROJECTS

Project Name	Reference No.	Storage Type	Storage Size	Description	Documentation*	Reason For Preliminary Elimination
Hulen Reservoir	23	On-Stream	96,000 to	Construction of a Dam on the North Fork of Cottonwood Creek.	CALFED NO. 24	Previous Extensive Study
Hungry Hollow Reservoir	65	Off-Stream and On-Stream	800,000	Construction of a 260 foot high dam on Deer Creek. Would store in-stream flows and diversions from Lake Success.	URS NO. S14	Retained For Further Consideration
In-Delta Storage	16	Island Storage	230,000	Conversion of several south delta islands to reservoirs. Water would be diverted from the Sacramento or San Joaquin Rivers during high flows and released during lower flows.	CALFED NO. 14	Source of Diversion
Ingram Canyon	31	Off-Stream	333,000 to 1,201,000	The reservoir would be located on Ingram Creek in Stanislaus County. Flows would be diverted from the California Aqueduct.	CALFED NO. 25	Source of Diversion
Kettleman Plain	32	Off-Stream	133,000 to 283,000	The reservoir would be located in Kings County west of the California Aqueduct. Flows would be diverted from the California Aqueduct.	CALFED NO. 26	Source of Diversion
Kosk Reservoir	8	On-Stream	800,000	Construction of a reservoir on the Pit River approximately two miles downstream of Big Bend.	CALFED NO. 27	Significant Existing Storage
Lake Beryessa Enlargement	24	Off-Stream and On-Stream	4,400,000 to	Construction of a new dam 2 miles downstream of the existing Montecello Dam. Flows would be diverted from the Sacramento River.	CALFED NO. 4	Retained For Further Consideration
Little Salado-Crow Reservoir	33	Off-Stream	132,000 to 250,000	The Reservoir would be located Crow Creek in Stanislaus County. Flows would be diverted from the California Aqueduct.	CALFED NO. 28	Source of Diversion
Los Banos Grandes	34	Off-Stream	275,000 to 2,030,000	The reservoir would be located on Los Banos Creek in Merced County. Flows would be diverted from the California Aqueduct.	CALFED NO. 29 URS NO. S15	Source of Diversion
Los Vaqueros Enlargement	35	Off-Stream	965,000	Increase the size of the existing Los Vaqueros Reservoir located on Kellogg Creek in Contra Costa County. Flows would be diverted from the California Aqueduct.	CALFED NO. 30	Source of Diversion
Mammoth Pool Expansion	54	On-Stream	35,000	Installation of spillway gates to raise the normal operating pool and increase the active storage.	URS NO. S3	200,000 ac-ft or Smaller
Marysville Reservoir	9	On-Stream	916,000	The reservoir would be located on the mainstem of the Yuba River downstream of Englebright Reservoir	CALFED NO. 31	Previous Extensive Study

* Documentation Refers to:

Initial Surface Water Storage Screening, Integrated Storage Investigation, CALFED Bay-Delta Program, August 2000.

Technical Memorandum 4, Draft Long List of Alternatives, Development of Water Supply Alternatives for Use in Habitat Restoration for the San Joaquin River, Friant Water Users Association and National Resource and Natural Resources Defense Council Coalition, Nov 22, 2000.

TABLE VIII-1 (CONT.)

COMPOSITE LIST OF POTENTIAL WATER STORAGE PROJECTS

Project Name	Reference No.	Storage Type	Storage Size	Description	Documentation*	Reason For Preliminary Elimination
Mill Creek Dam	59	Off-Stream	1,000,000	Construction of a new dam on Mill Creek 1.3 miles upstream from the confluence of Mill Creek and the Kings River. Flow would be diverted from Pine Flat Reservoir	URS NO. S8	Retained For Further Consideration
Millerton Lake Enlargement	47	On-Stream	720,000	Increase the height of Friant Dam 144 feet and construct three saddle dams	CALFED NO. 32 URS NO. S1	Retained For Further Consideration
Millville Reservoir	10	On-Stream	206,000	The reservoir would be located on south Cow Creek in Shasta County	CALFED NO. 33	Retained For Further Consideration
Montgomery Reservoir	48	Off-Stream	240,000	The reservoir would be located on Dry Creek in Merced County. Flows would be diverted from Lake McClure	CALFED NO. 34	Retained For Further Consideration
Nashville Reservoir	49	Off-Stream and On-Stream	1,155,000	The reservoir would be located on the Cosumnes River approximately 5 miles north of Plymouth.	CALFED NO. 35	Retained For Further Consideration
Orestimba Reservoir	36	Off-Stream	380,000 to 1,140,000	The reservoir would be located on Orestimba Creek in Stanislaus County. Flow would be diverted from the California Aqueduct.	CALFED NO. 36	Source of Diversion
Panoche Reservoir	37	Off-Stream	160,000 to 3,100,000	The reservoir would be located on Panoche and Silver Creeks in San Benito and Fresno Counties. Flow would be diverted from the California Aqueduct.	CALFED NO. 37 URS NO. S16	Source of Diversion
Pardee Reservoir Enlargement	50	On-Stream	150,000	Enlargement of the Pardee Reservoir	CALFED NO. 38	200,000 ac-ft or Smaller
Quinto Creek Reservoir	38	Off-Stream	332,000 to 381,000	The reservoir would be located on Quinto Creek in Merced and Stanislaus Counties. Flow would be diverted from the California Aqueduct.	CALFED NO. 39	Source of Diversion
Raise Pine Flat Dam	57	On-Stream	45,000	Raise crest of Pine Flat Dam by adding a 7-ft parapet wall	URS NO. S6	200,000 ac-ft or Smaller
Raise Terminus Dam	61	On-Stream	250,000 to 1,200,000	Raise dam crest by 106, 206 or 306 ft. It is probable that the existing dam would need to be replaced to achieve these levels of construction.	URS NO. S10	Retained For Further Consideration
Red Bank Project (Dippingvat-Schoenfield)	25	Off-Stream and On-Stream	354,000	Construction of 104,000 Acre-foot Dippingvat Reservoir on the Southfork of Cottonwood Creek and 250,000 Acre-foot Schoenfield Reservoir on Red Bank Creek.	CALFED NO. 40	Previous Extensive Study
Rogers Crossing Dam	58	On-Stream	950,000	Construction of a dam 1/2 mile upstream of the confluence of the North Fork and the Kings River	URS NO. S7	Retained For Further Consideration
Romero	39	Off-Stream	184,000	Not Provided	CALFED NO. 41	200,000 ac-ft or Smaller
San Luis Reservoir Enlargement	40	Off-Stream	390,000	Raise the height of the existing San Luis Reservoir dam by 40 feet. Flow would be diverted from the California Aqueduct.	CALFED NO. 52	Source of Diversion
<p>* Documentation Refers to: Initial Surface Water Storage Screening, Integrated Storage Investigation, CALFED Bay-Delta Program, August 2000. Technical Memorandum 4, Draft Long List of Alternatives, Development of Water Supply Alternatives for Use in Habitat Restoration for the San Joaquin River, Friant Water Users Association and National Resource and Natural Resources Defense Council Coalition, Nov 22, 2000.</p>						

**TABLE VIII-1 (CONT.)
COMPOSITE LIST OF POTENTIAL WATER STORAGE PROJECTS**

Project Name	Reference No.	Storage Type	Storage Size	Description	Documentation*	Reason For Preliminary Elimination
Shasta Lake Enlargement	26	On-Stream	300,000	Raise Shasta Dam 6 to 8 feet.	CALFED NO. 43	Retained For Further Consideration
Sites Reservoir	27	Off-Stream	1,200,000 to 1,900,000	Reservoir would be formed by Golden Gate Dam on Funks Creek and Sites Dam on Stone Corral Creek. The smaller version would require the construction of 5 dikes. The	CALFED NO. 44	Retained For Further Consideration
South Gulch Reservoir	51	Off-Stream	180,000	The reservoir would be located on South Gulch in San Joaquin County. Flows would be diverted from the Calaveras and Stanislaus Rivers.	CALFED NO. 45	200,000 ac-ft or Smaller
Squaw Valley Reservoir	11	Off-Stream and On-Stream	400,000	The reservoir would be located on Squaw Valley Creek, a tributary to the McCloud River.	CALFED NO. 52	Significant Existing Storage
Success Dam Raise	64	On-Stream	28,000	Raise the Height of Success Dam by 10-Feet	URS NO. S13	200,000 ac-ft or Smaller
Sunflower Reservoir	41	Off-Stream	360,000 to 600,000	The reservoir would be located on Avenal Creek in Kings and Kern Counties. Flow would be diverted from the California Aqueduct.	CALFED NO. 47	Source of Diversion
Temperance Flat Dam	53	On-Stream	1,400,000	Construction of a dam upstream of Friant Dam in the upstream end of Millerton Lake	URS NO. S2	Retained For Further Consideration
Thomes- Newville Reservoir	28	Off-Stream	1,840,000 to 3,080,000	Reservoir would be constructed on the North Fork of Stony Creek. An afterbay would be constructed downstream. Flow would be diverted from Stony Creek, Thomes Creek and the Sacramento River.	CALFED NO. 48	Retained For Further Consideration
Trinity Lake Enlargement (Formerly Clair Engle Lake)	17	Off-Stream and On-Stream	4,800,000	Increase storage capacity of Trinity Lake by raising the height of Trinity Dam by 200 feet. Flow would be diverted from Shasta Lake.	CALFED NO. 6	Source of Diversion
Tulare Lake Basin	67	Off-Stream	100,000	Purchase of Storage Facilities created at the south end of the Tulare Lake Basin. Flow would be diverted from the California Aqueduct, Kings, Kaweah, and Tule Rivers	URS NO. S18	200,000 ac-ft or Smaller
Tuscan Buttes Reservoir	12	Off-Stream	3,675,000 to 5,500,000	The reservoir would be located on Paynes and Inks Creeks. Flows would be diverted from the Sacramento river.	CALFED NO. 49	Retained For Further Consideration
<p>* Documentation Refers to: <i>Initial Surface Water Storage Screening, Integrated Storage Investigation, CALFED Bay-Delta Program, August 2000.</i> <i>Technical Memorandum 4, Draft Long List of Alternatives, Development of Water Supply Alternatives for Use in Habitat Restoration for the San Joaquin River, Friant Water Users Association and National Resource and Natural Resources Defense Council Coalition, Nov 22, 2000.</i></p>						

TABLE VIII-1 (CONT.)

COMPOSITE LIST OF POTENTIAL WATER STORAGE PROJECTS

Project Name	Reference No.	Storage Type	Storage Size	Description	Documentation*	Reason For Preliminary Elimination
Waldo Reservoir	13	Off-Stream	60,000 to 300,000	The reservoir would be located on Dry Creek in Yuba County. Flows would be diverted from the Yuba, and Bear Rivers.	CALFED NO. 50	Retained For Further Consideration
Wing Reservoir	14	On-Stream	244,000	The reservoir would be located on Inks Creek at the same location as the Tuscan Buttes Reservoir.	CALFED NO. 51	Retained For Further Consideration
Yokohl Creek Dam	62	Off-Stream	970,000	Construction of a new dam on Yokohl Creek about 8 miles southwest of Terminus Dam. Flows would be diverted from the Kaweah River.	URS NO. S11	Retained For Further Consideration
<p><i>* Documentation Refers to:</i> Initial Surface Water Storage Screening, Integrated Storage Investigation, CALFED Bay-Delta Program, August 2000. Technical Memorandum 4, Draft Long List of Alternatives, Development of Water Supply Alternatives for Use in Habitat Restoration for the San Joaquin River, Friant Water Users Association and National Resource and Natural Resources Defense Council Coalition, Nov 22, 2000.</p>						

Step 3 - Ranking of Remaining Projects

The remaining projects were ranked based on parameters including flow excess, storage size, and basin area. Flow excess was defined as the amount by which the annual 1-percent chance exceedence flow exceeded the objective flow or channel capacity at downstream reservoir control points or model index points (the maximum flow excess was used where multiple control or index points existed). The location of selected reservoir control and model index points are provided in Plate 7, and a summary of the points are provided in Table VIII-2.

The projects were ranked based on their ratios of project storage divided by flow excess; flow excess divided by basin area; and project storage divided by basin area. For each of these ratios, larger values indicate the possibility of greater potential for flood damage reduction. The projects were sorted and ranked for each ratio, and the rankings were summed for each of the projects as an indicator of potential project performance.

Step 4 - Short-Listed Projects

Ten projects were short-listed for potential modeling analysis, based on the ranking described above and a review of their geographic locations. The intent of the short list was to provide team a list of potential projects that appeared feasible from technical and environmental perspectives, and had the greatest likelihood of providing flood damage reduction benefits in specific geographic regions where flooding or capacity problems had previously been identified. For each major region of the study area associated with flooding problems, the ranked list of projects was reviewed, and the most promising projects of each type (raising existing dams, new on-stream, and new off-stream storage) were identified in each region. Thus, if similar projects were proposed in the same region, but one appeared to have higher potential for flood damage reduction or greater likelihood of implementation, only one project was carried forward to the short list for that particular region. It should be noted that this short-listing was only intended to narrow the choices for modeling in this study, and not to assess the feasibility of individual projects. The short list of projects is shown in Table VIII-4.

Step 5 - Final Selection

Two scenarios were identified from the short list for modeling in this study. The selected scenarios included analysis of the regional flood damage reduction benefits of a generic off-stream storage reservoir in the Sacramento River Basin and a suite of three potential reservoir projects near Friant Dam in the San Joaquin River Basin. The Sacramento River Basin project would involve the transfer of conservation storage from Stony Gorge, East Park, Black Butte, Shasta, Oroville, and Folsom reservoirs to an off-stream site. The suite of Friant Dam projects would include raising Friant Dam, construction of Temperance Flat dam on the San Joaquin River upstream of Friant Dam, and construction Fine Gold dam on Fine Gold Creek upstream of Friant Dam.

**TABLE VIII-2
CONTROL OR INDEX POINTS REFERENCED TO MAP LOCATION**

Reservoir Control Point or Model Index Point	Flow (cfs)		Storm Centering	Percent Chance Exceedence Flow Exceeding Objective Flow	Map Reference Letter
	Objective	1% Exceedence Existing			
Bend Bridge	100,000	160,000	Shasta	2%	A
Ord Ferry	130,000	160,000	Black Butte	4%	B
Gridley	150,000	150,000	Oroville Dam	0.5%	C
Yuba City	180,000	180,000	Oroville Dam	0.2%	
Marysville	300,000	130,000	Oroville Dam	None	D
Nicolaus	320,000	325,000	Oroville Dam	1% (minimal), 0.5%	E
Marysville (Yuba R)	180,000	160,000	New Bullards Bar	0.5%	
Marysville (Feather R)	300,000	300,000	New Bullards Bar	0.5%	
Nicolaus (Feather)	320,000	325,000	New Bullards Bar	2% & 1% (minimal), 0.5%	
Rumsey	20,000	45,000	Indian Valley	10%	F
Friant Kern Canal	7,950	15,000	Pine Flat	2%	G
Mendota Gage	6,500	37,000	Friant Dam	2%	H
Madera Canal	5,000	7,500	Hidden	4% or 1%	J
Madera Canal	7,000	7,500	Buchanan	1%	K
Cressey	6,000	55,000	New Exchequer	2%	L
Modesto	9,000	80,000	Don Pedro	2%	M
Orange Blossom	8,000	12,000	New Melones	2% (minimal), 1%	N
Los Banos	1,000	1,000	Los Banos	0.5%	I
El Nido	17,000	50,000	El Nido		O
Newman	45,000	70,000	Newman		P
Vernalis	52,000	99,000	Vernalis		Q

**TABLE VIII-3
RANKING OF SELECTED POTENTIAL WATER STORAGE PROJECTS**

Project Name	Reference No.	Approximate Basin Area (Mi ²)	Maximum Potential Storage Size (AF)	Location with Respect to Downstream Objective Flow Point In Downstream Order	Maximum Flow Excess (cfs)	Storage/Flow Excess		Flow Excess /Basin Area		Storage/Basin Area		Total Ranking
						Value (ac-ft/cfs)	Ranking	Value (cfs/Mi ²)	Ranking	Value (ac-ft/Mi ²)	Ranking	
Coloma Reservoir	3	650	710,000	No Downstream Objective Flow Point	NA	NA	NA	NA	NA	1,092	8	NA
Colusa Reservoir Complex	18	60	3,300,000	No Downstream Objective Flow Point	NA	NA	NA	NA	NA	55,000	25	NA
Cooperstown Reservoir	43	125	609,000	Tuolumne River at Modesto San Joaquin River at Vernalis	71,000	117	15	568	15	4,872	15	45
Deer Creek Reservoir	44	100	600,000	No Downstream Objective Flow Point	NA	NA	NA	NA	NA	6,000	17	NA
Dry Creek Dam	63	NA	444,000	Kings River at Friant Kern Canal San Joaquin River at Mendota Gage San Joaquin River at El Nido San Joaquin River at Newman San Joaquin River at Vernalis	47,000	106	14	NA	NA	NA	NA	NA
Fine Gold Creek Dam	55	90	350,000	San Joaquin River at Mendota Gage San Joaquin River at El Nido San Joaquin River at Newman San Joaquin River at Vernalis	47,000	134	16	522	14	3,889	14	44
Folsom Reservoir Enlargement	5	1,875	365,000	American River at Folsom Dam Outflow	5,000	14	4	3	1	195	2	7
Freemans Crossing Reservoir	6	100	300,000	Yuba River at Marysville Feather River at Marysville Feather River at Nicolaus	5,000	17	5	50	9	3,000	11	25
Garden Bar Reservoir	7	300	245,000	Feather River at Nicolaus	5,000	20	7	17	3	817	4	14
Garzas Reservoir	30	75	1,754,000	No Downstream Objective Flow Point	NA	NA	NA	NA	NA	23,387	22	NA
Glenn Reservoir Project	22	700	8,206,000	Sacramento River at Ord Ferry	30,000	4	1	43	7	11723	19	27
Hungry Hollow Reservoir	65	10	800,000	No Downstream Objective Flow Point	NA	NA	NA	NA	NA	85,000	26	NA
Lake Beryessa Enlargement	24	560	11,700,000	No Downstream Objective Flow Point	NA	NA	NA	NA	NA	20,893	21	63
Mill Creek Dam	59	125	1,000,000	Kings River at Friant Kern Canal San Joaquin River at Mendota Gage San Joaquin River at El Nido San Joaquin River at Newman San Joaquin River at Vernalis	47,000	47	10	376	11	8,000	18	39
Millerton Lake Enlargement	47	1,650	720,000	San Joaquin River at Mendota Gage San Joaquin River at El Nido San Joaquin River at Newman San Joaquin River at Vernalis	47,000	65	13	28	4	436	3	20
Millville Reservoir	10	125	206,000	Sacramento River at Bend Bridge Sacramento River at Ord Ferry	60,000	291	20	480	12	1,648	9	41
Montgomery Reservoir	48	75	240,000	Merced River at Cressey San Joaquin River at Vernalis	49,000	204	18	653	18	3,200	13	49
Nashville Reservoir	49	450	1,155,000	No Downstream Objective Flow Point	NA	NA	NA	NA	NA	2,567	10	NA

**TABLE VIII-3 (CONT.)
RANKING OF SELECTED POTENTIAL WATER STORAGE PROJECTS**

Project Name	Reference No.	Approximate Basin Area (Mi ²)	Maximum Potential Storage Size (AF)	Location with Respect to Downstream Objective Flow Point In Downstream Order	Maximum Flow Excess (cfs)	Storage/Flow Excess		Flow Excess /Basin Area		Storage/Basin Area		Total Ranking
						Value (AF/cfs)	Ranking	Value (cfs/Mi ²)	Ranking	Value (AF/Mi ²)	Ranking	
Raise Terminus Dam	61	1,200	1,200,000	Kings River at Friant Kern Canal San Joaquin River at Mendota Gage San Joaquin River at El Nido San Joaquin River at Newman San Joaquin River at Vernalis	47,000	39	9	39	6	1,000	7	22
Rogers Crossing Dam	58	1,000	950,000	Kings River at Friant Kern Canal San Joaquin River at Mendota Gage San Joaquin River at El Nido San Joaquin River at Newman San Joaquin River at Vernalis	47,000	49	12	47	8	950	6	26
Shasta Lake Enlargement	26	6,400	300,000	Sacramento River at Bend Bridge Sacramento River at Ord Ferry	60,000	200	17	9	2	47	1	20
Sites Reservoir	27	Unknown	1,900,000	No Downstream Objective Flow Point	NA	NA	NA	NA	NA	NA	NA	NA
Temperance Flat Dam	53	1,600	1,400,000	San Joaquin River at Mendota Gage San Joaquin River at El Nido San Joaquin River at Newman San Joaquin River at Vernalis	47,000	34	8	29	5	875	5	18
Thomes-Newville Reservoir	28	60	3,080,000	Sacramento River at Ord Ferry	30,000	10	2	500	13	51,333	23	38
Tuscan Buttes Reservoir	12	100	5,500,000	Sacramento River at Bend Bridge Sacramento River at Ord Ferry	60,000	11	3	600	16	55,000	24	43
Waldo Reservoir	13	100	300,000	Yuba River at Marysville Feather River at Marysville Feather River at Nicolaus	5,000	17	6	50	10	3,000	12	28
Wing Reservoir	14	50	244,000	Sacramento River at Bend Bridge Sacramento River at Ord Ferry	60,000	246	19	1,200	19	4,880	16	54
Yokohl Creek Dam	62	75	970,000	Kings River at Terminus Kings River at Friant Kern Canal San Joaquin River at Mendota Gage San Joaquin River at El Nido San Joaquin River at Newman San Joaquin River at Vernalis	47,000	48	11	627	17	12,933	20	48

**TABLE VIII-4
SHORT-LISTED PROJECTS**

Proposed Project	Reason for Short Listing
Deer Creek Reservoir (44)	Potential for flood reduction on the Cosumnes River and the American River. Project could store water currently held in Folsom Lake leaving more capacity in Folsom for flood management.
Folsom Dam Height Increase (5)	The USACE has already studied the feasibility of increasing the height of Folsom Dam. However, it may be useful to include this project in the comprehensive study to demonstrate possible benefits.
Garden Bar Reservoir (7)	Flood reduction potential is difficult to assess due to the reservoir control point location.
Glenn Reservoir Project (22)	Ranks high based on the selection criteria. This project is located near the potential Thomas-Newville Reservoir (28). However, the Glenn Reservoir project would be larger and would have greater flood reduction potential. Therefore the Glenn Reservoir project was selected instead of the Thomas-Newville Reservoir.
Millerton Lake Enlargement (47) and Fine Gold Creek Dam (55)	Ranks high based on the selection criteria. The Temperance Dam project (53 is located directly upstream) would have similar results. Raising the height of the existing dam seems more feasible.
Montgomery Reservoir (48)	Potential flood reduction on the Merced River at Cressey. Diversions from Lake McClure appear to be feasible.
Raise Terminus Dam (61)	Ranks high based on the selection criteria. This project may have flood reduction potential for the Kings River at the Friant-Kern Canal. The analysis may include an assessment of off-stream storage generated by the potential Yokohl Creek Dam (62), and Dry Creek Dam (63).
Shasta Dam Height Increase (26)	Project ranks high based on the selection criteria. However, the existing capacity of Shasta Dam provides adequate management of most flood flows. Additional capacity may have little impact on flood flows at the Bend Bridge control point.
Sites Reservoir (27)	Has the potential for flood reduction on Stony Creek and the Sacramento River. Possible off-stream storage for the existing Stony Gorge, East Park, or Black Butte Reservoirs, and direct diversions from the Sacramento River. The results of this analysis would be similar for the proposed Colusa Reservoir Complex.
Tuscan Buttes Reservoir (12)	May have potential for flood reduction on the Sacramento River at Bend Bridge. This project is located near the potential Milleville Reservoir (10) and Wing Reservoir (14) projects. The most feasible of these projects would be included in the model.

ANALYSIS OF SCENARIOS

Sacramento River Basin-Generic Off-Stream Storage Project

In the Sacramento River Basin, the regional flood damage reduction benefits of a generic off-stream storage reservoir were investigated (i.e. an off-stream storage project located at an unidentified site which could provide storage for water which is currently held at existing on-stream reservoirs). The generic project had the following characteristics:

- Maximum capacity of 500 TAF, 1,000 TAF, or 2,000 TAF
- Project to be filled by transfer of existing conservation storage in East Park, Stony Gorge, Shasta, Oroville, and/or Folsom reservoirs
- Project to have the capability for direct diversions from the Sacramento River below Shasta Dam (at Keswick) and Stony Creek below Black Butte Dam
- Diversions limited to a maximum of 3,000 cubic feet per second (cfs) from Stony Creek and 10,000 cfs from the Sacramento River.

The process used to distribute storage from the off-stream storage project among the candidate reservoirs is discussed in further detail below. Operations for the generic off-stream storage project were not modeled as an independent functioning system; the reservoir was assumed to have zero outflow until the maximum storage level was reached at which time it was assumed to pass inflow. The reservoir itself being generic, has no physical design criterion. Discharges from the generic off-stream storage reservoir were returned to the Sacramento River at Ord Ferry.

HEC-5 Modeling

The influences of the Sacramento River Basin generic off-stream storage project were analyzed using the HEC-5 models previously developed by the USACE. The models were updated as necessary to reflect the transfer of water from existing projects to the new storage site. The HEC-5 models were also updated to include direct diversions from the Sacramento River and Stony Creek as described below. Allocation of storage in the generic off-stream storage project was “optimized” for the occurrence of a 1-percent chance exceedence event as described below (i.e., the target event for flood damage reduction was the 1-percent chance exceedence flood). The HEC-5 models were run for 5 storm centerings (Stony Creek, Shasta, Oroville Dam, Folsom Dam, and Sacramento), as previously developed by the USACE.

Storage Allocation – Six reservoirs were selected for potential transfer of storage to the off-stream storage project. These included East Park, Stony Gorge, and Black Butte on the Stony Creek system, as well as Shasta, Oroville, and Folsom. As described above, three increments of storage (alternatives) in the generic off-stream reservoir were evaluated: 500 TAF, 1,000 TAF, and 2,000 TAF. The storage was allocated among the six reservoirs based on the current level of protection provided at the reservoir and existing storage capacity as documented in previous incremental analyses by the USACE. Priority in allocation was given to the reservoirs with the lowest levels of existing flood protection. Therefore, in each of the three alternatives the entire

conservation storage in the Stony Creek system (67.4 TAF at East Park and Stony Gorge) was transferred to the generic off-stream storage project. In addition to this passive transfer of conservation storage, 156.6 TAF of active storage space in the project was allocated to accommodate a 3,000 cfs diversion from Stony Creek below Black Butte. The amount of active storage required for the diversion was determined from an initial simulation of the 1-percent chance exceedence event. Thus, the Stony Creek system was given the highest priority in allocating the additional storage for each alternative.

Considering the existing levels of protection, each of the three alternatives also included at least 50 TAF of transfer from conservation storage at Folsom Lake, which previous modeling had shown would allow Folsom outflows to meet objectives up to and including the annual 1-percent chance exceedence flood. This transfer was thus the second highest priority under each of the alternatives analyzed.

The remaining storage for each alternative was allocated based on the potential increase in flood protection or the expectation that the additional storage would help meet objective flows for larger events as determined from the previous incremental modeling analysis. Storage allocations from Shasta, Oroville, and Folsom; to the generic off-stream storage project for the three alternatives, are summarized in Table VIII-5.

**TABLE VIII-5
SACRAMENTO RIVER BASIN GENERIC OFF-STREAM RESERVOIR STORAGE
ALLOCATION**

	Allocated Storage by Alternative (TAF)		
	R01A	R02A	R03A
Stony Creek Conservation Storage	67.4	67.4	67.4
Stony Creek Diversion Storage	156.6	156.6	156.6
Folsom Conservation Storage	76.0	217.2	217.2
Oroville Conservation Storage	100.0	100.0	100.0
Shasta Conservation Storage	100.0	458.8	1458.8
Total Off-stream Storage Allocated	500.0	1,000.0	2,000.0

The 217.2 TAF transfer of storage from Folsom in alternatives R02A and R03A represents the entire conservation storage volume above the hydropower pool. The 100 TAF transfers from Oroville and Shasta represent the additional flood control storage required for the reservoirs to contain their respective 0.5-percent chance exceedence events, though objective flows would still be exceeded in both cases. Remaining storage in alternatives R02A and R03A was added to Shasta rather than Oroville because the incremental analyses indicated more opportunity to meet objective flows and control the annual 0.2-percent chance exceedence event. It should be noted that no active storage is reserved for the Sacramento River diversion, as the flows corresponding to a 1-percent chance exceedence event at Keswick do not exceed the 79,000 cfs objective.

Headwater Model Modifications – The Sacramento River Basin headwater HEC-5 model was modified to reflect changes to East Park and Stony Gorge conservation storage. For each of these projects, all storage above the minimum pool levels (5 TAF in East Park and 7.5 TAF in Stony Gorge) was transferred to the generic off-stream storage project. In addition to this transfer of storage, release schedules from each of these projects were modified to allow the projects to effectively use the additional storage for reducing flood peak discharges. Maximum non-spill releases from East Park were increased from 5 cfs to 1,500 cfs and from Stony Gorge were increased from 15 cfs to 7,500 cfs. These modifications allowed the projects to pass inflow during the early part of large storms, retaining most of the flood storage pool for use near the peak of the events. The releases were selected based on preliminary runs of the HEC-5 model and comparison of the timing of filling and spilling of the three Stony Creek projects.

It should be noted that neither the physical outlet capacity of the Stony Creek projects, nor the potential downstream impacts of higher flows were considered in setting the new maximum releases in the schedule. The modifications were designed to provide an “optimal” flood management configuration for 1-percent chance exceedence flood discharges from Black Butte dam. Sensitivity analyses indicated that the maximum discharges from Black Butte would not be significantly affected by moderate (up to 50 percent) reductions in the modeled peak outflow from the upstream projects. However, for purposes of the current analysis it was decided to use the discharges listed above.

After the revised headwaters model was run for each storm centering, a DSSMATH macro was run to calculate a revised top of conservation storage for reservoirs with credit space agreements. Modifications were made to the macro for Black Butte and Folsom conservation storage calculations to reflect storage transfers for each of the three alternatives.

Mainstem Model Modifications – Transfers of conservation storage for Shasta and Oroville were modeled by reducing the top of conservation storage, thus enlarging the flood control pool. Both the HEC-5 model and the input DSS files contain specifications for the top of conservation at these reservoirs. Conservation storage values were changed in both files and the initial storage volumes at each of the projects were changed so that the model would begin at the modified top of conservation storage.

Two diversions were added to the Sacramento River Basin model as part of the generic off-stream storage alternative. The Stony Creek diversion, assumed to be located just below Black Butte Reservoir, was configured to divert Stony Creek flows above 5,000 cfs (up to a maximum diversion of 3,000 cfs) to the off-stream reservoir. This allows flows in Stony Creek to be maintained at the non-damaging level for longer periods than are currently attained. To maximize the benefit of the diversion, the target releases from Black Butte were increased from 5,000 cfs to 8,000 cfs.

A 10,000 cfs diversion was also added to the HEC-5 model, corresponding to an assumed diversion from the Sacramento River at Keswick Dam (below Shasta Dam). Similar to the Stony Creek diversion, this diversion was configured to maintain flows below Keswick Dam at their target levels. As with the Stony Creek model, releases from Shasta Dam were modified to reflect the diversion capacity, with the current 79,000 cfs target increased to 89,000 cfs. Because the baseline HEC-5 model indicated that flows downstream of Keswick do not exceed 79,000 cfs in passing the annual 1-percent chance exceedence event, no storage space in the generic off-stream storage project was reserved for diversions from the Sacramento River. However, the assumed

diversion from the Sacramento River at Keswick Dam is utilized in passing the 0.5- and 0.2-percent chance exceedence events.

Model results provide verification that the allocation of storage in each of the generic off-stream storage alternatives, were “optimized” for the 1-percent chance exceedence event. The model shows that for each project alternative, the off-stream reservoir just fills in simulating the 1-percent chance exceedence event for the Stony Creek centering. The maximum 1-percent chance exceedence storage is slightly less for each of the other storm centerings. The maximum storage values in the generic off-stream reservoir for various storm centerings are provided in Table VIII-6.

TABLE VIII-6
MAXIMUM STORAGE IN THE SACRAMENTO RIVER BASIN GENERIC OFF-STREAM STORAGE PROJECT BASED ON HEC-5 SIMULATIONS OF THE 1% CHANCE EXCEEDENCE EVENT

Storm Centering	Maximum Storage by Alternative (TAF)		
	R01A (500 TAF)	R02A (1,000 TAF)	R03A (2,000 TAF)
Stony	499.4	999.4	1,999.4
Shasta	494.2	990.5	1,985.5
Oroville	421.9	919.8	1,919.3
American	489.9	989.9	1,989.9
Sacramento	489.5	988.5	1,988.5

Results

The effects of the off-stream storage alternatives were evaluated by comparing peak flows at four reservoir control points—Sacramento River at Keswick, Stony Creek below the proposed diversion (calculated as the difference of Black Butte outflow and Stony Creek diversion flow), Feather River below Oroville, American River below Folsom, and Sacramento River system at the latitude of Sacramento (Sacramento River at I Street gage plus Yolo Bypass at Interstate-80). Results of baseline and alternative scenarios for all 5 storm centerings are summarized in Tables VIII-7 through VIII-11. All three alternatives are effective in controlling the 1-percent chance exceedence flow to objective flows, except for the Stony Creek centering at Stony Creek and Oroville centering at Oroville simulations (see Tables VIII-8 and VIII-9). In the Oroville case, objective flows are exceeded by 1.5 percent.

TABLE VIII-7
MAXIMUM REGULATED FLOW FOR SACRAMENTO RIVER AT KESWICK,
VARIOUS STORM CENTERINGS

Reservoir Model	Maximum Regulated Flow By Percent Chance Exceedence (CFS)						
	50%	10%	4%	2%	1%	0.5%	0.2%
AMR-BASE	36,709	44,973	44,973	55,629	67,157	73,728	83,651
AMR-R01A	36,709	44,973	44,973	58,828	75,839	79,000	79,000
AMR-R02A	36,709	44,973	44,973	61,377	62,385	77,505	79,000
AMR-R03A	36,709	44,973	44,973	44,973	61,386	60,380	74,446
ORO-BASE	44,973	44,973	56,703	69,754	73,953	99,977	193,629
ORO-R01A	44,973	44,973	59,940	78,226	79,000	79,000	155,959
ORO-R02A	44,973	44,973	59,858	64,917	79,000	79,000	85,280
ORO-R03A	44,973	44,973	44,973	57,971	62,106	74,561	79,000
SAC-BASE	44,973	61,369	56,112	68,630	73,953	79,195	172,748
SAC-R01A	44,973	61,394	61,656	77,227	79,000	79,000	132,034
SAC-R02A	44,973	44,973	58,404	63,803	78,552	79,000	79,000
SAC-R03A	44,973	44,973	44,973	57,210	61,236	73,864	78,900
SHA-BASE	44,973	61,369	67,248	73,953	78,859	140,398	235,281
SHA-R01A	44,973	61,392	77,700	79,000	79,000	108,879	205,914
SHA-R02A	44,973	44,973	62,532	77,745	79,000	79,000	117,090
SHA-R03A	44,973	44,973	61,375	60,620	64,789	76,850	79,000
STY-BASE	42,324	44,973	54,966	68,929	73,953	79,127	184,482
STY-R01A	42,324	44,973	61,371	77,506	78,923	79,000	144,321
STY-R02A	42,324	44,973	58,159	64,096	78,866	79,000	79,000
STY-R03A	42,324	44,973	44,973	58,572	61,572	74,803	79,000
Model Prefix	Storm Centering	Model Suffix		Model Alternative			
AMR	American	BASE		Baseline scenario			
ORO	Oroville Dam	R01A		0.5 MAF off-stream storage reservoir			
SAC	Sacramento	R02A		1.0 MAF off-stream storage reservoir			
SHA	Shasta	R03A		2.0 MAF off-stream storage reservoir			
STY	Stony						
Objective Flow= 79,000 cfs							

TABLE VIII-8
MAXIMUM REGULATED FLOW FOR STONY CREEK BELOW PROPOSED
DIVERSION*, VARIOUS STORM CENTERINGS

Reservoir Model	Maximum Regulated Flow By Percent Chance Exceedence (CFS)						
	50%	10%	4%	2%	1%	0.5%	0.2%
AMR-BASE	5,000	9,837	12,450	14,950	20,000	47,823	63,293
AMR-R01A	5,000	7,903	9,450	9,450	11,950	11,950	46,783
AMR-R02A	5,000	7,903	9,450	9,450	11,950	11,950	46,783
AMR-R03A	5,000	7,903	9,450	9,450	11,950	11,950	46,783
ORO-BASE	3,110	5,000	5,242	9,629	12,450	14,950	20,000
ORO-R01A	3,334	5,000	5,619	7,827	9,450	9,450	11,950
ORO-R02A	3,334	5,000	5,619	7,827	9,450	9,450	11,950
ORO-R03A	3,334	5,000	5,619	7,827	9,450	9,450	11,950
SAC-BASE	5,000	11,858	12,450	14,950	18,091	45,789	60,330
SAC-R01A	5,000	8,646	9,450	9,450	11,950	11,950	44,007
SAC-R02A	5,000	8,646	9,450	9,450	11,950	11,950	44,007
SAC-R03A	5,000	8,646	9,450	9,450	11,950	11,950	44,007
SHA-BASE	5,242	5,242	12,450	14,950	14,950	20,000	53,885
SHA-R01A	5,619	5,619	8,964	9,450	10,951	11,950	19,800
SHA-R02A	5,619	5,619	8,964	9,450	10,951	11,950	19,800
SHA-R03A	5,619	5,619	8,964	9,450	10,951	11,950	19,800
STY-BASE	5,242	12,450	14,950	24,450	50,820	62,914	77,720
STY-R01A	5,619	9,450	11,950	11,950	17,000	46,377	66,148
STY-R02A	5,619	9,450	11,950	11,950	17,000	46,377	66,148
STY-R03A	5,619	9,450	11,950	11,950	17,000	46,377	66,148
Model Prefix	Storm Centering	Model Suffix		Model Alternative			
AMR	American	BASE		Baseline scenario			
ORO	Oroville Dam	R01A		0.5 MAF off-stream storage reservoir			
SAC	Sacramento	R02A		1.0 MAF off-stream storage reservoir			
SHA	Shasta	R03A		2.0 MAF off-stream storage reservoir			
STY	Stony						
Objective Flow= 15,000 cfs							
* Calculated as difference of Black Butte reservoir outflow and diversion flow (if any).							

TABLE VIII-9
MAXIMUM OUTFLOW FOR OROVILLE DAM (FEATHER RIVER),
VARIOUS STORM CENTERINGS

Reservoir Model	Maximum Regulated Flow By Percent Chance Exceedence (CFS)						
	50%	10%	4%	2%	1%	0.5%	0.2%
AMR-BASE	60,000	60,000	100,000	150,000	150,000	150,000	224,695
AMR-R01A	60,000	60,000	100,000	139,263	150,000	150,000	187,516
AMR-R02A	60,000	60,000	100,000	139,263	150,000	150,000	187,516
AMR-R03A	60,000	60,000	100,000	139,263	150,000	150,000	187,516
ORO-BASE	60,000	100,000	150,000	150,000	150,459	165,708	326,818
ORO-R01A	60,000	100,000	136,199	150,000	150,363	152,100	288,654
ORO-R02A	60,000	100,000	136,199	150,000	150,363	152,100	288,654
ORO-R03A	60,000	100,000	136,199	150,000	150,363	152,100	288,654
SAC-BASE	60,000	100,000	150,000	150,000	150,000	150,000	292,115
SAC-R01A	59,826	100,000	141,510	150,000	150,000	150,000	258,501
SAC-R02A	59,826	100,000	141,510	150,000	150,000	150,000	258,501
SAC-R03A	59,826	100,000	141,510	150,000	150,000	150,000	258,501
SHA-BASE	60,000	60,000	60,000	60,000	100,000	150,000	150,000
SHA-R01A	60,000	60,000	60,000	60,000	100,000	136,632	150,000
SHA-R02A	60,000	60,000	60,000	60,000	100,000	136,632	150,000
SHA-R03A	60,000	60,000	60,000	60,000	100,000	136,632	150,000
STY-BASE	60,000	60,000	60,000	60,000	100,000	150,000	150,000
STY-R01A	60,000	60,000	60,000	60,000	100,000	136,632	150,000
STY-R02A	60,000	60,000	60,000	60,000	100,000	136,632	150,000
STY-R03A	60,000	60,000	60,000	60,000	100,000	136,632	150,000
Model Prefix	Storm Centering		Model Suffix		Model Alternative		
AMR	American		BASE		Baseline scenario		
ORO	Oroville Dam		R01A		0.5 MAF off-stream storage reservoir		
SAC	Sacramento		R02A		1.0 MAF off-stream storage reservoir		
SHA	Shasta		R03A		2.0 MAF off-stream storage reservoir		
STY	Stony						
Objective Flow= 150,000 cfs							

TABLE VIII-10
MAXIMUM OUTFLOW FOR FOLSOM DAM (AMERICAN RIVER),
VARIOUS STORM CENTERINGS

Reservoir Model	Maximum Regulated Flow By Percent Chance Exceedence (CFS)						
	50%	10%	4%	2%	1%	0.5%	0.2%
AMR-BASE	37,183	115,000	115,000	115,000	120,169	301,121	532,698
AMR-R01A	35,490	115,000	115,000	115,000	115,000	220,991	529,475
AMR-R02A	33,240	115,000	115,000	115,000	115,000	127,272	502,082
AMR-R03A	33,240	115,000	115,000	115,000	115,000	127,272	502,082
ORO-BASE	22,058	92,364	115,000	115,000	115,000	125,709	412,227
ORO-R01A	20,971	90,991	115,000	115,000	115,000	115,000	365,523
ORO-R02A	19,303	88,179	115,000	115,000	115,000	115,000	225,993
ORO-R03A	19,303	88,179	115,000	115,000	115,000	115,000	225,993
SAC-BASE	33,938	112,364	115,000	115,000	115,000	204,615	493,030
SAC-R01A	32,849	110,765	115,000	115,000	115,000	138,853	481,887
SAC-R02A	30,924	107,567	115,000	115,000	115,000	115,000	384,190
SAC-R03A	30,924	107,567	115,000	115,000	115,000	115,000	384,190
SHA-BASE	18,755	18,755	37,183	87,308	115,000	115,000	115,000
SHA-R01A	17,887	17,887	35,490	85,984	115,000	115,000	115,000
SHA-R02A	16,604	16,604	33,240	83,250	115,000	115,000	115,000
SHA-R03A	16,604	16,604	33,240	83,250	115,000	115,000	115,000
STY-BASE	18,755	18,755	37,183	87,308	115,000	115,000	115,000
STY-R01A	17,887	17,887	35,490	85,984	115,000	115,000	115,000
STY-R02A	16,604	16,604	33,240	83,250	115,000	115,000	115,000
STY-R03A	16,604	16,604	33,240	83,250	115,000	115,000	115,000
Model Prefix	Storm Centering	Model Suffix		Model Alternative			
AMR	American	BASE		Baseline scenario			
ORO	Oroville Dam	R01A		0.5 MAF off-stream storage reservoir			
SAC	Sacramento	R02A		1.0 MAF off-stream storage reservoir			
SHA	Shasta	R03A		2.0 MAF off-stream storage reservoir			
STY	Stony						
Objective Flow=115,000cfs							

TABLE VIII-11
MAXIMUM REGULATED FLOW AT SACRAMENTO*,
VARIOUS STORM CENTERINGS

Reservoir Model	Maximum Regulated Flow By Percent Chance Exceedence (CFS)						
	50%	10%	4%	2%	1%	0.5%	0.2%
AMR-BASE	168,462	350,978	490,156	608,791	630,864	864,951	1,246,585
AMR-R01A	168,143	350,424	489,005	599,713	617,790	788,973	1,190,757
AMR-R02A	166,722	349,418	488,805	599,713	617,789	698,440	1,147,701
AMR-R03A	166,722	349,479	488,334	599,061	617,789	698,440	1,147,701
ORO-BASE	156,968	369,732	549,751	599,691	646,959	747,649	1,235,883
ORO-R01A	151,443	370,320	535,404	599,585	642,735	721,080	1,166,212
ORO-R02A	149,785	370,125	535,402	599,582	642,735	721,080	1,067,242
ORO-R03A	149,785	369,979	535,402	599,582	642,735	721,080	1,067,242
SAC-BASE	180,195	423,140	583,813	618,412	664,200	830,053	1,313,486
SAC-R01A	177,403	423,732	570,694	617,695	652,256	757,366	1,256,611
SAC-R02A	175,851	423,752	570,694	617,694	652,256	736,035	1,198,006
SAC-R03A	175,851	423,661	570,694	617,694	652,256	736,035	1,198,006
SHA-BASE	169,655	202,237	249,983	367,765	508,164	641,958	678,638
SHA-R01A	168,777	201,455	243,411	366,970	505,299	621,166	675,369
SHA-R02A	167,986	200,534	240,595	366,810	504,079	621,166	672,213
SHA-R03A	168,016	200,007	240,595	366,810	504,079	621,166	670,853
STY-BASE	162,495	219,706	271,312	393,306	535,000	675,632	714,483
STY-R01A	161,608	217,586	264,298	390,869	530,547	654,899	695,994
STY-R02A	160,663	216,816	263,718	391,036	529,327	654,899	695,843
STY-R03A	160,663	216,637	263,408	391,036	529,327	654,899	695,843
Model Prefix	Storm Centering	Model Suffix		Model Alternative			
AMR	American	BASE		Baseline scenario			
ORO	Oroville Dam	R01A		0.5 MAF off-stream storage reservoir			
SAC	Sacramento	R02A		1.0 MAF off-stream storage reservoir			
SHA	Shasta	R03A		2.0 MAF off-stream storage reservoir			
STY	Stony						
* Calculated as sum of Sacramento River at I St. Gage and Yolo Bypass at I-80.							

The analysis indicated that there are likely to be significant benefits associated with storage projects on tributary systems, especially Stony Creek. Models showed that exceedence of the 15,000 cfs objective flow below the proposed Stony Creek diversion structure is reduced from around a 4-percent chance exceedence event to at least a 2-percent chance exceedence event under project conditions. The peak flow associated with a 1-percent chance exceedence is reduced from 50,820 cfs to 17,000 cfs (a decrease of 67 percent). These benefits rely on the diversion capacity and modification of upstream storage facilities.

The reduction in flood potential for the index point on the Sacramento River system at the latitude of Sacramento was smaller in magnitude than for Stony Creek. For the annual 1-percent chance exceedence storm runoff, flows at Sacramento would be reduced from 0.65 percent to 2 percent depending on the storm centering, with minimal difference between alternative scenarios. The largest reductions are seen for the 0.5-percent chance exceedence events, particularly for the American and Sacramento storm centerings. This benefit appears primarily to be a result of substantial reductions in flows below Folsom. This is probably due to the location of the American River confluence with respect to the Sacramento index point. This may indicate that greater benefit could be achieved by altering the reservoir releases from Shasta, Oroville, and/or Folsom (i.e. redefining reservoir operations to reflect additional storage). With the exception of these two storm centerings, there is very little difference in the performance of the three alternative off-stream reservoir projects.

In the existing condition, the Shasta and Oroville projects control discharges associated with the 1-percent chance exceedence event to objective flows, thus the proposed project alternatives have the most apparent benefit at the 0.5-percent chance exceedence level. The 0.5-percent chance exceedence flow at Keswick Dam with the Shasta Storm runoff centering would be reduced from 140,398 cfs to less than the 79,000 cfs objective flow for Alternatives R02A and R03A. The 0.5-percent chance exceedence flow for the R01A alternative would be reduced to 108,879 cfs.

San Joaquin Basin-Friant Projects

In the San Joaquin River Basin, the regional flood damage reduction benefits of a suite of three potential reservoir projects near Friant Dam were investigated. The projects include raising Friant Dam, construction of Temperance Flat dam on the San Joaquin River upstream of Friant Dam, and construction Fine Gold Dam on Fine Gold Creek upstream of Friant Dam. Each project was evaluated separately, and additional models were used to simulate a combination of projects.

Analyses were conducted for the following seven cases:

- FRI-R01A evaluated doubling the existing flood space in Millerton Lake by increasing the height of Friant Dam 32 feet.
- FRI-R02A evaluated raising Friant Dam 20 feet and using all of the additional storage as flood space.
- FRI-R03A evaluated raising Friant Dam 20 feet and apportioning the additional storage between conservation and flood space based on the existing proportion.

- TMP-R01A evaluated construction of Temperance Flat Dam upstream of Friant Dam and using all of the additional storage for flood management.
- FNG-R01A evaluated construction of a 350 TAF Fine Gold off-stream reservoir located on Fine Gold Creek upstream of Friant Dam.
- SJQ-R01A evaluated a combination of the FRI-R01A, TMP-R01A, and FNG-R01A scenarios.
- SJQ-R02A evaluated a combination of the FRI-R01A, and FNG-R01A cases.

The process used to evaluate these cases is discussed in further detail below. Operations for the Fine Gold off-stream storage project were not modeled explicitly as flows must be pumped into the project. It was assumed that pumped diversions from Millerton Lake to the Fine Gold reservoir might not be feasible during flood flows. Therefore, it was assumed that Millerton Lake water would be pumped to the Fine Gold reservoir prior to the flood season allowing conservation storage in Millerton Lake to be reduced by an equal amount. Thus, the Fine Gold Creek project was assessed by reducing the amount of conservation storage in Millerton Lake and allocating this space to the flood control pool.

HEC-5 Modeling

Each of the cases described above was analyzed using HEC-5 models previously developed by the USACE. The models were updated as necessary to reflect the project characteristics. The HEC-5 models were run with the Friant and El Nido storm centerings, previously developed by the USACE for the Sacramento San Joaquin Comprehensive Study. Model results were tabulated and compared with the base condition for the 50-, 10-, 4-, 2-, 1-, 0.5-, and 0.2-percent chance exceedence storm runoff events.

Several of the project cases required modifications to the top of conservation storage at Friant Dam. Both the HEC-5 model and the input DSS files contain specifications for the top of conservation at this reservoir. The top of conservation at Friant Dam is subject to a credit space agreement, and is calculated using the DSS input file containing reservoir inflows and a DSSMATH macro depending on a base value and the storage in Mammoth reservoir. The macro was modified for each project case that required changing the top of conservation at Millerton Lake. Initial storage volumes were adjusted in the HEC-5 model as necessary.

FRI-R01A – The existing model of Friant Dam was modified to reflect a 32-foot increase of the spillway crest elevation. No modifications were made to the top of conservation. This increased the volume of the flood pool from 170 TAF to 340 TAF (assuming a minimum top of conservation storage of 350.5 TAF from the credit space agreement). The increased storage was based on the elevation-storage-area curves presented in the URS study (FWUA and NRDC, 2000). The model was used to generate outflows for the Friant and El Nido storm centerings.

FRI-R02A – The existing model of Friant Dam was modified to reflect a 20-foot increase of the spillway crest elevation. No modifications were made to the top of conservation. This increased the maximum volume of the flood pool from 170 TAF to 275 TAF (assuming a minimum top of conservation storage of 350.5 TAF from the credit space agreement). The model was used to generate outflows for the Friant and El Nido storm centerings.

FRI-R03A – The existing model of Friant Dam was modified to reflect a 20-foot increase of the spillway crest elevation while maintaining the same proportion of conservation and flood storage. The maximum volume of the flood pool was increased from 170 TAF to 188 TAF. In order to maintain the existing proportion between conservation storage and flood space, 87.5 TAF was assigned to conservation storage in both the HEC-5 model and the DSS input file for each storm centering. The model was used to generate outflows for the Friant and El Nido storm centerings.

TMP-R01A – The existing HEC-5 model was modified, by adding the Temperance Flat reservoir upstream of Friant Dam. The model was based on the elevation-storage-area curves presented in the URS study (FWUA and NRDC, 2000). The outlet and spillway configurations were copied from the Friant Dam model and elevations were adjusted accordingly. The inactive pool was defined at an elevation of 650 feet with storage of 80,000 acre-feet. All storage except for the inactive pool was allocated to flood storage by setting the top of buffer and top of conservation storage at the top of inactive pool. The total volume at the top of flood pool is defined as 1,368,000 acre-feet at an elevation of 993 feet. The Temperance Flat model was set to operate in tandem with Friant Dam (i.e., the model maintains the same percentage of encroachment into the flood pool at both reservoirs). The model was used to generate outflows for the Friant and El Nido storm centerings.

FGD-R01A – As discussed above, operations for the Fine Gold off-stream storage project were not modeled explicitly. It was assumed that pumped diversions from Millerton Lake to Fine Gold reservoir would be used to fill Fine Gold reservoir prior to the flood season and Millerton Lake would enter the flood season with conservation storage reduced by an equal amount. The effect of the Fine Gold reservoir project was assessed, by increasing the amount of flood control storage at Friant Dam. The existing HEC-5 model was modified, by changing the top of conservation storage at Friant and decreasing conservation storage in the DSS input files for each storm centering by 275 TAF. This was the difference between Fine Gold's total storage of 350 TAF and inactive storage of 75 TAF as described in the URS study (FWUA and NRDC, 2000). The model was used to generate outflows for the Friant and El Nido storm centerings.

SJO-R01A – This model was created by combining the models developed for Temperance Flat (TMP-R01A), the 32-foot Friant Dam raise (FRI-R01A), and Fine Gold (FNG-R01A). The model was used to generate outflows for the Friant and El Nido storm centerings.

SJO-R02A – This model was created, by combining the models developed for the 32-foot Friant Dam raise (FRI-R01A), and Fine Gold (FNG-R01A). The model was used to generate outflows for the Friant and El Nido storm centerings.

Results

The effects of the storage alternatives were evaluated by comparing peak flows at two reservoir control points—San Joaquin River at Friant, and San Joaquin River at El Nido. Maximum regulated outflows for the 50-, 10-, 4-, 2-, 1-, 0.5-, and 0.2-percent chance exceedence events at Friant Dam with the Friant Storm centering are provided in Table VIII-12. Maximum regulated flows for the same events for the San Joaquin River at El Nido with the El Nido storm centering are provided in Table VIII-13.

**TABLE VIII-12
MAXIMUM REGULATED FLOW, SAN JOAQUIN RIVER
AT FRIANT DAM, FRIANT STORM CENTERING**

Reservoir Model	Maximum Regulated Flow By Percent Chance Exceedence (CFS)						
	50%	10%	4%	2%	1%	0.5%	0.2%
FRI-Base	3,032	7,972	9,001	25,481	71,093	108,585	139,402
FRI-R01A	2,446	7,982	8,000	8,000	10,878	52,946	125,723
FRI-R02A	2,565	8,000	8,000	8,194	26,583	63,867	137,026
FRI-R03A	2,896	7,976	8,000	20,027	55,691	109,121	139,645
TMP-R01A	2,204	6,259	7,905	8,000	8,000	8,000	8,000
FGD-R01A	2,358	7,904	8,000	8,000	8,000	15,770	83,071
SJQ-R01A	3,041	4,418	6,197	7,353	8,000	8,000	8,000
SJQ-R02A	2,276	6,939	8,000	8,000	8,000	8,000	26,677
Hydraulic Model	Model Description						
FRI-Base	Base hydraulic model, Friant Storm Centering						
FRI-R01A	Double the flood space in Millerton Lake (32-Foot Dam Raise)						
FRI-R02A	Raise Friant Dam 20-Feet and use all additional storage as flood space						
FRI-R03A	Raise Friant Dam 20-Feet and maintain same proportion of conservation space to flood space						
TMP-R01A	Add Temperance Flat Dam upstream of Friant, all additional storage used as flood space						
FGD-R01A	Add Fine Gold Off-stream Reservoir, conservation storage at Friant reduced by 275,000 acre feet.						
SJQ-R01A	Combine FRI-R01A, TMP-R01A, and FGD-R01A						
SJQ-R02A	Combine FRI-R01A, and FGD-R01A						
Objective Flow = 8,000 cfs							

**TABLE VIII-13
MAXIMUM REGULATED FLOW, SAN JOAQUIN RIVER AT
EL NIDO, EL NIDO STORM CENTERING**

Reservoir Model	Maximum Regulated Flow By Percent Chance Exceedence (CFS)						
	50%	10%	4%	2%	1%	0.5%	0.2%
NID-Base	3,694	14,596	20,247	28,812	50,286	77,953	115,431
FRI-R01A	3,610	14,294	19,090	22,544	24,623	41,019	93,881
FRI-R02A	3,633	14,410	19,111	22,649	31,482	55,379	104,372
FRI-R03A	3,683	14,591	19,033	24,597	47,042	74,100	114,704
TMP-R01A	3,183	11,615	18,941	22,409	24,762	25,362	42,315
FGD-R01A	3,603	13,345	18,911	22,380	24,773	26,656	76,740
SJQ-R01A	3,185	11,551	16,917	21,973	24,698	25,342	42,315
SJQ-R02A	3,579	12,698	18,864	22,521	24,631	25,363	44,647
Hydraulic Model	Model Description						
FRI-Base	Base hydraulic model, Friant Storm Centering						
FRI-R01A	Double the flood space in Millerton Lake (32-Foot Dam Raise)						
FRI-R02A	Raise Friant Dam 20-Feet, all additional storage used as flood space						
FRI-R03A	Raise Friant Dam 20-Feet and maintain same proportion of conservation space to flood space						
TMP-R01A	Add Temperance Flat Dam upstream of Friant, all additional storage used as flood space						
FGD-R01A	Add Fine Gold Off-stream Reservoir, conservation storage at Friant reduced by 275,000 acre feet.						
SJQ-R01A	Combine FRI-R01A, TMP-R01A, and FGD-R01A						
SJQ-R02A	Combine FRI-R01A, and FGD-R01A						
Objective Flow = 17,000 cfs							

FRI-R01A – Under existing conditions, the objective flow at Friant Dam is exceeded around the occurrence of a 10-percent chance exceedence event. Raising Friant Dam by 32 feet and using all of the additional space for the flood pool (FRI-R01A) reduces releases to less than the objective flow through the 2-percent chance exceedence event. The FRI-R01A alternative also decreases the peak outflow during the 1-percent chance exceedence event from 71,093 cfs to 10,878 cfs, or approximately 85 percent. For the simulated 0.5- and 0.2-percent chance exceedence events this percentage decreases to 51 percent and 10 percent, respectively. At the El Nido control point, the objective flow is exceeded above the 10-percent chance exceedence event for the El Nido storm centering under existing conditions. For the FRI-R01A alternative, the objective flow is still exceeded above a 10-percent chance exceedence event. However, the alternative decreases the peak outflow during the 1-percent chance exceedence event from 50,286 cfs to 24,623 cfs, or approximately 51 percent. For the 0.5- and 0.2-percent chance exceedence events the percentage decreases to 47 percent and 19 percent, respectively.

FRI-R02A – Raising Friant Dam by 20 feet and using all of the additional space for the flood pool (FRI-R02A) reduces releases to less than the objective flow through the 4-percent chance exceedence event. The objective flow is exceeded slightly at the 2-percent chance exceedence event, but the peak outflow is decreased from 25,481 in the base condition to 8,194 cfs, or 68 percent. For larger events, this percentage decreases. For the 0.2-percent chance exceedence event, the peak outflow is decreased from 139,402 cfs to 137,026 cfs, a 2-percent decrease. At the El Nido control point and El Nido storm centering, performance is similar to the FRI-R01A alternative for the 4-percent chance exceedence event. However, reductions in peak flow from the base conditions are lower than the FRI-R01A alternative for larger events.

FRI-R03A – Raising Friant Dam by 20 feet and apportioning the additional space between conservation storage and flood space (FRI-R01A) provides the least amount of flood damage reduction potential. This alternative meets the objective flow target for events including and occurring more frequently than the 4-percent chance exceedence event and decreases the peak outflow of Friant Dam during the 4-percent chance exceedence event from 25,481 to 20,027 cfs, or 21 percent. The performance at El Nido is similar to the FRI-R01A and FRI-R02A alternatives through the 4-percent chance exceedence event, but lower for less frequent events.

TMP-R01A – The TMP-R01A model shows that the 1,368,000 acre-feet of additional storage provided by Temperance Flat Dam allows reduction of Friant outflows to target levels for all events modeled (i.e., up to the 0.2-percent chance exceedence event). The Temperance Flat alternative only meets the objective flow target with the occurrence of a 50-percent chance exceedence through 10-percent chance exceedence events at the El Nido index point. However, this alternative provides substantial peak reduction for larger events. For example, the peak associated with the occurrence of a 0.2-percent chance exceedence event is reduced from 115,431 cfs to 42,315 cfs.

FNG-R01A – The FNG-R01A model shows that the increase in flood storage at Friant Dam associated with a transfer of conservation space to Fine Gold Dam reduces releases to less than the objective flow through the 1-percent chance exceedence event. The FGD-R01A alternative also decreases the peak outflow during the 0.2-percent chance exceedence event from 139,402 cfs to 83,071 cfs, or approximately 40 percent. The FNG-R01A alternative only meets the objective flow target for the 50- through 10-percent chance exceedence events at the El Nido index point. However, this alternative provides substantial peak reduction for larger events. For

example, the peak associated with the 0.2-percent chance exceedence event is reduced from 115,431 cfs to 76,740 cfs.

SJQ-R01A – The combination of FRI-R01A, TMP-R01A, and FNG-R01A alternatives (SJQ-R01A) produces results similar to the TMP-R01A alternative for the Friant Dam control point. The Temperance Flat Dam is sufficiently large enough to reduce all of the Friant outflows to target levels for all of the events modeled. The additional storage capacity modeled in the SJQ-R01A alternative obtained from raising Friant Dam 32 feet and Fine Gold Dam provides no increase in flood reduction potential for any of the events at the Friant Dam control point. At the El Nido index point, the SJQ-R01A model meets the objective flow target through the 4-percent chance exceedence event. Peak flows at the El Nido index point are similar to the TMP-R01A alternative for the larger events.

SJQ-R02A – The SJQ-R02A model shows that a combination of a 32-foot raise at Friant Dam and an additional 275 TAF of storage facilitated by Fine Gold reduces peak outflows from Friant to the target flows for events up to the 0.5-percent chance exceedence event. For the 0.2-percent chance exceedence event, the alternative reduces the peak discharge by approximately 80 percent. This alternative only meets the objective flow target for the 50- through 10-percent chance exceedence events at the El Nido index point. However, the alternative provides substantial peak reduction for larger events. For example, the peak associated with the occurrence of a 0.2-percent chance exceedence event is reduced from 115,431 cfs to 44,647 cfs.

SUMMARY

The preceding text documents the study undertaken to investigate the potential for flood damage reduction in the Sacramento and San Joaquin River Basins as a result of reservoir raises and/or the construction of new on-stream and off-stream storage projects. Potential projects, proposed primarily for water supply objectives, were identified and ranked for their potential flood damage reduction benefits using a screening process. The scenarios to be modeled were selected based on this ranking.

Two alternative scenarios, an off-stream storage project in the Sacramento River Basin and a suite of potential flood damage reduction measures in the vicinity of Friant Dam in the San Joaquin River Basin, were evaluated. Each of these scenarios consisted of multiple modifications to the existing flood damage reduction facilities in these basins. For purposes of evaluating their potential benefits, the storage associated with proposed projects was investigated for flood damage reduction benefits without regard to water supply objectives. Additional project formulation and analysis would be required to assess the feasibility and effectiveness of particular projects, and to determine the optimal combination of water supply and flood damage reduction benefits.

Based on the results of this effort, the modeled off-stream project in the Sacramento system did not result in any significant flood flow reductions at the downstream location near Sacramento. This is likely due to a number of factors including: the effect of tributary inflows downstream of the projects evaluated for this study; the difference in timing between the tributary systems where flows are reduced (e.g. Stony Creek) and the main stem flooding; and the fact that Oroville and Shasta already control flows occurring as frequent or more frequently than the 1-percent chance exceedence event to their target levels. It is possible that more significant

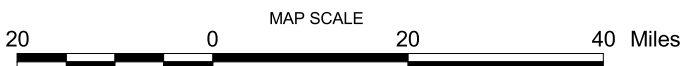
reductions in flood flows at Sacramento could be achieved by modifying flood operations at Shasta and/or Oroville in conjunction with the proposed off-stream storage project. Optimizing use of the enlarged flood control space could allow objective flows to be reduced, resulting in lower flows at the Sacramento model index point. The analysis did indicate that there are likely to be significant benefits associated with storage projects on tributary systems such as Stony Creek.

It appears that projects on the San Joaquin River may warrant further review. None of the alternatives modeled controlled flows at El Nido to the objective flow of 17,000 cfs for events greater than an annual 4-percent chance exceedence event. However, all of the alternatives offer significant flow reductions at El Nido for the 4- and 1-percent chance exceedence events; the Temperance Flat and Fine Gold alternatives offer continued significant flow reductions for the 0.5-percent chance exceedence event; and the Temperance Flat alternative provides significant flow reductions for even the 0.2-percent chance exceedence event. Evaluation of the project-related costs and potential flood damage reduction benefits was not undertaken as part of this study. Neither was an independent assessment of the feasibility or constraints on the development of these projects. However, based on the results of this study, it would appear that further review of these or similar projects are warranted.

As noted above, this study was intended to provide an initial evaluation of the potential for flood damage reduction through raising existing dams or construction of new on-stream and off-stream storage projects. The results of this study indicate that projects that have been proposed for water supply or other purposes may be able to provide flood damage reduction benefits as well. Further modeling and a more detailed evaluation of the feasibility of particular projects, appears to be justified.



CALIFORNIA
NEVADA



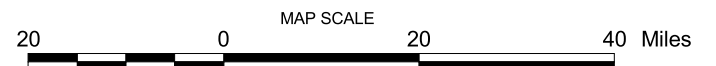
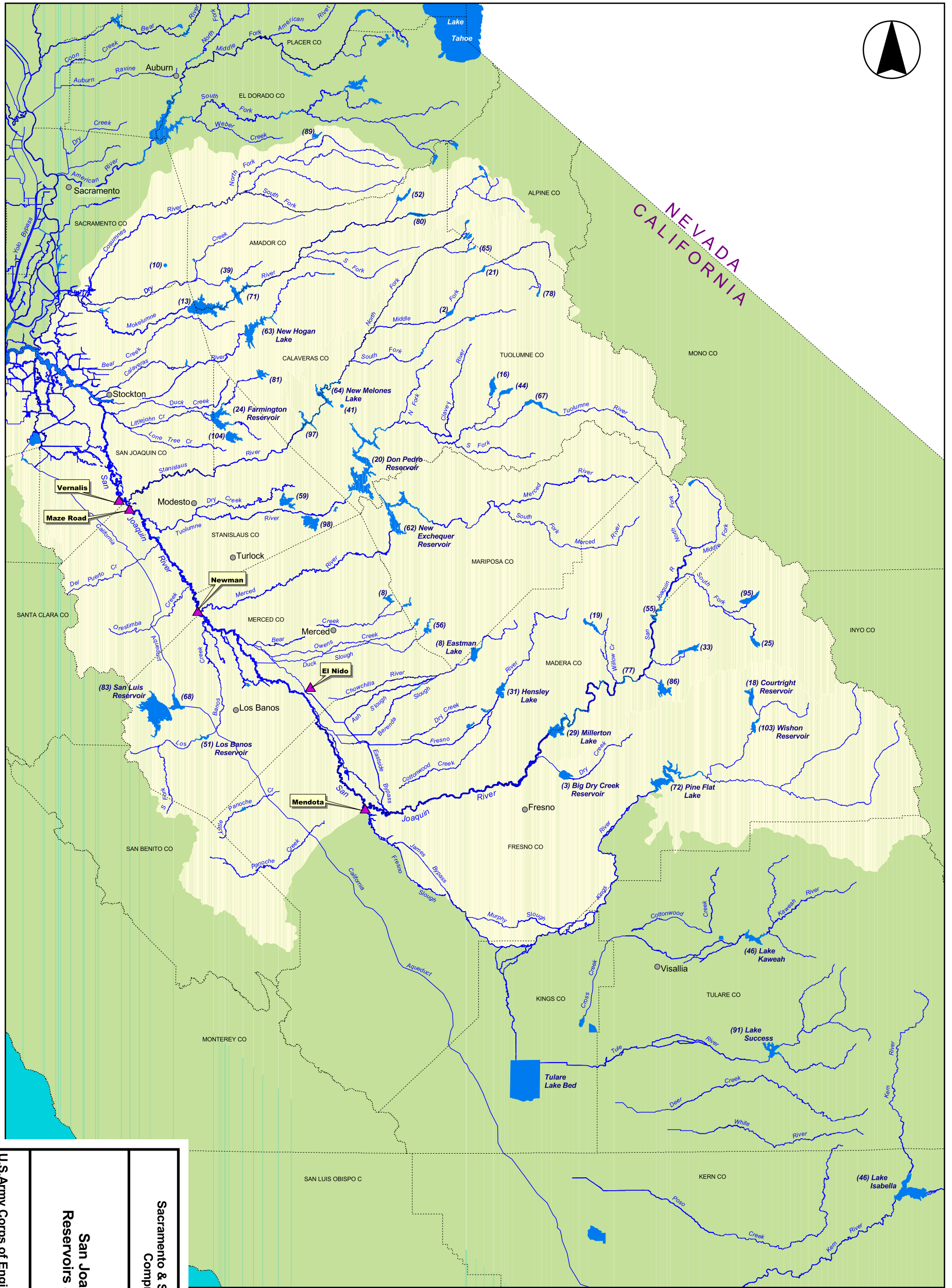
Map Legend:

- Sacramento Basin
- Lake or Reservoir*
- River or Stream
- County Boundary
- Gaging Stations
- City

*Refer to Table II-1 of Appendix C for reservoir inventory number.

U.S. Army Corps of Engineers
 Reclamation Board, State of California
 June 2002
 PLATE 1

Sacramento & San Joaquin River Basins
 Comprehensive Study
 Sacramento River Basin
 Reservoirs and Gage Locations



Map Legend:

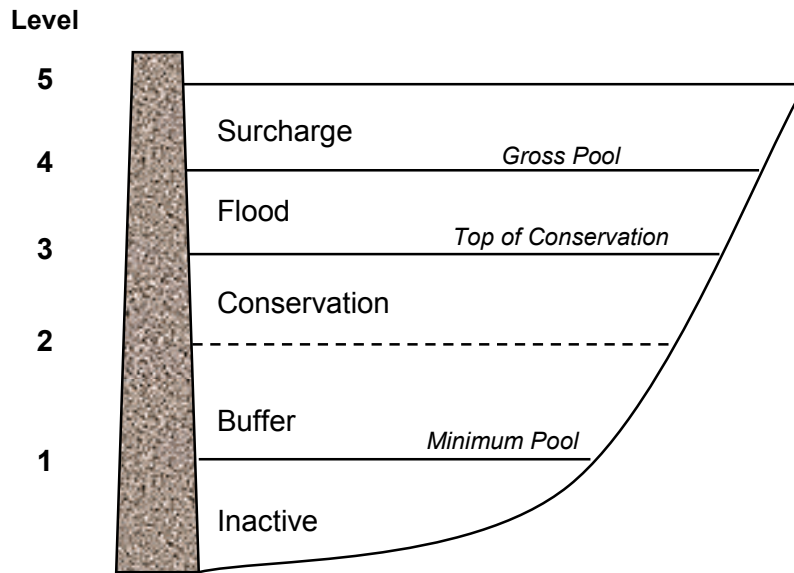
- San Joaquin Basin
- River or Stream
- Gaging Stations
- Lake or Reservoir*
- County Boundary
- City

*Refer to Table II-1 of Appendix C for reservoir inventory number.

U.S. Army Corps of Engineers
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 June 2002
 PLATE 2

Sacramento & San Joaquin River Basins
 Comprehensive Study

San Joaquin River Basin
 Reservoirs and Gage Locations



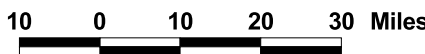
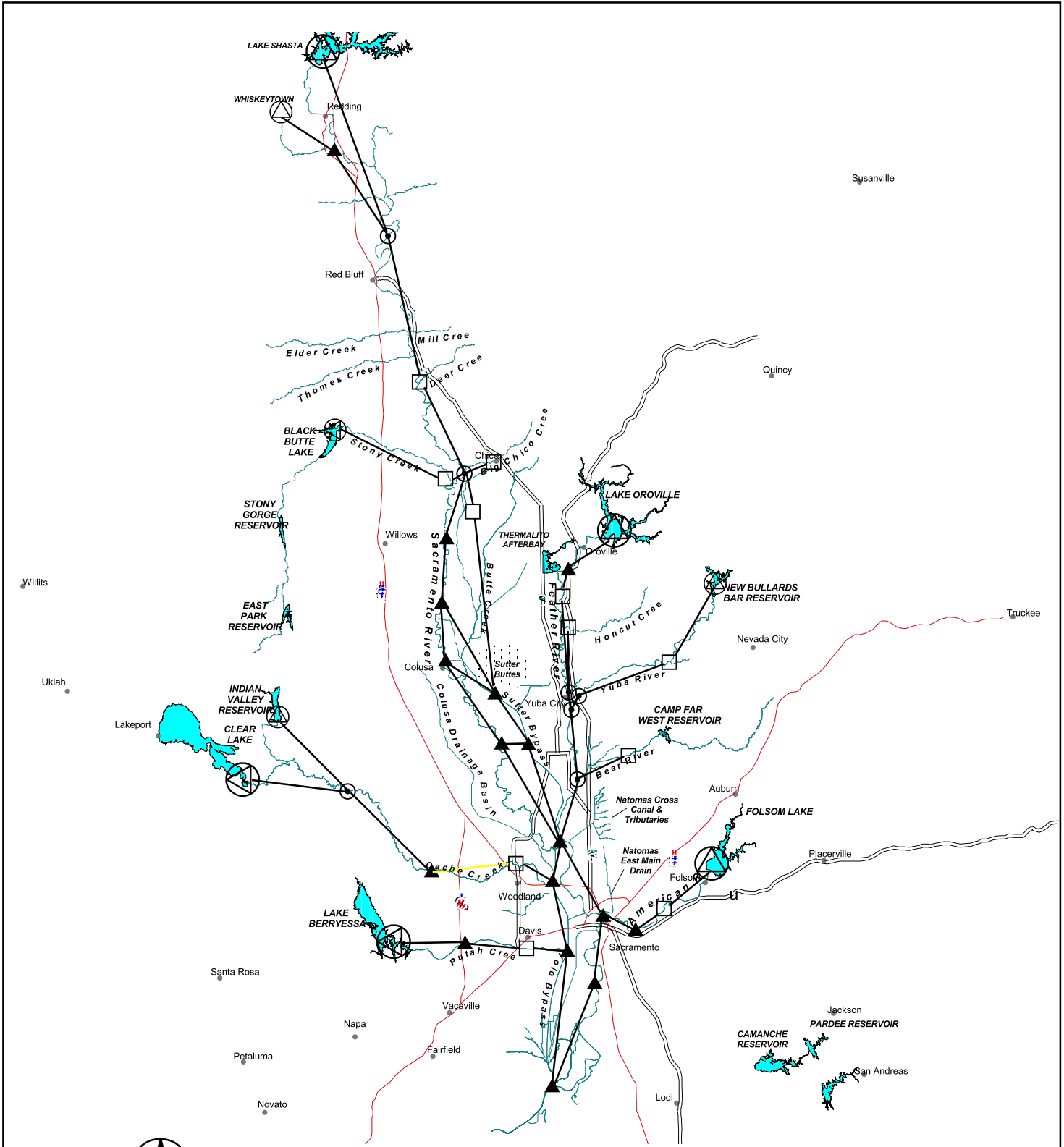
Reservoir Storage Zones and Levels

- Level 1** **Top of Inactive Pool** – The storage at this level may be zero, or may be a minimum pool level.
- Level 2** **Top of Buffer Pool** – The Buffer Pool is a division of the Conservation Pool. When the pool level drops into a Buffer Zone, a drought condition is indicated. During these times, only essential demands will be met (required flows).
- Level 3** **Top of Conservation** – Space in the Conservation Pool is reserved for the various water demands on the reservoir: agricultural, environmental, municipal and industrial, and other needs.
- Level 4** **Flood Control Pool** – Water is stored in this zone when it cannot be safely passed through the downstream channel system.
- Level 5** **Surcharge Pool** – Typically, a reservoir has surcharge storage to accommodate water above the emergency spillway. In the surcharge zone, the outflow is determined by the spillway capacity.

Sacramento & San Joaquin River Basins
Comprehensive Study

Plate 3
Flood Control Space Diagram

US Army Corps of Engineers
The Reclamation Board, State of California December 2002



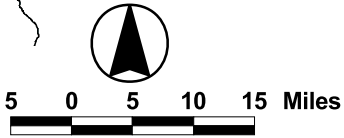
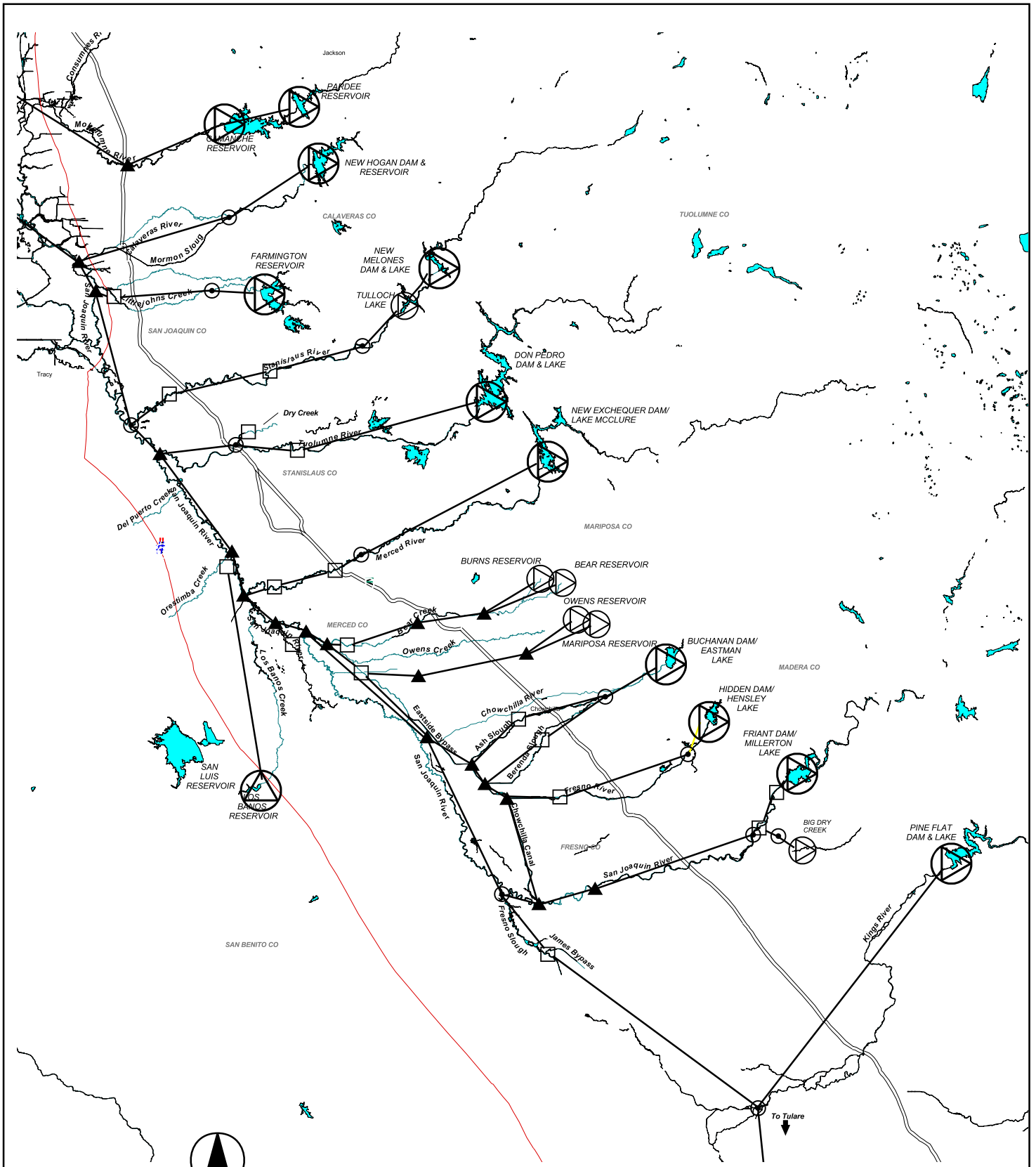
Legend

- ▲ Nodes
- UNET Handoff Points
- ⊙ Reservoir
- ⊙ Operational Points

Sacramento & San Joaquin River Basins
Comprehensive Study

Plate 4
Sacramento River Basin
HEC-5 Model Schematic
Lower Basin

U.S. Army Corps of Engineers
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Legend

- ▲ Nodes
- UNET Handoff Points
- ⊙ Reservoir
- ⊙ Operational Points

Sacramento & San Joaquin River Basins
Comprehensive Study

Plate 5
San Joaquin River Basin
HEC-5 Model Schematic
Lower Basin

U.S. Army Corps of Engineers
Reclamation Board, State of California June 2002

Full natural flows into major lower basin reservoirs developed in the synthetic hydrology (sec A appendix) (lower basin)



Full natural flow into the major reservoirs distributed (split) to headwaters reservoirs based on normal annual precipitation, historic sub-basin yield, and % of total watershed area.



Q_{hw-nat}

Step 1
HEC-5 simulation
of headwaters reservoirs

Q_{hw-reg}

Regulated inflow to lower basin reservoirs

Step 2
Compute
top of conservation



Q_{in-reg}

Step 3
HEC-5 simulation of
lower basin reservoir

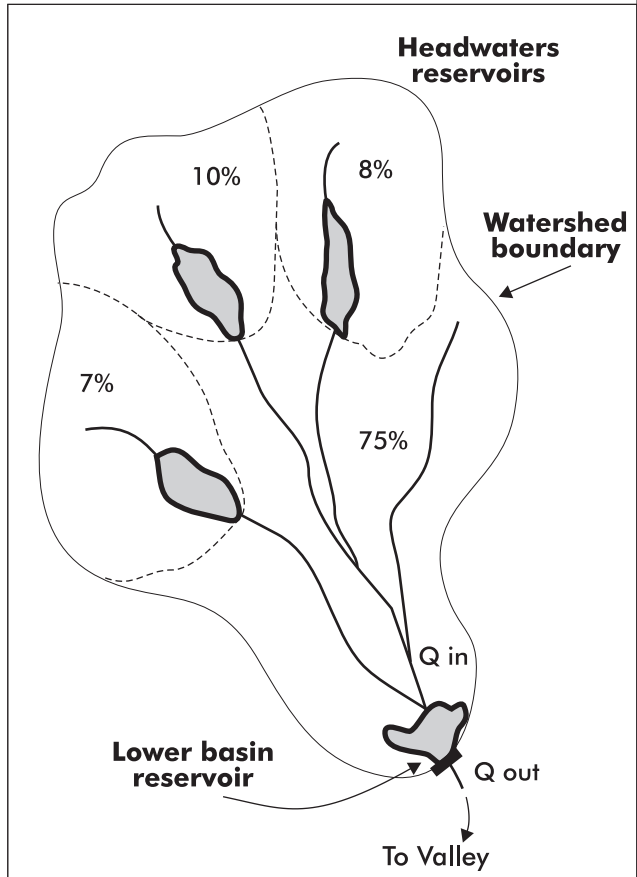


Q_{lb-reg}

Regulated outflow hydrographs for lower basin reservoirs

HYDRAULIC MODELING

Flowchart Key

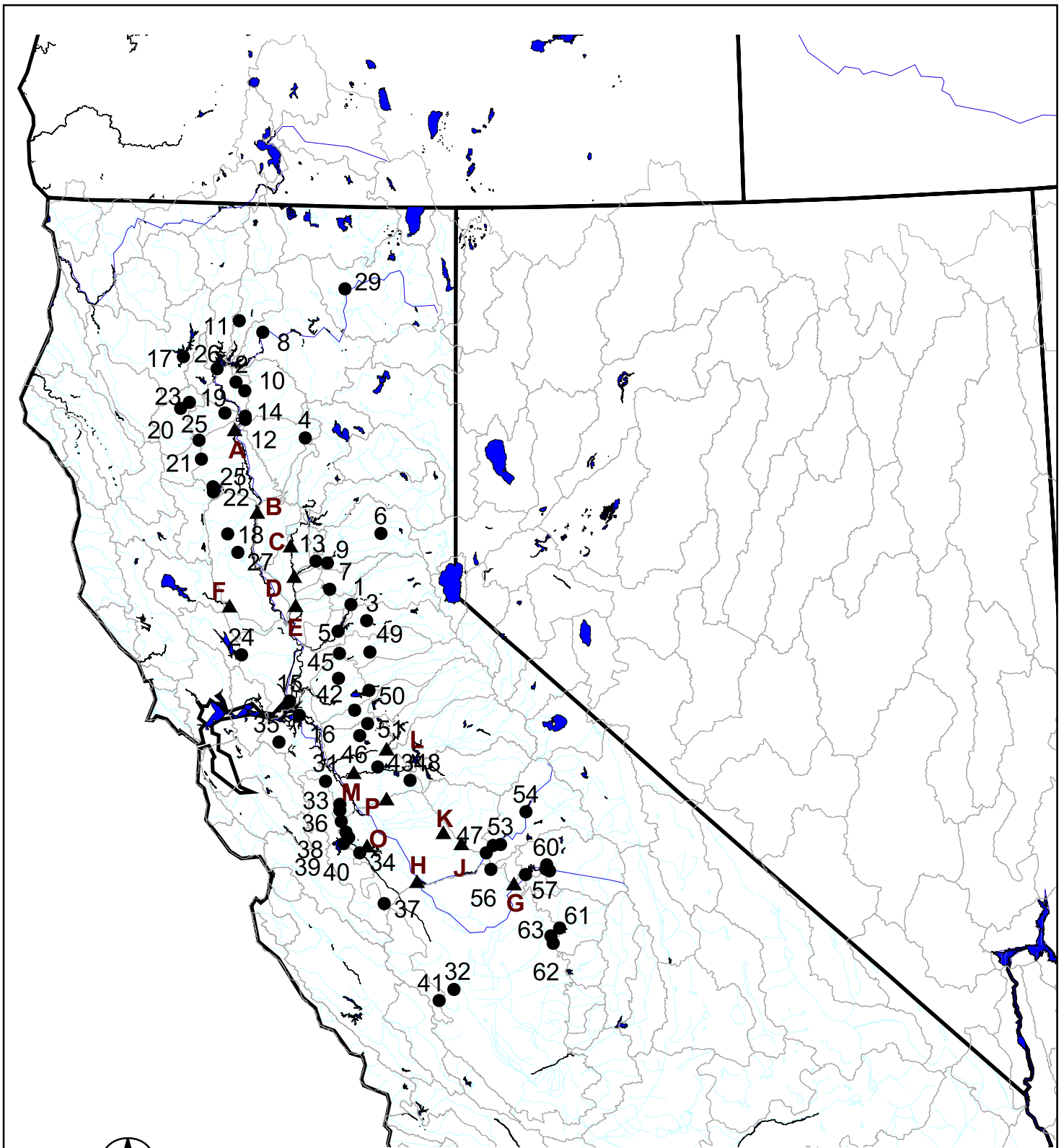


- Nat – Natural flow not accounting for reservoir operation
- Reg – Flow accounting for regulation by reservoir
- Q – Flow
- lb – Lower basin

Sacramento & San Joaquin River Basins
Comprehensive Study

**Plate 6
PROCESS FLOWCHART**

U.S. Army Corps of Engineers
Reclamation Board, State of California
June 2002



8 0 8 16 Miles

- Legend**
- ▲ Control Points
 - Project Locations
 - Rivers and Flow Conveyance Facilities
 - Watershed

Sacramento & San Joaquin River Basins
Comprehensive Study

Plate 7
On-Stream and Off-Stream Storage
Proposed Project Location

ATTACHMENT C.1

RESERVOIR OPERATION HYDROGRAPHS AT CONTROLLING RESERVOIRS

FIGURES – SACRAMENTO RIVER BASIN

Figure C.1-1a	Shasta – 50% Chance Exceedence Event
Figure C.1-1b	Shasta – 10% Chance Exceedence Event
Figure C.1-1c	Shasta – 4% Chance Exceedence Event
Figure C.1-1d	Shasta – 2% Chance Exceedence Event
Figure C.1-1e	Shasta – 1% Chance Exceedence Event
Figure C.1-1f	Shasta – 0.5% Chance Exceedence Event
Figure C.1-1g	Shasta – 0.2% Chance Exceedence Event
Figure C.1-1h	Shasta – Regulated Outflow (all events)
Figure C.1-2a	Black Butte – 50% Chance Exceedence Event
Figure C.1-2b	Black Butte – 10% Chance Exceedence Event
Figure C.1-2c	Black Butte – 4% Chance Exceedence Event
Figure C.1-2d	Black Butte – 2% Chance Exceedence Event
Figure C.1-2e	Black Butte – 1% Chance Exceedence Event
Figure C.1-2f	Black Butte – 0.5% Chance Exceedence Event
Figure C.1-2g	Black Butte – 0.2% Chance Exceedence Event
Figure C.1-2h	Black Butte – Regulated Outflow (all events)
Figure C.1-3a	Oroville – 50% Chance Exceedence Event
Figure C.1-3b	Oroville – 10% Chance Exceedence Event
Figure C.1-3c	Oroville – 4% Chance Exceedence Event
Figure C.1-3d	Oroville – 2% Chance Exceedence Event
Figure C.1-3e	Oroville – 1% Chance Exceedence Event
Figure C.1-3f	Oroville – 0.5% Chance Exceedence Event
Figure C.1-3g	Oroville – 0.2% Chance Exceedence Event
Figure C.1-3h	Oroville – Regulated Outflow (all events)
Figure C.1-4a	Bullards Bar – 50% Chance Exceedence Event
Figure C.1-4b	Bullards Bar – 10% Chance Exceedence Event
Figure C.1-4c	Bullards Bar – 4% Chance Exceedence Event
Figure C.1-4d	Bullards Bar – 2% Chance Exceedence Event
Figure C.1-4e	Bullards Bar – 1% Chance Exceedence Event
Figure C.1-4f	Bullards Bar – 0.5% Chance Exceedence Event
Figure C.1-4g	Bullards Bar – 0.2% Chance Exceedence Event
Figure C.1-4h	Bullards Bar – Regulated Outflow (all events)

Figure C.1-5a	Indian Valley – 50% Chance Exceedence Event
Figure C.1-5b	Indian Valley – 10% Chance Exceedence Event
Figure C.1-5c	Indian Valley – 4% Chance Exceedence Event
Figure C.1-5d	Indian Valley – 2% Chance Exceedence Event
Figure C.1-5e	Indian Valley – 1% Chance Exceedence Event
Figure C.1-5f	Indian Valley – 0.5% Chance Exceedence Event
Figure C.1-5g	Indian Valley – 0.2% Chance Exceedence Event
Figure C.1-5h	Indian Valley – Regulated Outflow (all events)
Figure C.1-6a	Folsom – 50% Chance Exceedence Event
Figure C.1-6b	Folsom – 10% Chance Exceedence Event
Figure C.1-6c	Folsom – 4% Chance Exceedence Event
Figure C.1-6d	Folsom – 2% Chance Exceedence Event
Figure C.1-6e	Folsom – 1% Chance Exceedence Event
Figure C.1-6f	Folsom – 0.5% Chance Exceedence Event
Figure C.1-6g	Folsom – 0.2% Chance Exceedence Event
Figure C.1-6h	Folsom – Regulated Outflow (all events)

FIGURES – SAN JOAQUIN RIVER BASIN

Figure C.1-7a	Pine Flat – 50% Chance Exceedence Event
Figure C.1-7b	Pine Flat – 10% Chance Exceedence Event
Figure C.1-7c	Pine Flat – 4% Chance Exceedence Event
Figure C.1-7d	Pine Flat – 2% Chance Exceedence Event
Figure C.1-7e	Pine Flat – 1% Chance Exceedence Event
Figure C.1-7f	Pine Flat – 0.5% Chance Exceedence Event
Figure C.1-7g	Pine Flat – 0.2% Chance Exceedence Event
Figure C.1-7h	Pine Flat – Regulated Outflow (all events)
Figure C.1-8a	Friant – 50% Chance Exceedence Event
Figure C.1-8b	Friant – 10% Chance Exceedence Event
Figure C.1-8c	Friant – 4% Chance Exceedence Event
Figure C.1-8d	Friant – 2% Chance Exceedence Event
Figure C.1-8e	Friant – 1% Chance Exceedence Event
Figure C.1-8f	Friant – 0.5% Chance Exceedence Event
Figure C.1-8g	Friant – 0.2% Chance Exceedence Event
Figure C.1-8h	Friant – Regulated Outflow (all events)
Figure C.1-9a	Hidden – 50% Chance Exceedence Event
Figure C.1-9b	Hidden – 10% Chance Exceedence Event
Figure C.1-9c	Hidden – 4% Chance Exceedence Event
Figure C.1-9d	Hidden – 2% Chance Exceedence Event
Figure C.1-9e	Hidden – 1% Chance Exceedence Event
Figure C.1-9f	Hidden – 0.5% Chance Exceedence Event
Figure C.1-9g	Hidden – 0.2% Chance Exceedence Event
Figure C.1-9h	Hidden – Regulated Outflow (all events)
Figure C.1-10a	Buchanan – 50% Chance Exceedence Event
Figure C.1-10b	Buchanan – 10% Chance Exceedence Event
Figure C.1-10c	Buchanan – 4% Chance Exceedence Event

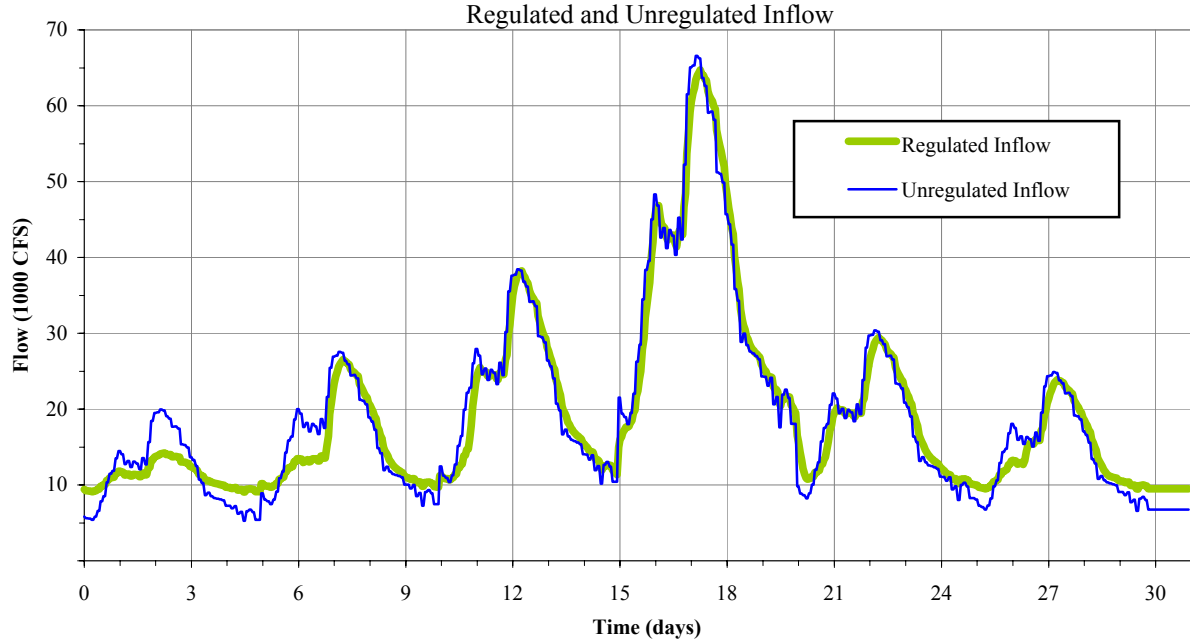
- Figure C.1-10d Buchanan – 2% Chance Exceedence Event
- Figure C.1-10e Buchanan – 1% Chance Exceedence Event
- Figure C.1-10f Buchanan – 0.5% Chance Exceedence Event
- Figure C.1-10g Buchanan – 0.2% Chance Exceedence Event
- Figure C.1-10h Buchanan – Regulated Outflow (all events)
- Figure C.1-11a New Exchequer – 50% Chance Exceedence Event
- Figure C.1-11b New Exchequer – 10% Chance Exceedence Event
- Figure C.1-11c New Exchequer – 4% Chance Exceedence Event
- Figure C.1-11d New Exchequer – 2% Chance Exceedence Event
- Figure C.1-11e New Exchequer – 1% Chance Exceedence Event
- Figure C.1-11f New Exchequer – 0.5% Chance Exceedence Event
- Figure C.1-11g New Exchequer – 0.2% Chance Exceedence Event
- Figure C.1-11h New Exchequer – Regulated Outflow (all events)
- Figure C.1-12a Don Pedro – 50% Chance Exceedence Event
- Figure C.1-12b Don Pedro – 10% Chance Exceedence Event
- Figure C.1-12c Don Pedro – 4% Chance Exceedence Event
- Figure C.1-12d Don Pedro – 2% Chance Exceedence Event
- Figure C.1-12e Don Pedro – 1% Chance Exceedence Event
- Figure C.1-12f Don Pedro – 0.5% Chance Exceedence Event
- Figure C.1-12g Don Pedro – 0.2% Chance Exceedence Event
- Figure C.1-12h Don Pedro – Regulated Outflow (all events)
- Figure C.1-13a New Melones – 50% Chance Exceedence Event
- Figure C.1-13b New Melones – 10% Chance Exceedence Event
- Figure C.1-13c New Melones – 4% Chance Exceedence Event
- Figure C.1-13d New Melones – 2% Chance Exceedence Event
- Figure C.1-13e New Melones – 1% Chance Exceedence Event
- Figure C.1-13f New Melones – 0.5% Chance Exceedence Event
- Figure C.1-13g New Melones – 0.2% Chance Exceedence Event
- Figure C.1-13h New Melones – Regulated Outflow (all events)

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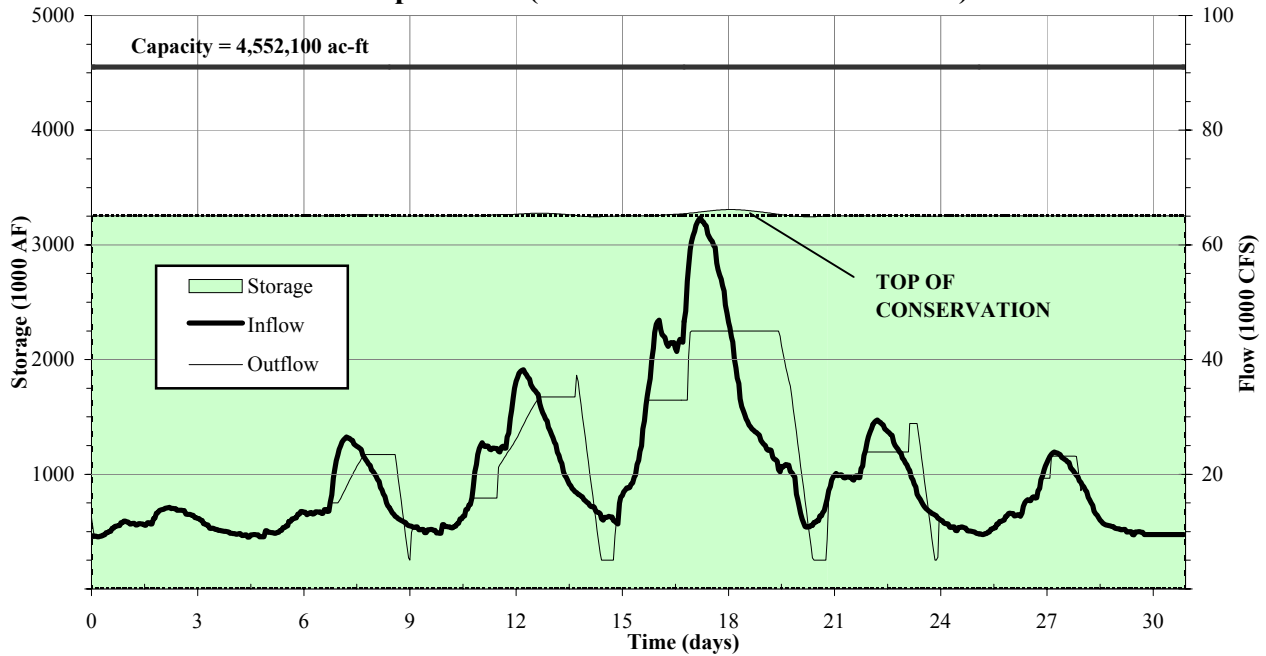
SACRAMENTO RIVER BASIN

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**SACRAMENTO RIVER
Shasta Inflow (50% Chance Exceedence Event)**

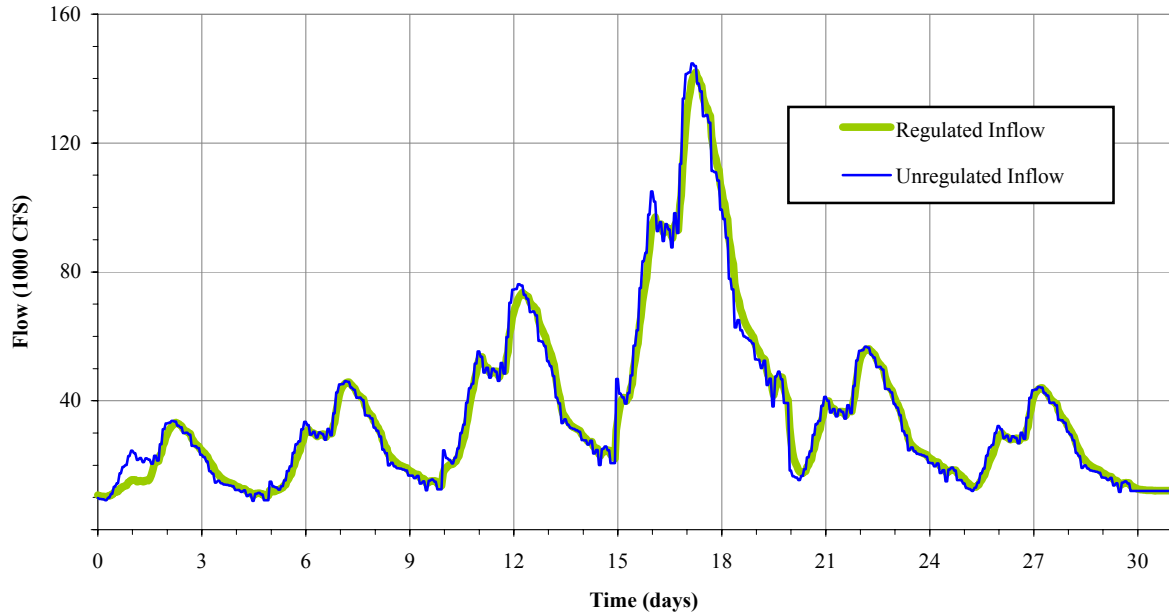


Shasta Operations (50% Chance Exceedence Event)

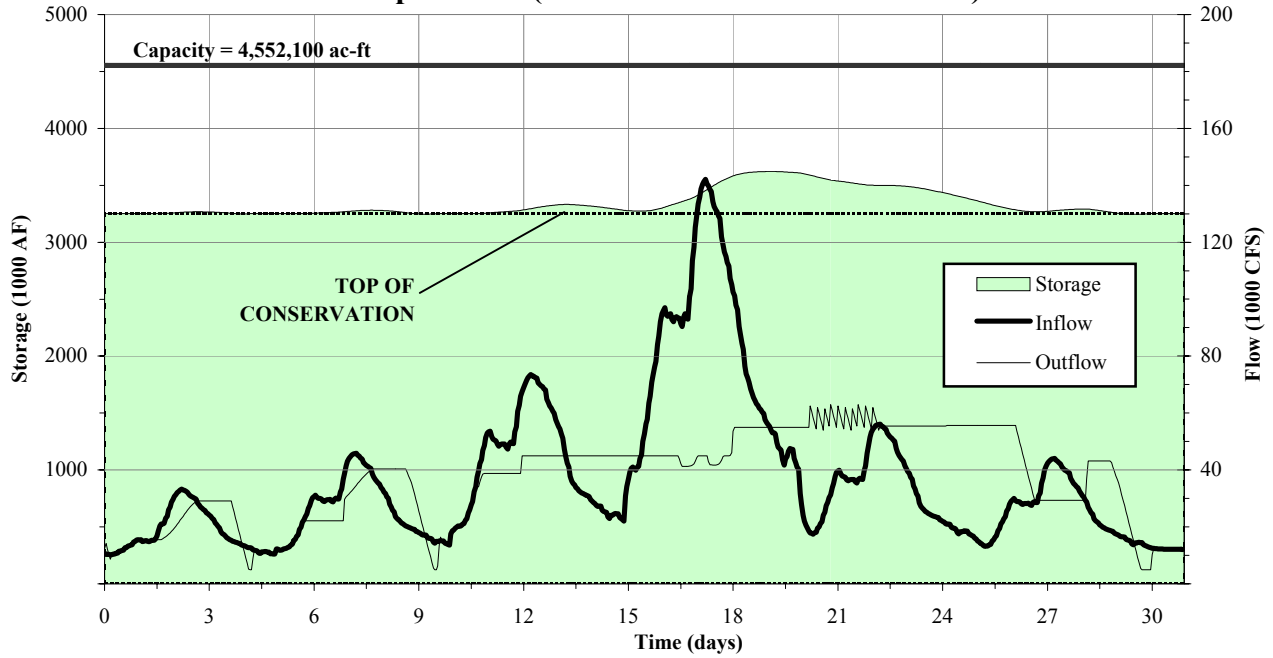


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Figure C.1-1a Reservoir Simulation Hydrographs Shasta (50% Chance Exceedence Event)
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SACRAMENTO RIVER
Shasta Inflow (10% Chance Exceedence Event)
 Regulated and Unregulated Inflow

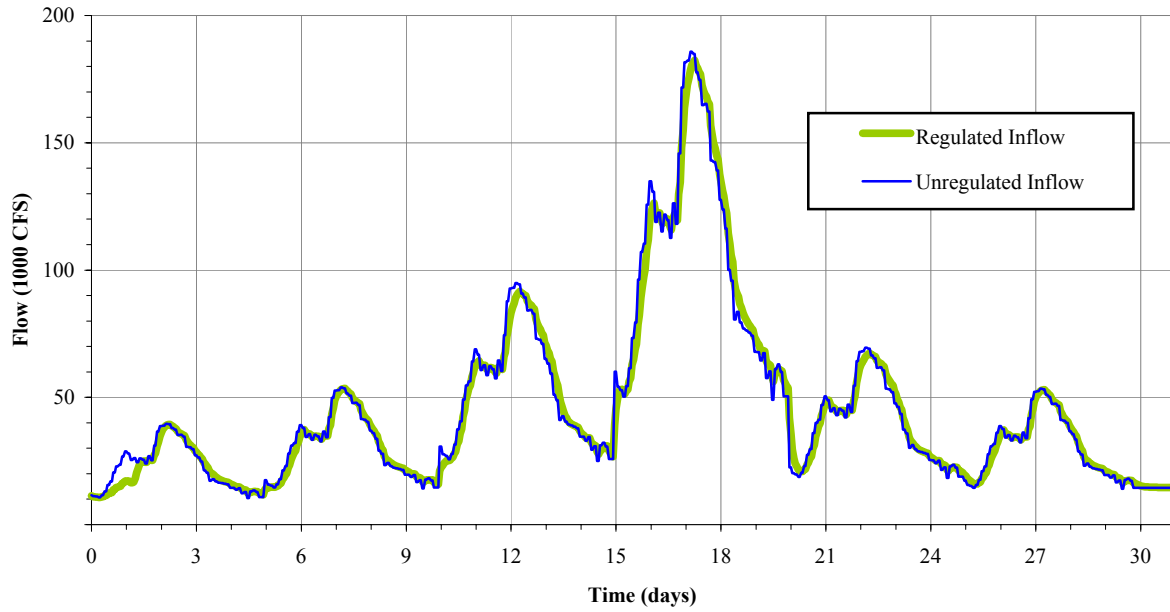


Shasta Operations (10% Chance Exceedence Event)

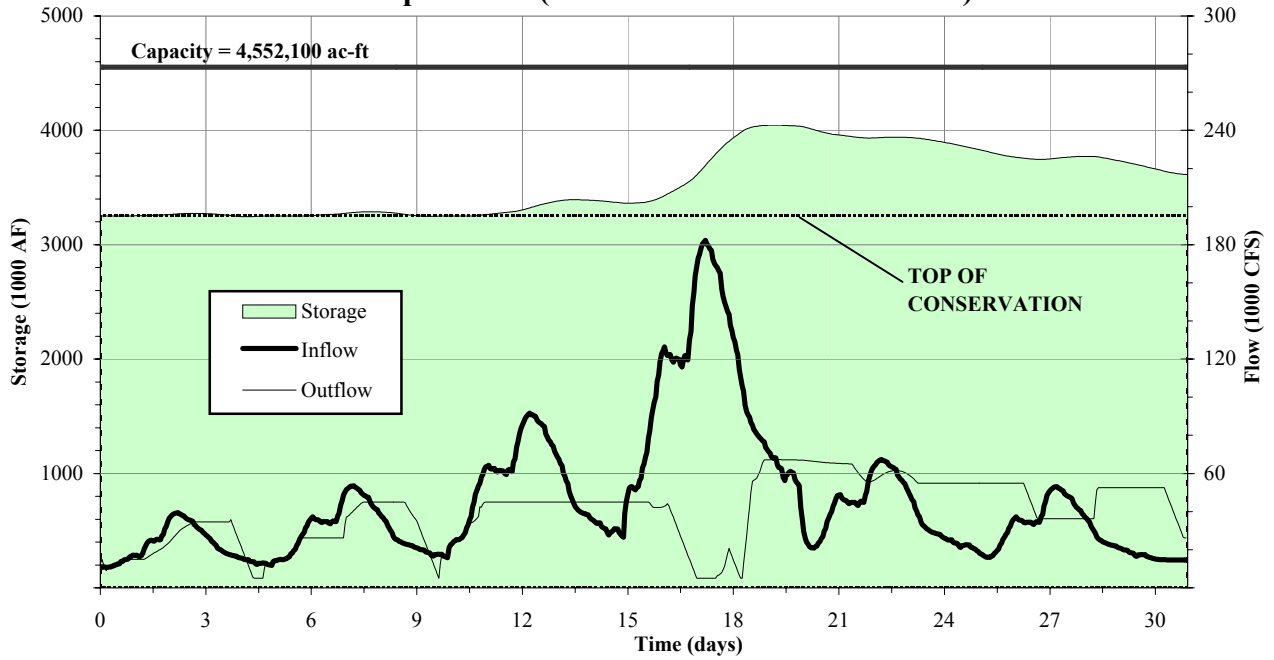


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Figure C.1-1b Reservoir Simulation Hydrographs Shasta (10% Chance Exceedence Event)
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SACRAMENTO RIVER
Shasta Inflow (4% Chance Exceedence Event)
 Regulated and Unregulated Inflow

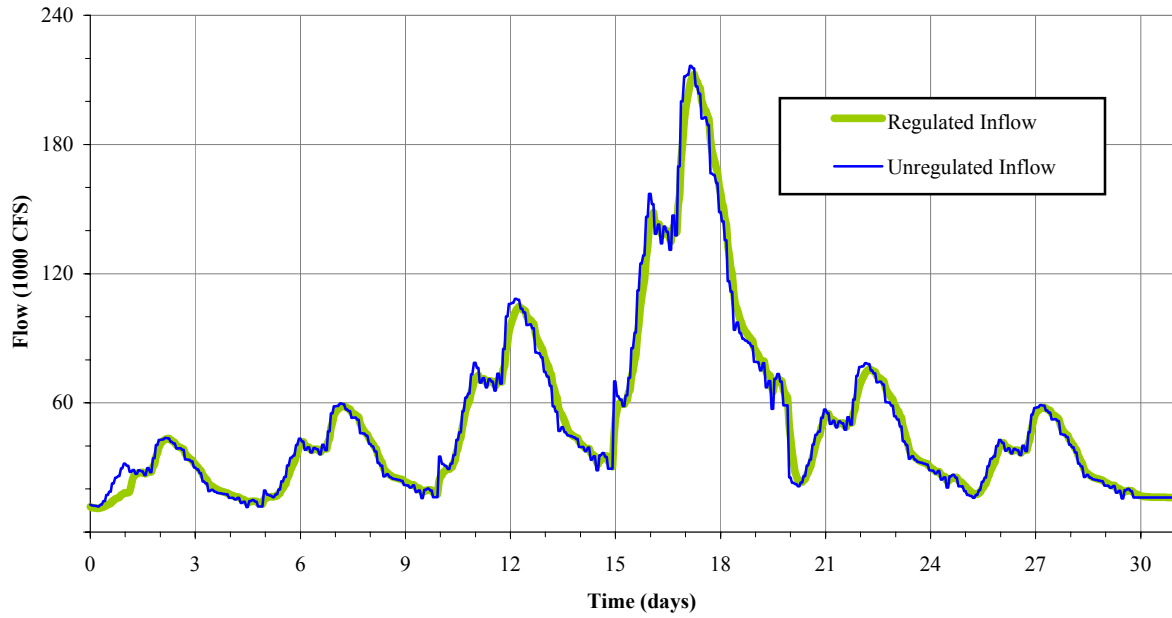


Shasta Operations (4% Chance Exceedence Event)

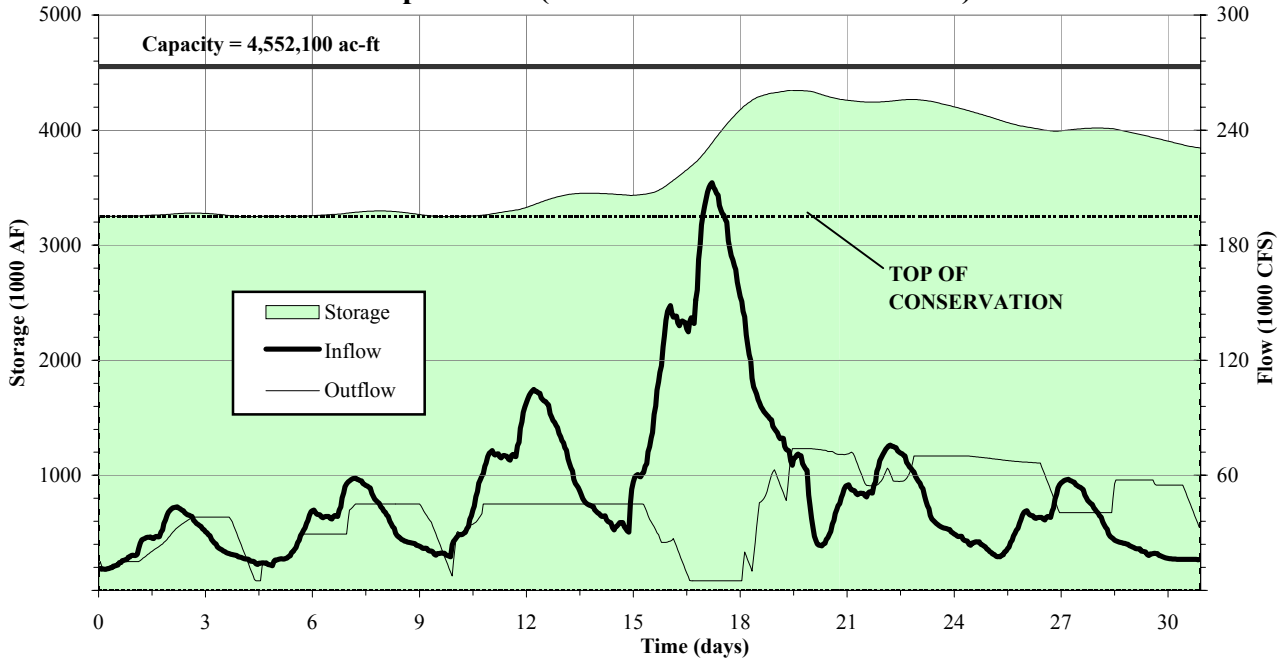


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Figure C.1-1c Reservoir Simulation Hydrographs Shasta (4% Chance Exceedence Event)
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SACRAMENTO RIVER
Shasta Inflow (2% Chance Exceedence Event)
 Regulated and Unregulated Inflow

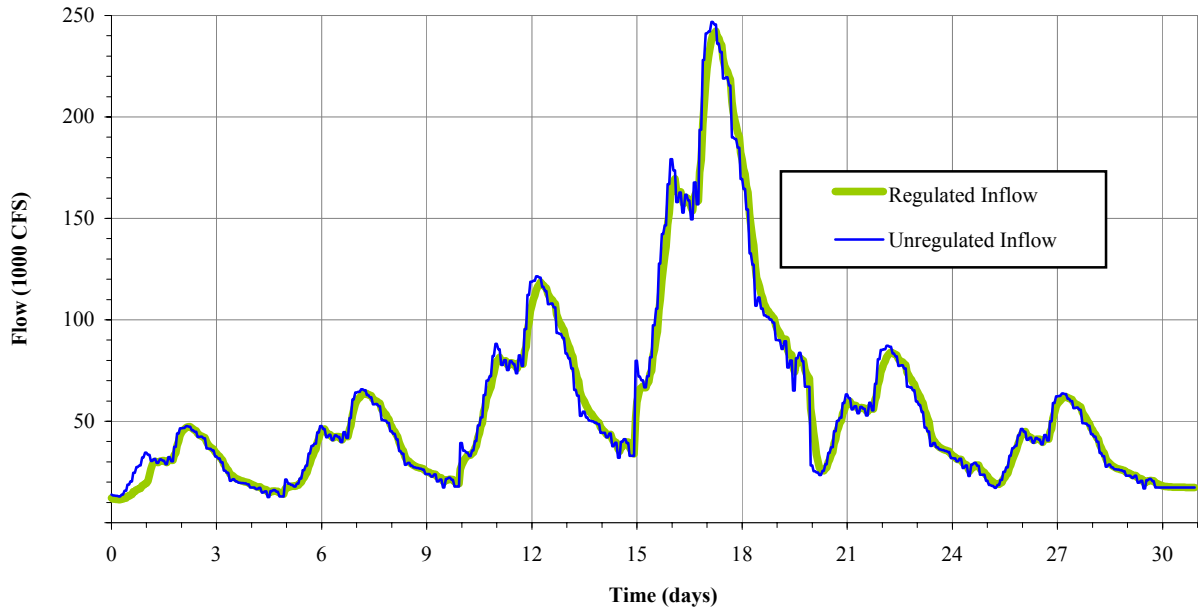


Shasta Operations (2% Chance Exceedence Event)

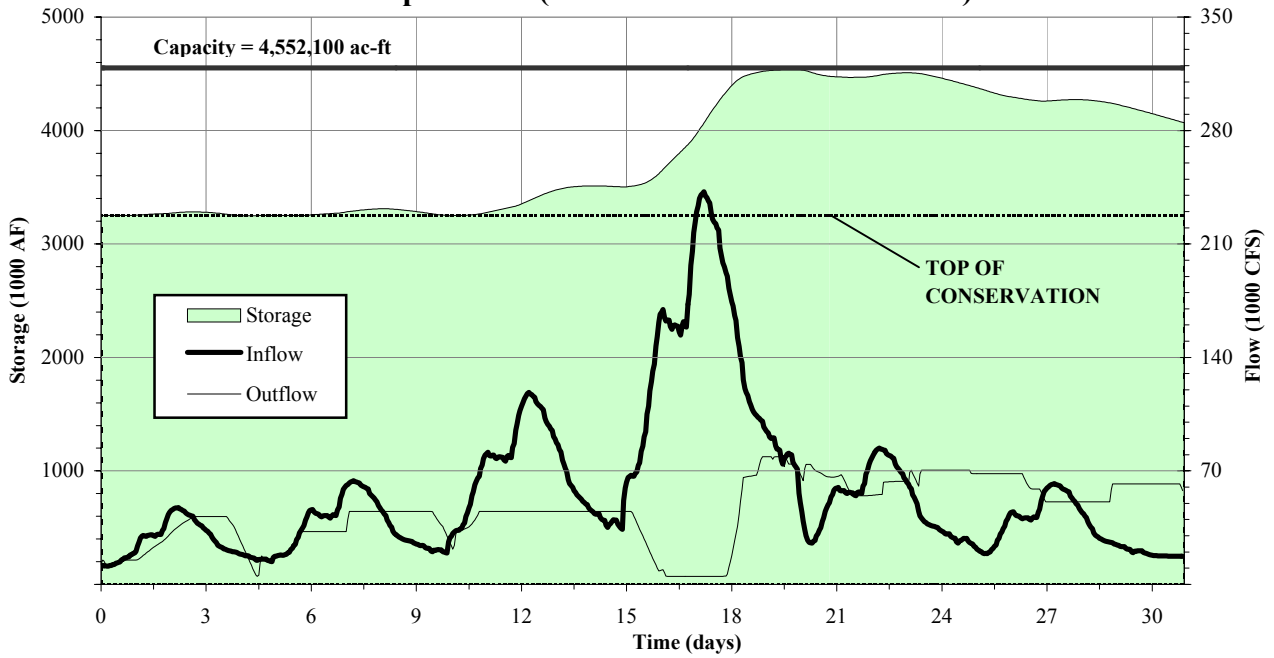


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Figure C.1-1d Reservoir Simulation Hydrographs Shasta (2% Chance Exceedence Event)
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SACRAMENTO RIVER
Shasta Inflow (1% Chance Exceedence Event)
 Regulated and Unregulated Inflow

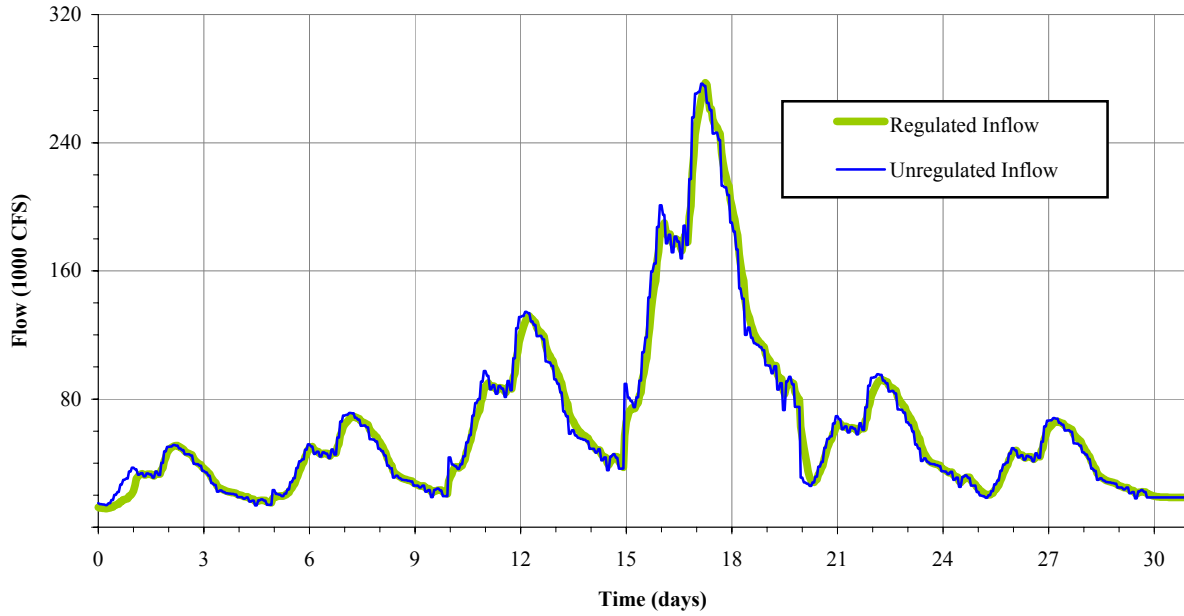


Shasta Operations (1% Chance Exceedence Event)

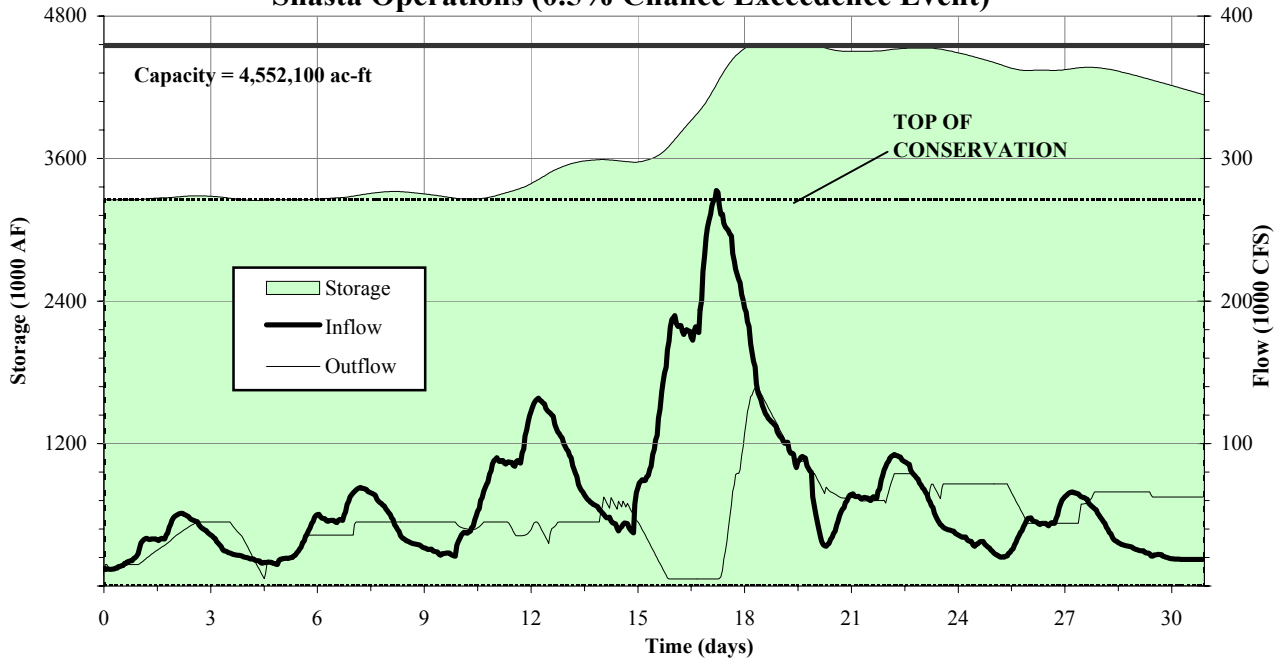


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Figure C.1-1e Reservoir Simulation Hydrographs Shasta (1% Chance Exceedence Event)
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SACRAMENTO RIVER
Shasta Inflow (0.5% Chance Exceedence Event)
 Regulated and Unregulated Inflow



Shasta Operations (0.5% Chance Exceedence Event)

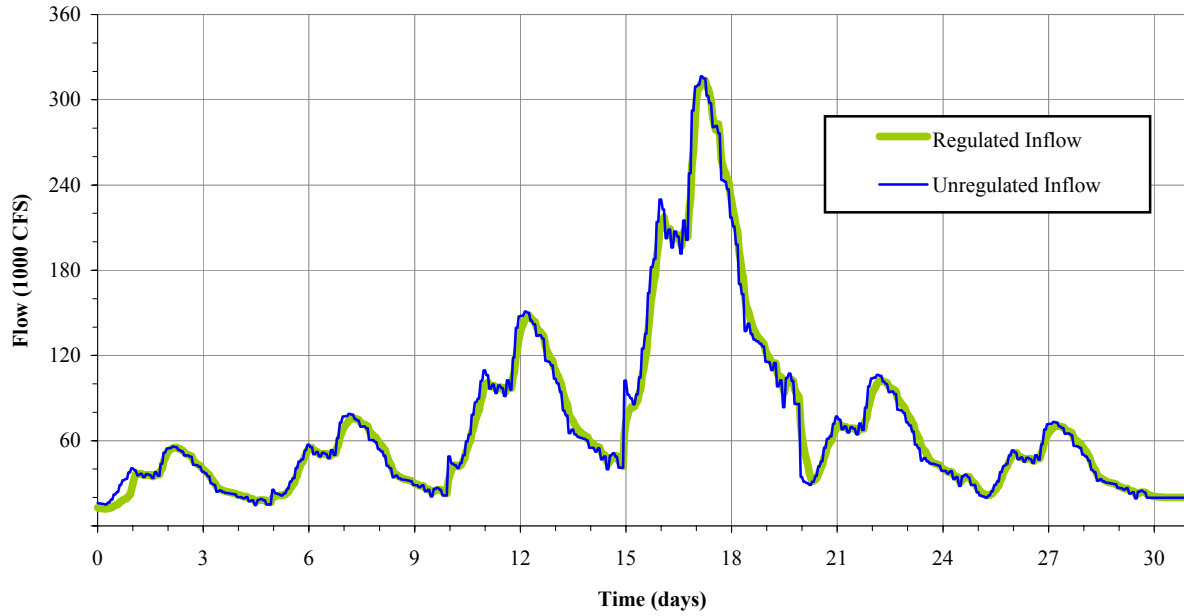


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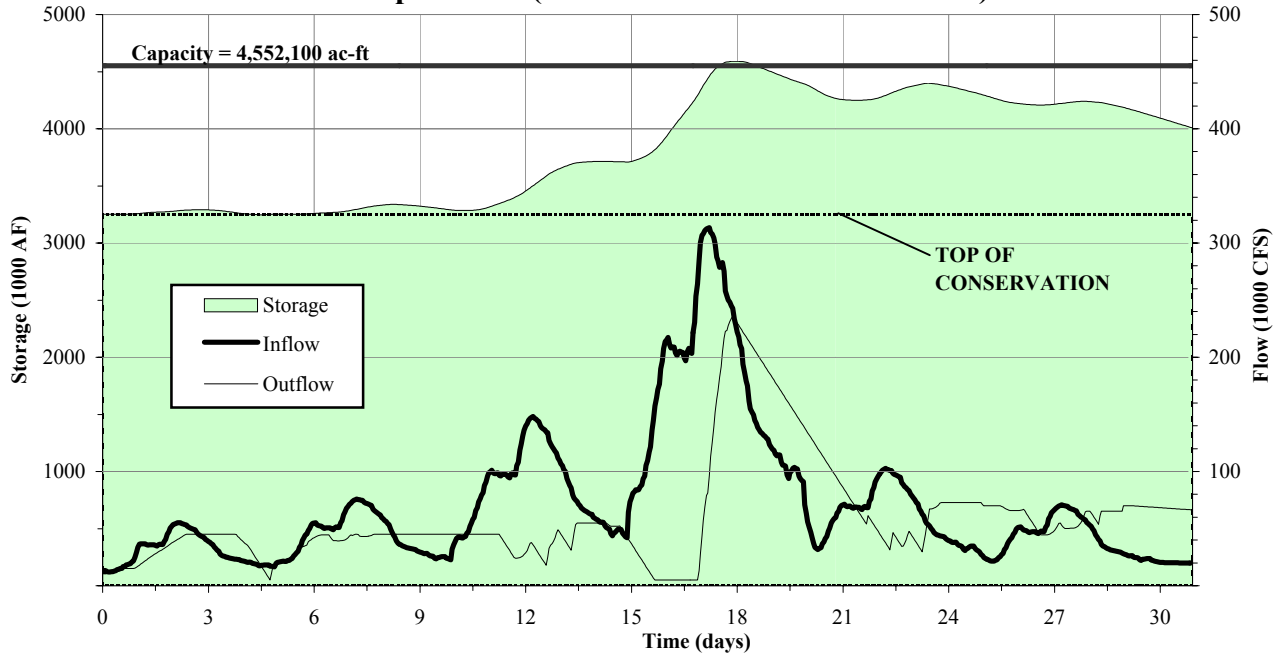
Figure C.1-1f
 Reservoir Simulation Hydrographs
 Shasta
 (0.5% Chance Exceedence Event)

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SACRAMENTO RIVER
Shasta Inflow (0.2% Chance Exceedence Event)
 Regulated and Unregulated Inflow



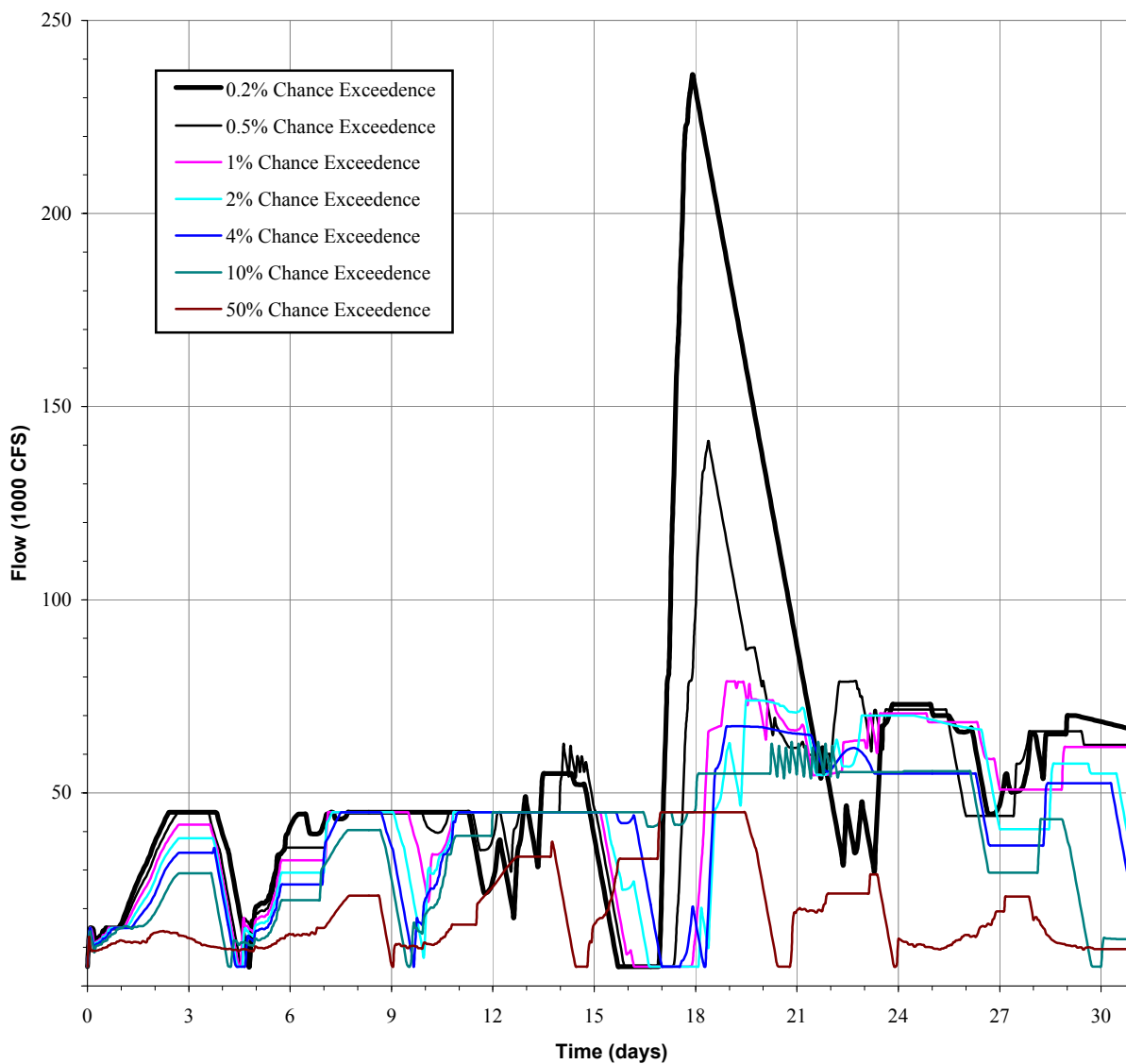
Shasta Operations (0.2% Chance Exceedence Event)



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Figure C.1-1g Reservoir Simulation Hydrographs Shasta (0.2% Chance Exceedence Event)
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SHASTA OUTFLOW

Regulated Outflow Hydrographs

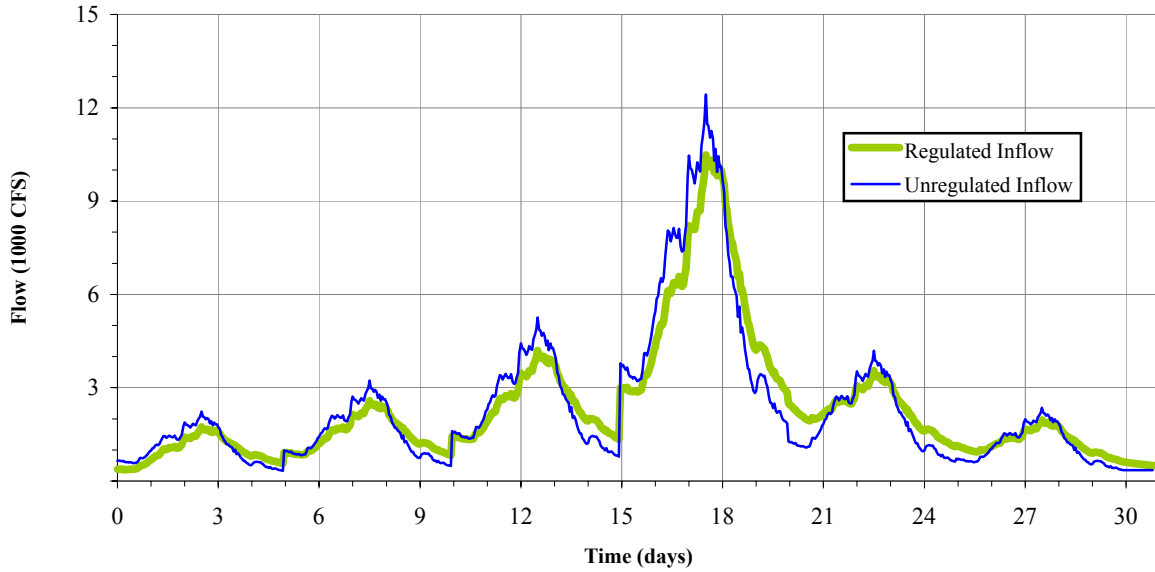


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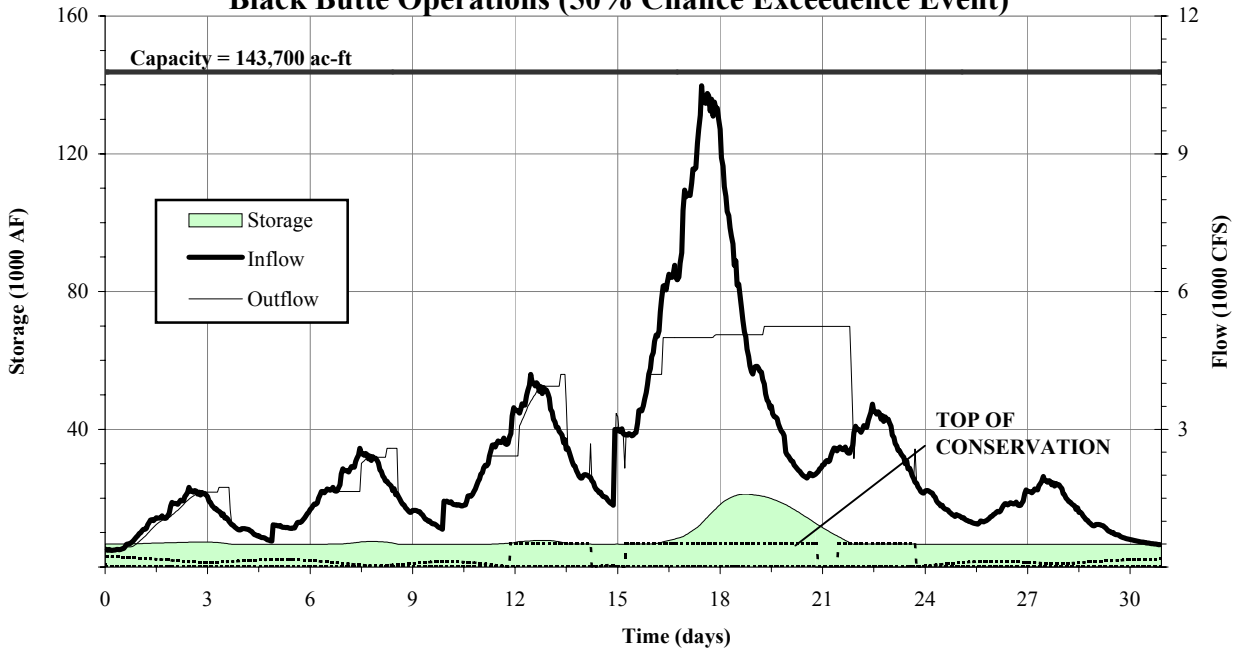
Figure C.1-1h
Reservoir Simulation Hydrographs
Regulated Outflow - Shasta

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STONY CREEK
Black Butte Inflow (50% Chance Exceedence Event)
 Regulated and Unregulated Inflow

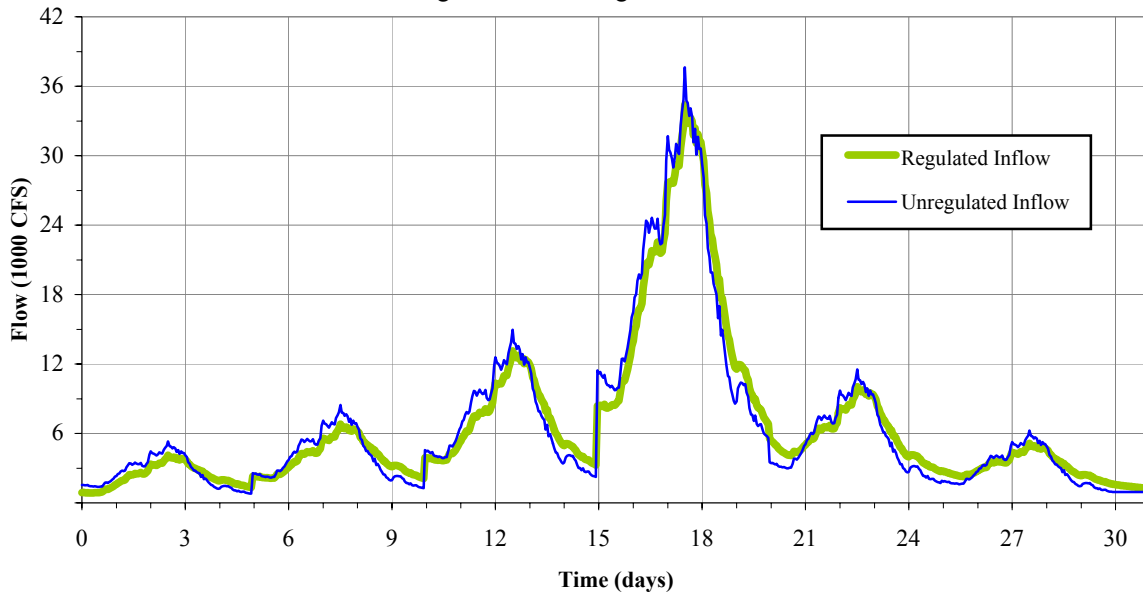


Black Butte Operations (50% Chance Exceedence Event)

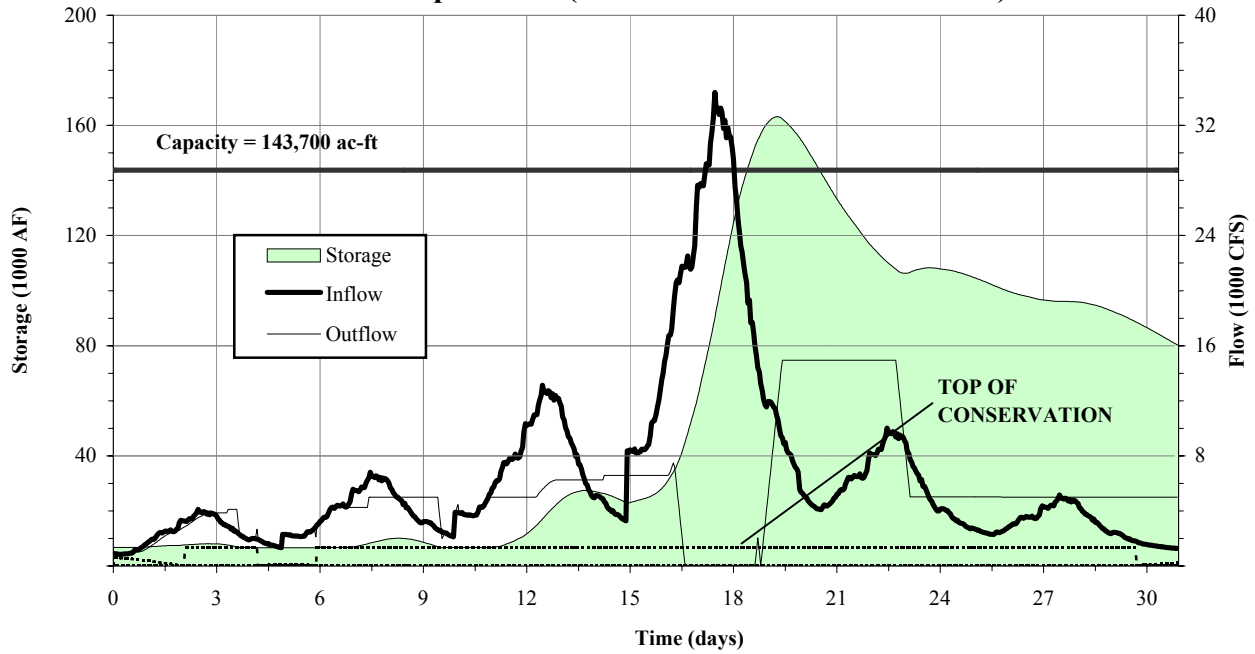


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Figure C.1-2a Reservoir Simulation Hydrographs Black Butte (50% Chance Exceedence Event)
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STONY CREEK
Black Butte Inflow (10% Chance Exceedence Event)
 Regulated and Unregulated Inflow



Black Butte Operations (10% Chance Exceedence Event)

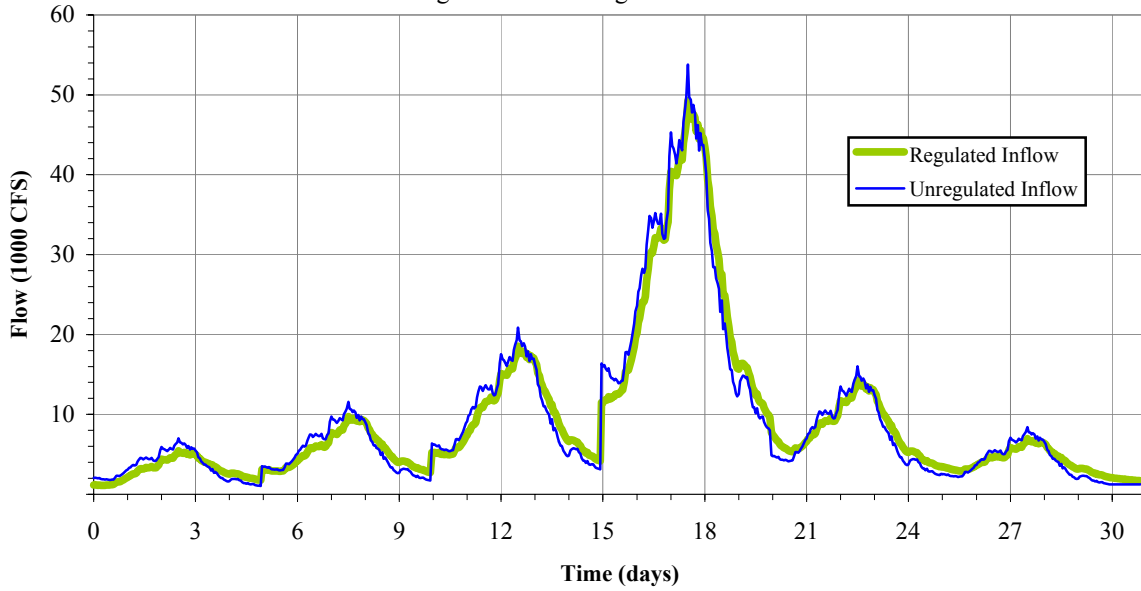


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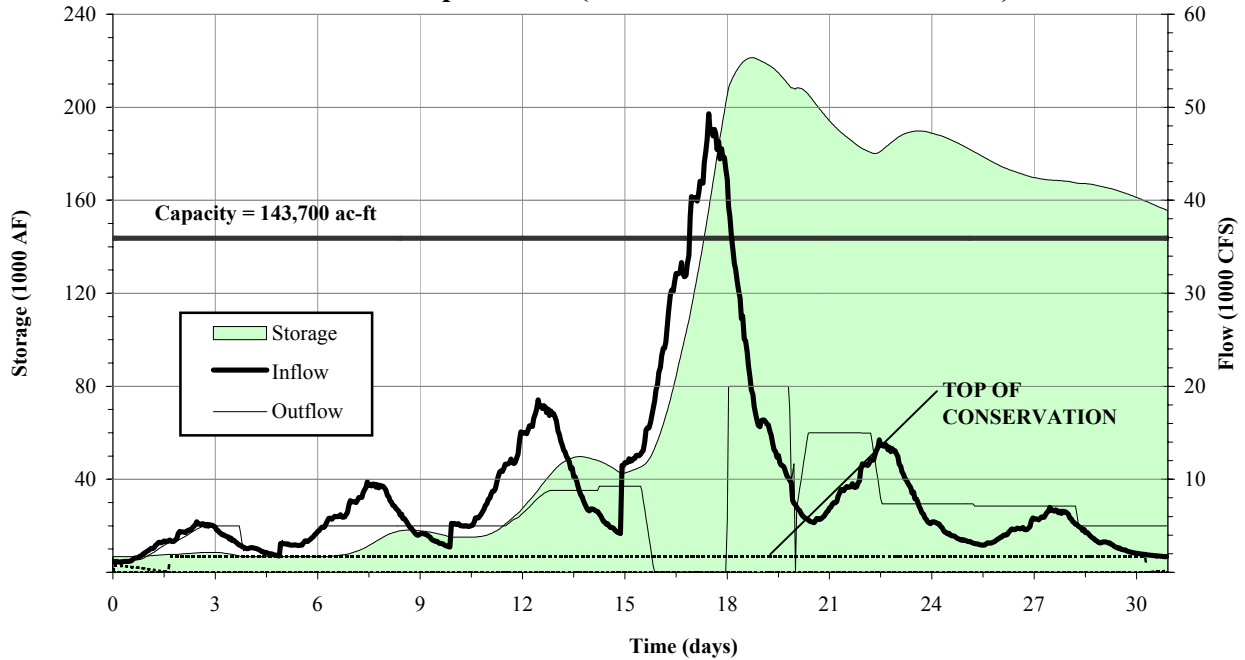
Figure C.1-2b
 Reservoir Simulation Hydrographs
 Black Butte
 (10% Chance Exceedence Event)

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 The Reclamation Board, State of California December 2002

STONY CREEK
Black Butte Inflow (4% Chance Exceedence Event)
 Regulated and Unregulated Inflow



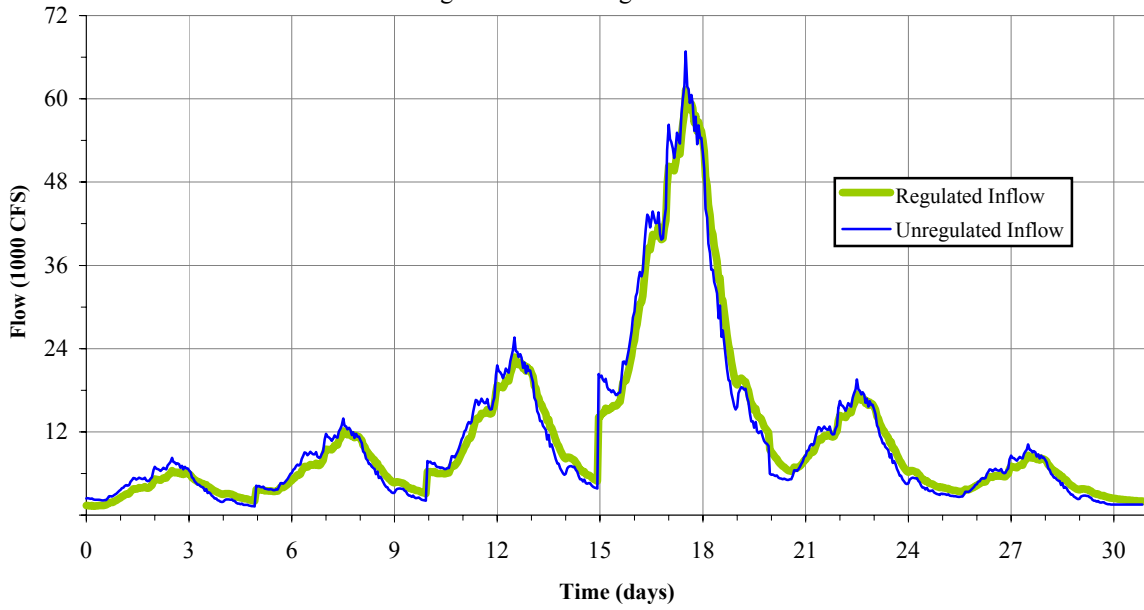
Black Butte Operations (4% Chance Exceedence Event)



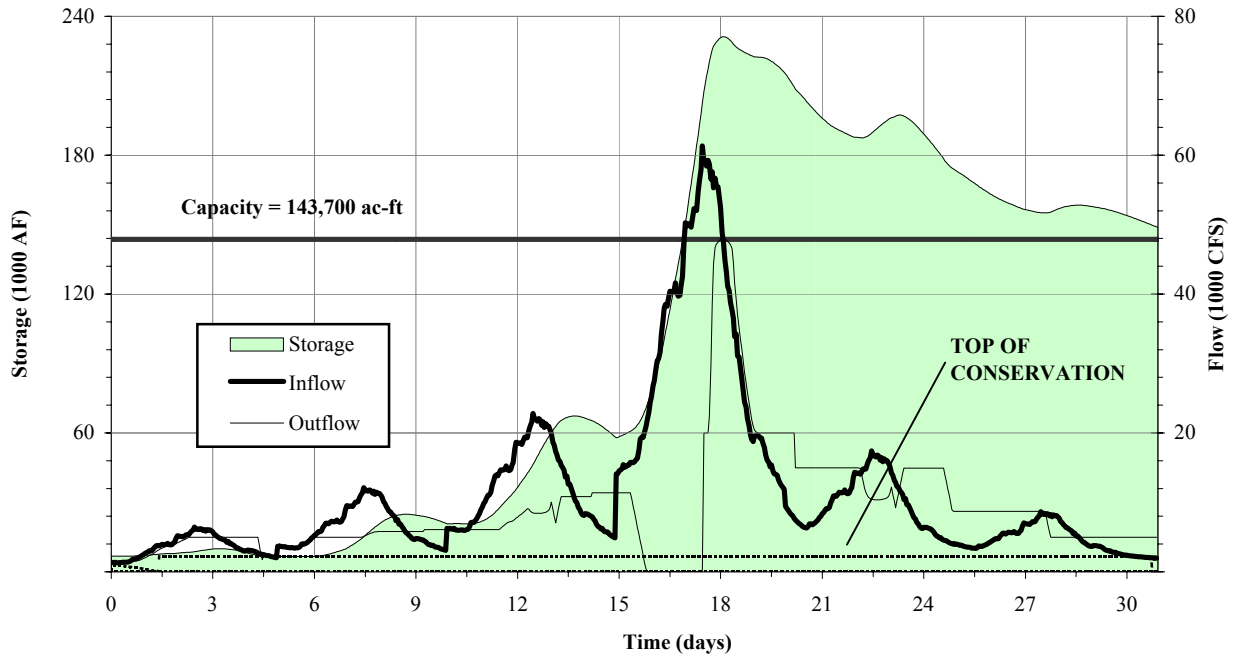
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Figure C.1-2c Reservoir Simulation Hydrographs Black Butte (4% Chance Exceedence Event)
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STONY CREEK
Black Butte Inflow (2% Chance Exceedence Event)

Regulated and Unregulated Inflow

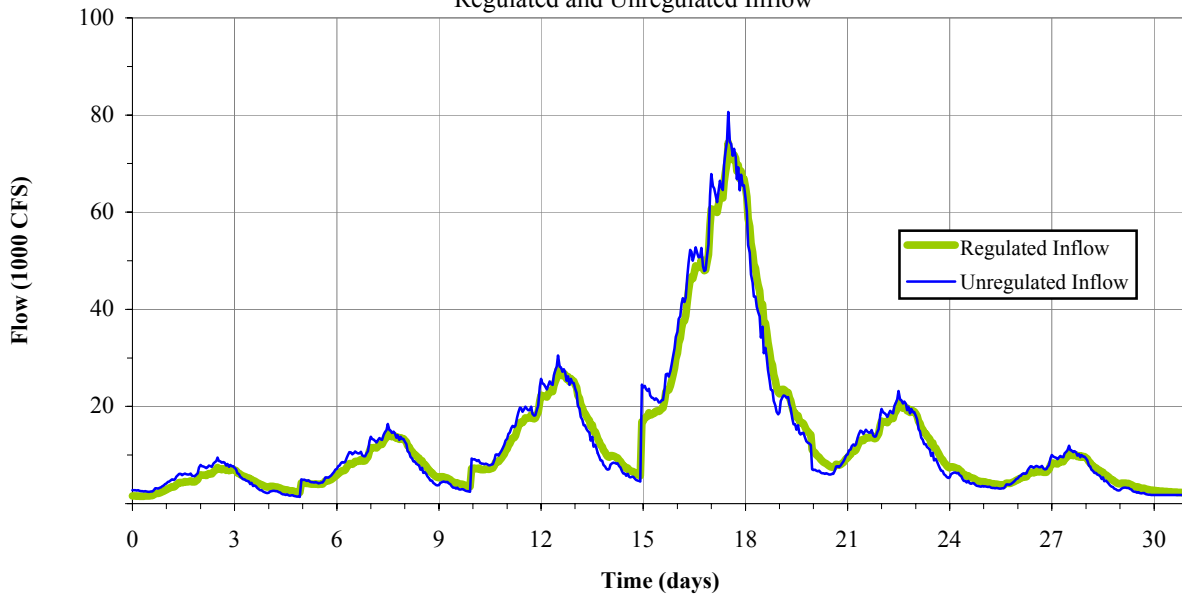


Black Butte Operations (2% Chance Exceedence Event)

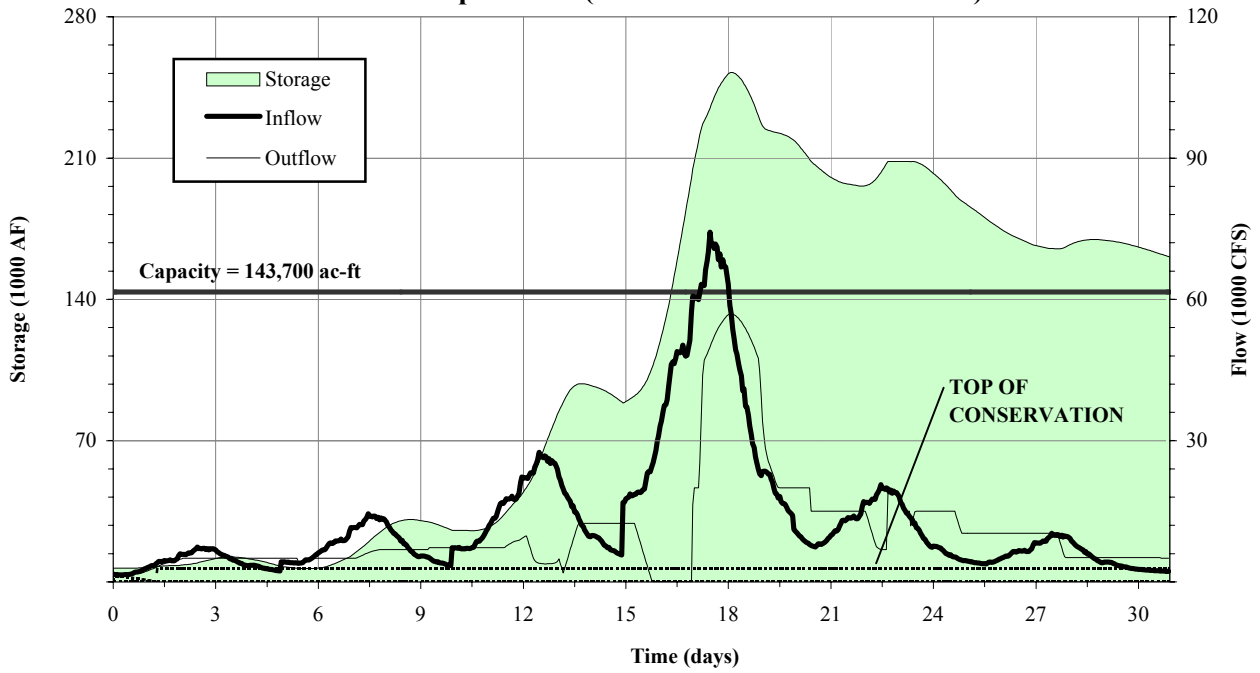


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Figure C.1-2d Reservoir Simulation Hydrographs Black Butte (2% Chance Exceedence Event)
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STONY CREEK
Black Butte Inflow (1% Chance Exceedence Event)
 Regulated and Unregulated Inflow



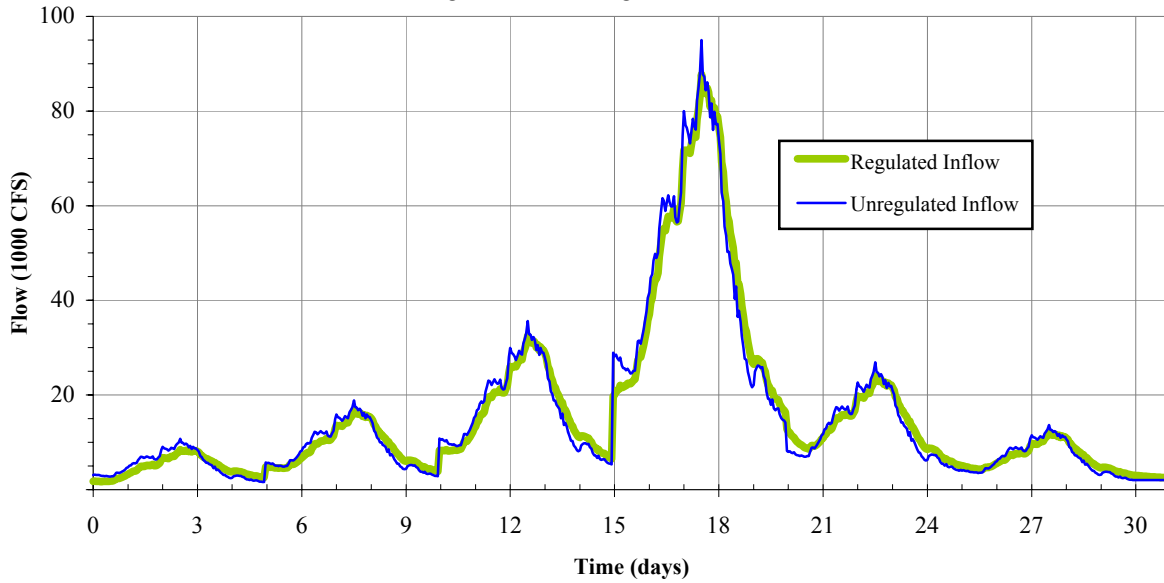
Black Butte Operations (1% Chance Exceedence Event)



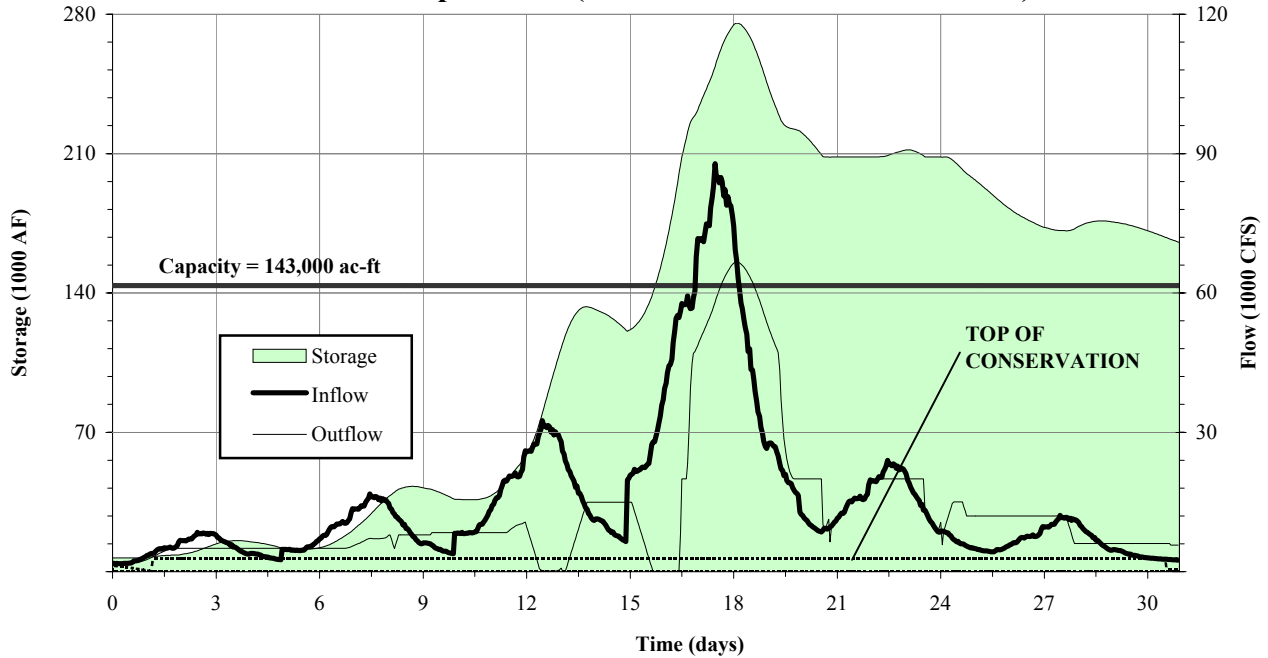
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Figure C.1-2e Reservoir Simulation Hydrographs Black Butte (1% Chance Exceedence Event)
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STONY CREEK
Black Butte Inflow (0.5% Chance Exceedence Event)

Regulated and Unregulated Inflow

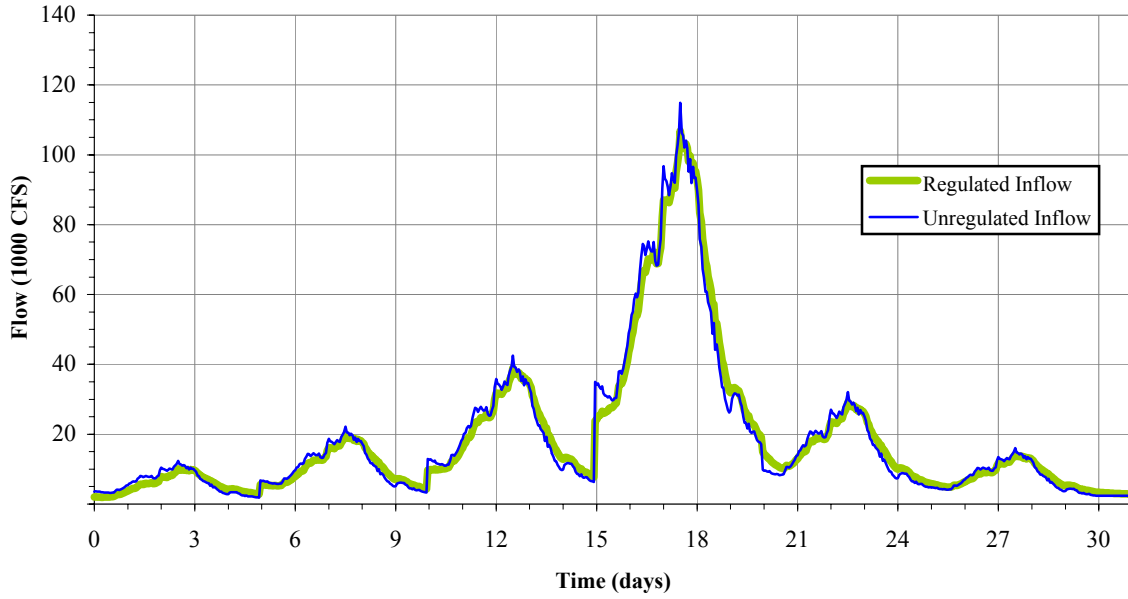


Black Butte Operations (0.5% Chance Exceedence Event)

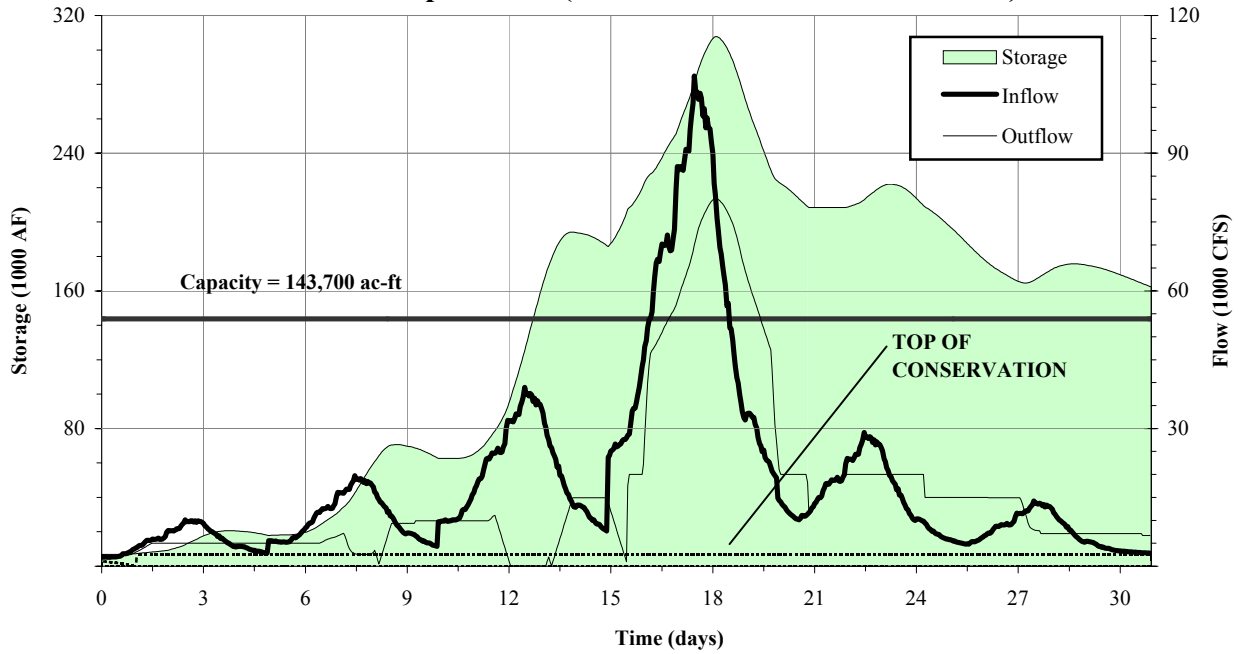


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Figure C.1-2f Reservoir Simulation Hydrographs Black Butte (0.5% Chance Exceedence Event)	
US Army Corps of Engineers The Reclamation Board, State of California	December 2002

STONY CREEK
Black Butte Inflow (0.2% Chance Exceedence Event)
 Regulated and Unregulated Inflow



Black Butte Operations (0.2% Chance Exceedence Event)



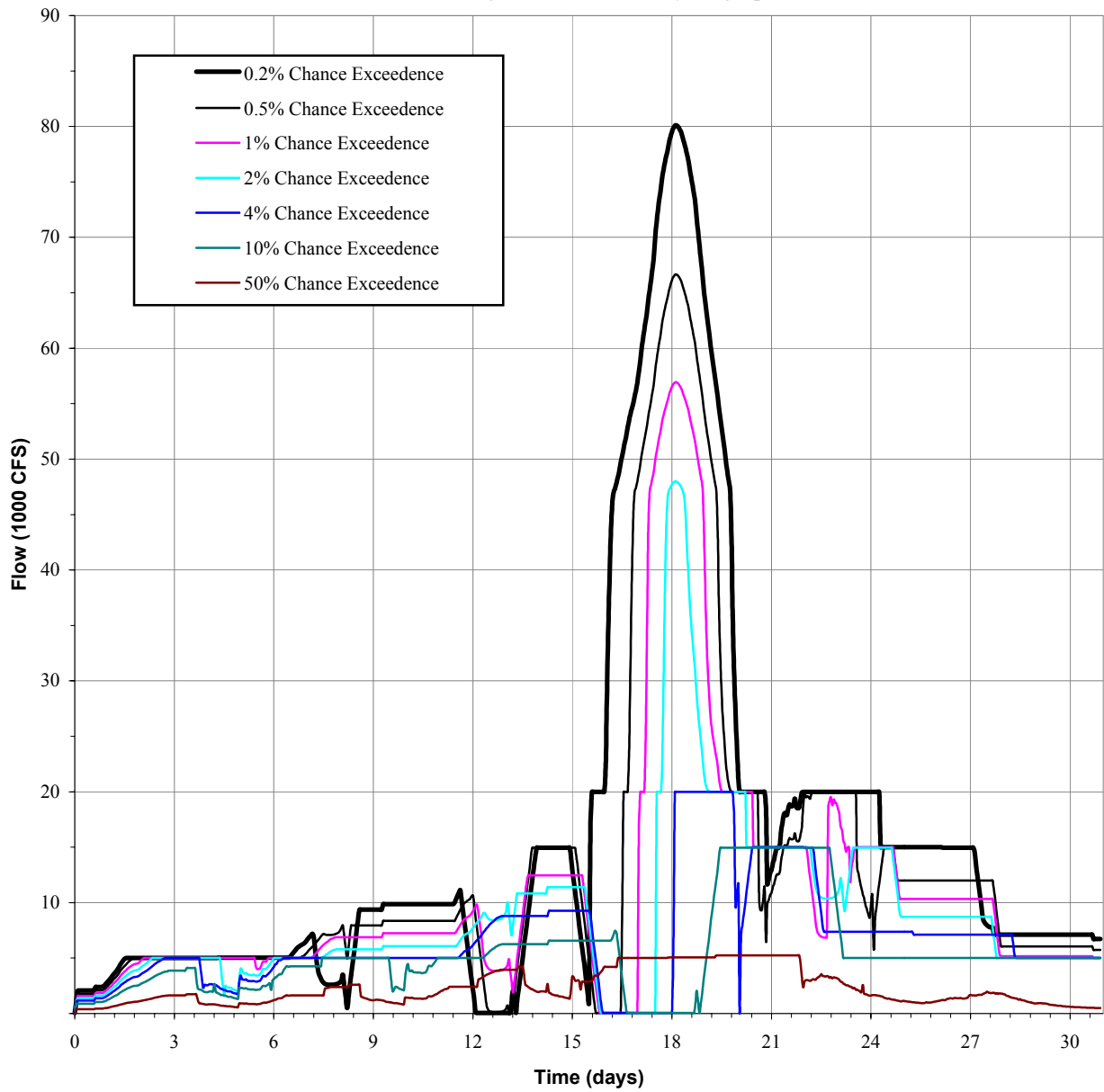
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Figure C.1-2g
 Reservoir Simulation Hydrographs
 Black Butte
 (0.2% Chance Exceedence Event)

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BLACK BUTTE OUTFLOW

Regulated Outflow Hydrographs

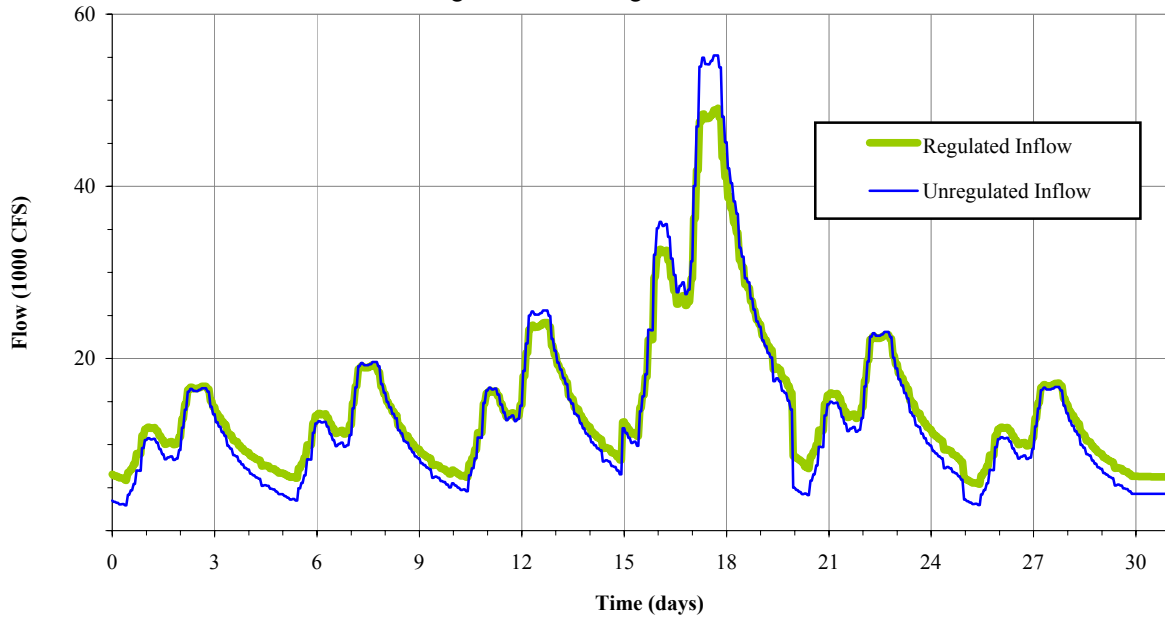


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Comprehensive Study

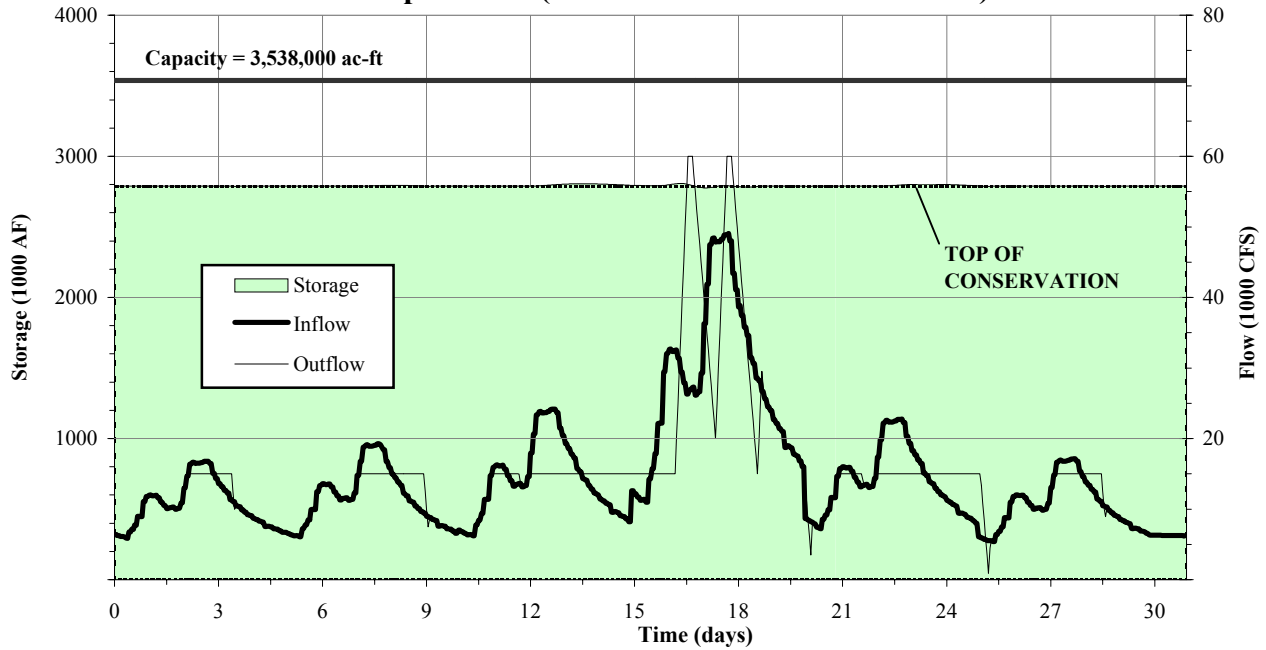
Figure C.1-2h
Reservoir Simulation Hydrographs
Regulated Outflow - Black Butte

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The Reclamation Board, State of California December 2002

FEATHER RIVER
Oroville Inflow (50% Chance Exceedence Event)
 Regulated and Unregulated Inflow

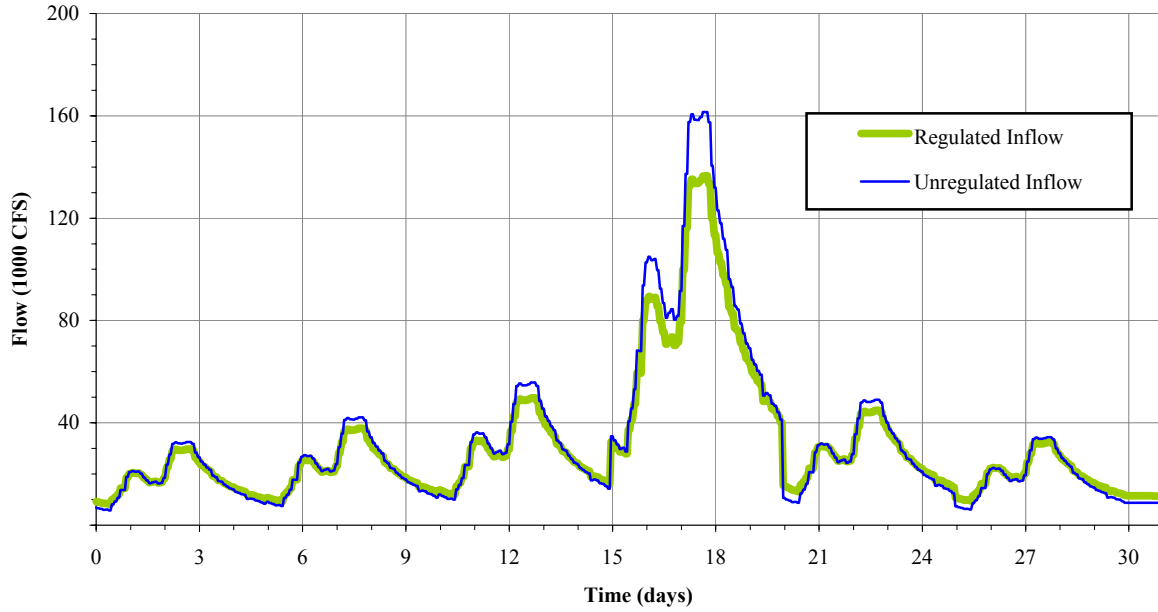


Oroville Operations (50% Chance Exceedence Event)

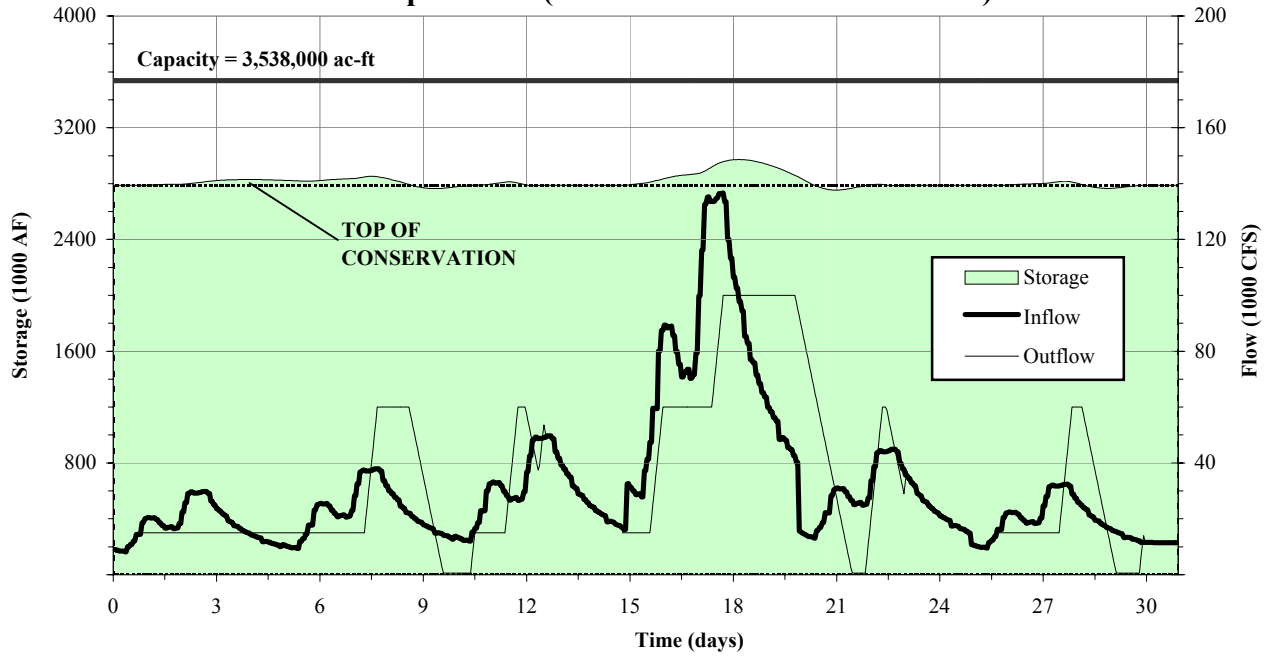


Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-3a Reservoir Simulation Hydrographs Oroville (50% Chance Exceedence Event)
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FEATHER RIVER
Oroville Inflow (10% Chance Exceedence Event)
 Regulated and Unregulated Inflow

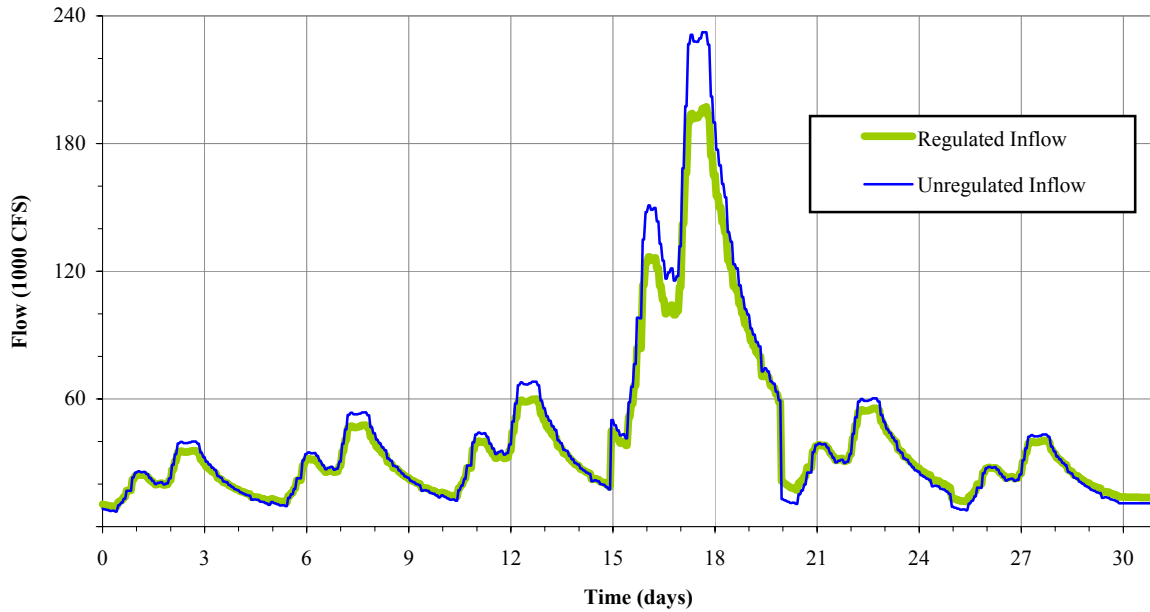


Oroville Operations (10% Chance Exceedence Event)

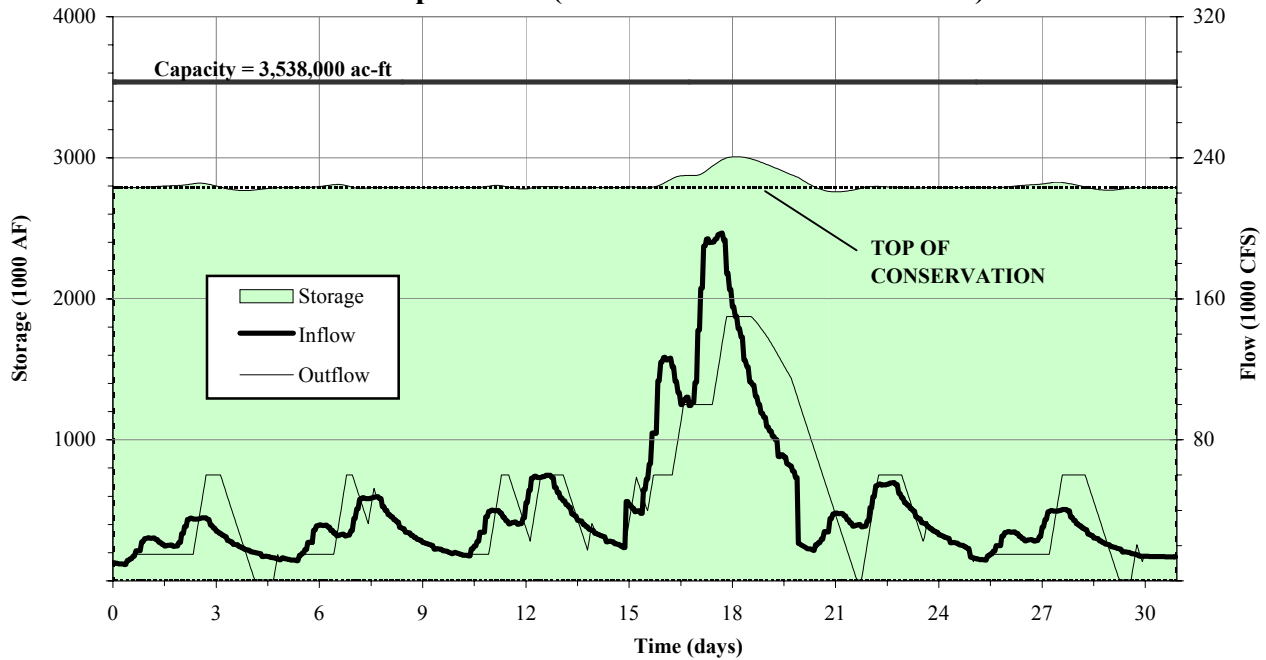


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Figure C.1-3b Reservoir Simulation Hydrographs Oroville (10% Chance Exceedence Event)
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FEATHER RIVER
Oroville Inflow (4% Chance Exceedence Event)
 Regulated and Unregulated Inflow

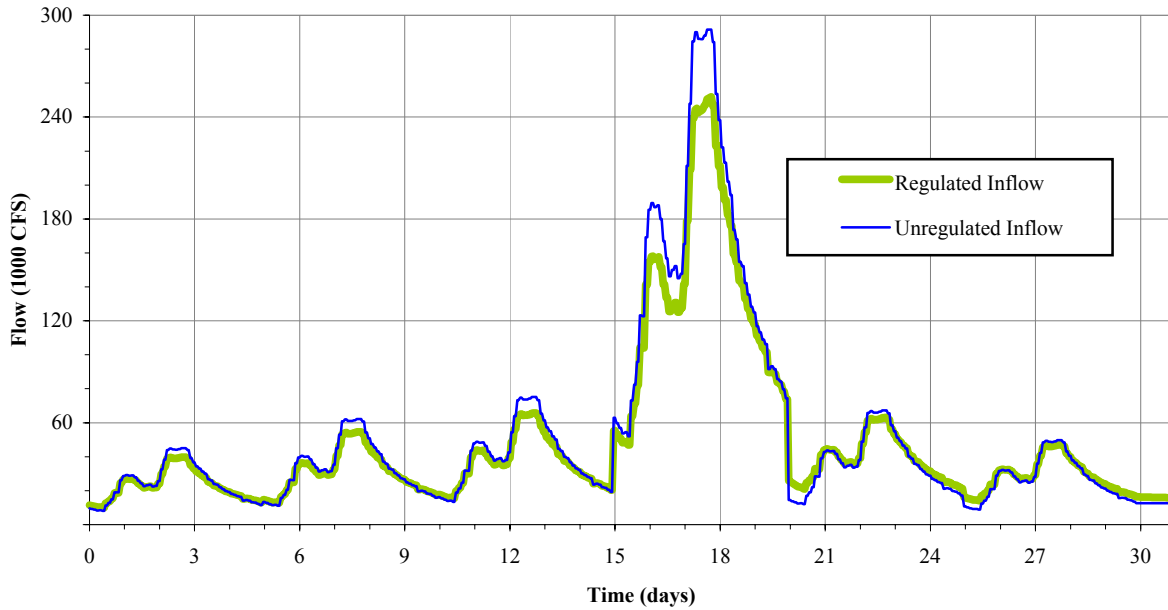


Oroville Operations (4% Chance Exceedence Event)

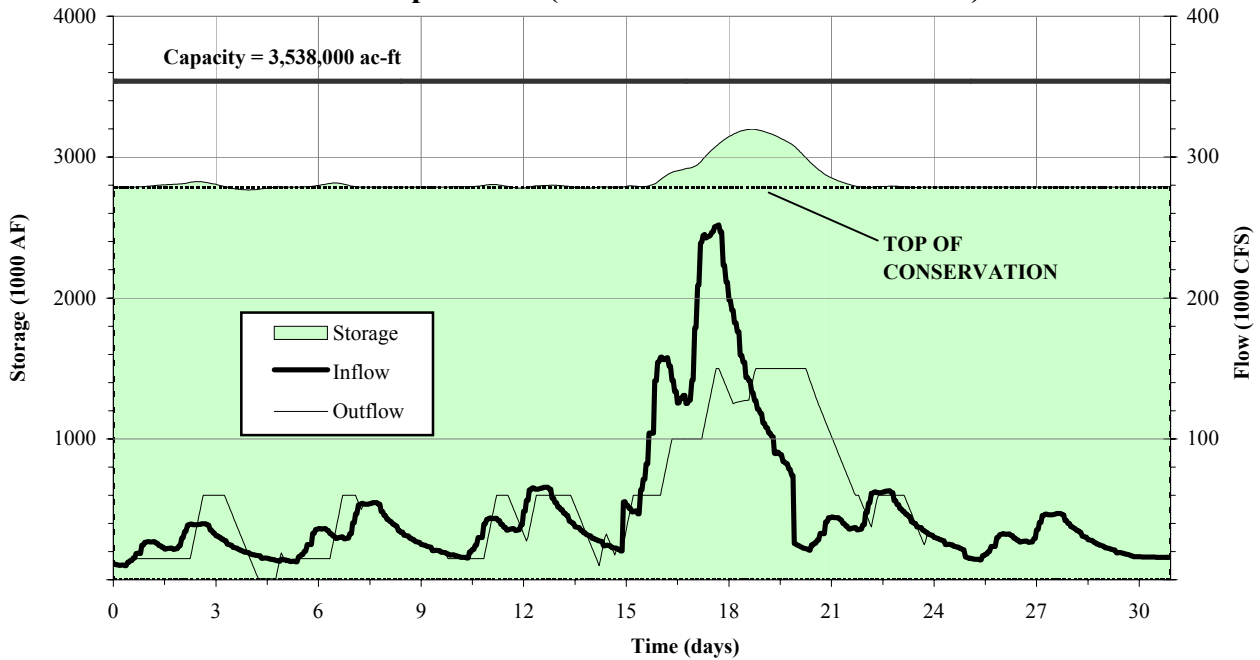


Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-3c Reservoir Simulation Hydrographs Oroville (4% Chance Exceedence Event)
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FEATHER RIVER
Oroville Inflow (2% Chance Exceedence Event)
 Regulated and Unregulated Inflow

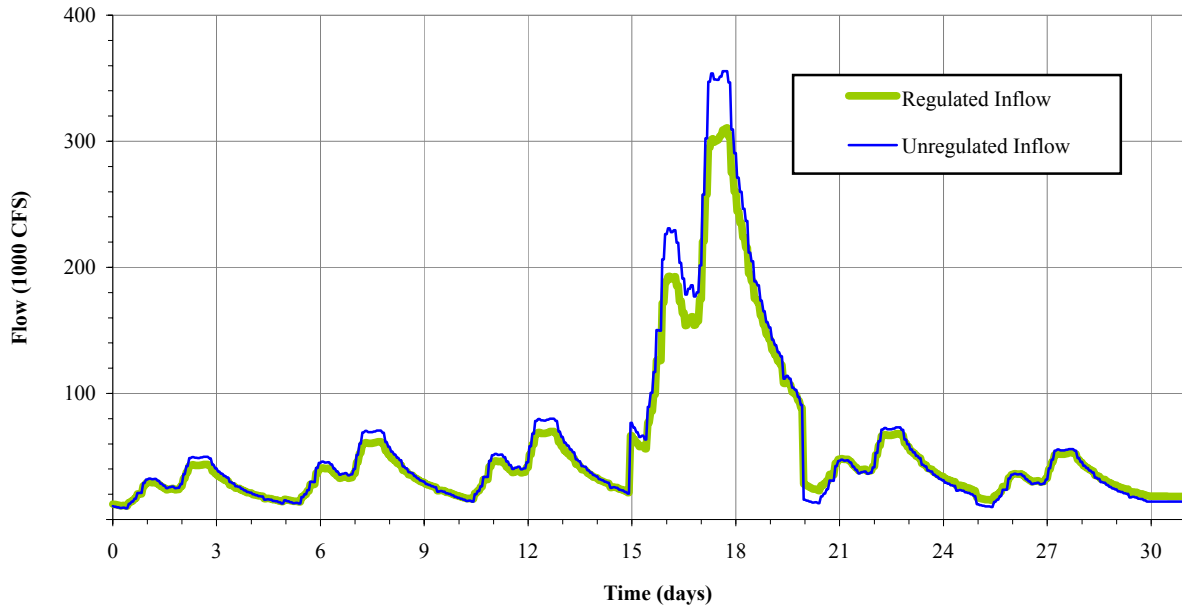


Oroville Operations (2% Chance Exceedence Event)

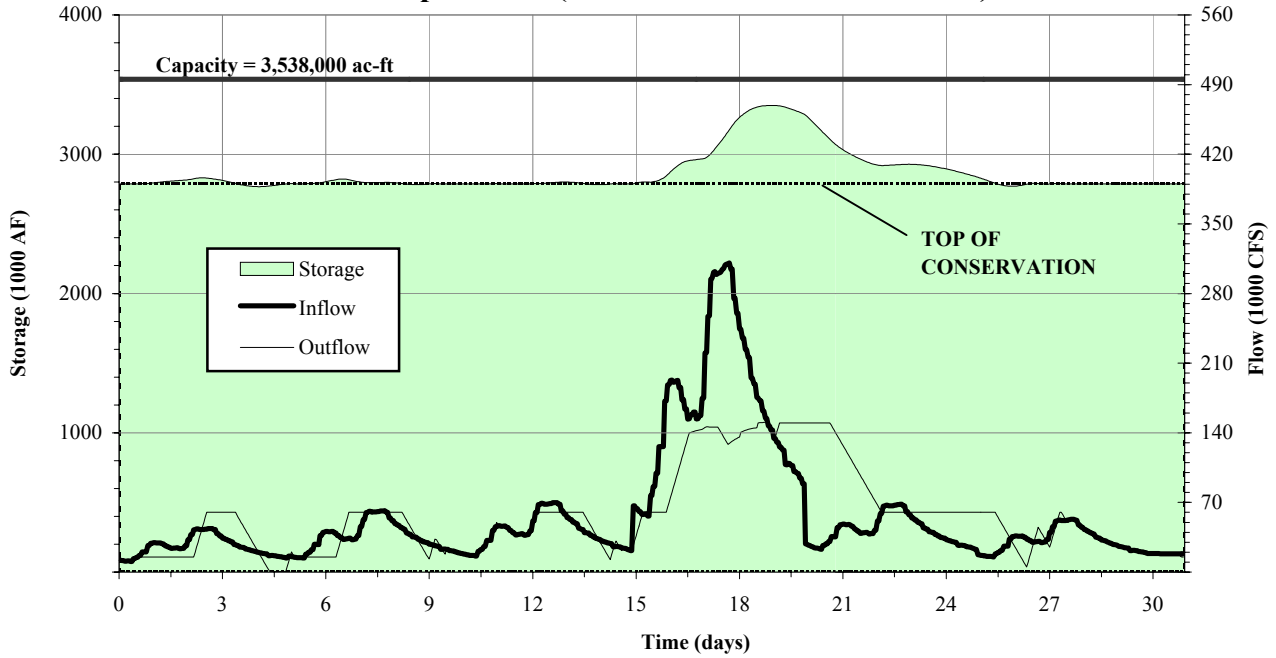


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Figure C.1-3d Reservoir Simulation Hydrographs Oroville (2% Chance Exceedence Event)
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FEATHER RIVER
Oroville Inflow (1% Chance Exceedence Event)
 Regulated and Unregulated Inflow

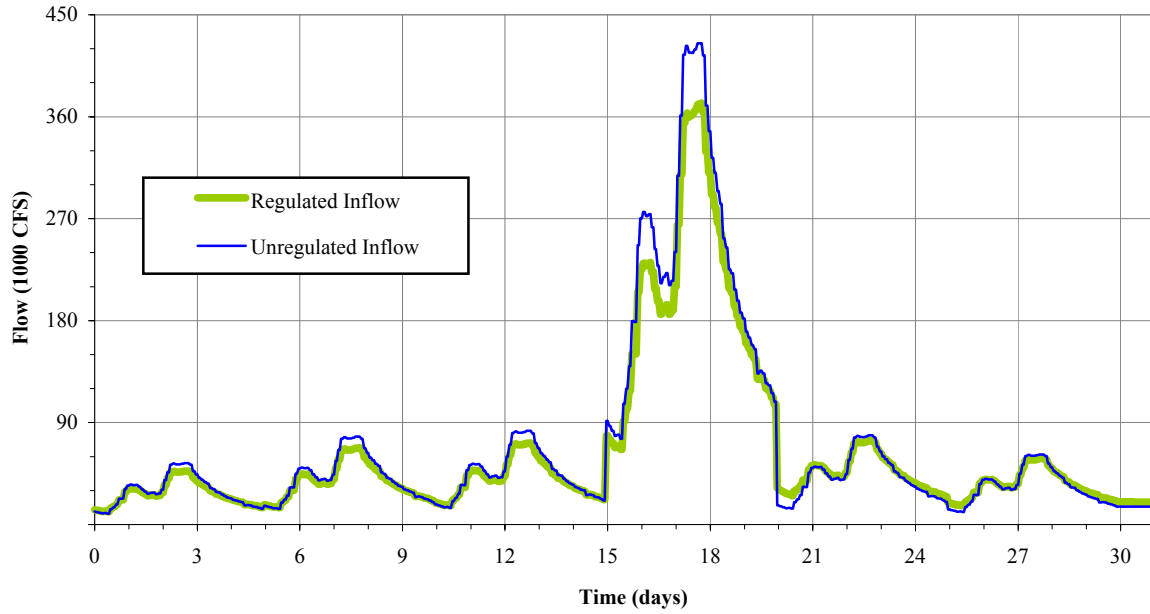


Oroville Operations (1% Chance Exceedence Event)

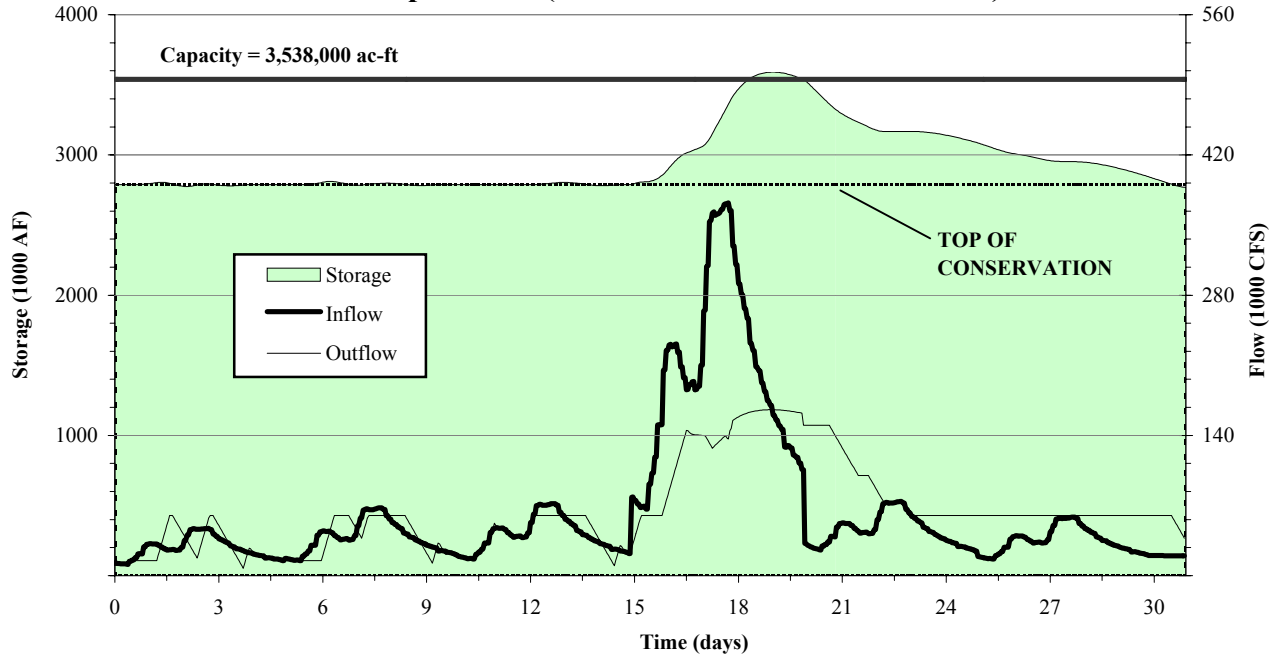


Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-3e Reservoir Simulation Hydrographs Oroville (1% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

FEATHER RIVER
Oroville Inflow (0.5% Chance Exceedence Event)
 Regulated and Unregulated Inflow

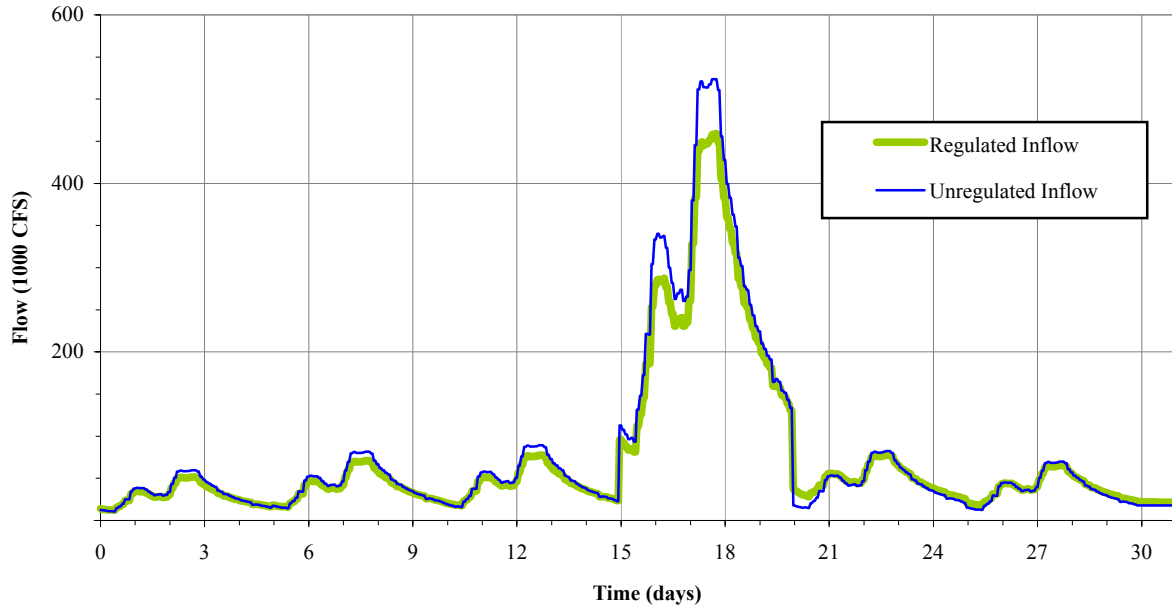


Oroville Operations (0.5% Chance Exceedence Event)

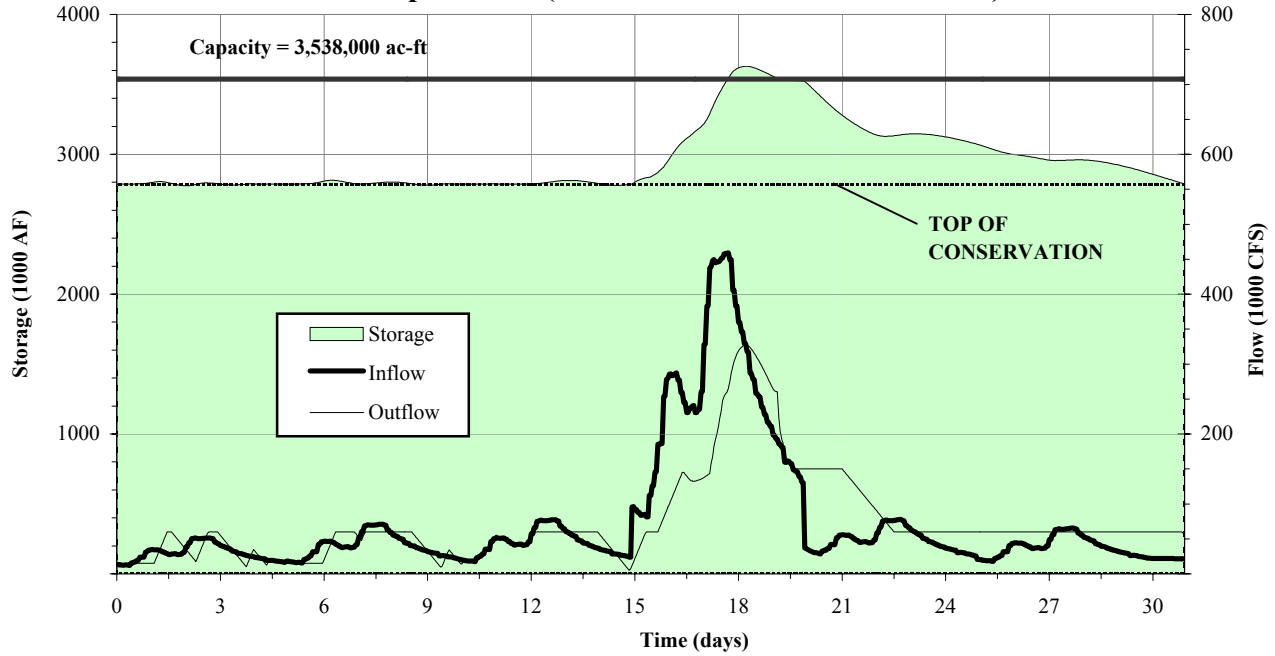


Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-3f Reservoir Simulation Hydrographs Oroville (0.5% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

FEATHER RIVER
Oroville Inflow (0.2% Chance Exceedence Event)
 Regulated and Unregulated Inflow



Oroville Operations (0.2% Chance Exceedence Event)



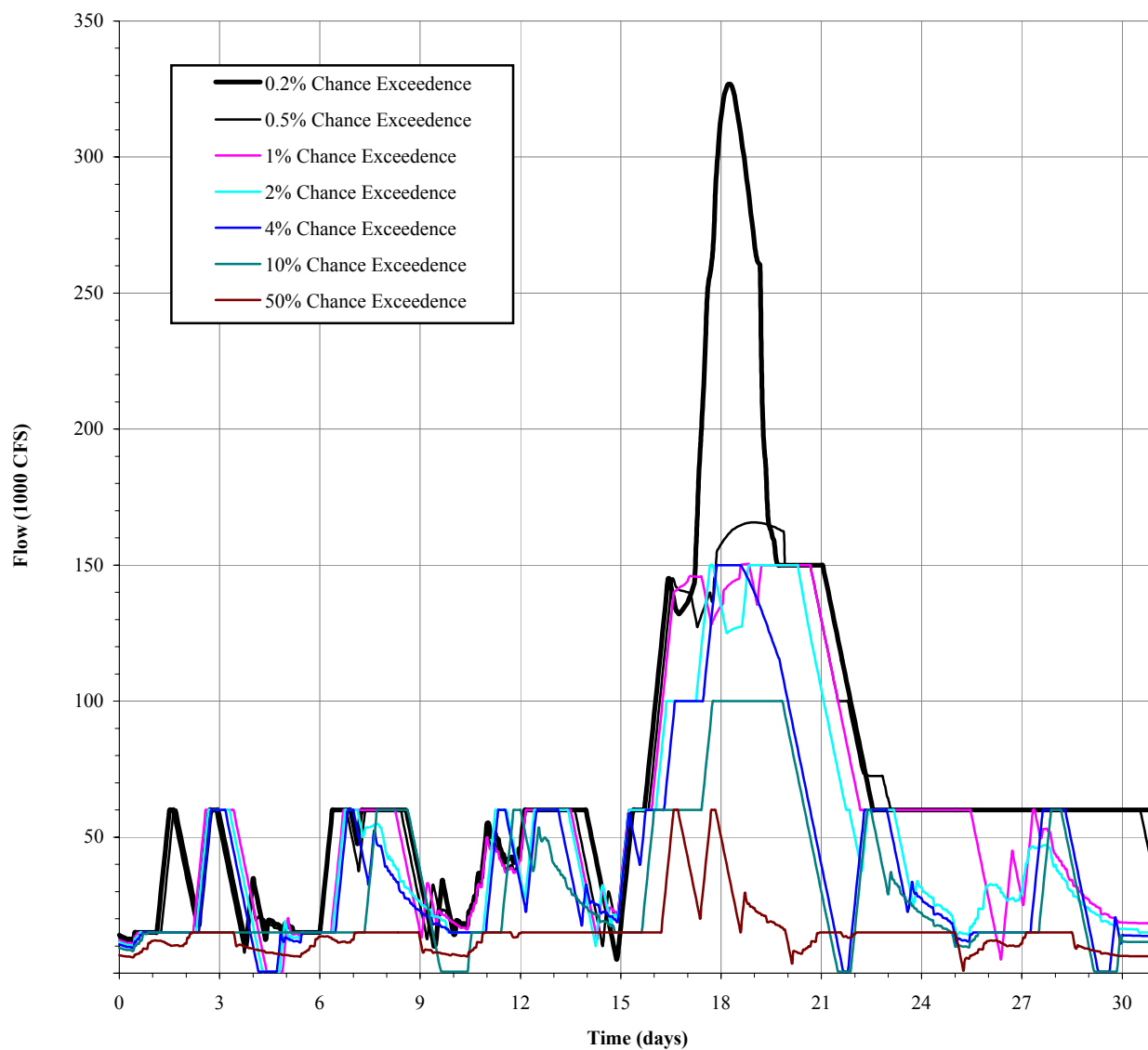
Sacramento & San Joaquin River Basins
 Comprehensive Study

Figure C.1-3g
 Reservoir Simulation Hydrographs
 Oroville
 (0.2% Chance Exceedence Event)

US Army Corps of Engineers
 The Reclamation Board, State of California December 2002

OROVILLE OUTFLOW

Regulated Outflow Hydrographs



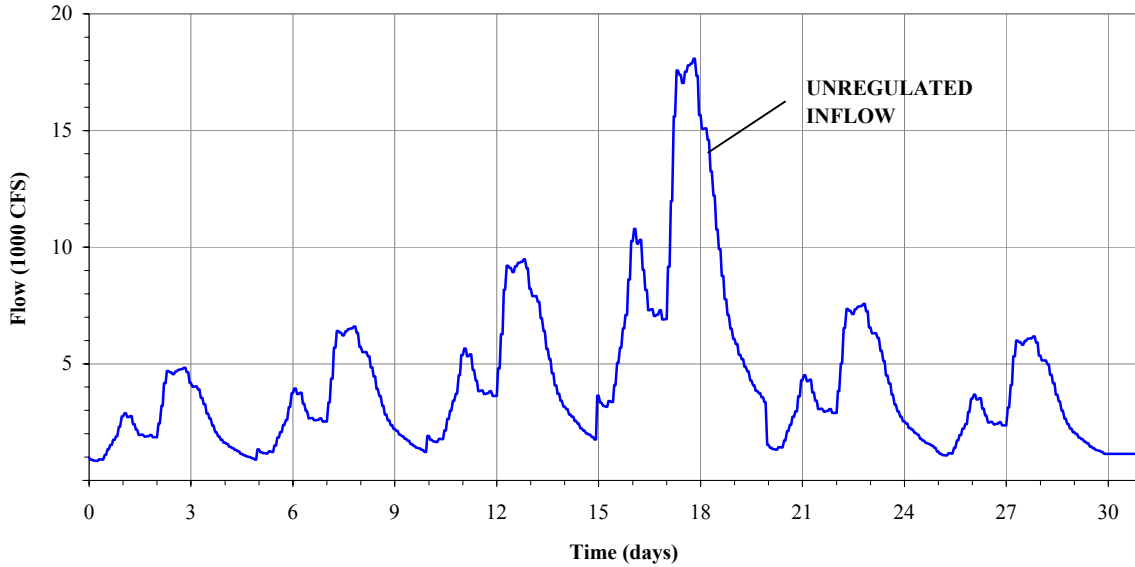
Sacramento & San Joaquin River Basins
Comprehensive Study

Figure C.1-3h
Reservoir Simulation Hydrographs
Regulated Outflow - Oroville

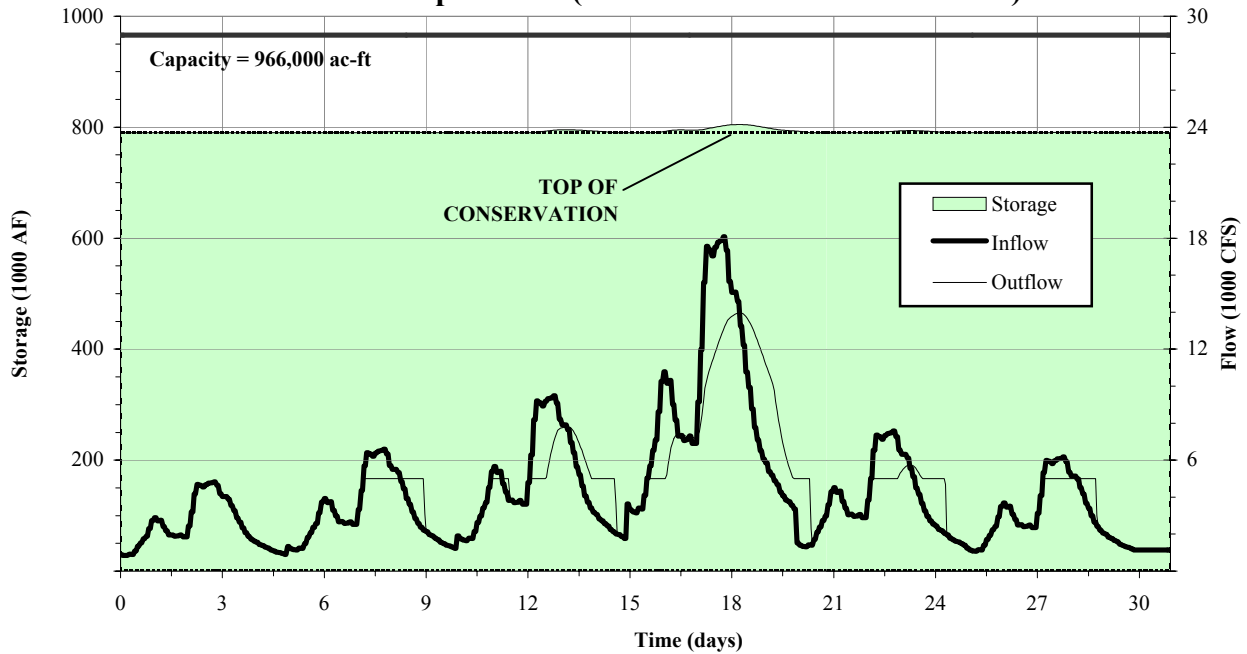
US Army Corps of Engineers
The Reclamation Board, State of California December 2002

NORTH YUBA RIVER
Bullards Bar Inflow (50% Chance Exceedence Event)
 Unregulated Inflow

Note: This reservoir has no major headwater reservoirs.



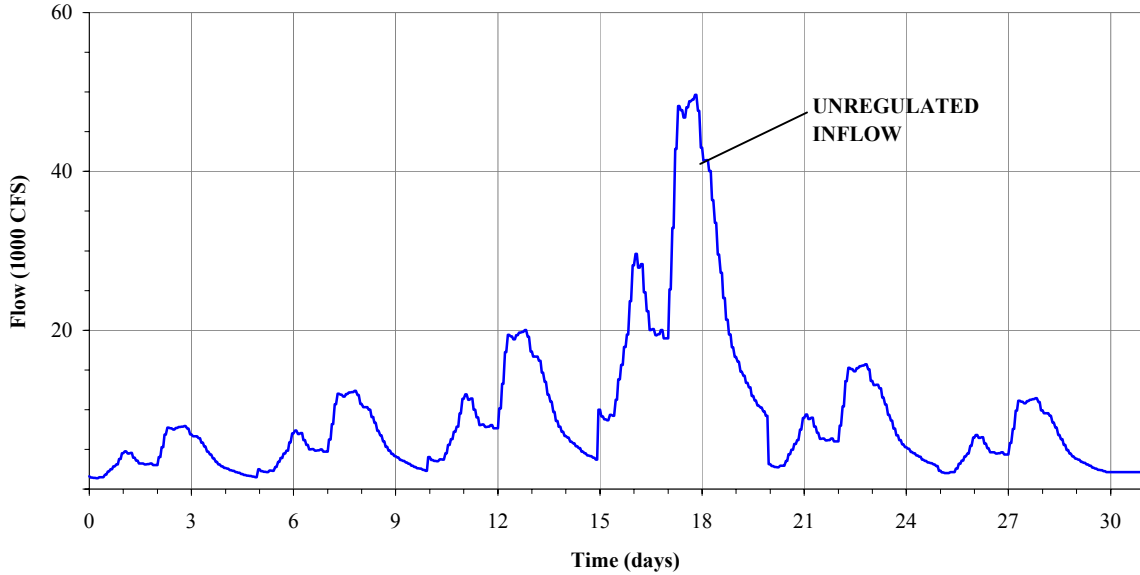
Bullards Bar Operations (50% Chance Exceedence Event)



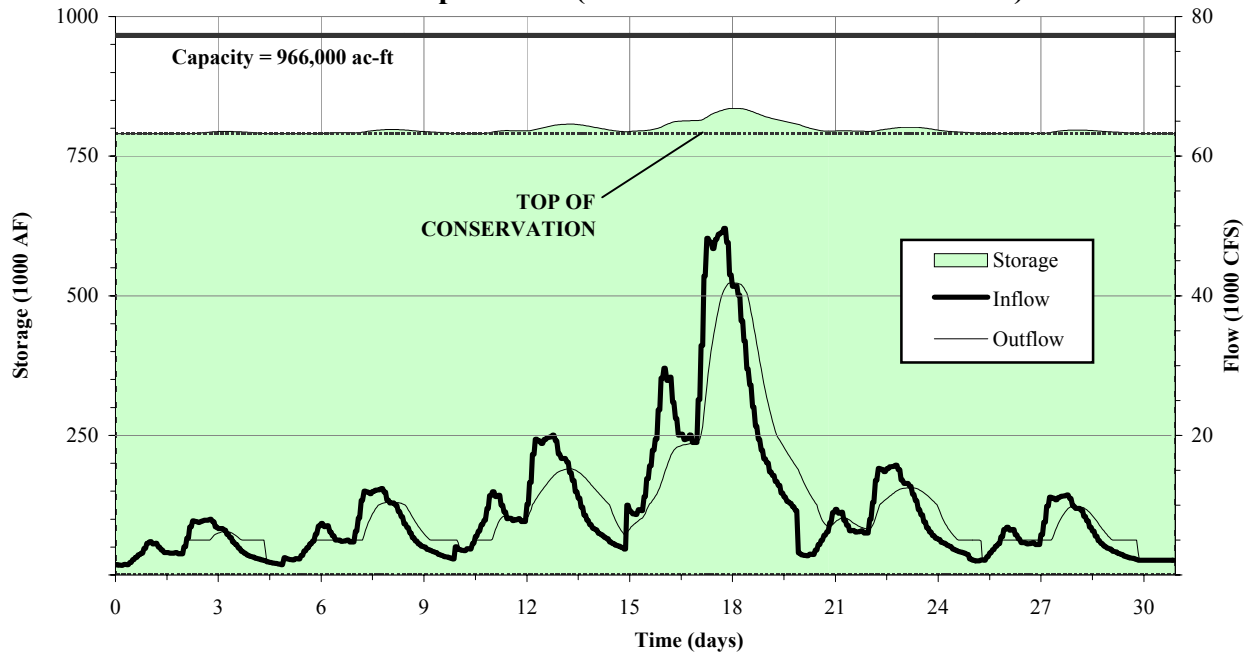
Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-4a Reservoir Simulation Hydrographs Bullards Bar (50% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

NORTH YUBA RIVER
Bullards Bar Inflow (10% Chance Exceedence Event)
 Unregulated Inflow

Note: This reservoir has no major headwater reservoirs.



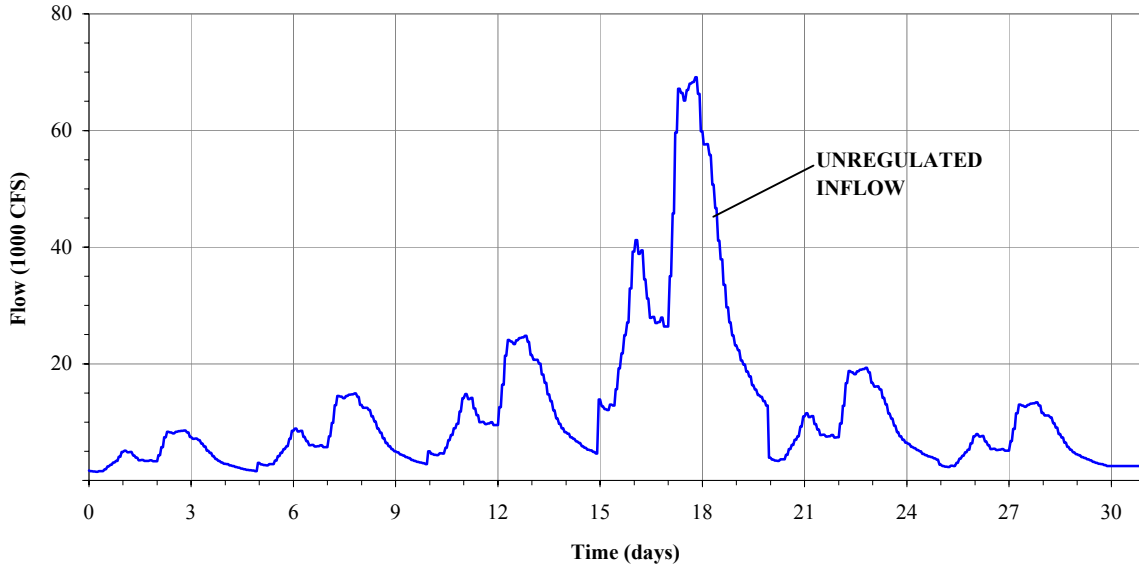
Bullards Bar Operations (10% Chance Exceedence Event)



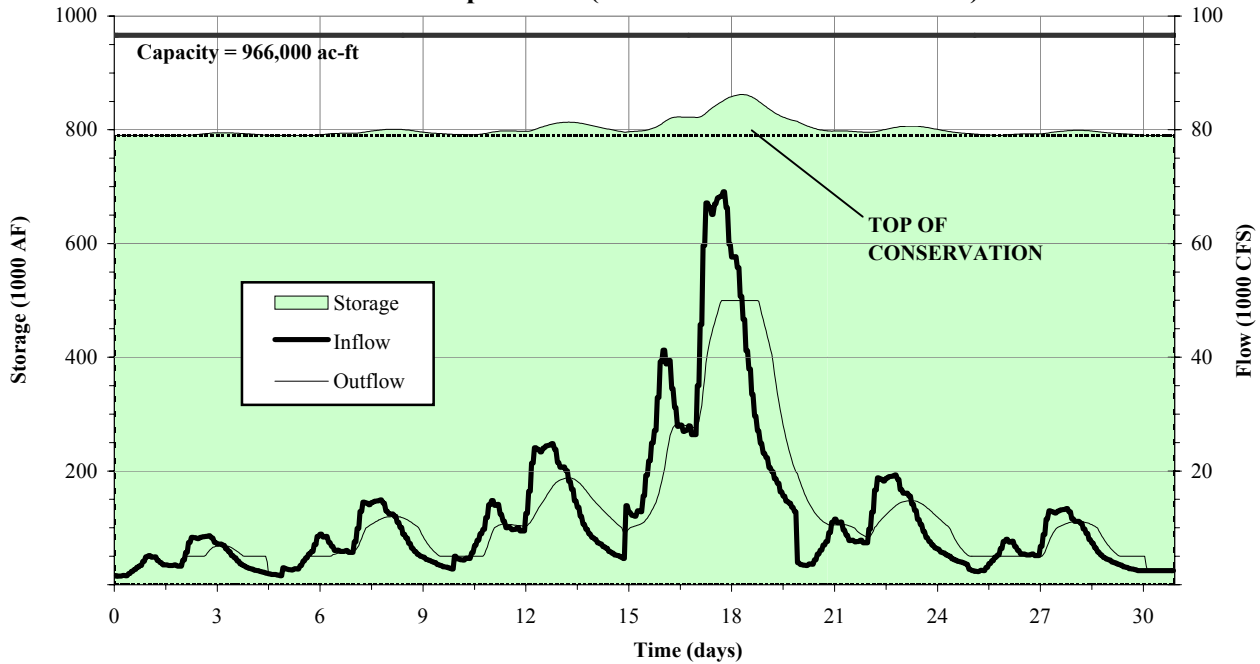
Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-4b Reservoir Simulation Hydrographs Bullards Bar (10% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

NORTH YUBA RIVER
Bullards Bar Inflow (4% Chance Exceedence Event)
 Unregulated Inflow

Note: This reservoir has no major headwater reservoirs.



Bullards Bar Operations (4% Chance Exceedence Event)

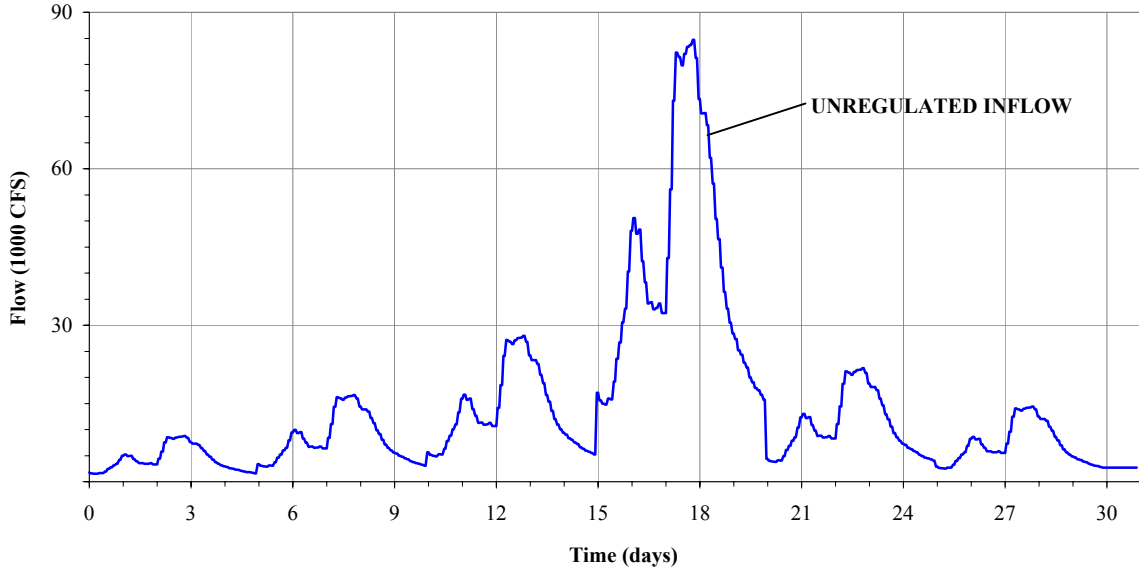


Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-4c Reservoir Simulation Hydrographs Bullards Bar (4% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

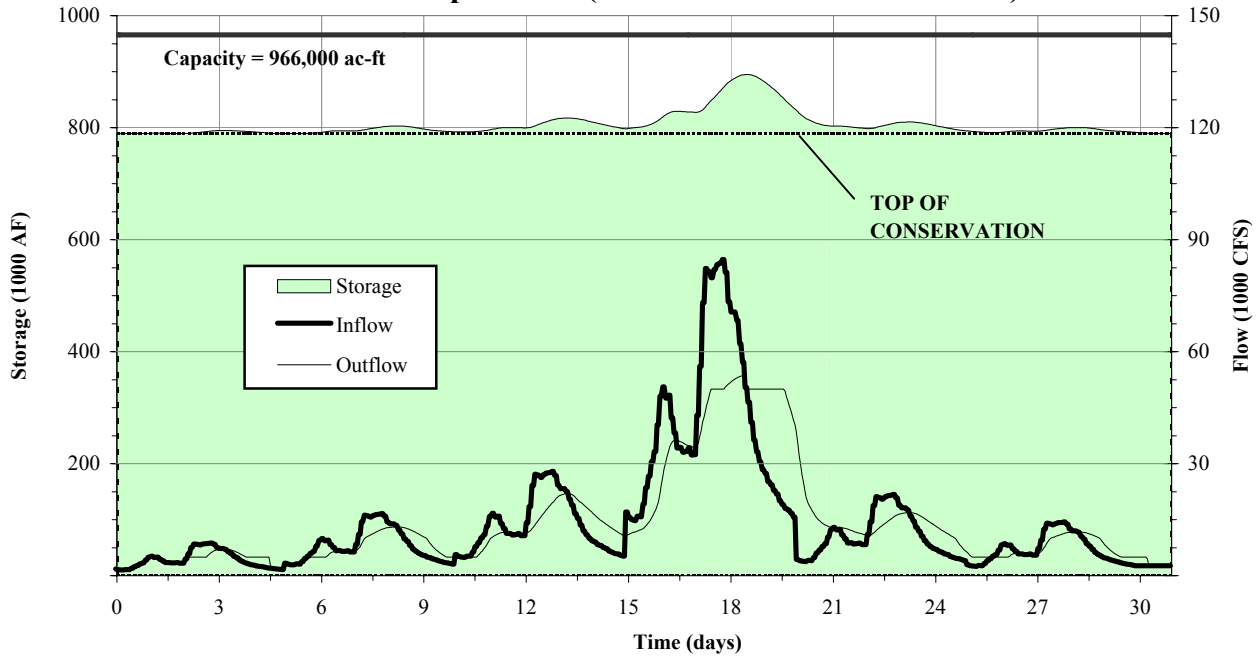
NORTH YUBA RIVER Bullards Bar Inflow (2% Chance Exceedence Event)

Unregulated Inflow

Note: This reservoir has no major headwater reservoirs.



Bullards Bar Operations (2% Chance Exceedence Event)

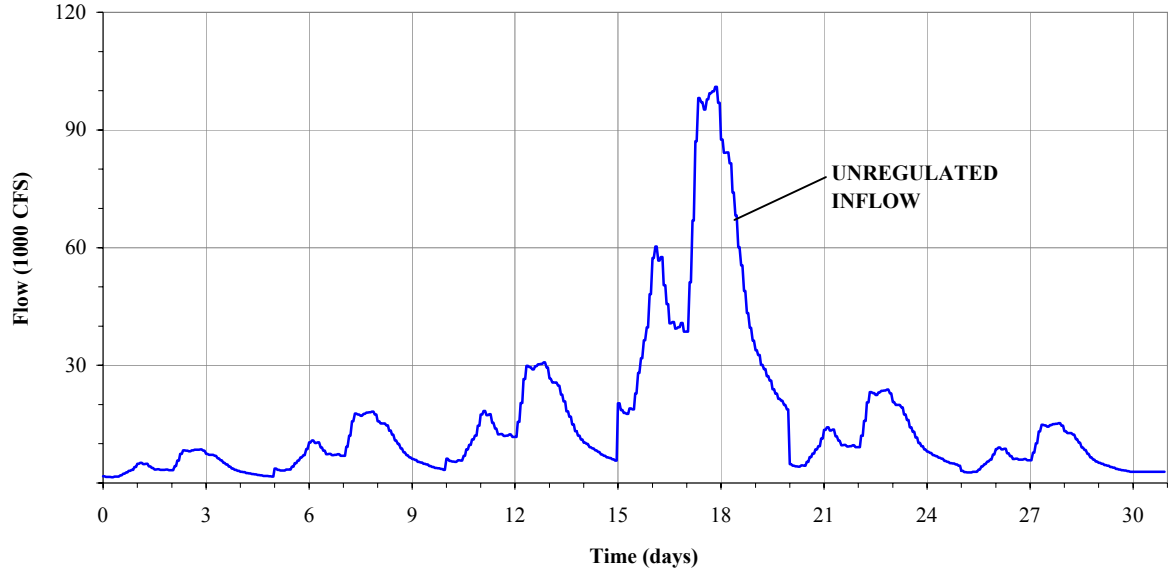


Sacramento & San Joaquin River Basins Comprehensive Study	
Figure C.1-4d Reservoir Simulation Hydrographs Bullards Bar (2% Chance Exceedence Event)	
US Army Corps of Engineers The Reclamation Board, State of California December 2002	

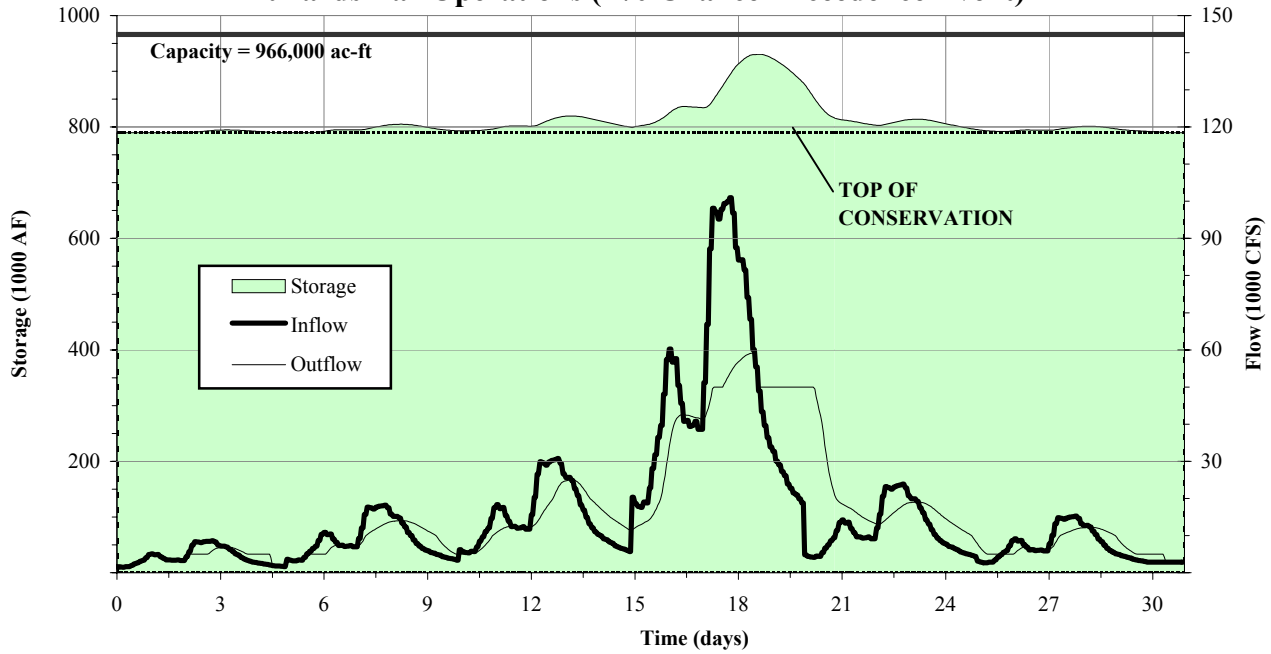
NORTH YUBA RIVER
Bullards Bar Inflow (1% Chance Exceedence Event)

Unregulated Inflow

Note: This reservoir has no major headwater reservoirs.



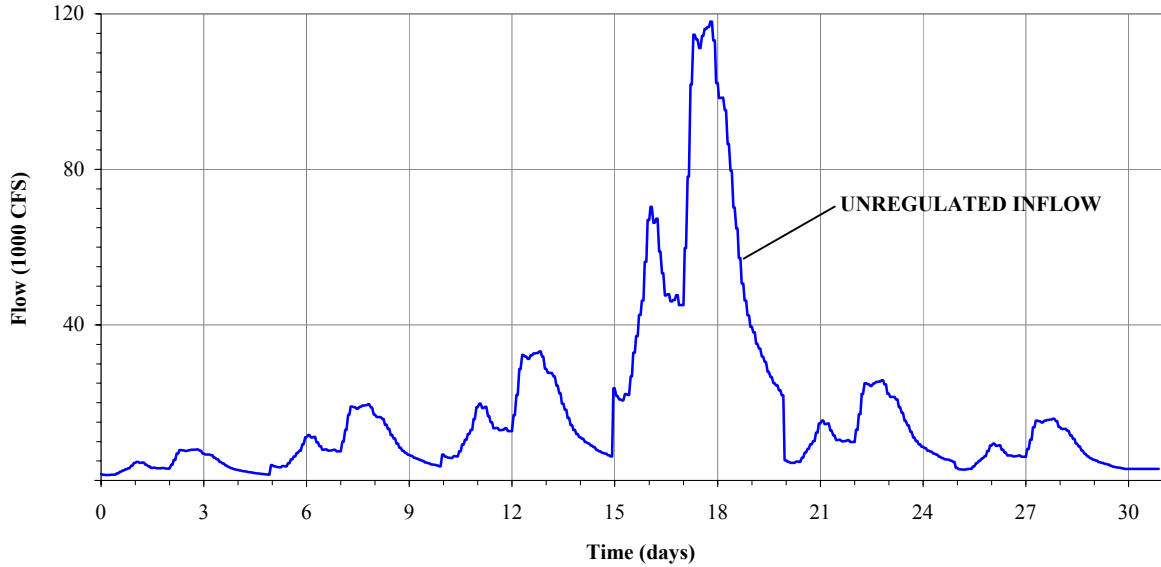
Bullards Bar Operations (1% Chance Exceedence Event)



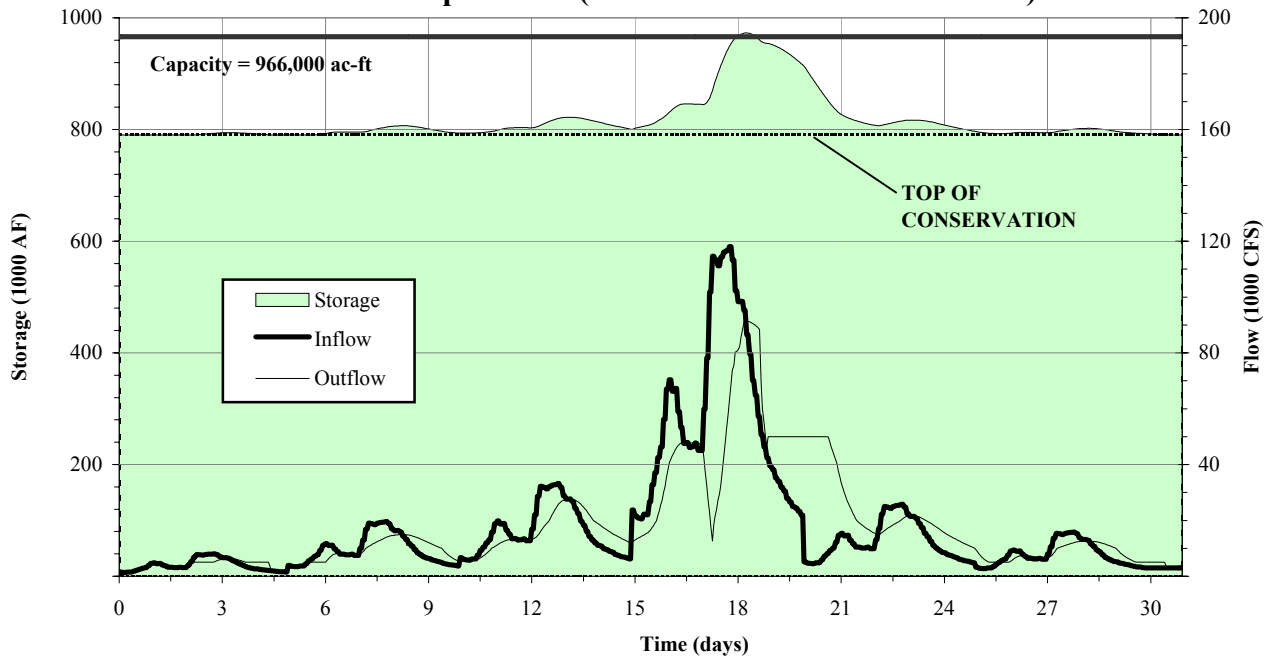
Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-4e Reservoir Simulation Hydrographs Bullards Bar (1% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

NORTH YUBA RIVER
Bullards Bar Inflow (0.5% Chance Exceedence Event)
 Unregulated Inflow

Note: This reservoir has no major headwater reservoirs.



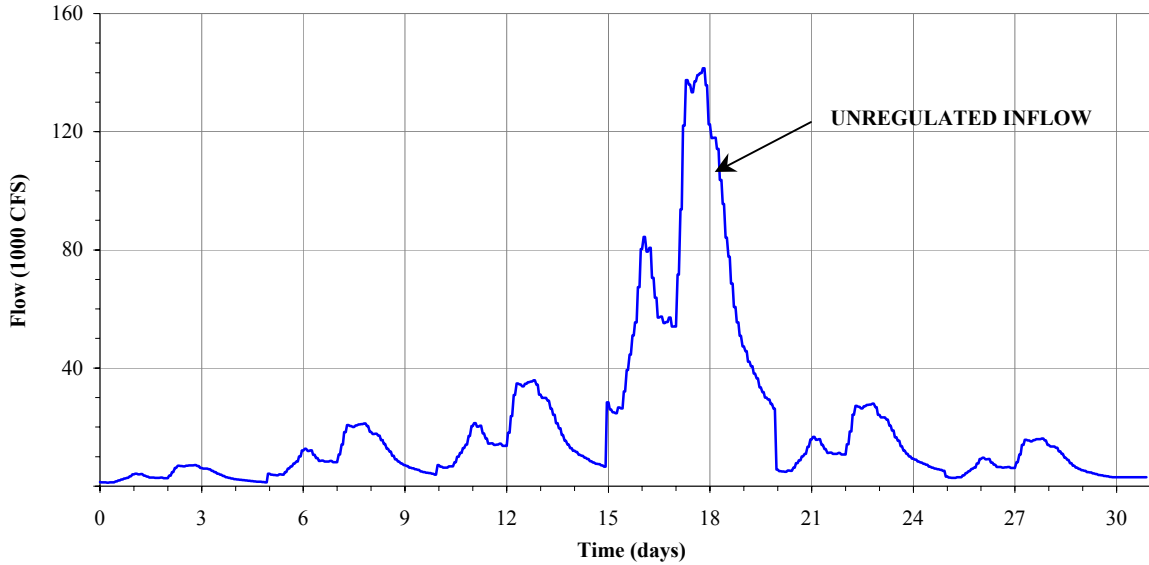
Bullards Bar Operations (0.5% Chance Exceedence Event)



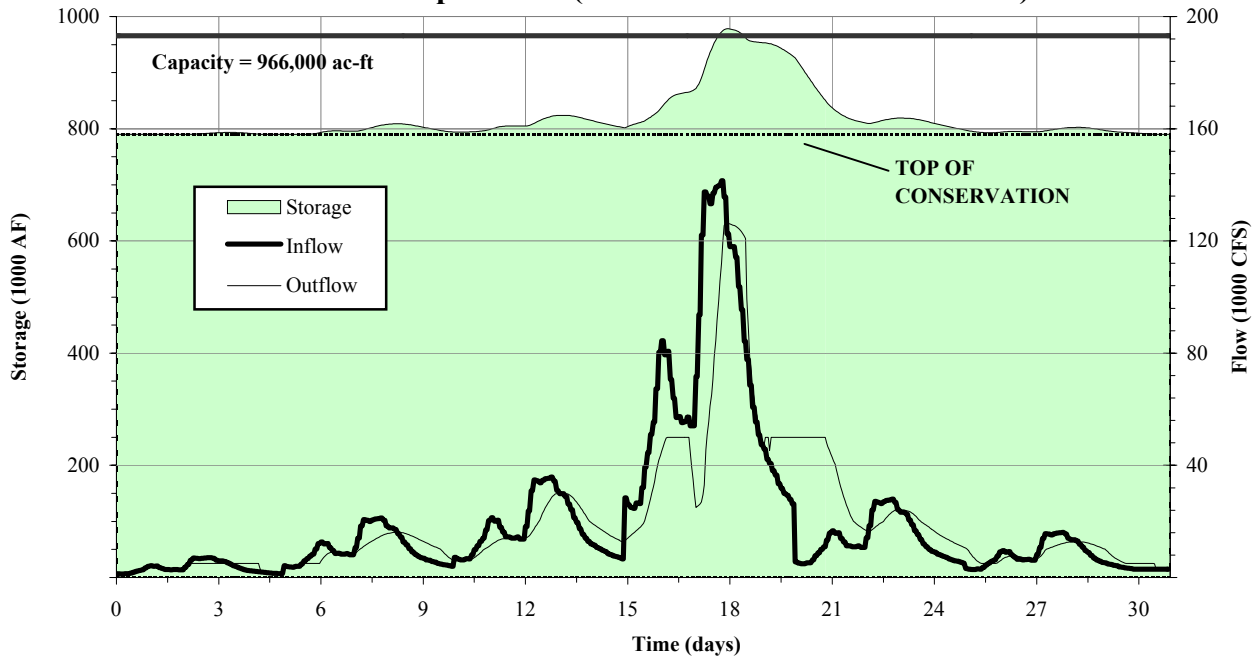
Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-4f Reservoir Simulation Hydrographs Bullards Bar (0.5% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

NORTH YUBA RIVER
Bullards Bar Inflow (0.2% Chance Exceedence Event)
 Unregulated Inflow

Note: This reservoir has no major headwater reservoirs.



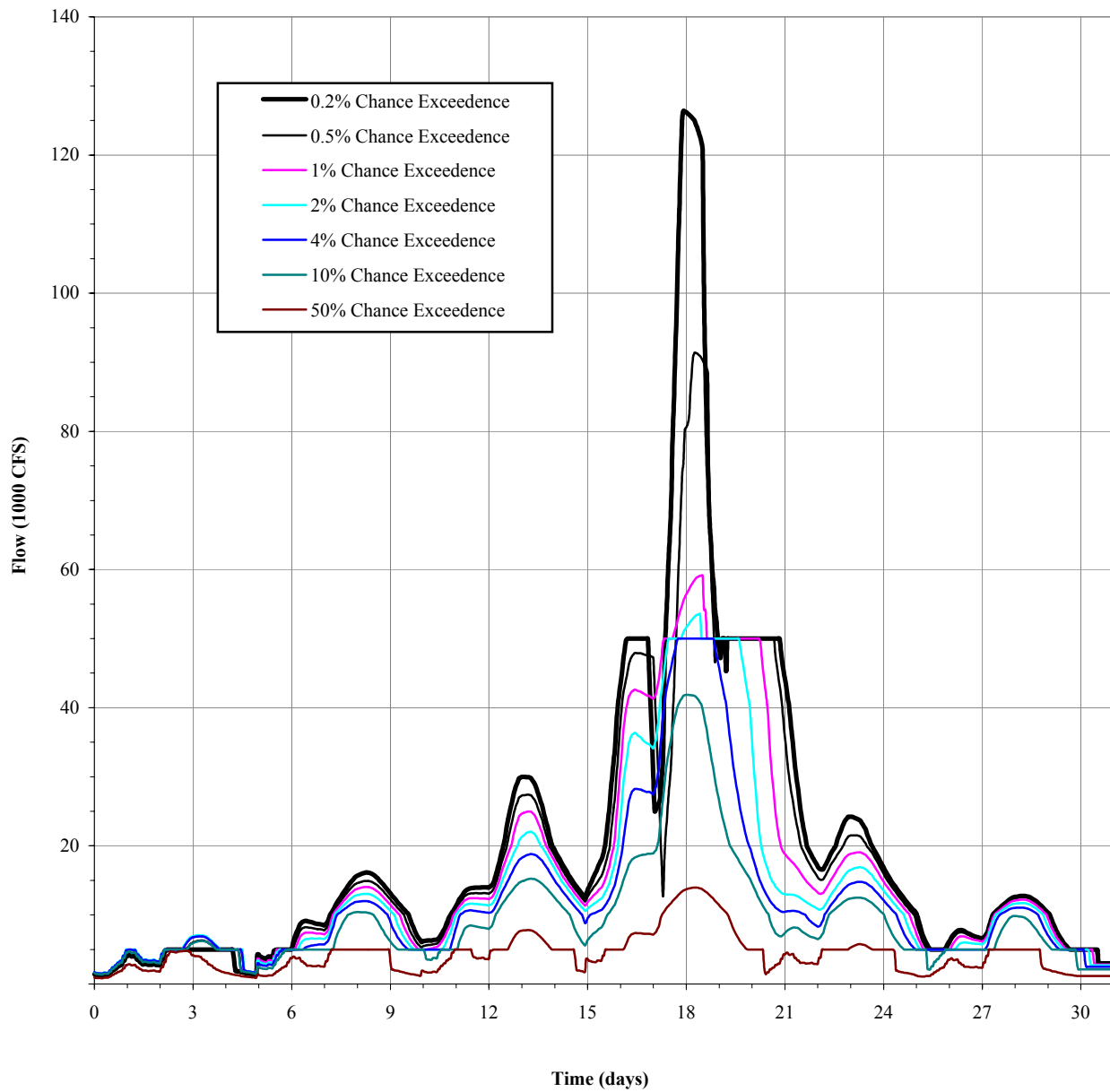
Bullards Bar Operations (0.2% Chance Exceedence Event)



Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-4g Reservoir Simulation Hydrographs Bullards Bar (0.2% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

BULLARDS BAR OUTFLOW

Regulated Outflow Hydrographs



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Comprehensive Study

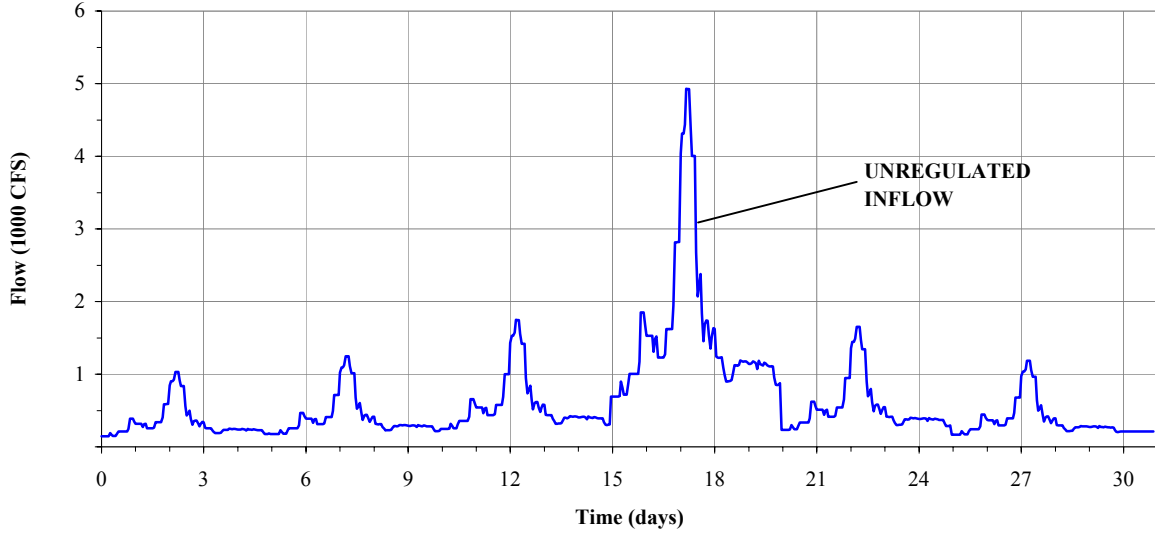
Figure C.1-4h
Reservoir Simulation Hydrographs
Regulated Outflow - Bullards Bar

US Army Corps of Engineers
The Reclamation Board, State of California December 2002

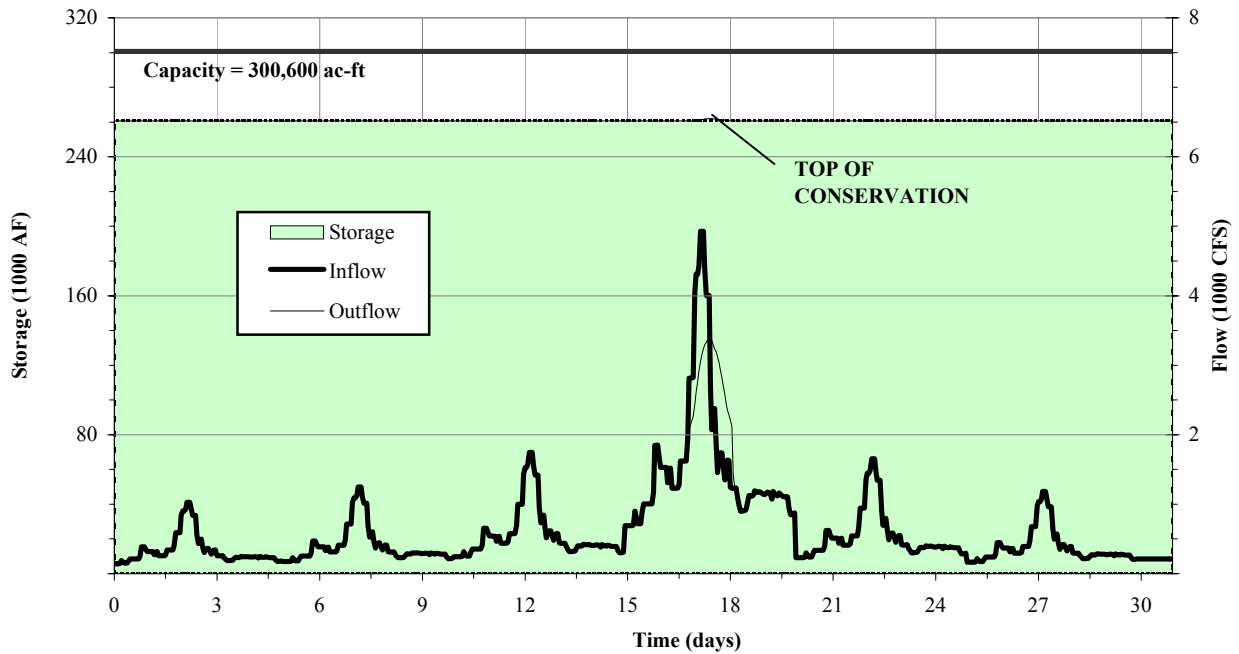
NORTH FORK CACHE CREEK
Indian Valley Inflow (50% Chance Exceedence Event)

Unregulated Inflow

Note: This reservoir has no major headwater reservoirs.



Indian Valley Operations (50% Chance Exceedence Event)

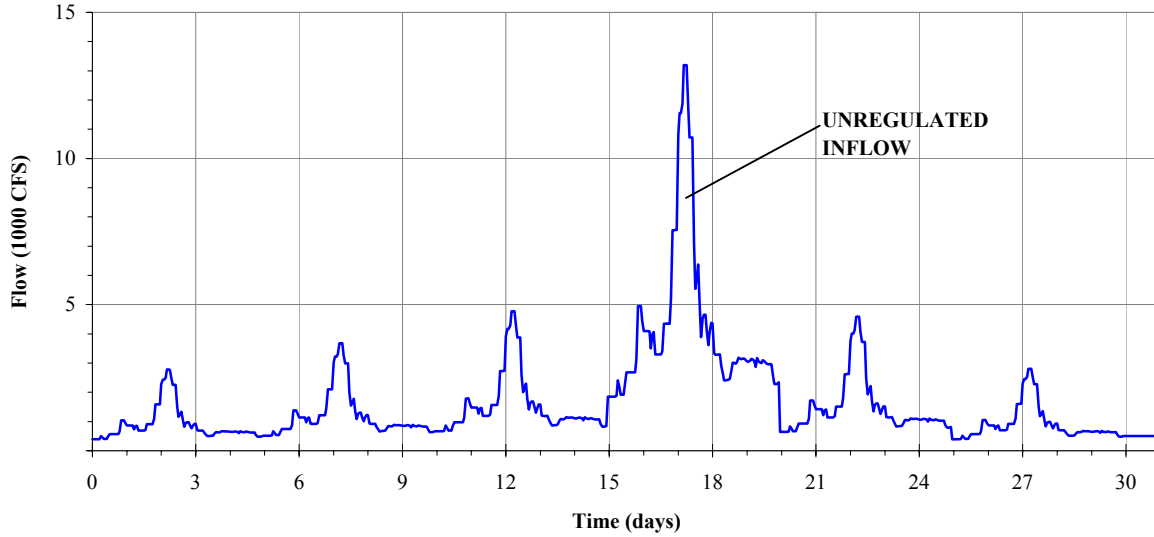


Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-5a Reservoir Simulation Hydrographs Indian Valley (50% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

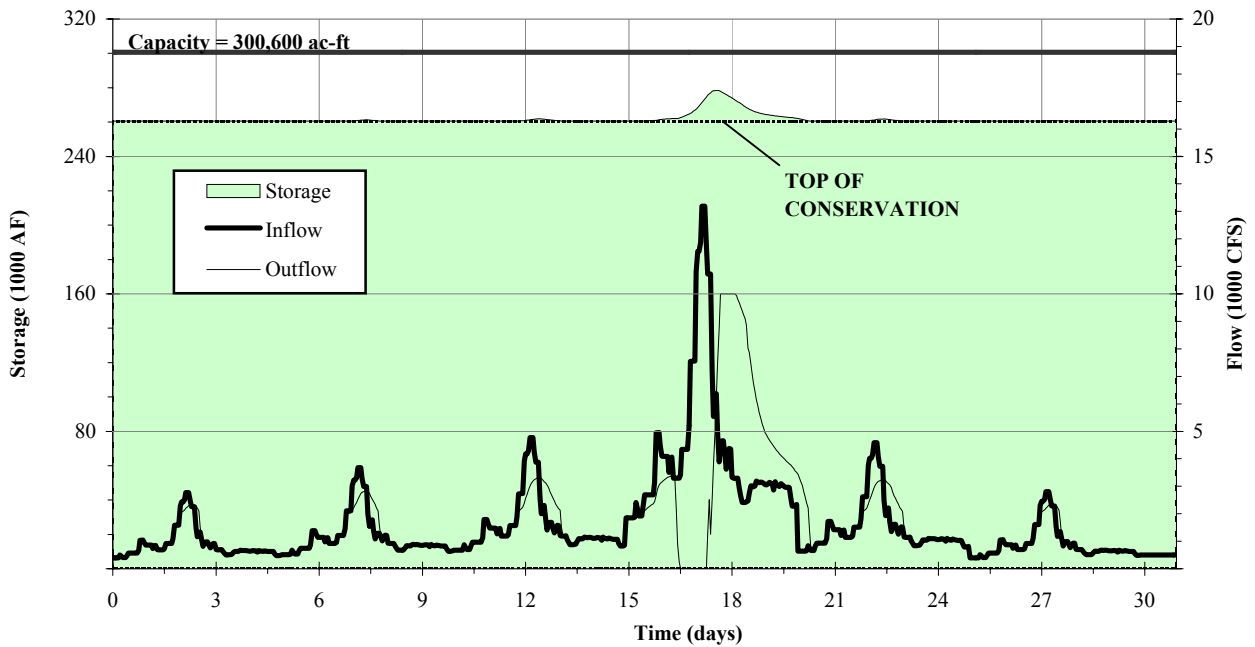
NORTH FORK CACHE CREEK
Indian Valley Inflow (10% Chance Exceedence Event)

Unregulated Inflow

Note: This reservoir has no major headwater reservoirs.



Indian Valley Operations (10% Chance Exceedence Event)

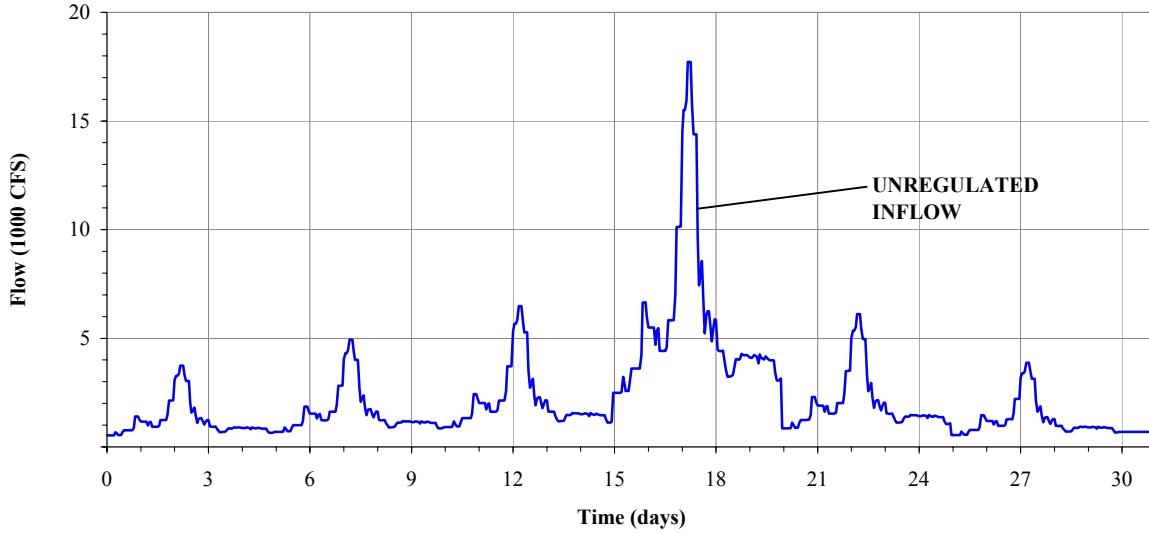


Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-5b Reservoir Simulation Hydrographs Indian Valley (10% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

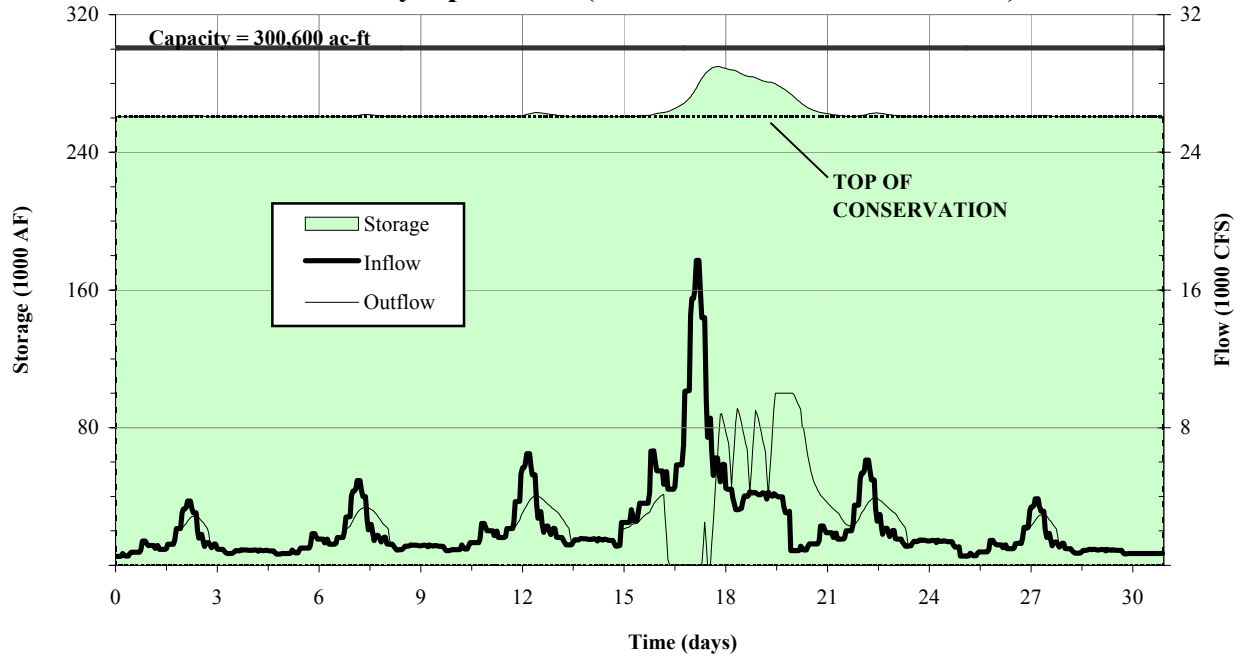
**NORTH FORK CACHE CREEK
Indian Valley Inflow (4% Chance Exceedence Event)**

Unregulated Inflow

Note: This reservoir has no major headwater reservoirs.



Indian Valley Operations (4% Chance Exceedence Event)

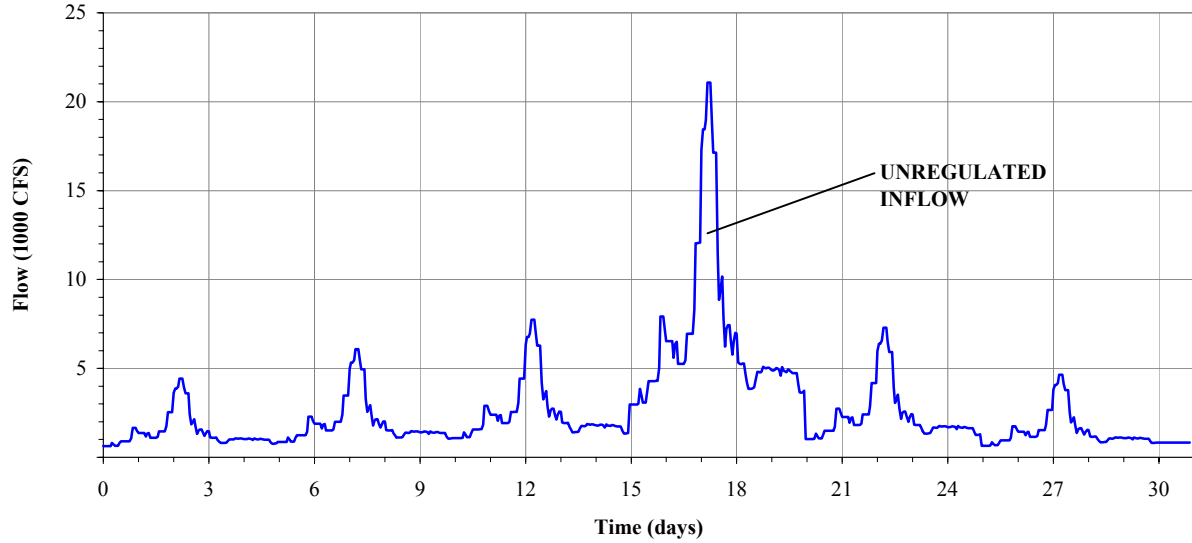


Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-5c Reservoir Simulation Hydrographs Indian Valley (4% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

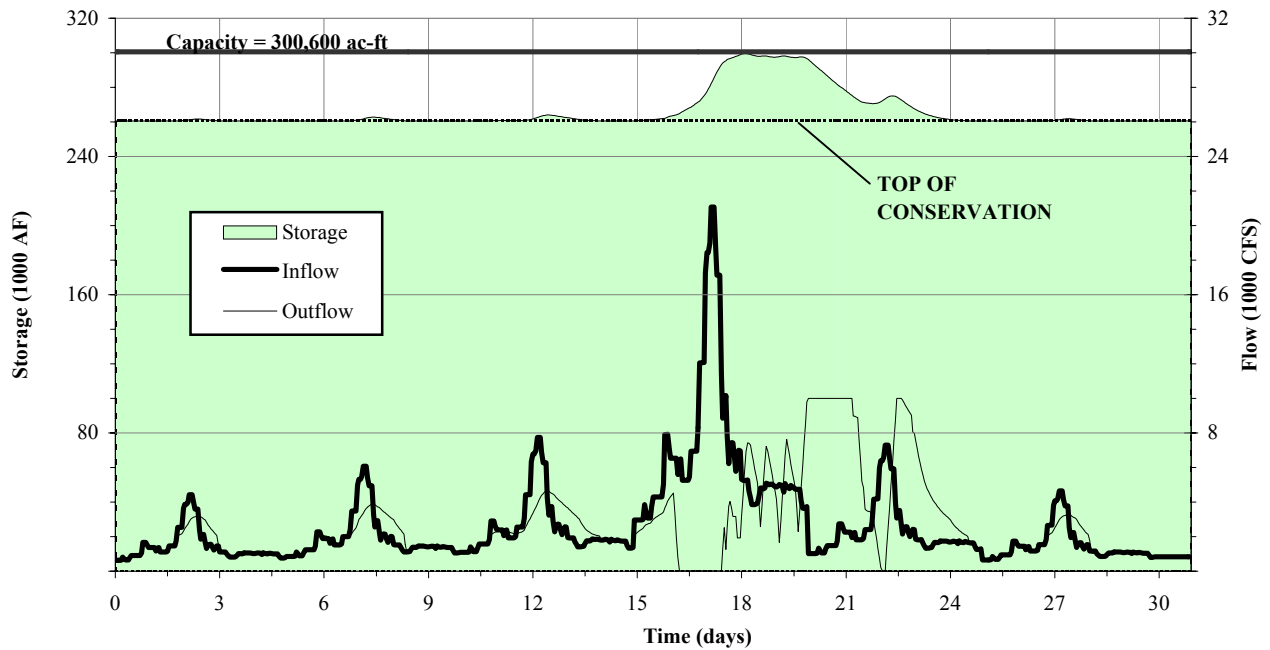
**NORTH FORK CACHE CREEK
Indian Valley Inflow (2% Chance Exceedence Event)**

Unregulated Inflow

Note: This reservoir has no major headwater reservoirs.



Indian Valley Operations (2% Chance Exceedence Event)



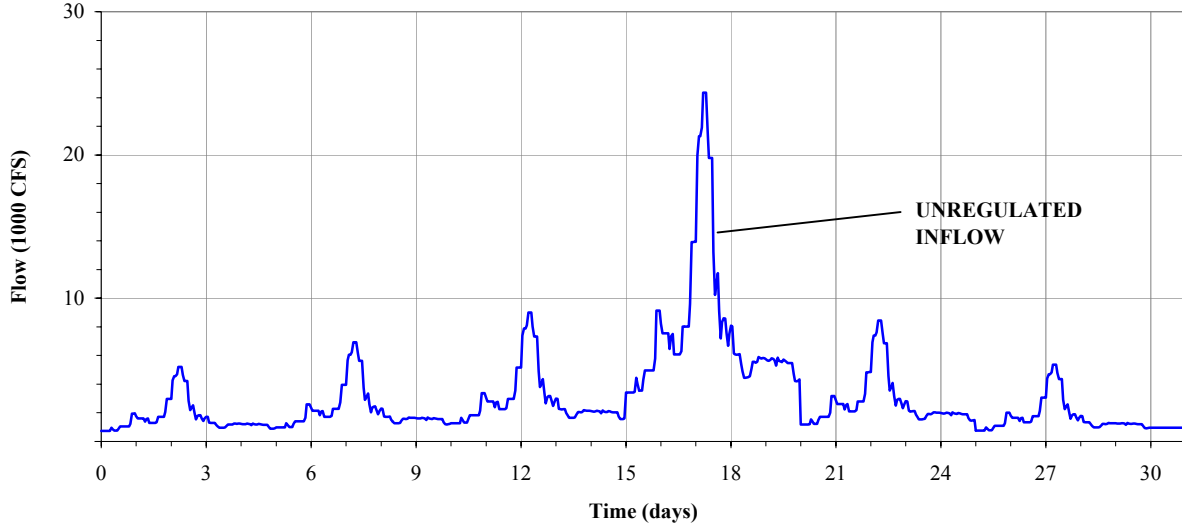
Sacramento & San Joaquin River Basins Comprehensive Study	
Figure C.1-5d Reservoir Simulation Hydrographs Indian Valley (2% Chance Exceedence Event)	
US Army Corps of Engineers The Reclamation Board, State of California	December 2002

NORTH FORK CACHE CREEK

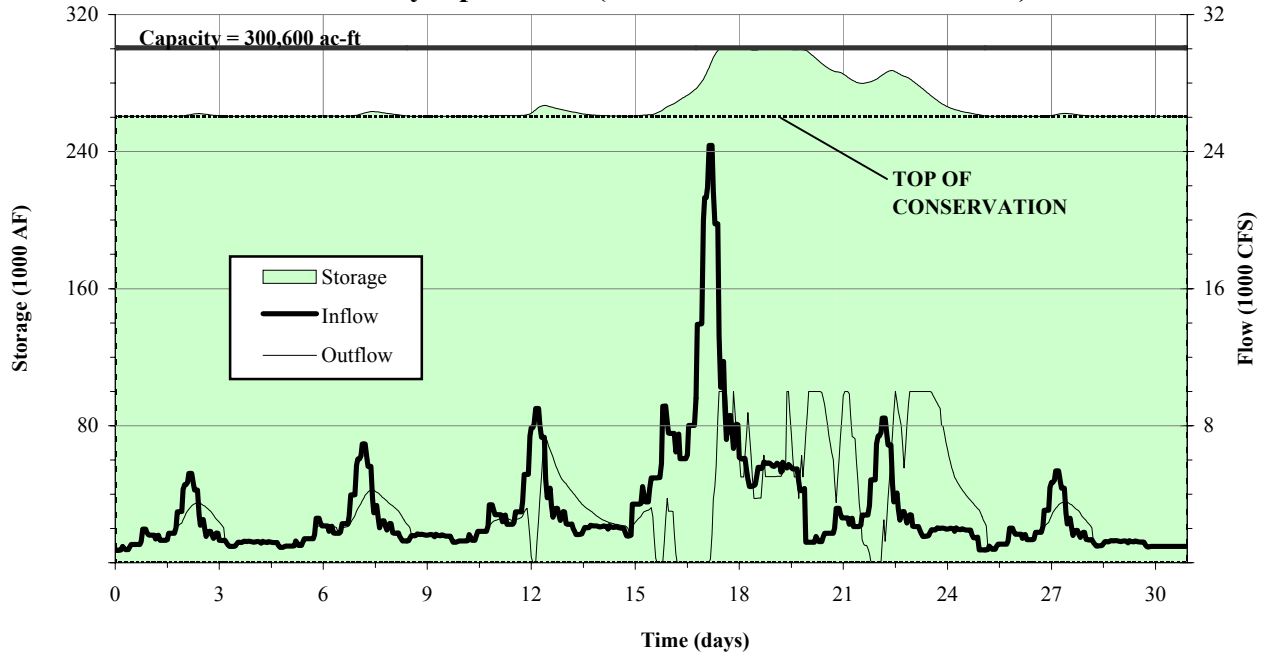
Indian Valley Inflow (1% Chance Exceedence Event)

Unregulated Inflow

Note: This reservoir has no major headwater reservoirs.



Indian Valley Operations (1% Chance Exceedence Event)



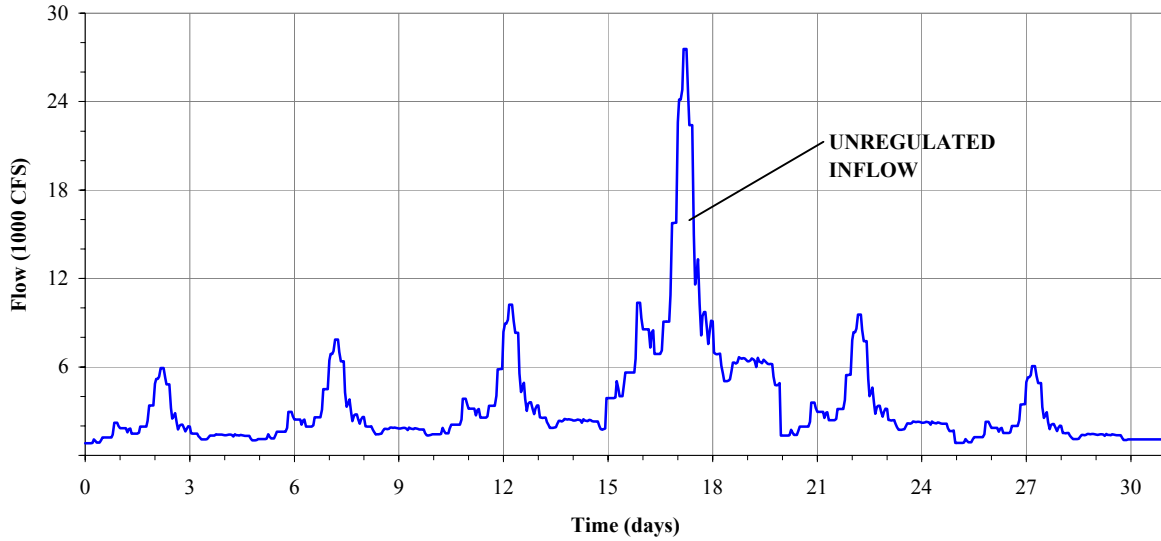
Sacramento & San Joaquin River Basins Comprehensive Study	
Figure C.1-5e Reservoir Simulation Hydrographs Indian Valley (1% Chance Exceedence Event)	
US Army Corps of Engineers The Reclamation Board, State of California December 2002	

NORTH FORK CACHE CREEK

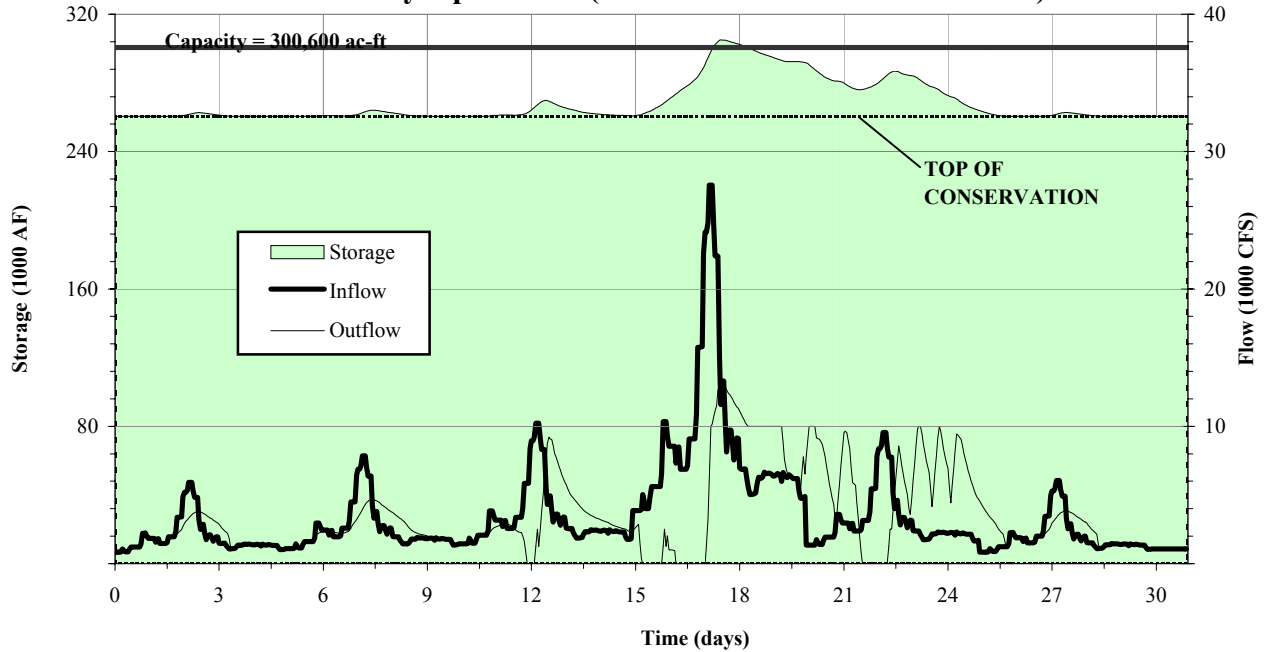
Indian Valley Inflow (0.5% Chance Exceedence Event)

Unregulated Inflow

Note: This reservoir has no major headwater reservoirs.

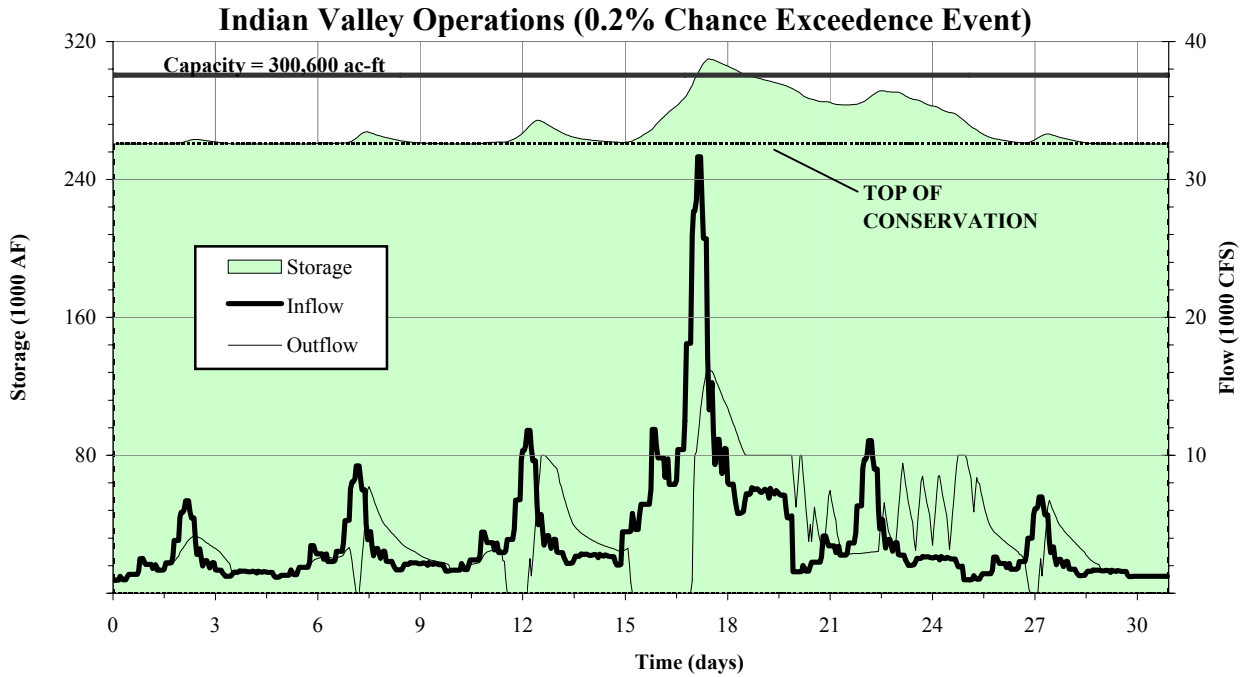
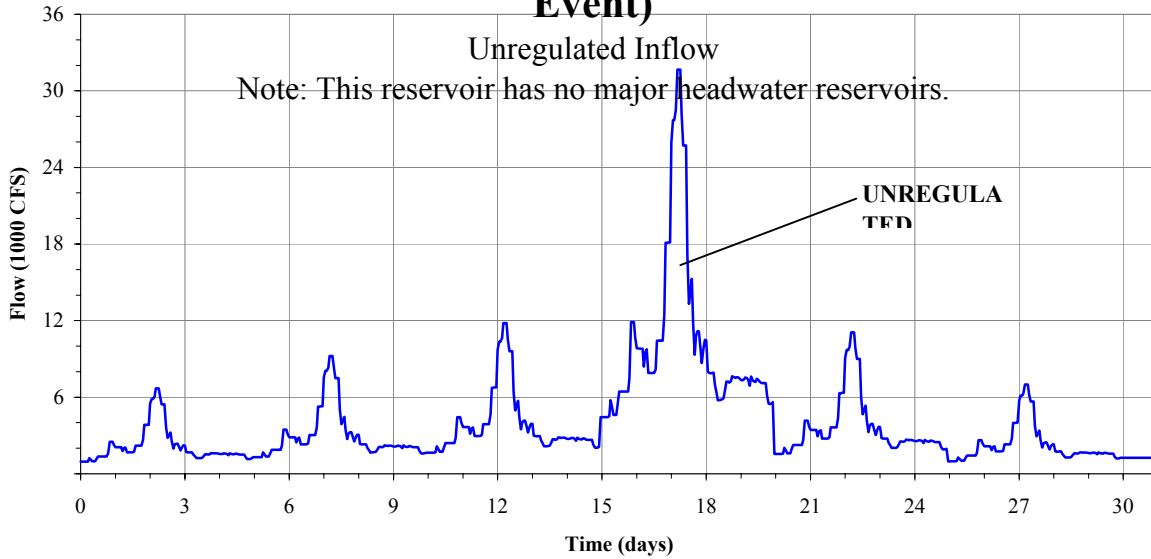


Indian Valley Operations (0.5% Chance Exceedence Event)



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Figure C.1-5f Reservoir Simulation Hydrographs Indian Valley (0.5% Chance Exceedence Event)	
US Army Corps of Engineers The Reclamation Board, State of California December 2002	

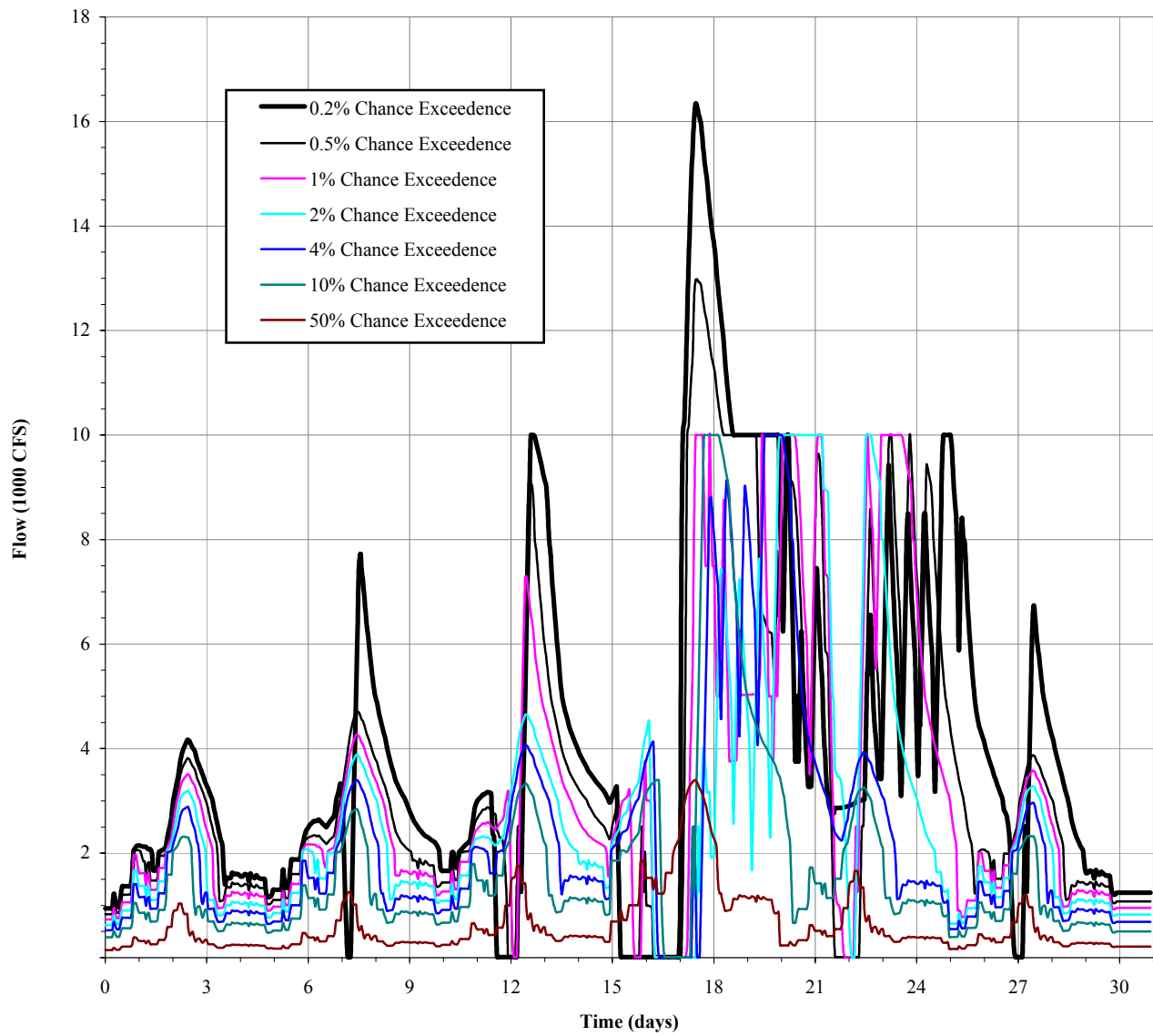
NORTH FORK CACHE CREEK Indian Valley Inflow (0.2% Chance Exceedence Event)



Sacramento & San Joaquin River Basins Comprehensive Study	
Figure C.1-5g Reservoir Simulation Hydrographs Indian Valley (0.2% Chance Exceedence Event)	
US Army Corps of Engineers The Reclamation Board, State of California December 2002	

INDIAN VALLEY OUTFLOW

Regulated Outflow Hydrographs

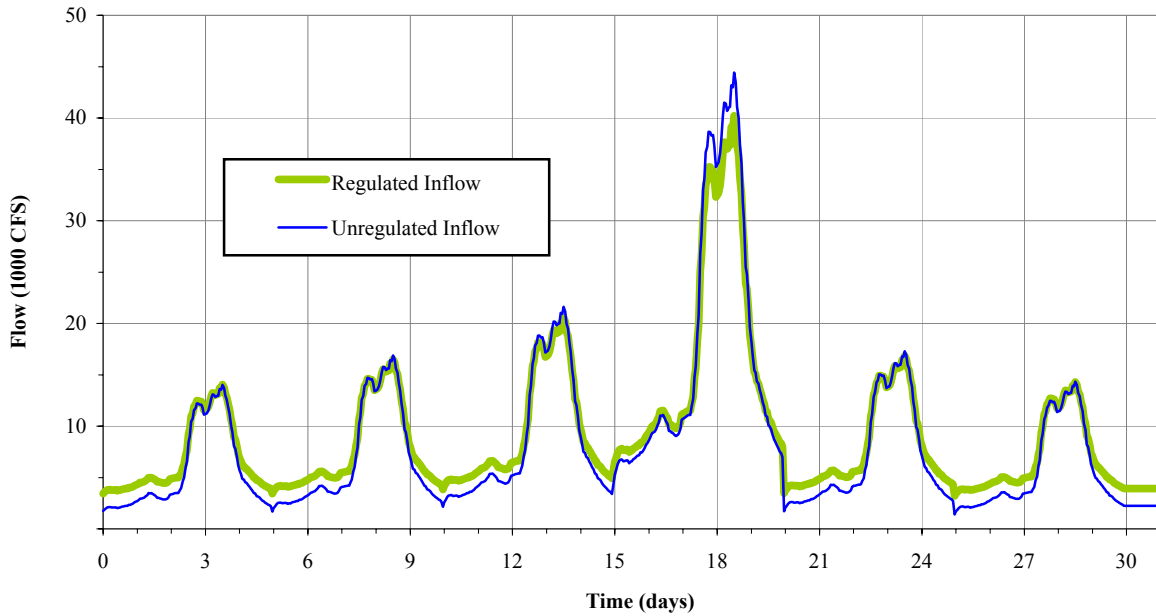


Sacramento & San Joaquin River Basins
Comprehensive Study

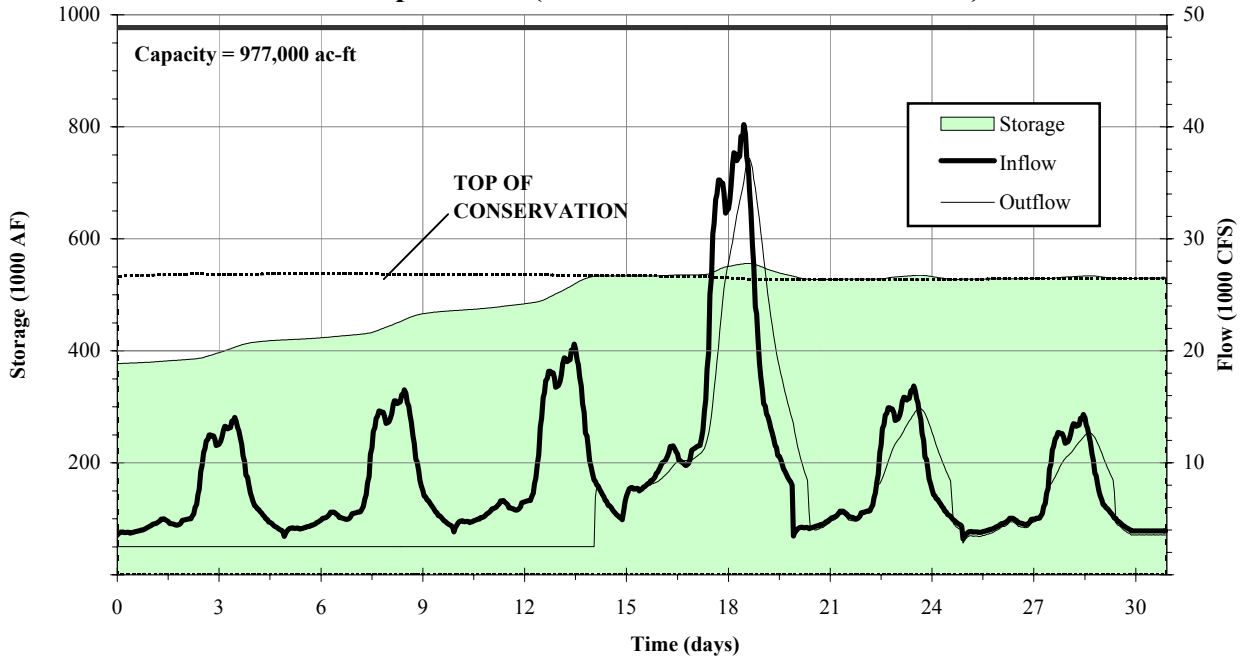
Figure C.1-5h
Reservoir Simulation Hydrographs
Regulated Outflow - Indian Valley

US Army Corps of Engineers
The Reclamation Board, State of California December 2002

AMERICAN RIVER
Folsom Inflow (50% Chance Exceedence Event)
 Regulated and Unregulated Inflow

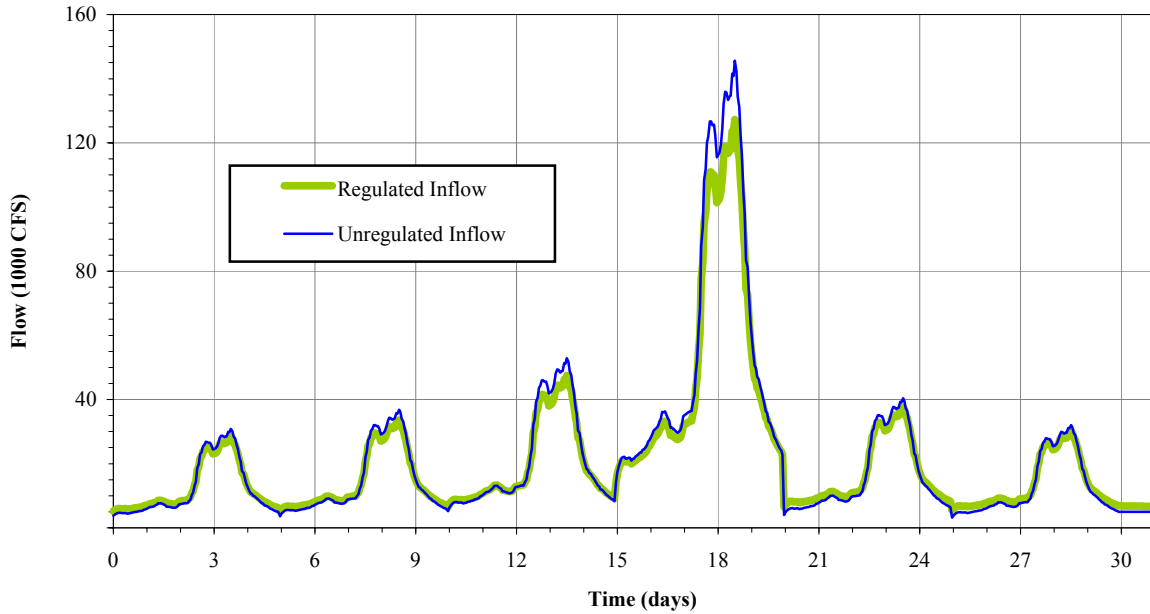


Folsom Operations (50% Chance Exceedence Event)

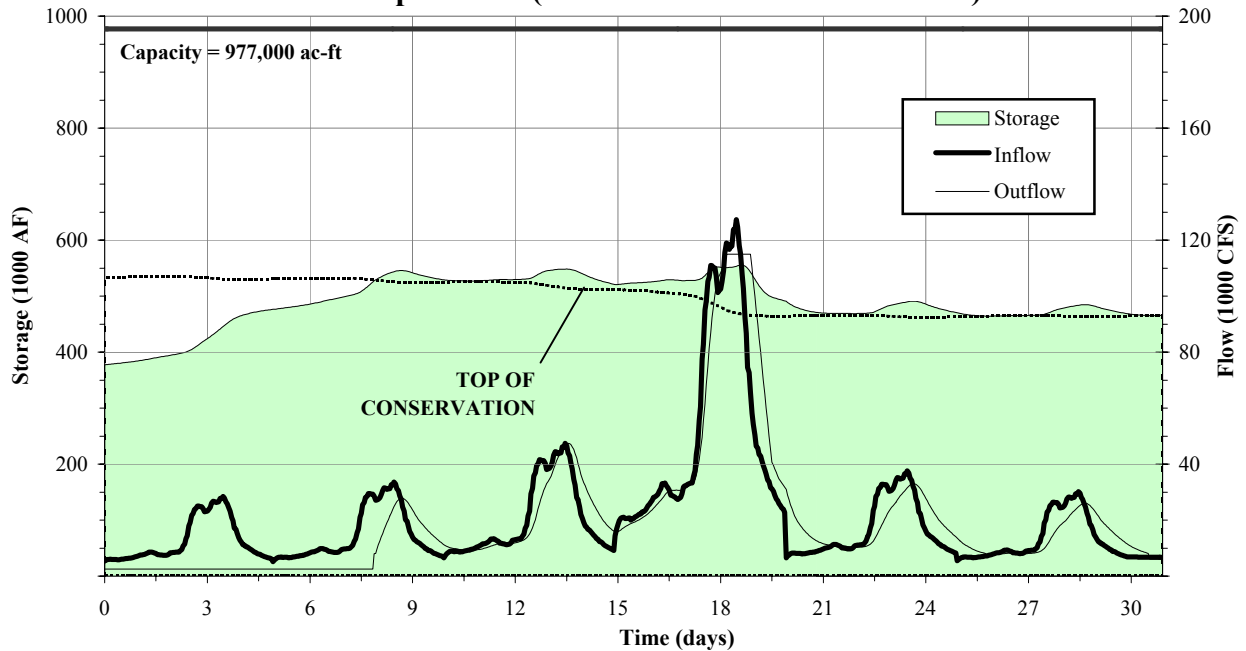


Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-6a Reservoir Simulation Hydrographs Folsom (50% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

AMERICAN RIVER
Folsom Inflow (10% Chance Exceedence Event)
 Regulated and Unregulated Inflow

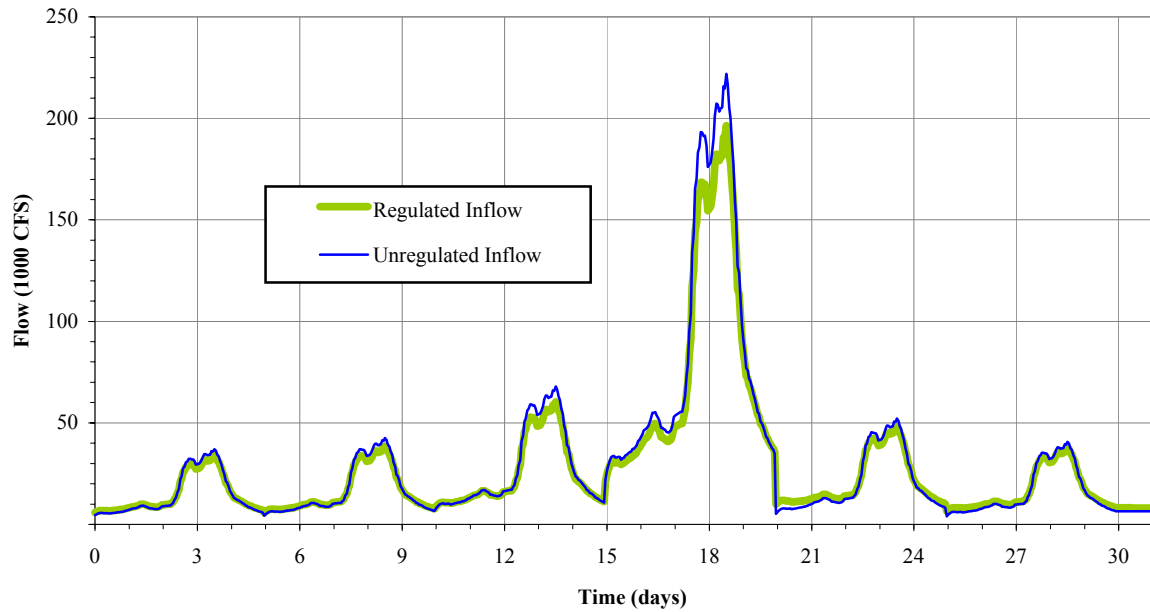


Folsom Operations (10% Chance Exceedence Event)

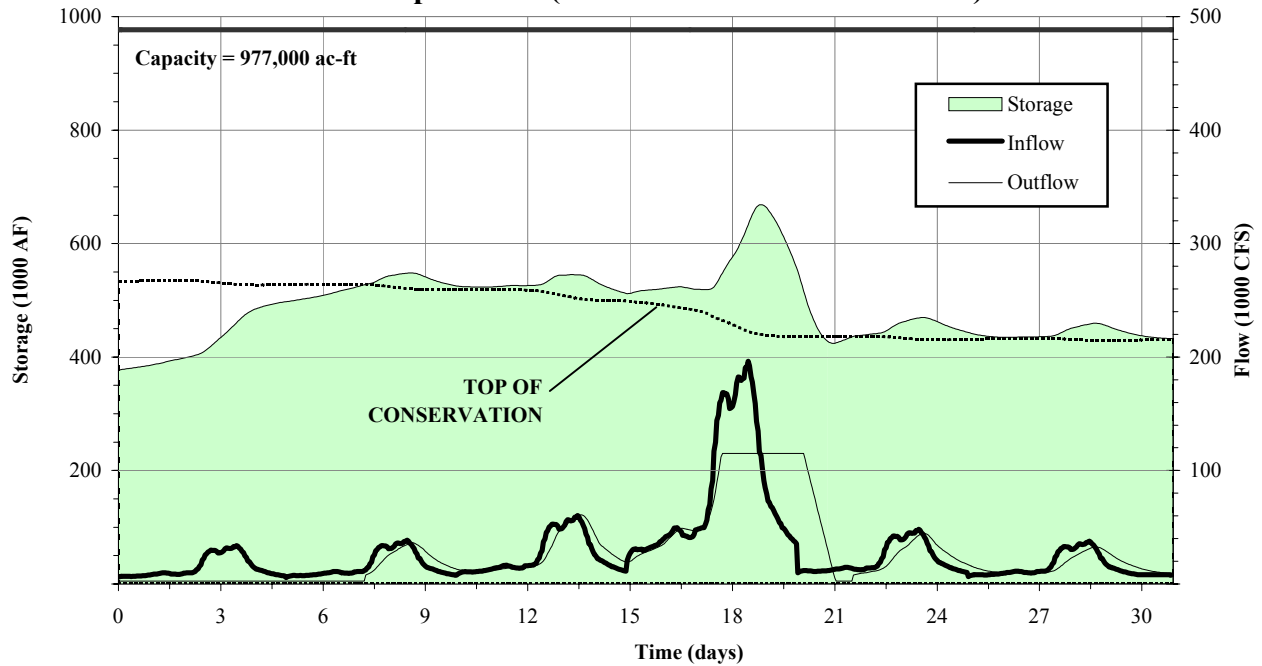


Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-6b Reservoir Simulation Hydrographs Folsom (10% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

AMERICAN RIVER
Folsom Inflow (4% Chance Exceedence Event)
 Regulated and Unregulated Inflow

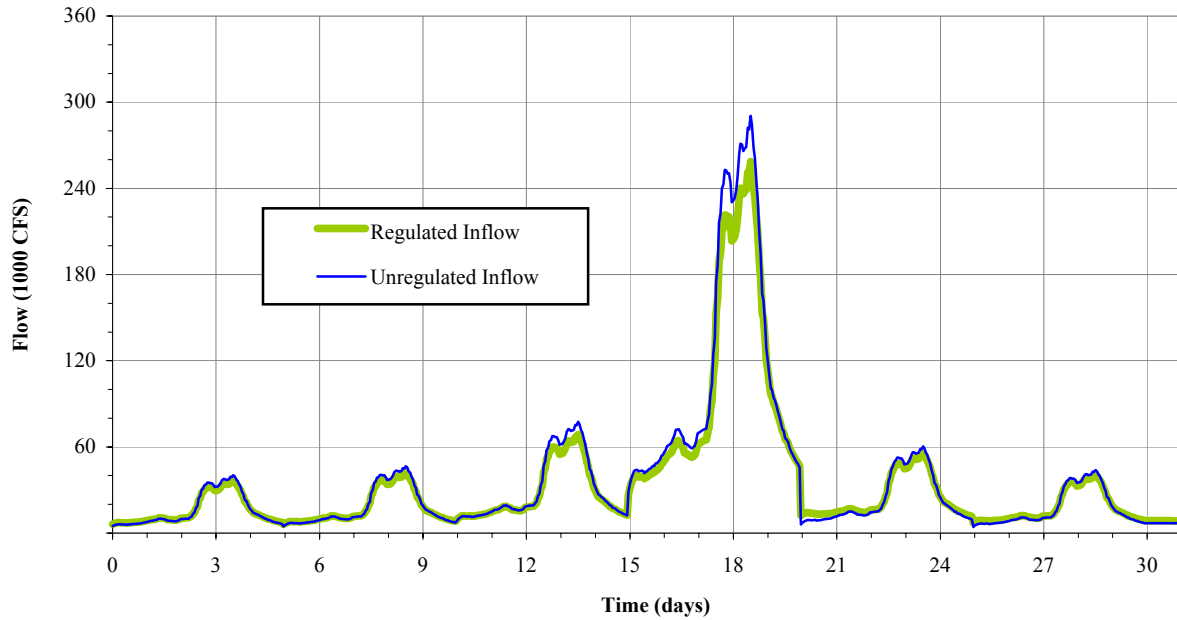


Folsom Operations (4% Chance Exceedence Event)

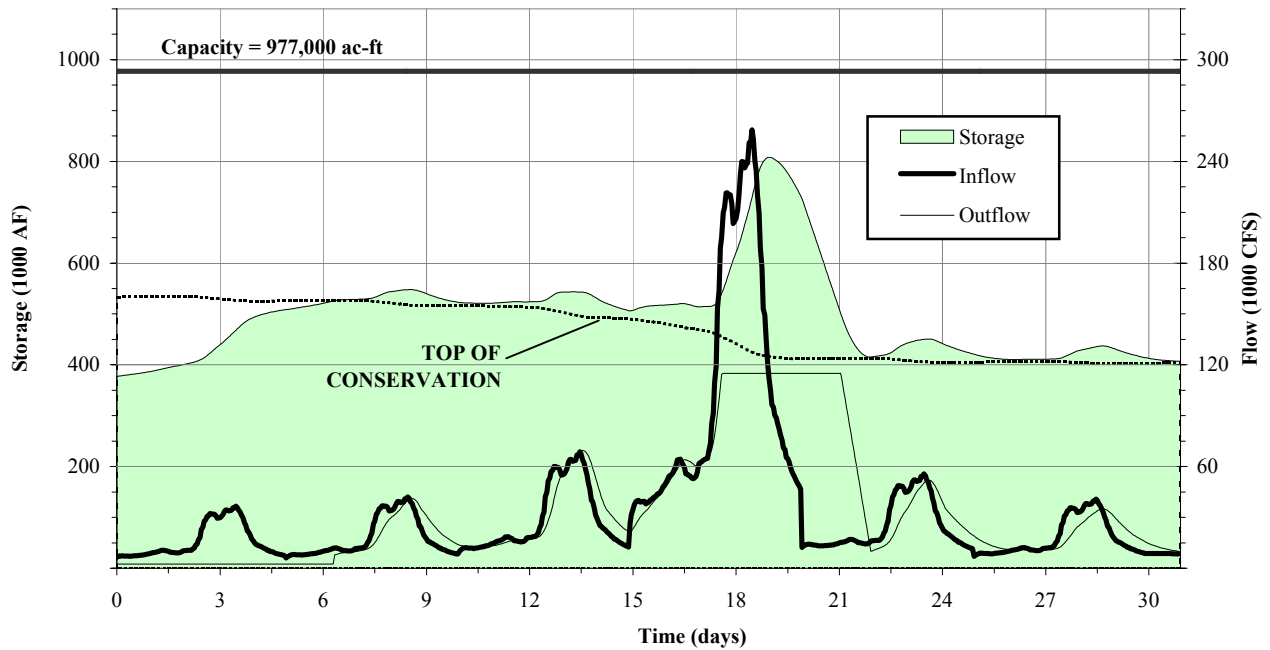


Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-6c Reservoir Simulation Hydrographs Folsom (4% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

AMERICAN RIVER
Folsom Inflow (2% Chance Exceedence Event)
 Regulated and Unregulated Inflow



Folsom Operations (2% Chance Exceedence Event)

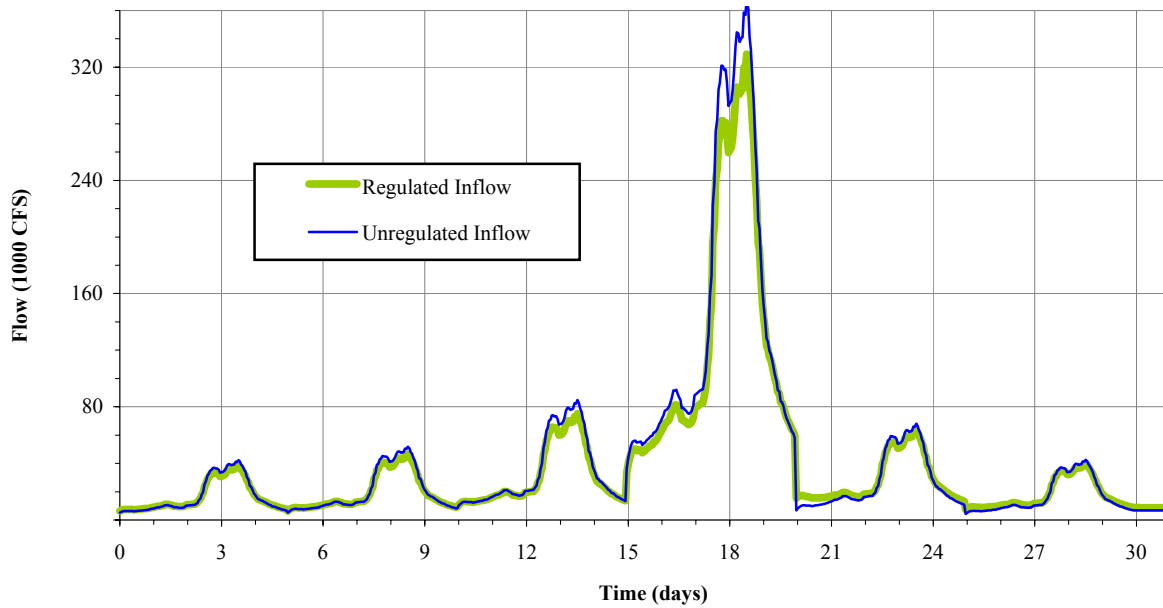


Sacramento & San Joaquin River Basins
 Comprehensive Study

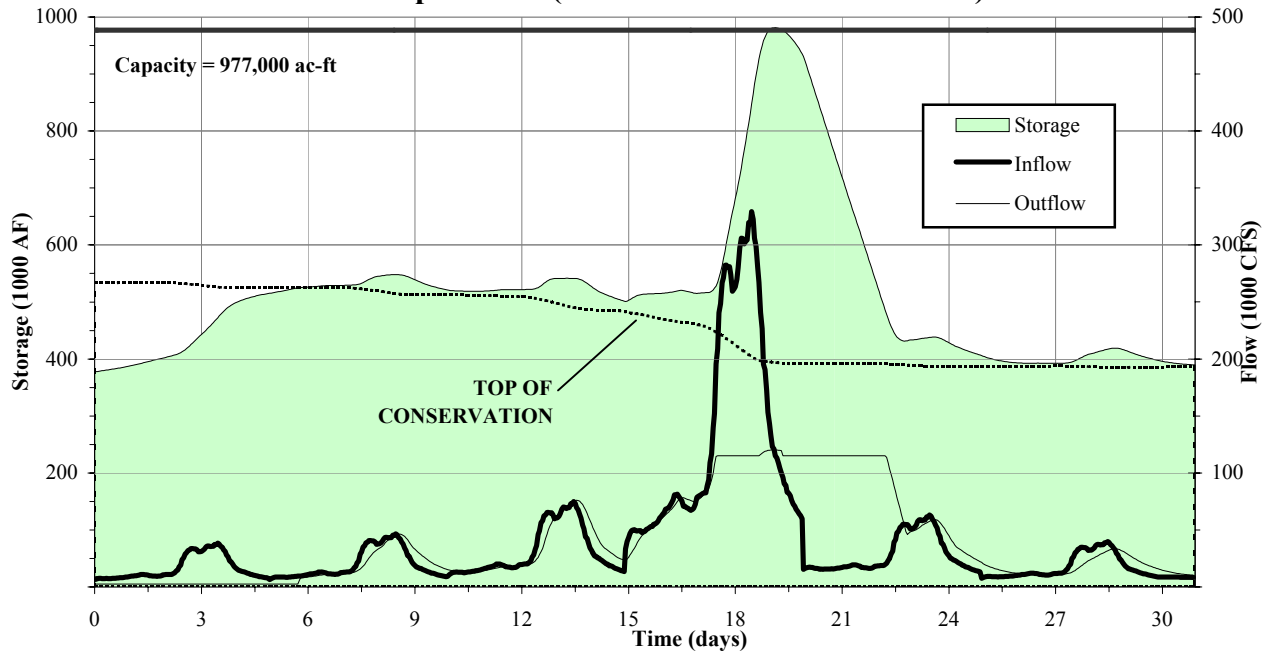
Figure C.1-6d
 Reservoir Simulation Hydrographs
 Folsom
 (2% Chance Exceedence Event)

US Army Corps of Engineers
 The Reclamation Board, State of California December 2002

AMERICAN RIVER
Folsom Inflow (1% Chance Exceedence Event)
 Regulated and Unregulated Inflow

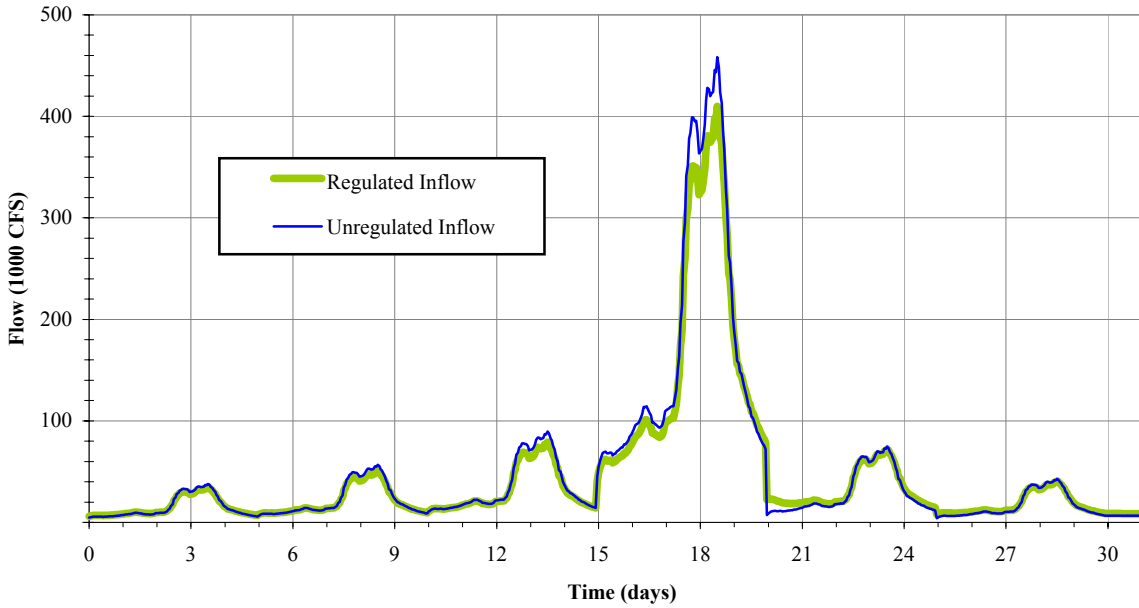


Folsom Operations (1% Chance Exceedence Event)

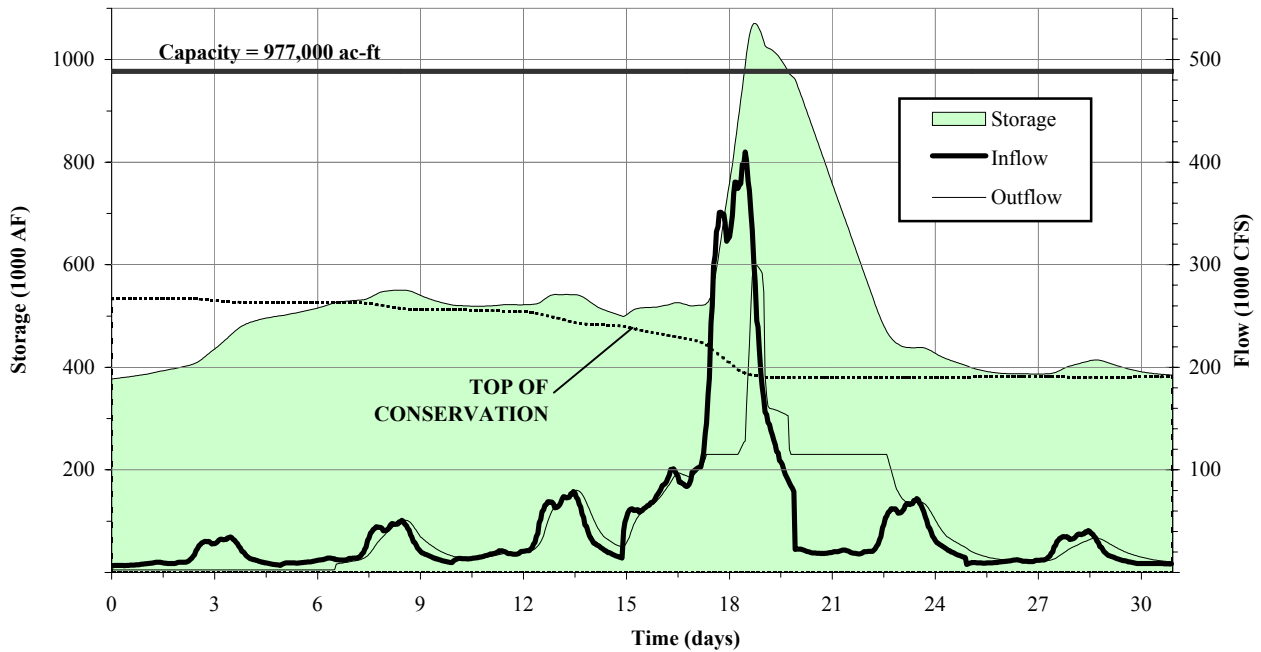


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Figure C.1-6e Reservoir Simulation Hydrographs Folsom (1% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

AMERICAN RIVER
Folsom Inflow (0.5% Chance Exceedence Event)
 Regulated and Unregulated Inflow



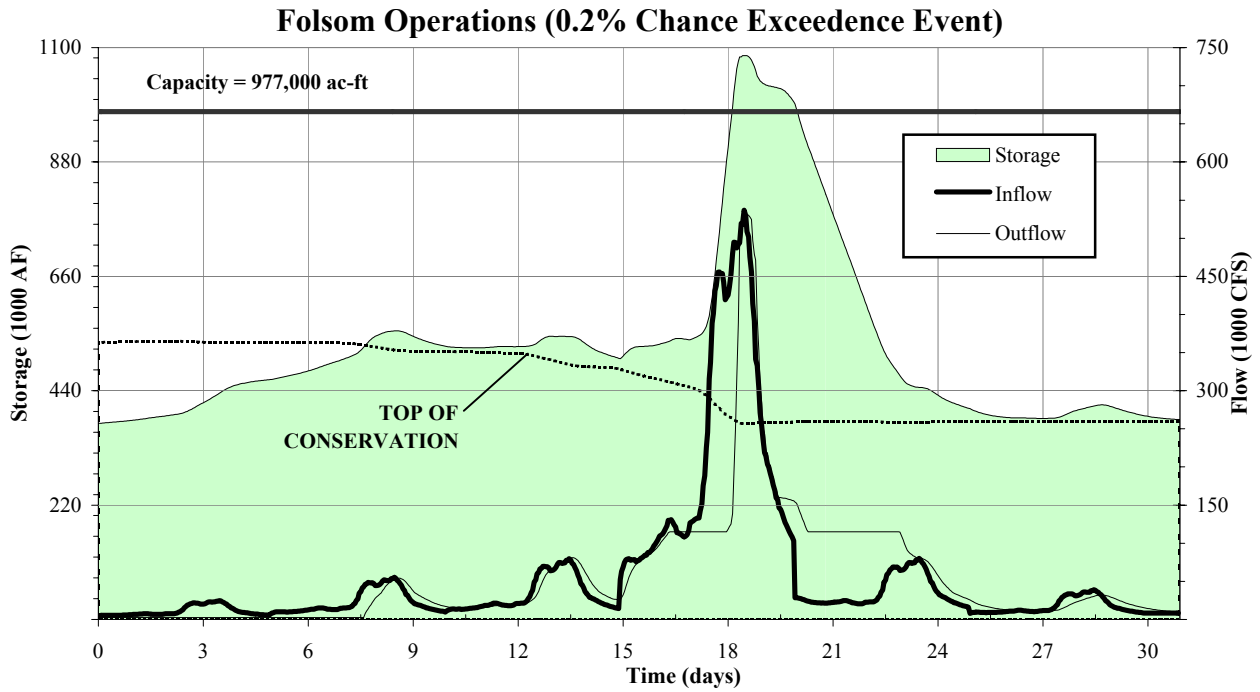
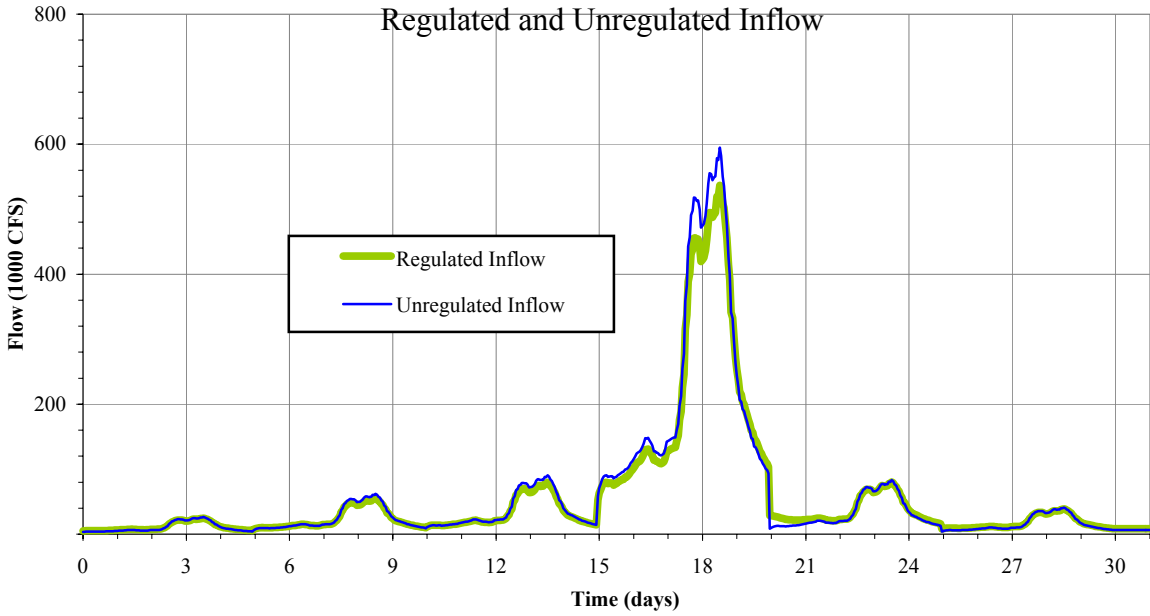
Folsom Operations (0.5% Chance Exceedence Event)



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Figure C.1-6f Reservoir Simulation Hydrographs Folsom (0.5% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

AMERICAN RIVER

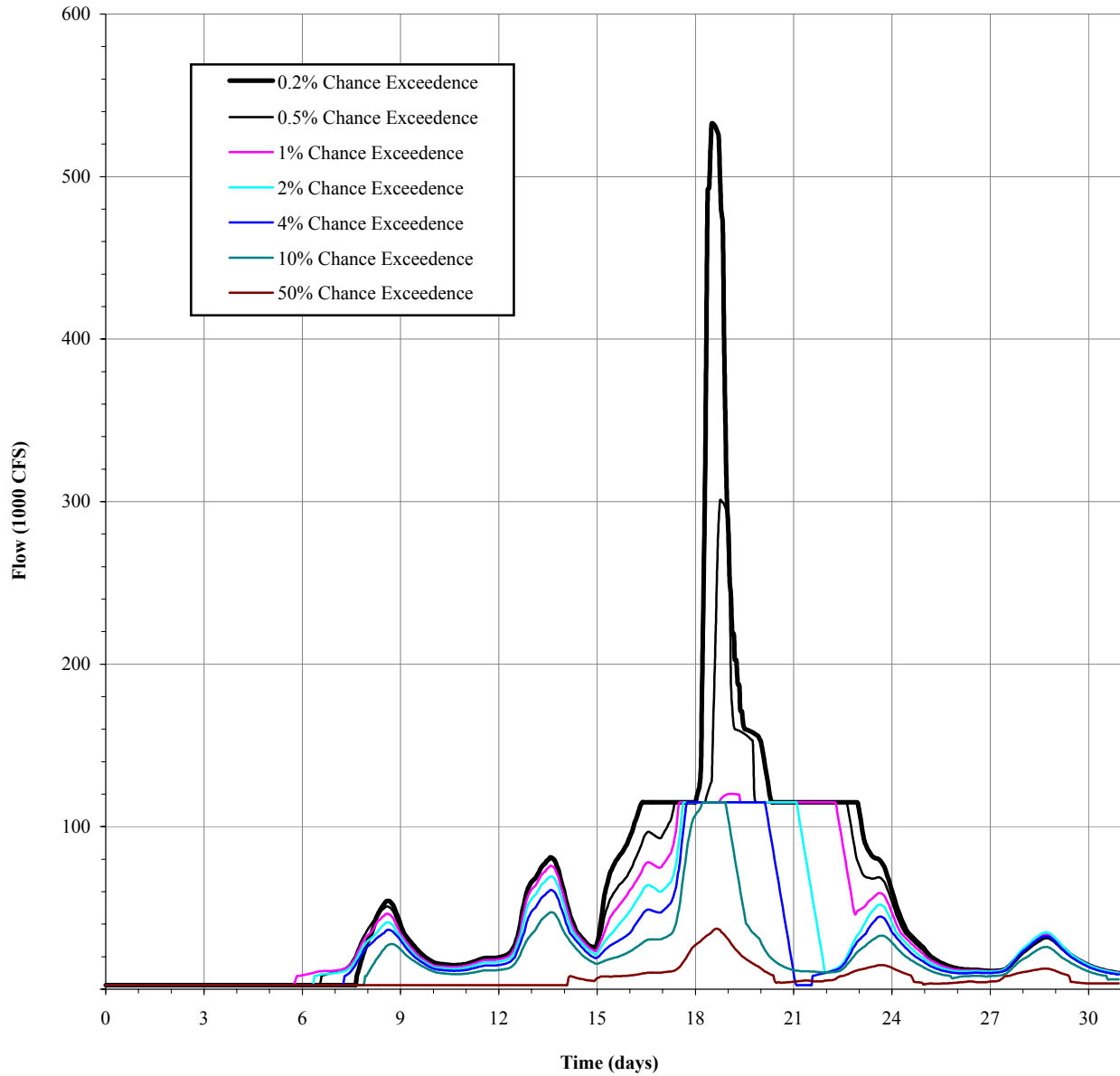
Folsom Inflow (0.2% Chance Exceedence Event)



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Figure C.1-6g Reservoir Simulation Hydrographs Folsom (0.2% Chance Exceedence Event)	
US Army Corps of Engineers The Reclamation Board, State of California December 2002	

FOLSOM OUTFLOW

Regulated Outflow Hydrographs



Sacramento & San Joaquin River Basins
Comprehensive Study

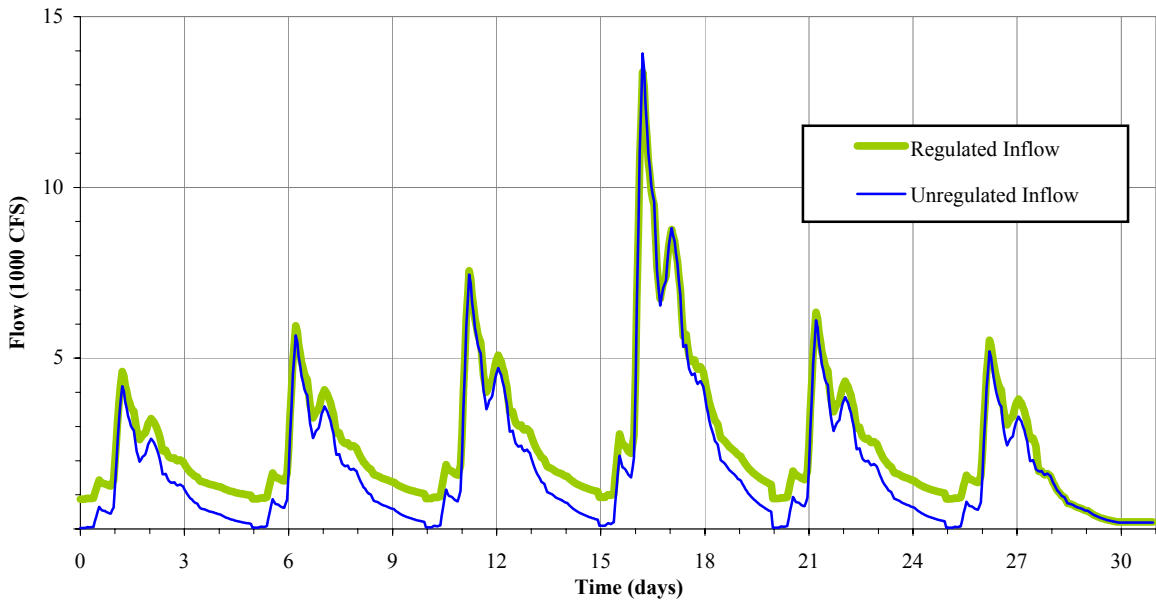
Figure C.1-6h
Reservoir Simulation Hydrographs
Regulated Outflow - Folsom

US Army Corps of Engineers
The Reclamation Board, State of California December 2002

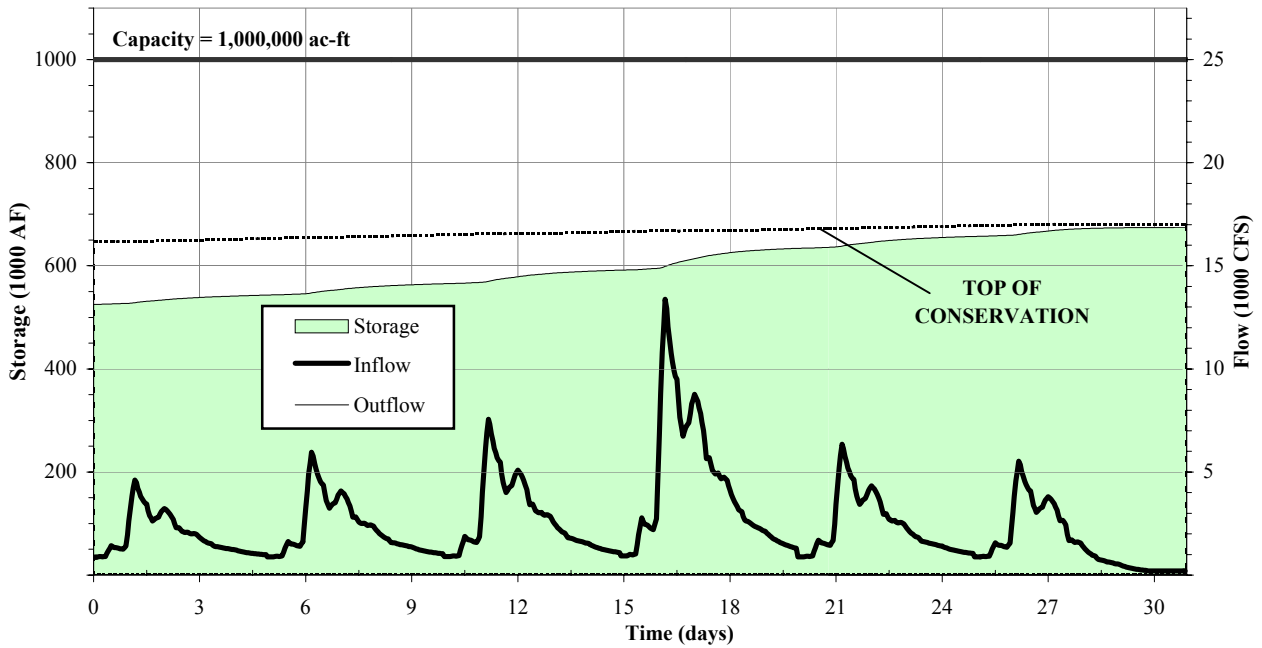
SAN JOAQUIN RIVER BASIN

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KINGS RIVER
Pine Flat Inflow (50% Chance Exceedence Event)
 Regulated and Unregulated Inflow

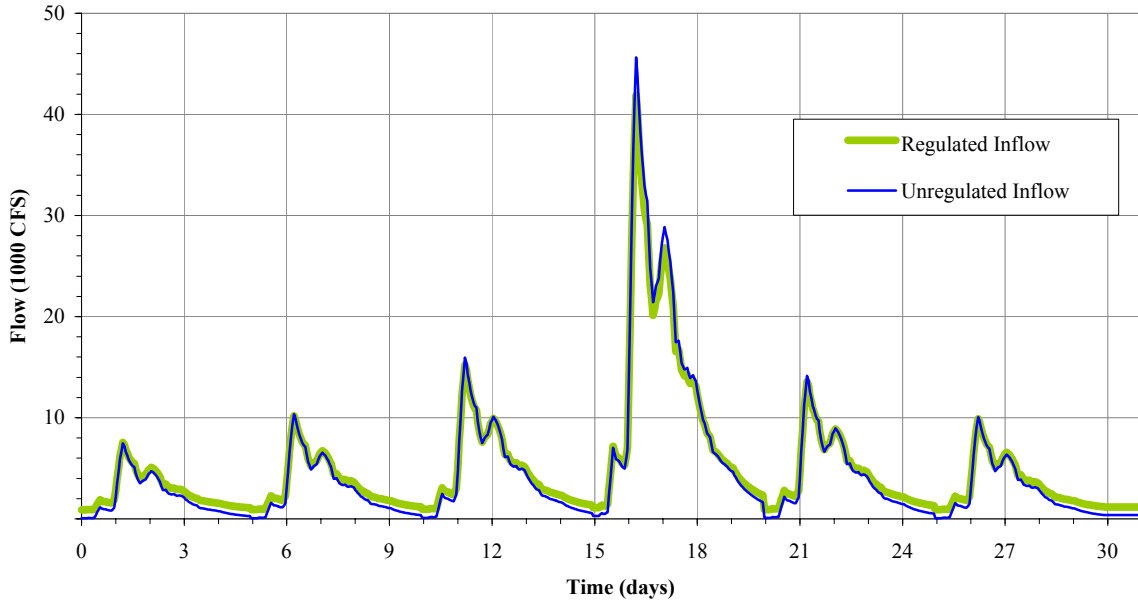


Pine Flat Operations (50% Chance Exceedence Event)

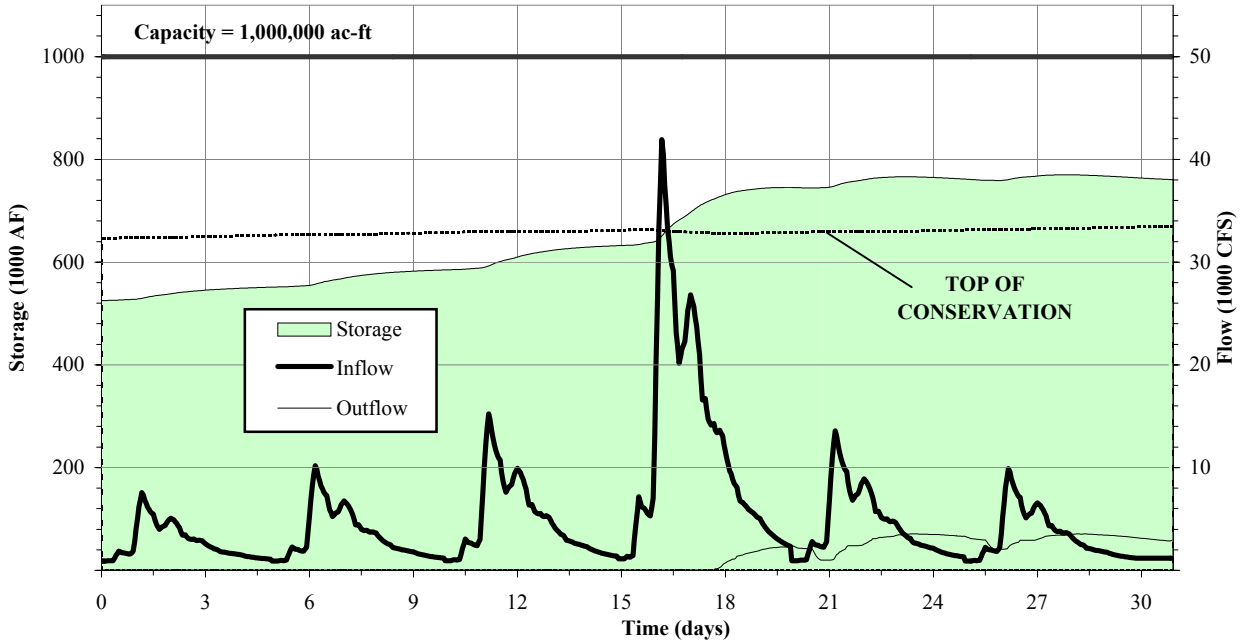


Sacramento & San Joaquin River Basins Comprehensive Study	
Figure C.1-7a Reservoir Simulation Hydrographs Pine Flat (50% Chance Exceedence Event)	
US Army Corps of Engineers The Reclamation Board, State of California December 2002	

KINGS RIVER
Pine Flat Inflow (10% Chance Exceedence Event)
 Regulated and Unregulated Inflow

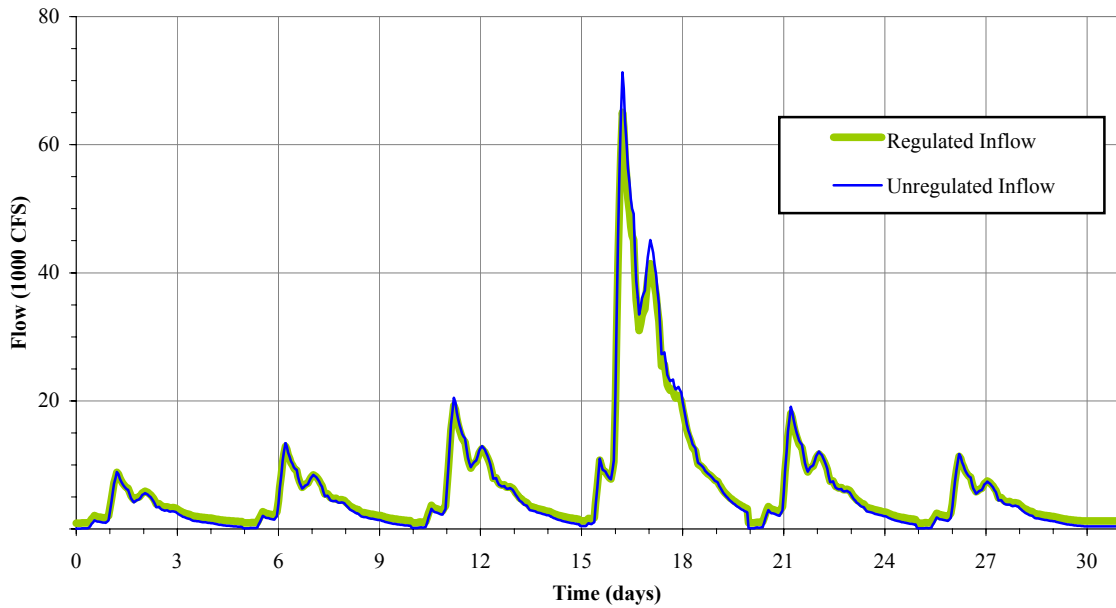


Pine Flat Operations (10% Chance Exceedence Event)

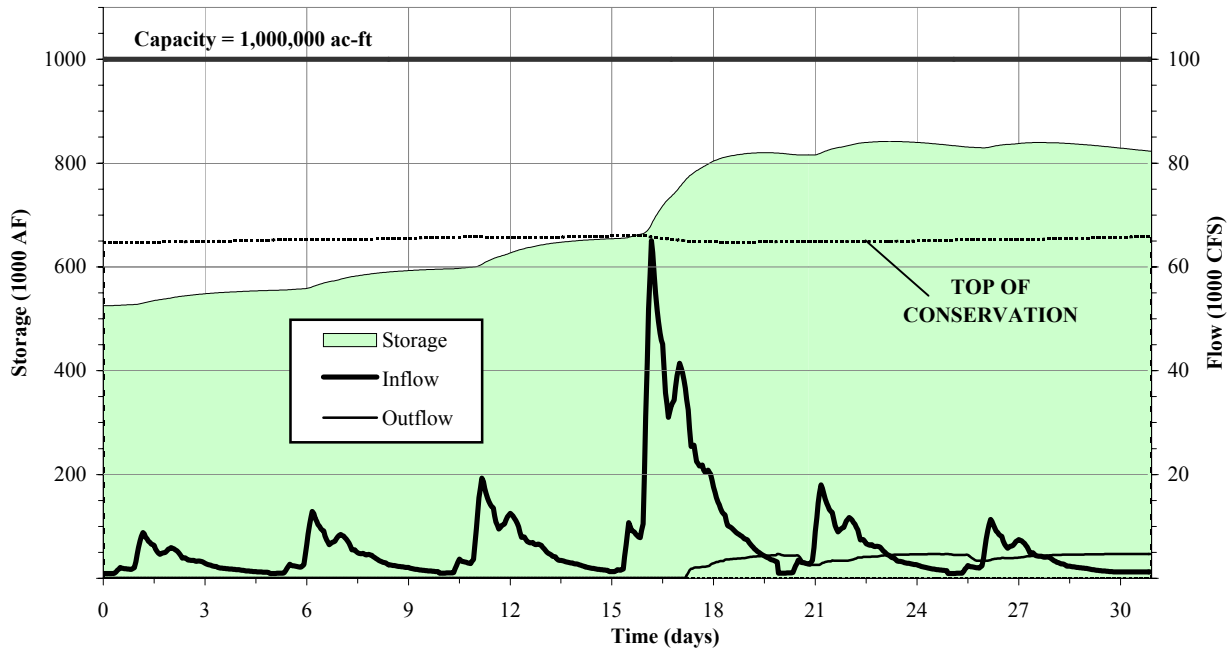


Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-7b Reservoir Simulation Hydrographs Pine Flat (10% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

KINGS RIVER
Pine Flat Inflow (4% Chance Exceedence Event)
 Regulated and Unregulated Inflow



Pine Flat Operations (4% Chance Exceedence Event)

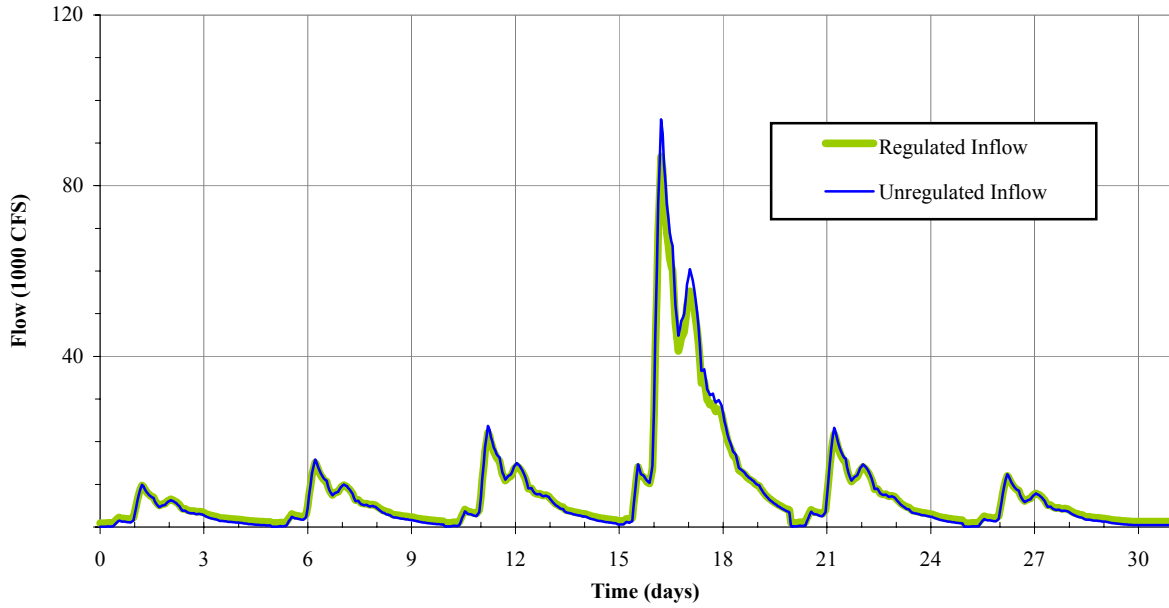


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 Comprehensive Study

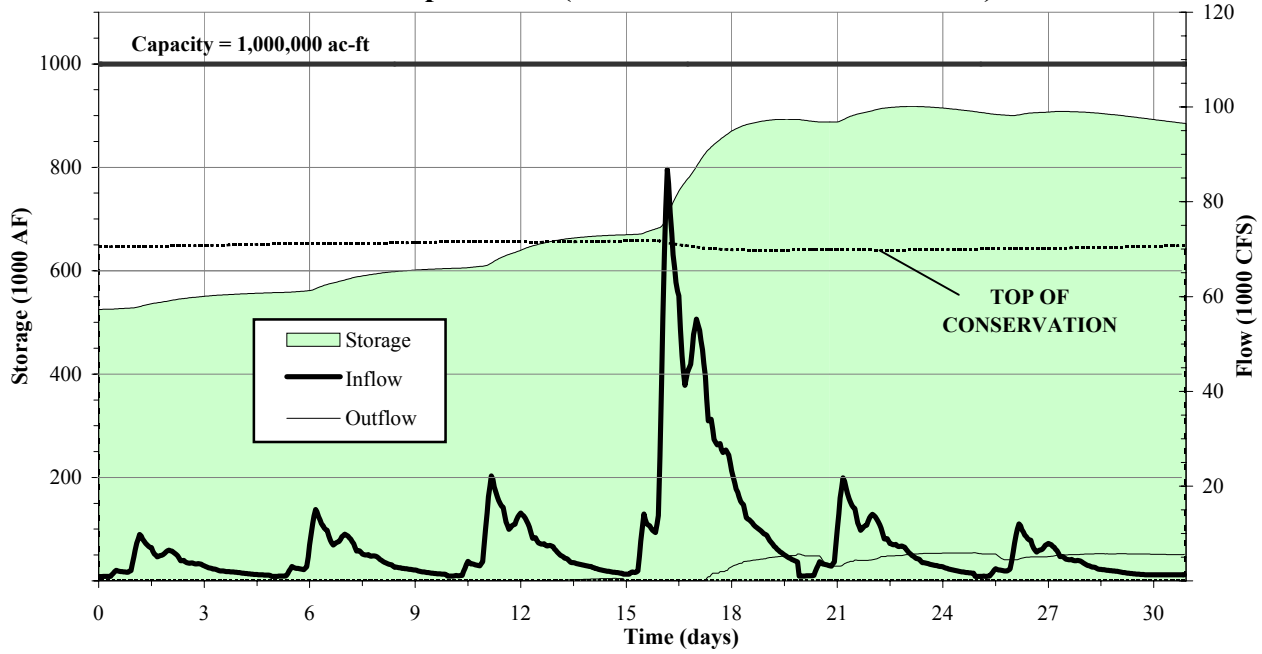
Figure C.1-7c
 Reservoir Simulation Hydrographs
 Pine Flat
 (4% Chance Exceedence Event)

US Army Corps of Engineers
 The Reclamation Board, State of California December 2002

KINGS RIVER
Pine Flat Inflow (2% Chance Exceedence Event)
 Regulated and Unregulated Inflow

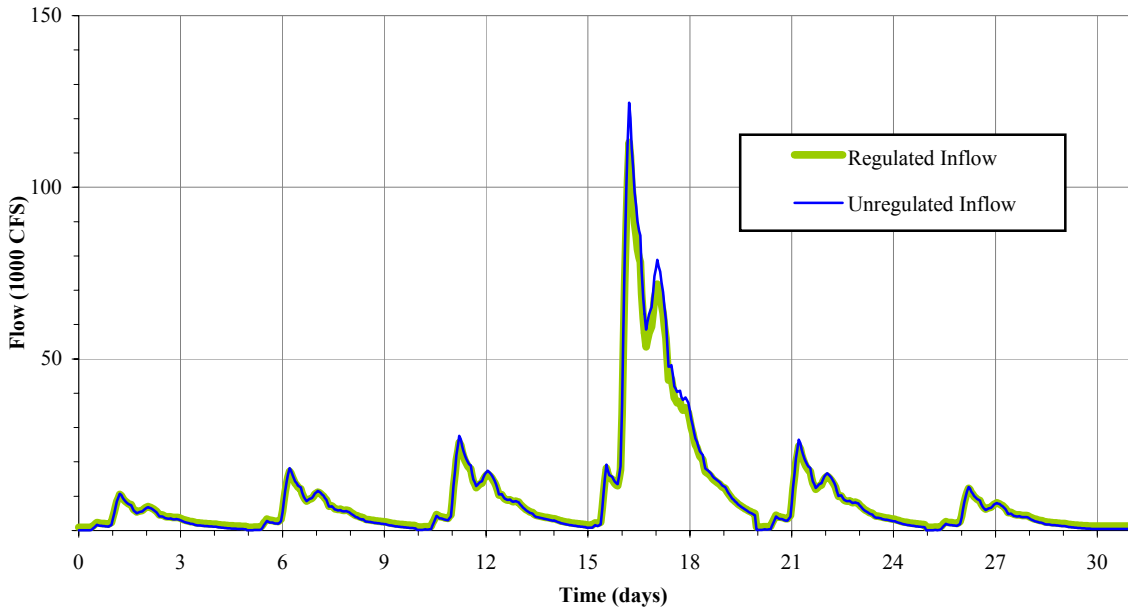


Pine Flat Operations (2% Chance Exceedence Event)

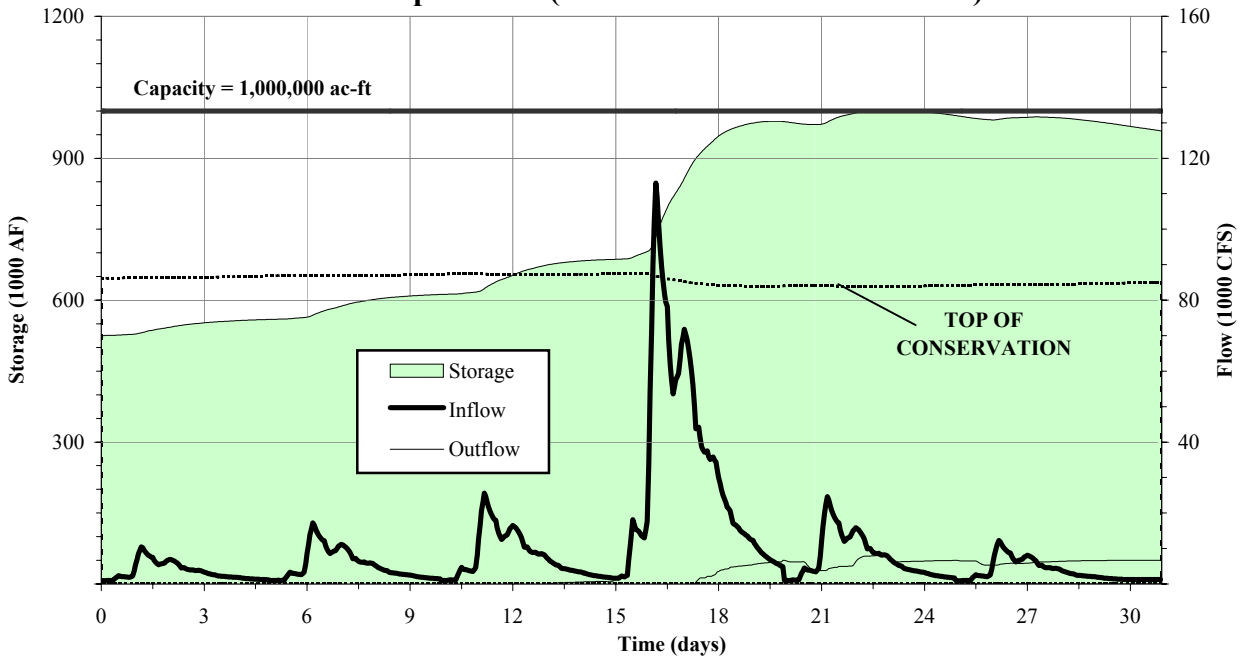


Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-7d Reservoir Simulation Hydrographs Pine Flat (2% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

KINGS RIVER
Pine Flat Inflow (1% Chance Exceedence Event)
Regulated and Unregulated Inflow

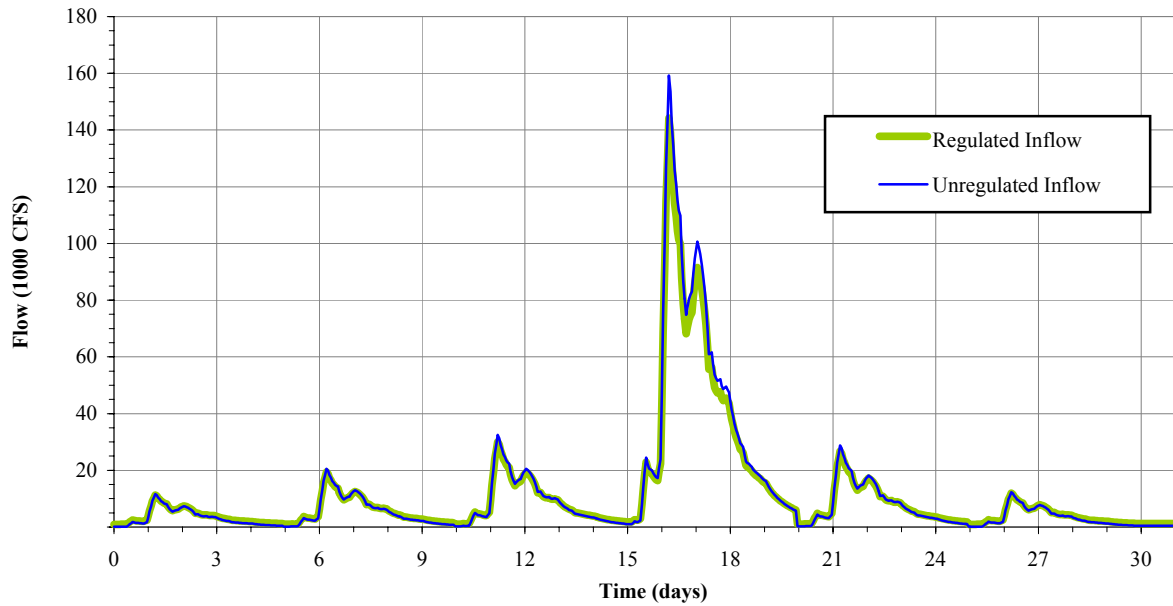


Pine Flat Operations (1% Chance Exceedence Event)

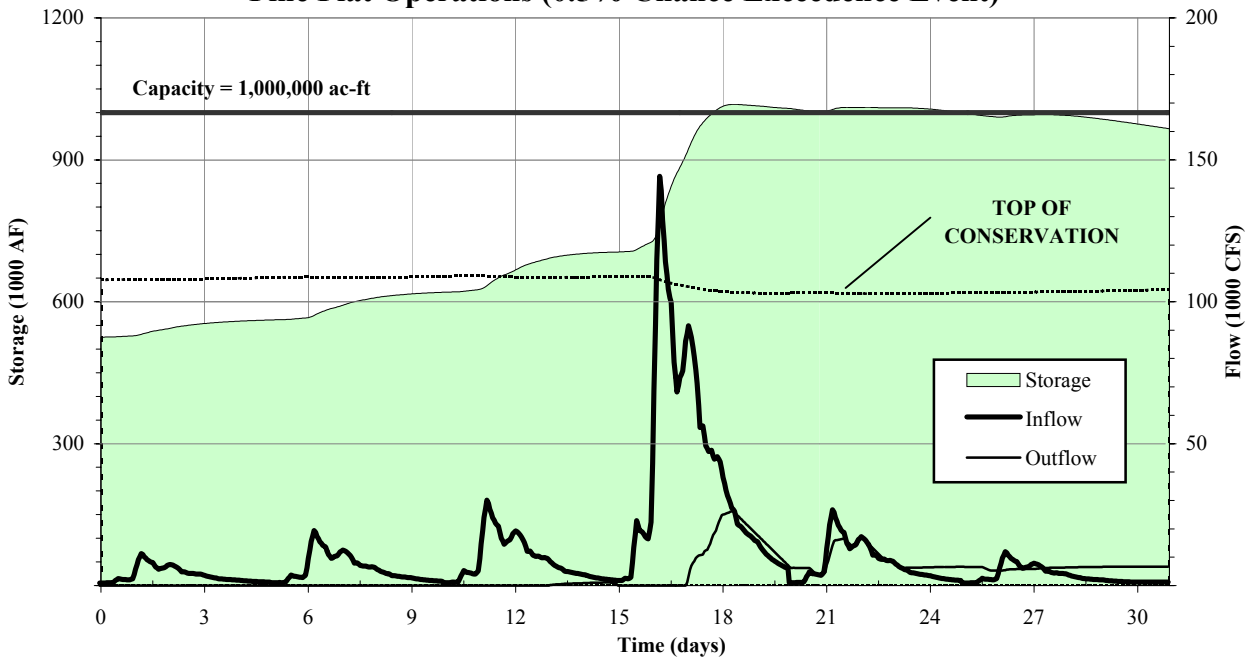


Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-7e Reservoir Simulation Hydrographs Pine Flat (1% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

KINGS RIVER
Pine Flat Inflow (0.5% Chance Exceedence Event)
 Regulated and Unregulated Inflow

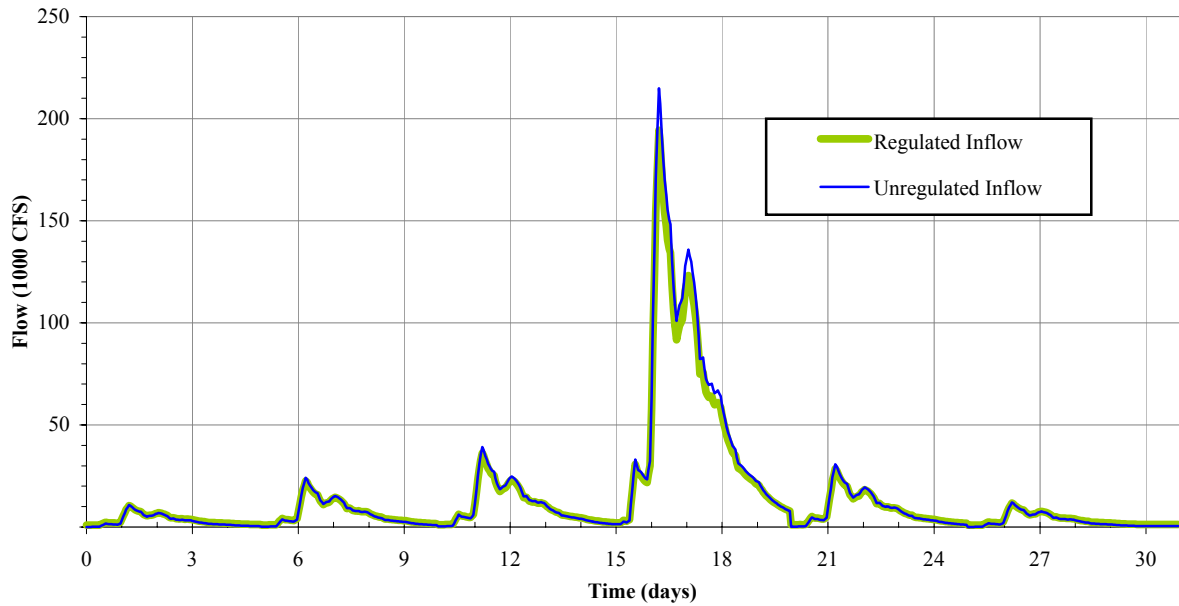


Pine Flat Operations (0.5% Chance Exceedence Event)

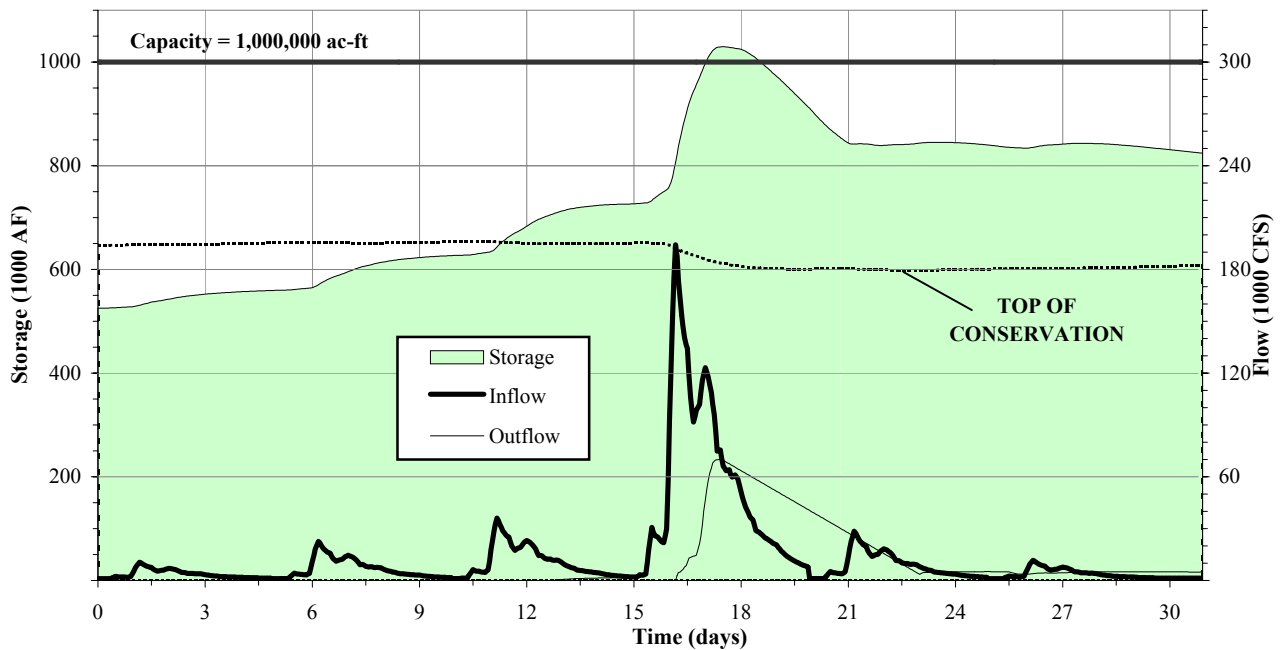


Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-7f Reservoir Simulation Hydrographs Pine Flat (0.5% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

KINGS RIVER
Pine Flat Inflow (0.2% Chance Exceedence Event)
 Regulated and Unregulated Inflow



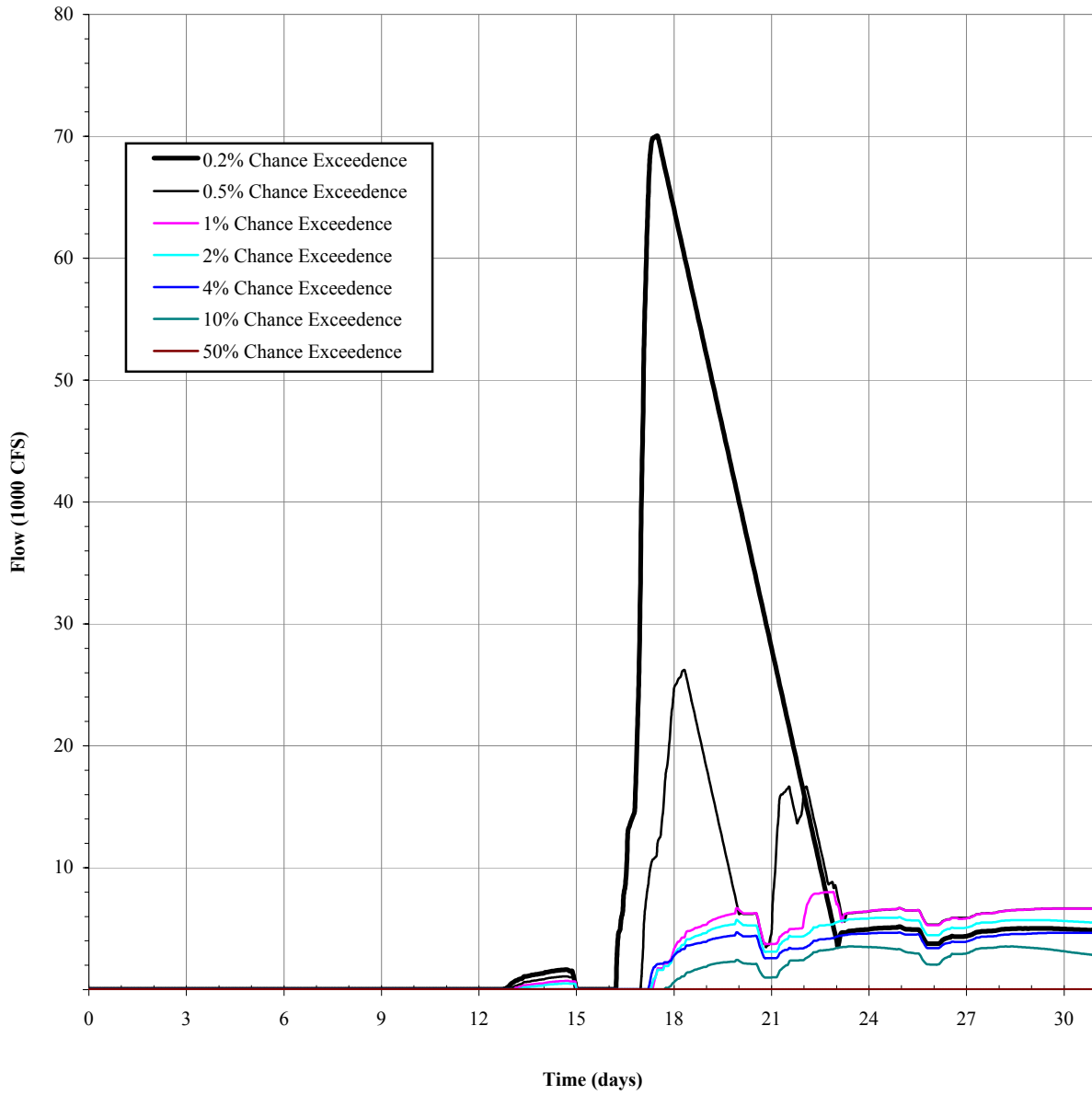
Pine Flat Operations (0.2% Chance Exceedence Event)



Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-7g Reservoir Simulation Hydrographs Pine Flat (0.2% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

Pine Flat Outflow

Regulated Outflow Hydrographs

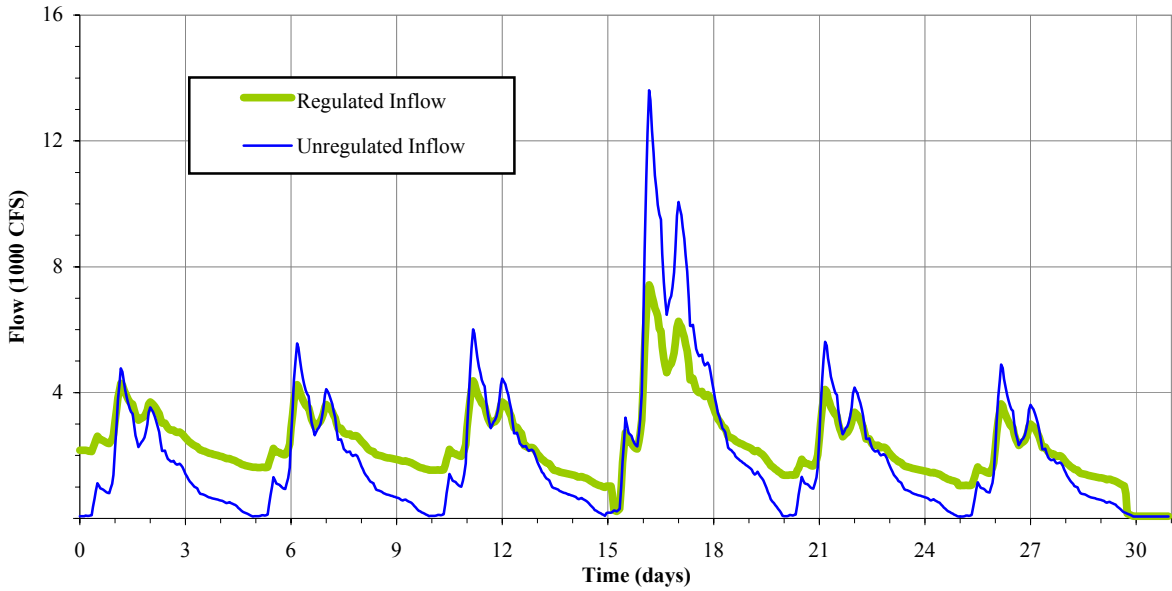


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Comprehensive Study

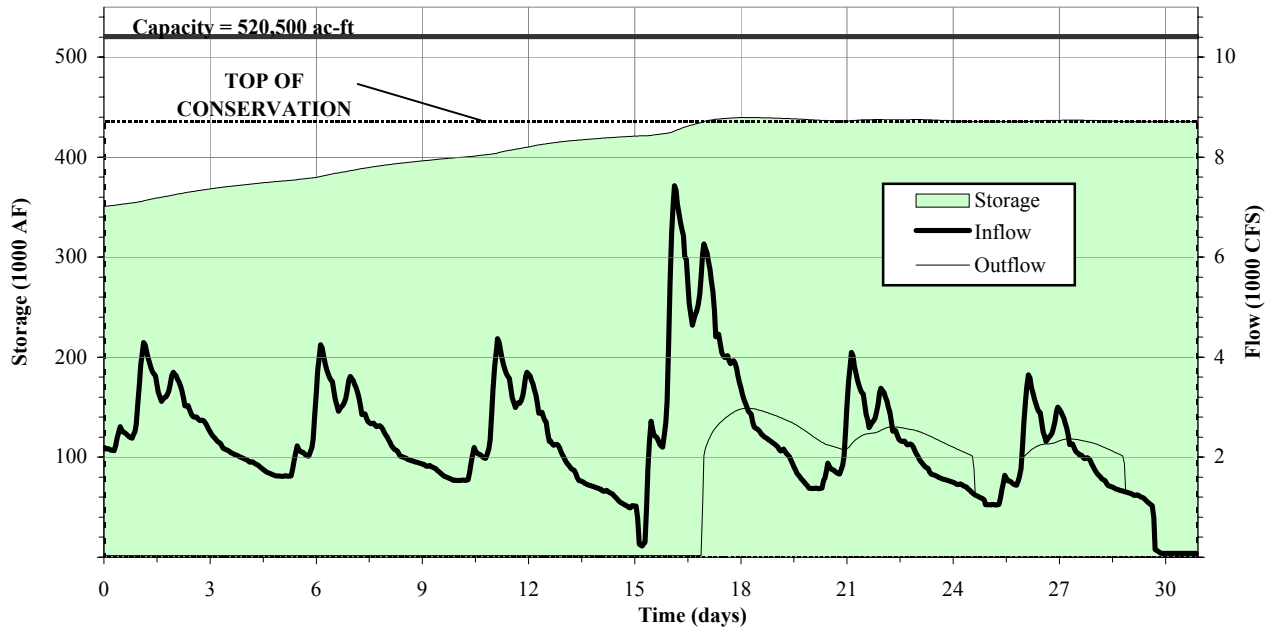
Figure C.1-7h
Reservoir Simulation Hydrographs
Regulated Outflow - Pine Flat

US Army Corps of Engineers
The Reclamation Board, State of California December 2002

SAN JOAQUIN RIVER
Friant Inflow (50% Chance Exceedence Event)
 Regulated and Unregulated Inflow

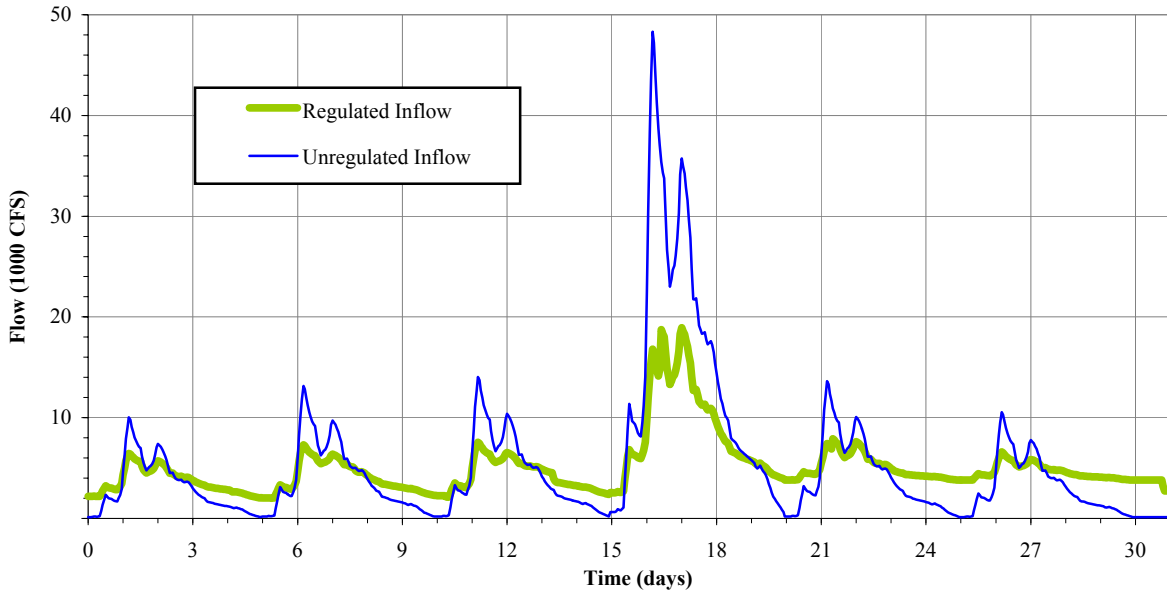


Friant Operations (50% Chance Exceedence Event)

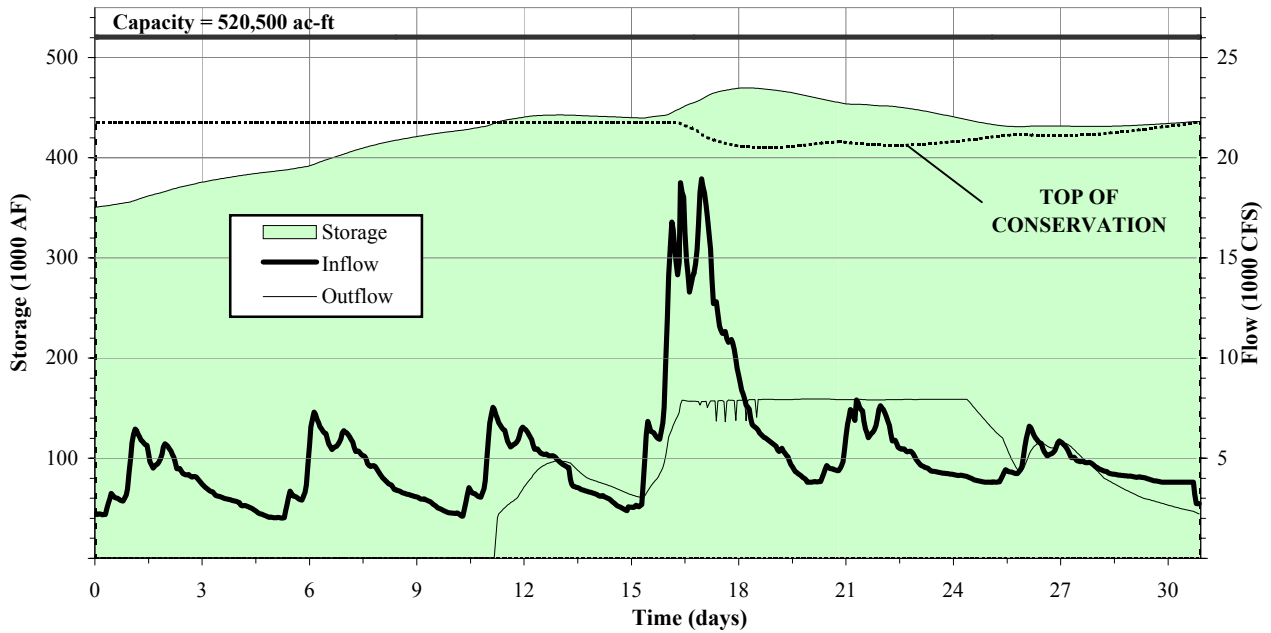


Sacramento & San Joaquin River Basins Comprehensive Study	
Figure C.1-8a Reservoir Simulation Hydrographs Friant (50% Chance Exceedence Event)	
US Army Corps of Engineers The Reclamation Board, State of California	December 2002

SAN JOAQUIN RIVER
Friant Inflow (10% Chance Exceedence Event)
 Regulated and Unregulated Inflow

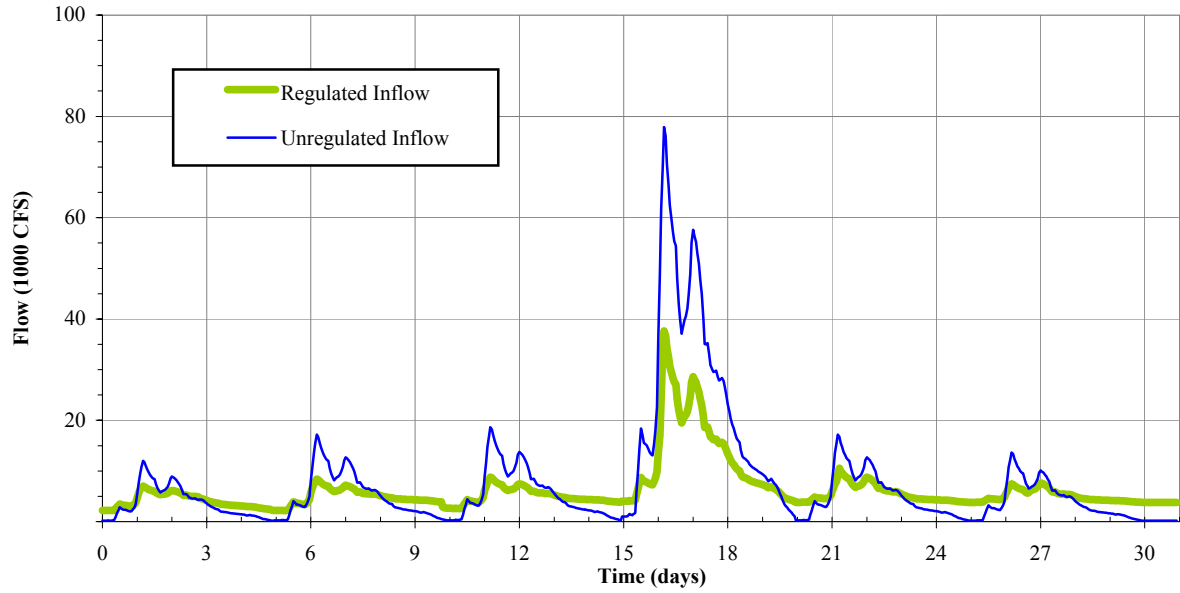


Friant Operations (10% Chance Exceedence Event)

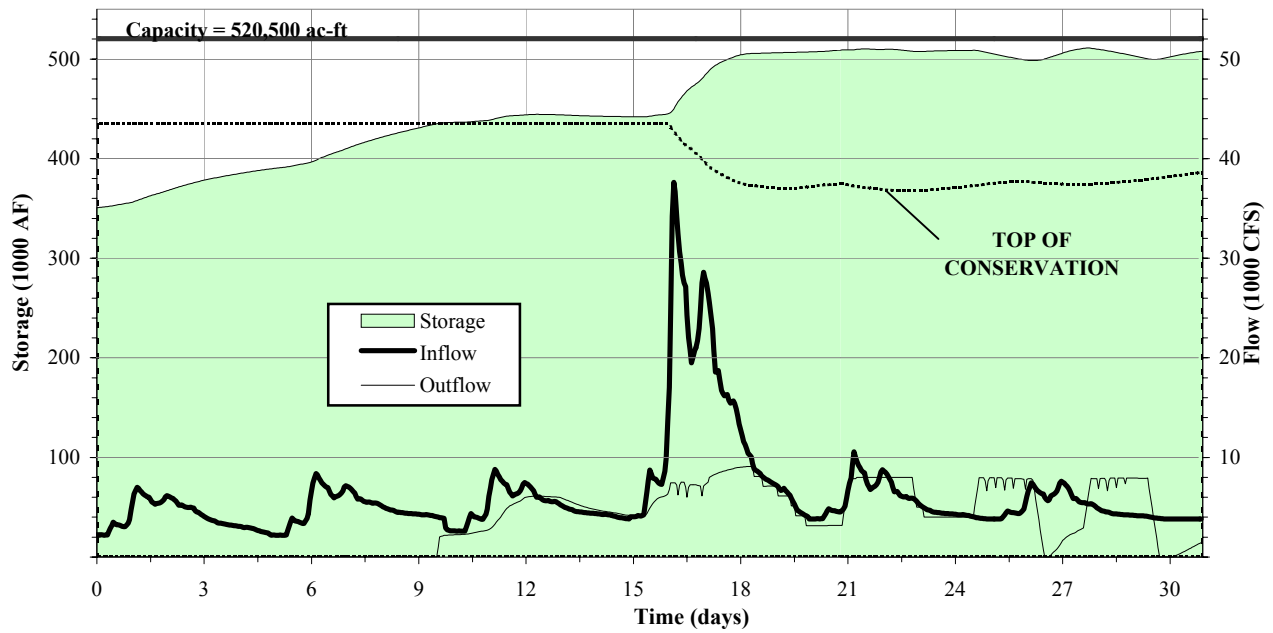


Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-8b Reservoir Simulation Hydrographs Friant (10% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

SAN JOAQUIN RIVER
Friant Inflow (4% Chance Exceedence Event)
 Regulated and Unregulated Inflow

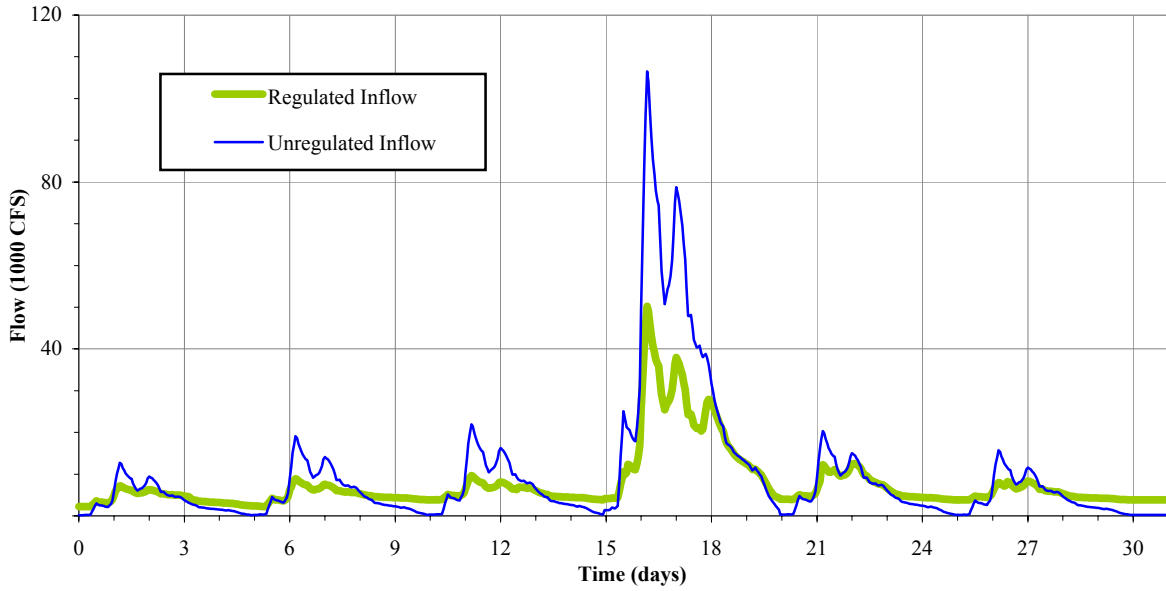


Friant Operations (4% Chance Exceedence Event)

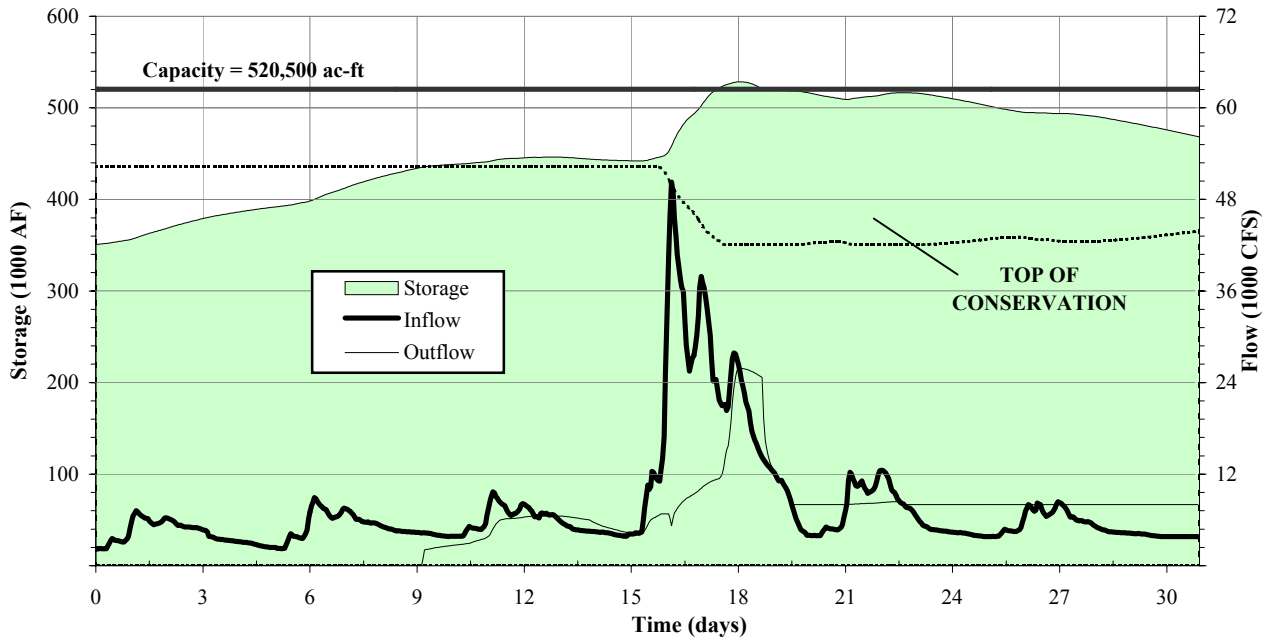


Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-8c Reservoir Simulation Hydrographs Friant (4% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

SAN JOAQUIN RIVER
Friant Inflow (2% Chance Exceedence Event)
 Regulated and Unregulated Inflow

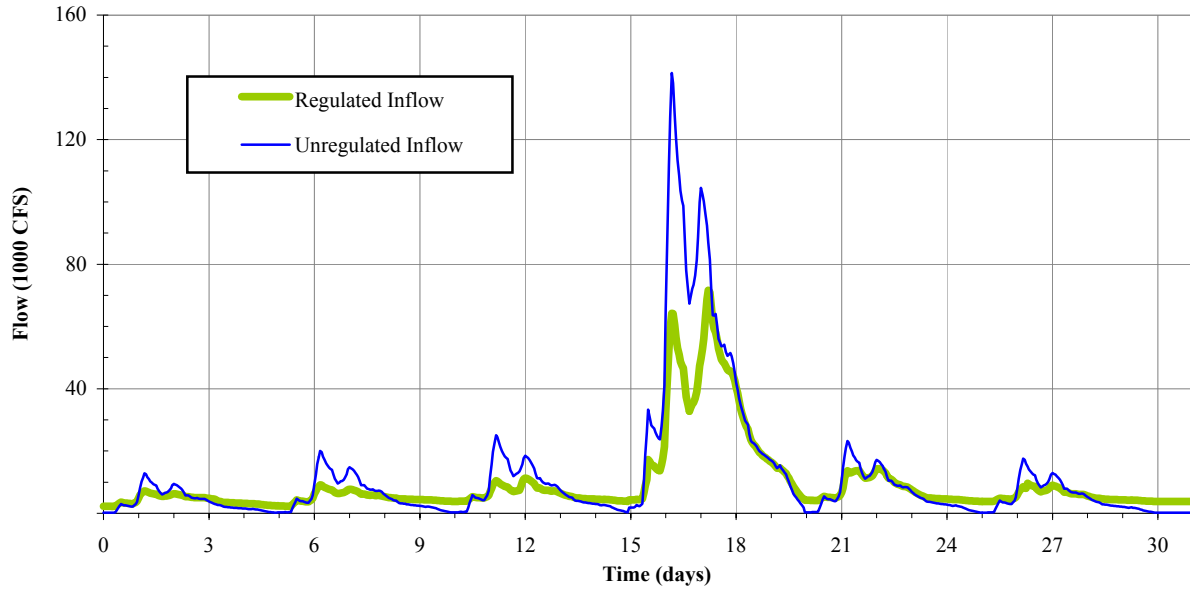


Friant Operations (2% Chance Exceedence Event)

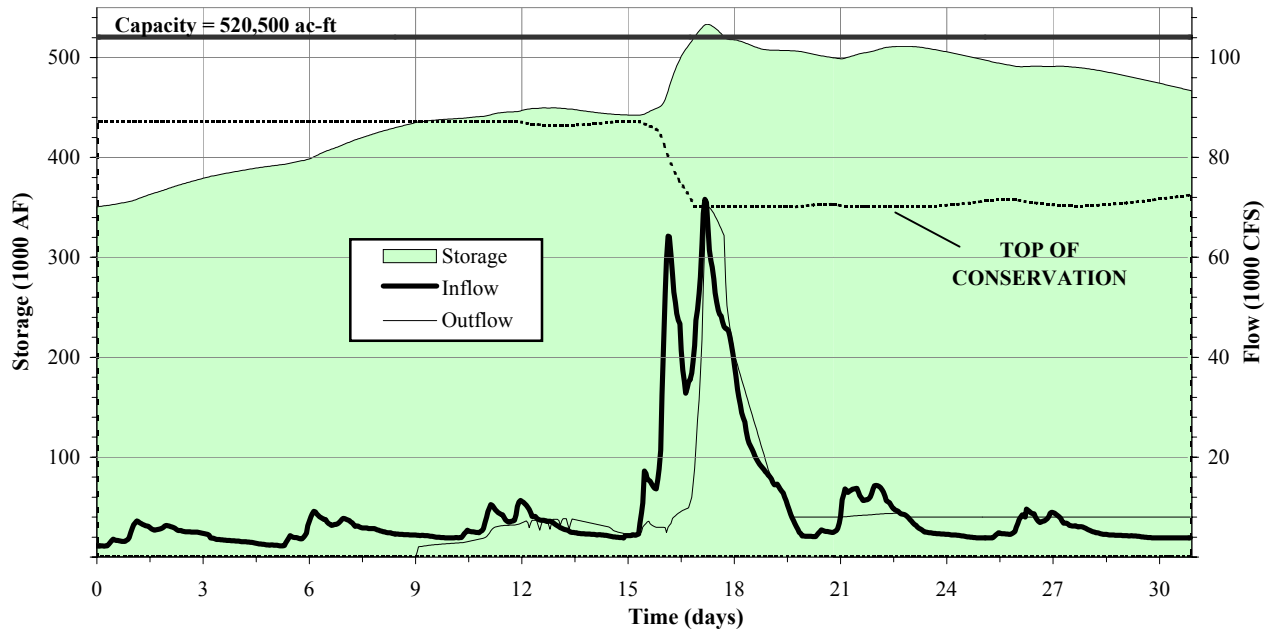


Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-8d Reservoir Simulation Hydrographs Friant (2% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

SAN JOAQUIN RIVER
Friant Inflow (1% Chance Exceedence Event)
 Regulated and Unregulated Inflow

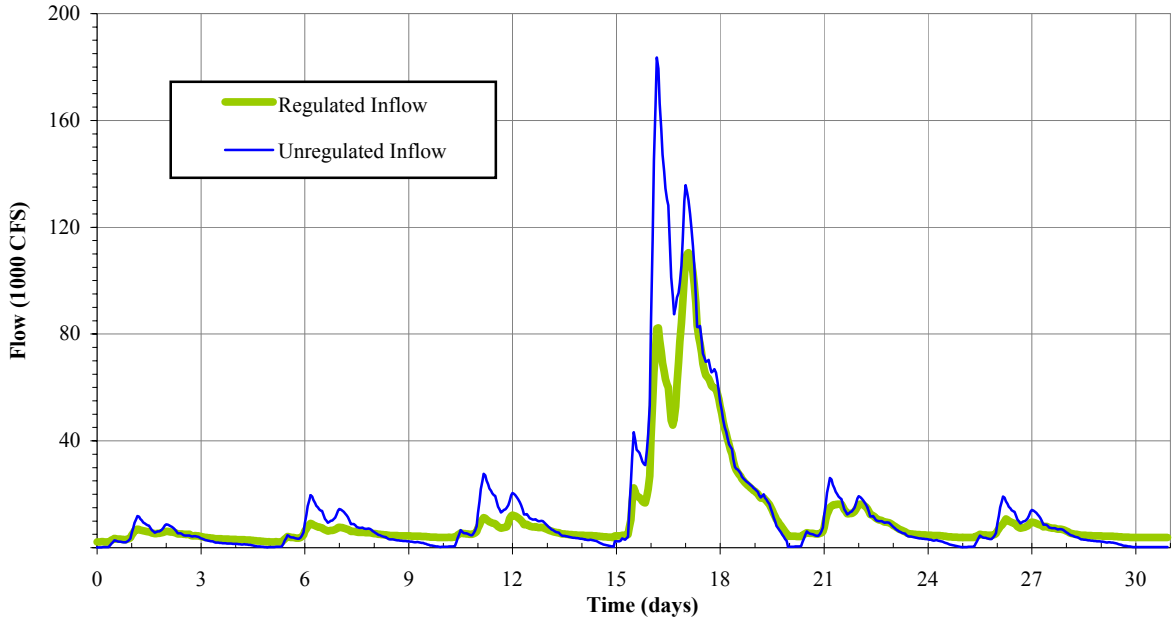


Friant Operations (1% Chance Exceedence Event)

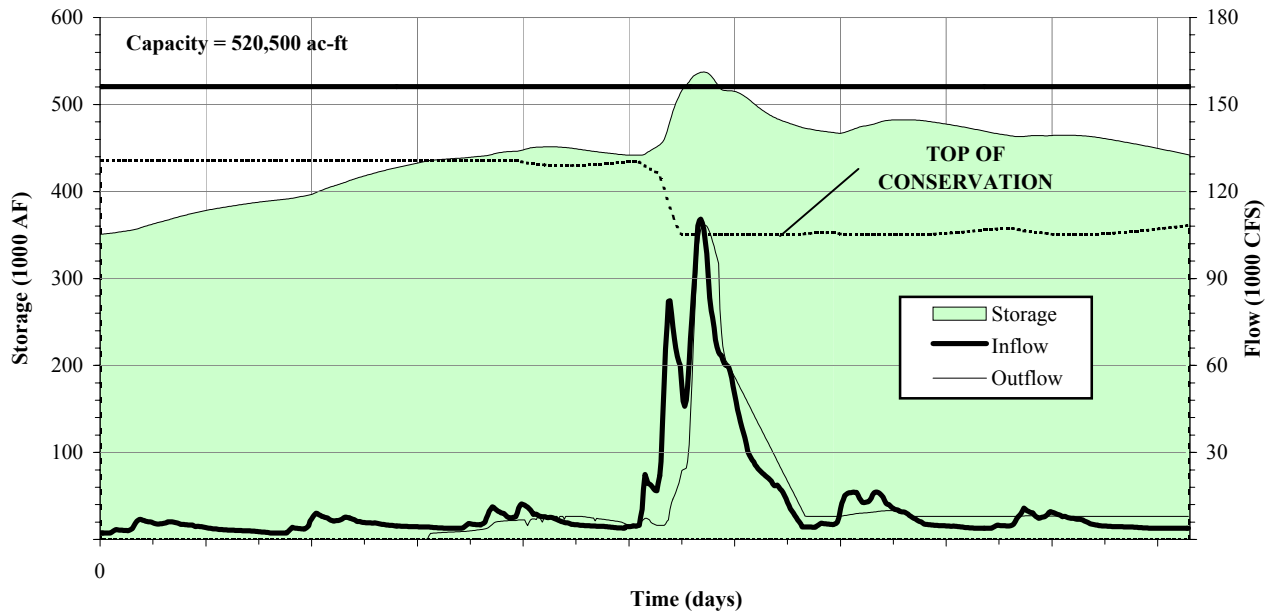


Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-8e Reservoir Simulation Hydrographs Friant (1% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

SAN JOAQUIN RIVER
Friant Inflow (0.5% Chance Exceedence Event)
 Regulated and Unregulated Inflow



Friant Operations (0.5% Chance Exceedence Event)

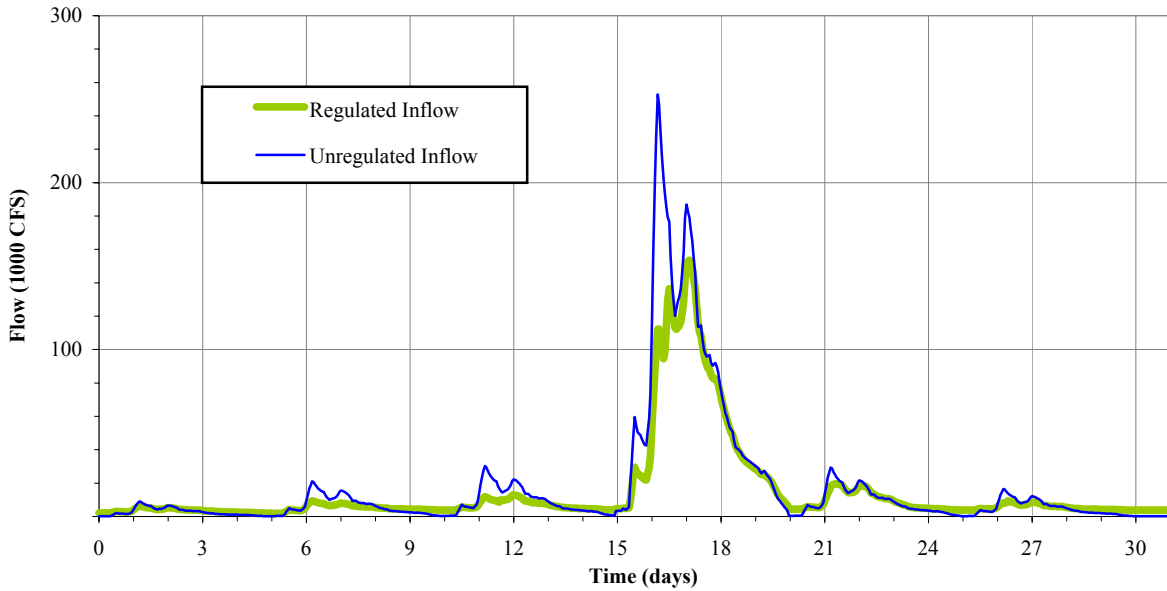


Sacramento & San Joaquin River Basins
 Comprehensive Study

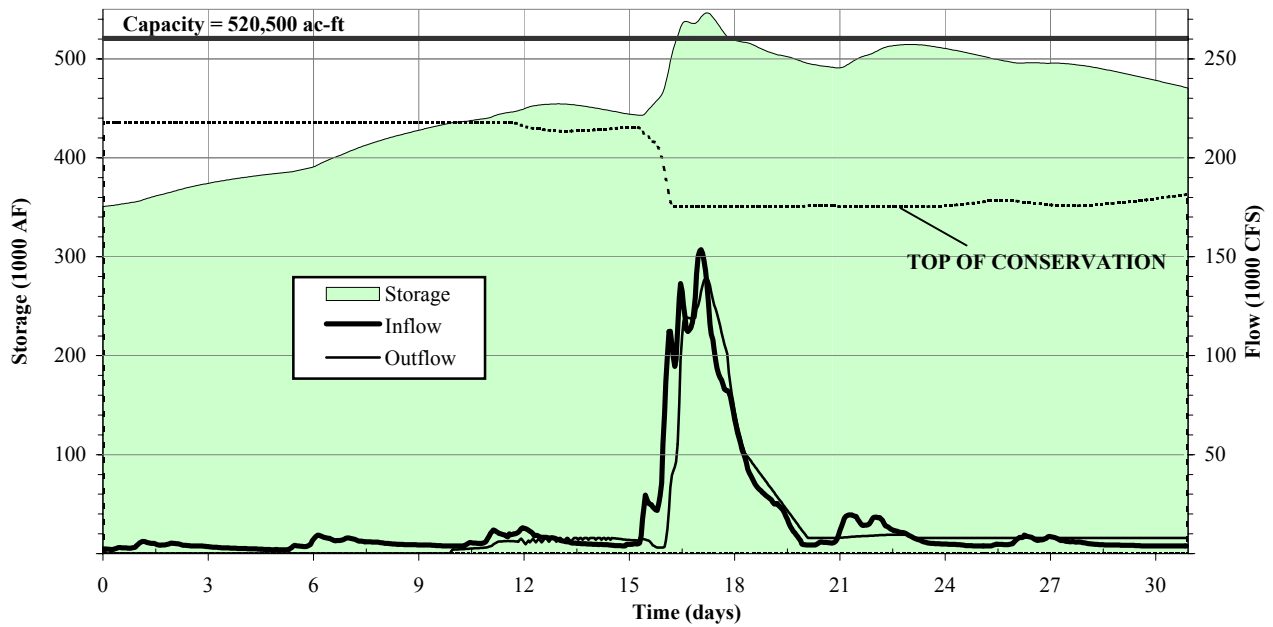
Figure C.1-8f
 Reservoir Simulation Hydrographs
 Friant
 (0.5% Chance Exceedence Event)

US Army Corps of Engineers
 The Reclamation Board, State of California December 2002

SAN JOAQUIN RIVER
Friant Inflow (0.2% Chance Exceedence Event)
 Regulated and Unregulated Inflow



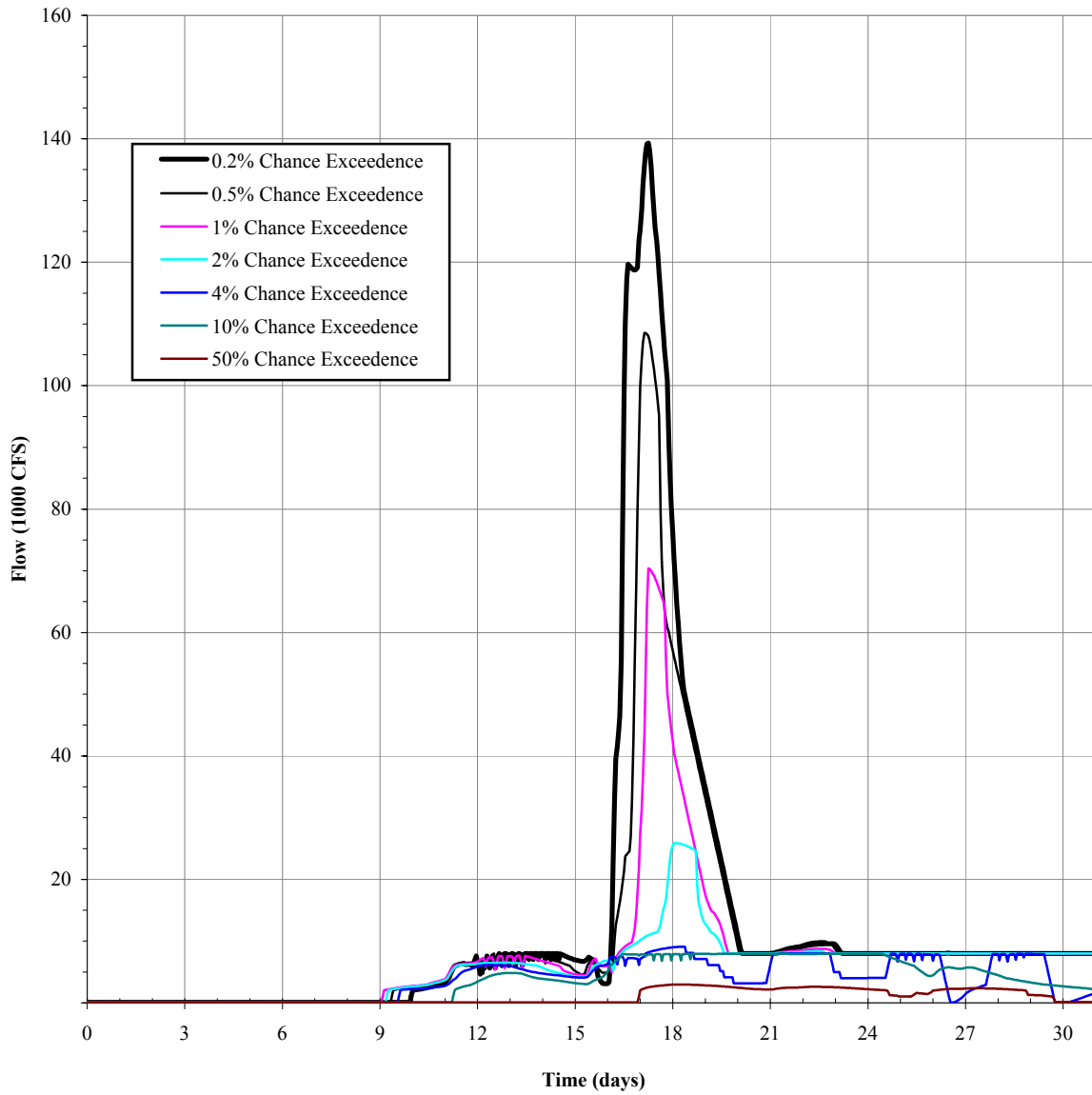
Friant Operations (0.2% Chance Exceedence Event)



Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-8g Reservoir Simulation Hydrographs Friant (0.2% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

Friant Outflow

Regulated Outflow Hydrographs



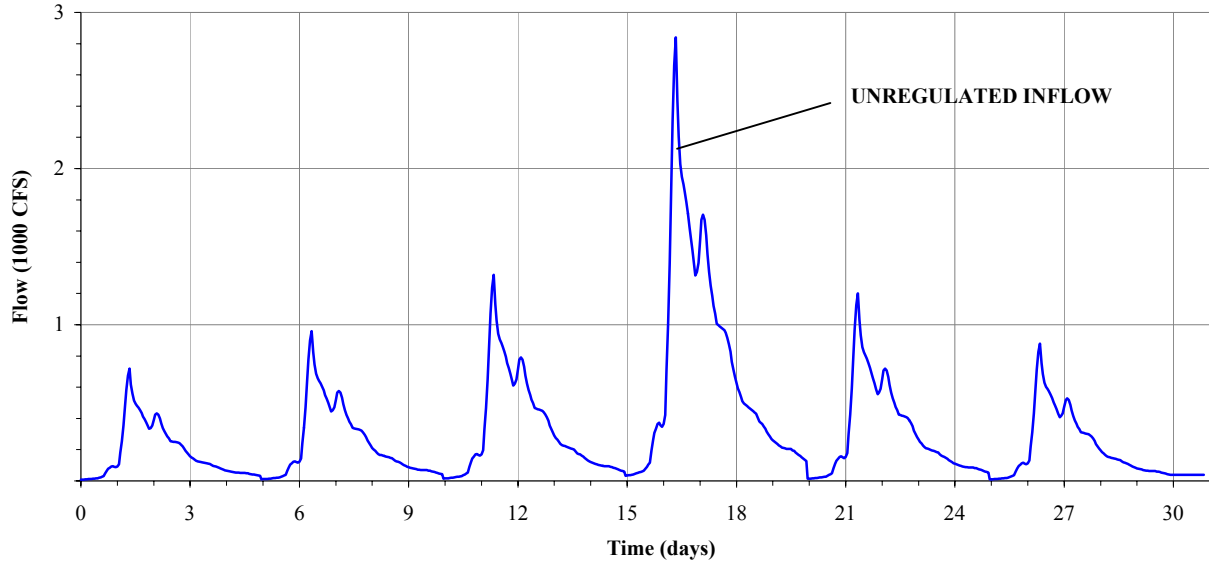
Sacramento & San Joaquin River Basins
Comprehensive Study

Figure C.1-8h
Reservoir Simulation Hydrographs
Regulated Outflow - Friant

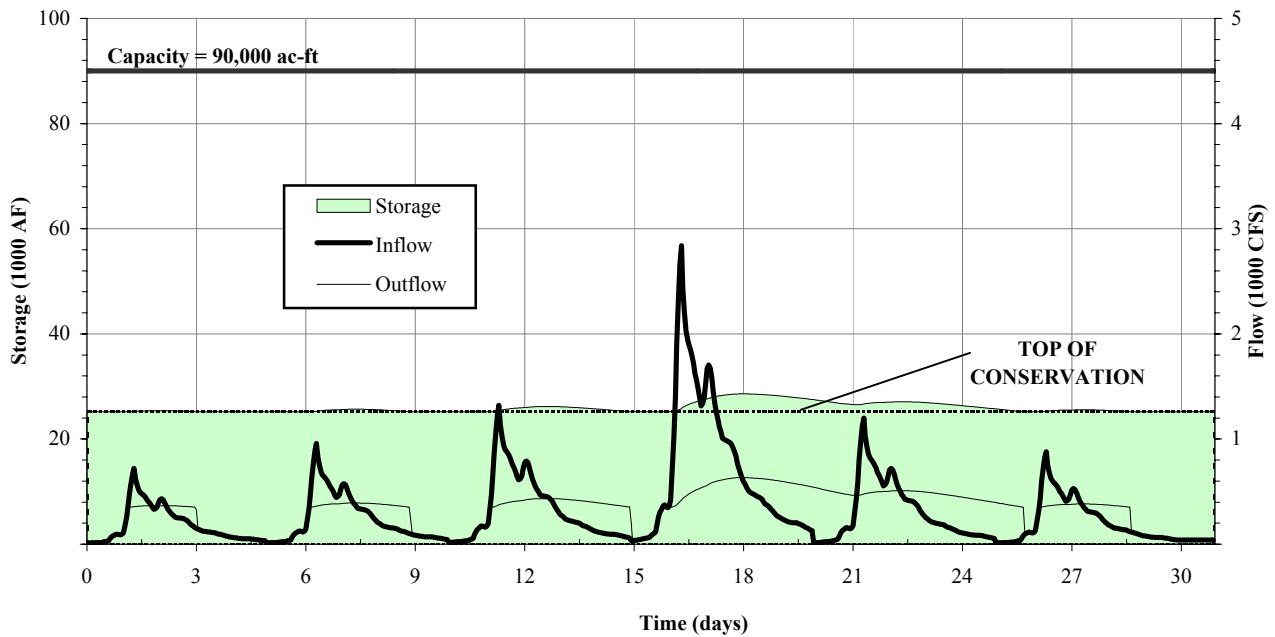
US Army Corps of Engineers
The Reclamation Board, State of California December 2002

FRESNO RIVER
Hidden Inflow (50% Chance Exceedence Event)
 Unregulated Inflow

Note: This reservoir has no major headwater reservoirs.



Hidden Operations (50% Chance Exceedence Event)



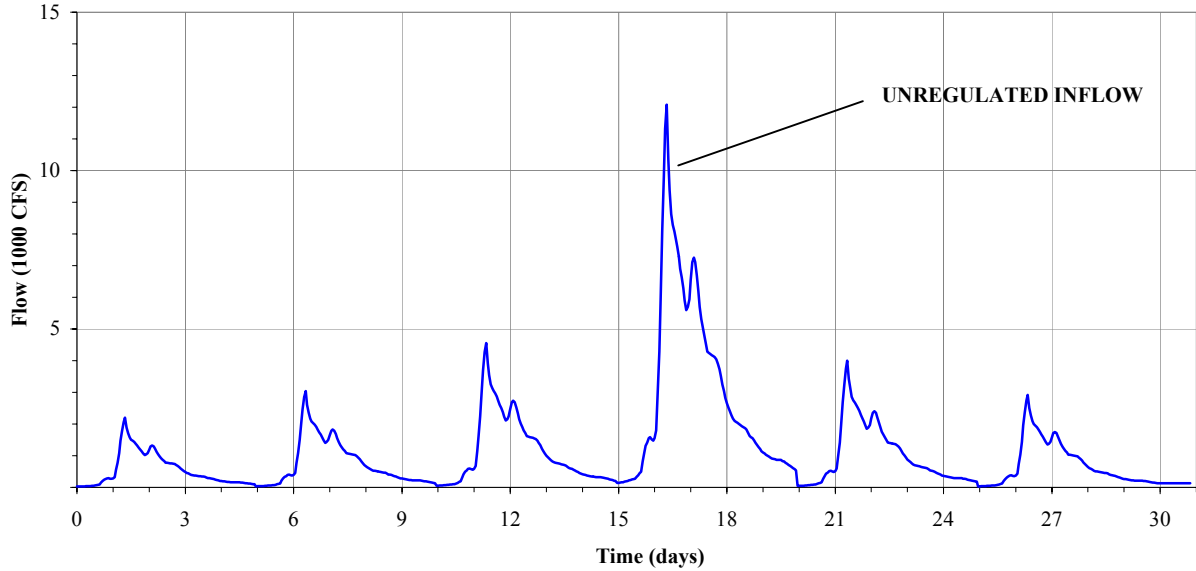
Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-9a Reservoir Simulation Hydrographs Hidden (50% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

FRESNO RIVER

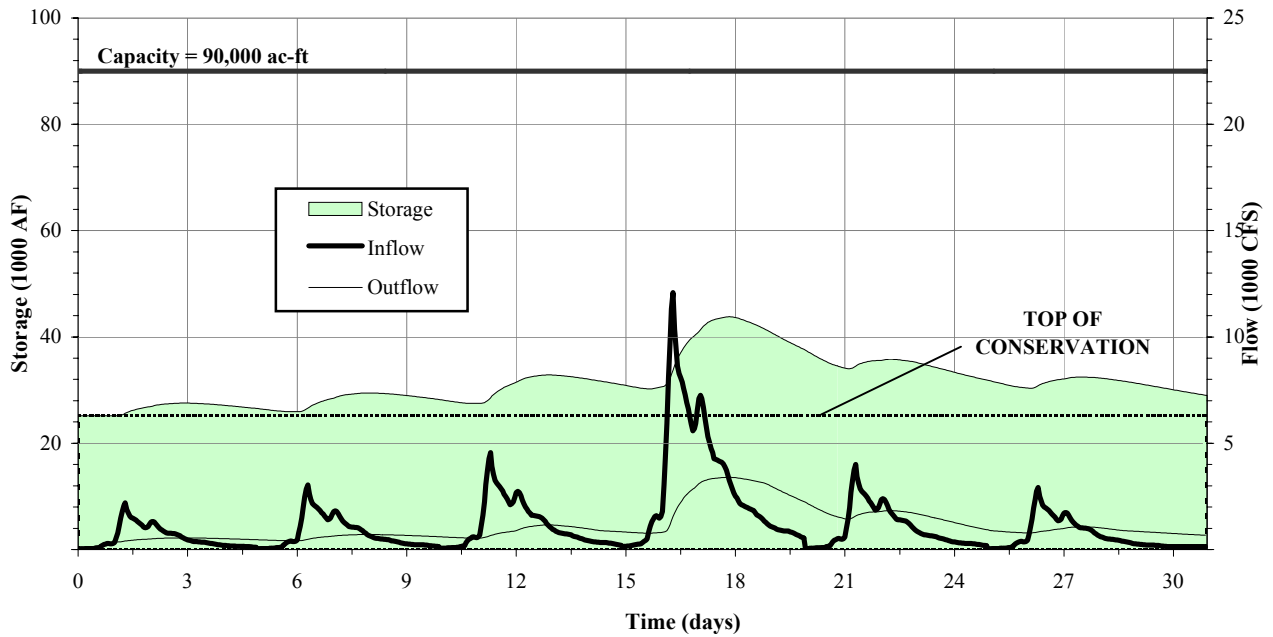
Hidden Inflow (10% Chance Exceedence Event)

Unregulated Inflow

Note: This reservoir has no major headwater reservoirs.



Hidden Operations (10% Chance Exceedence Event)



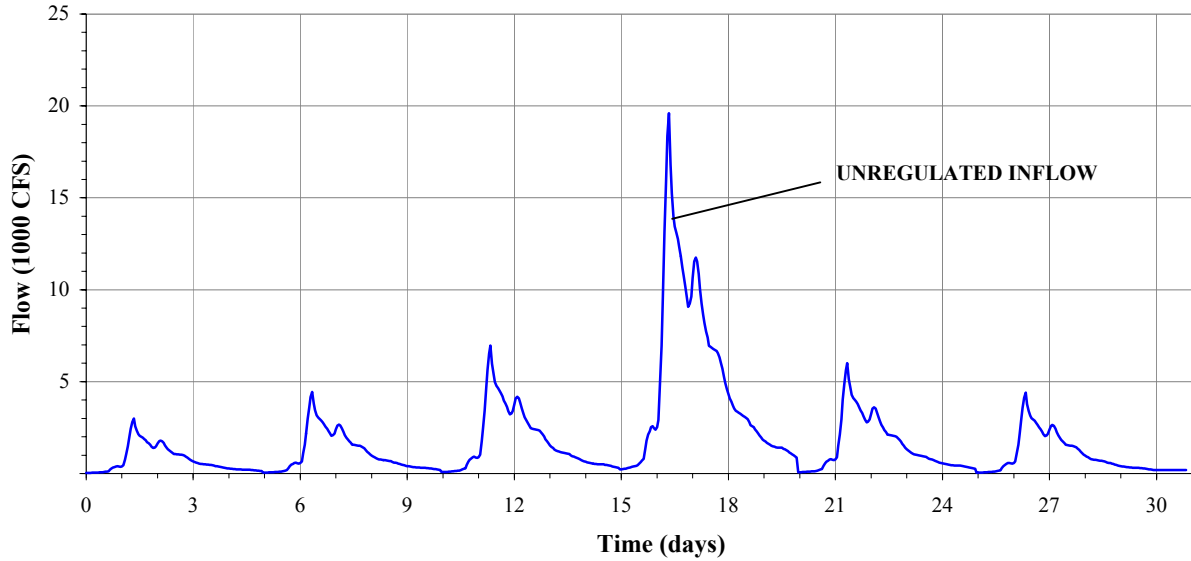
Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-9b Reservoir Simulation Hydrographs Hidden (10% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

FRESNO RIVER

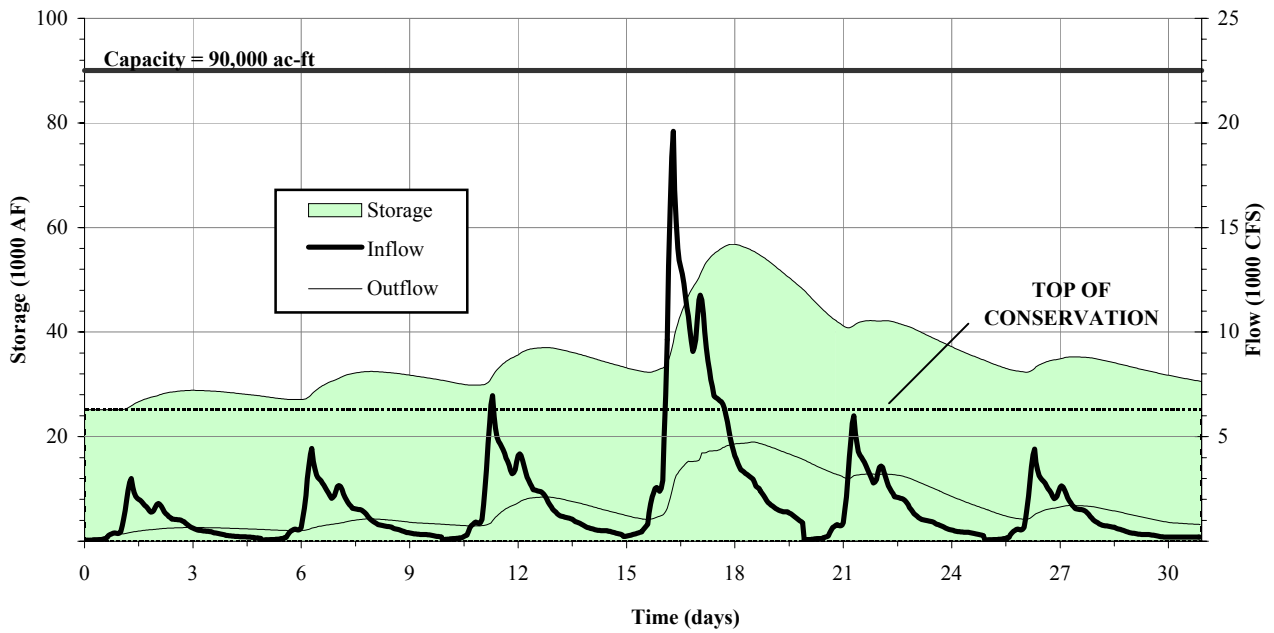
Hidden Inflow (4% Chance Exceedence Event)

Unregulated Inflow

Note: This reservoir has no major headwater reservoirs.



Hidden Operations (4% Chance Exceedence Event)



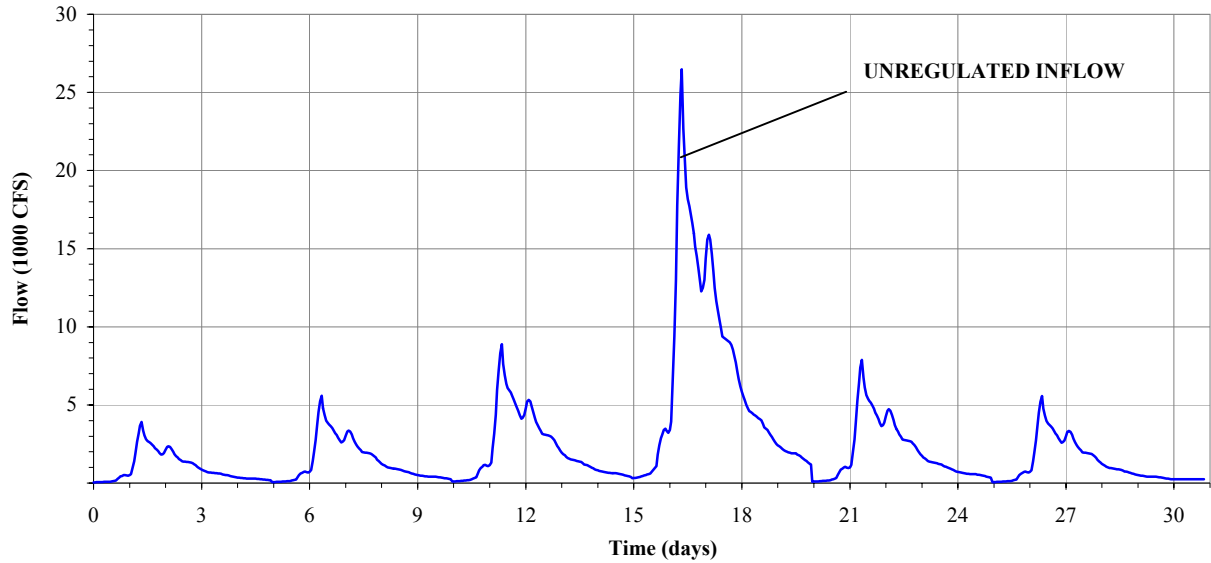
Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-9c Reservoir Simulation Hydrographs Hidden (4% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

FRESNO RIVER

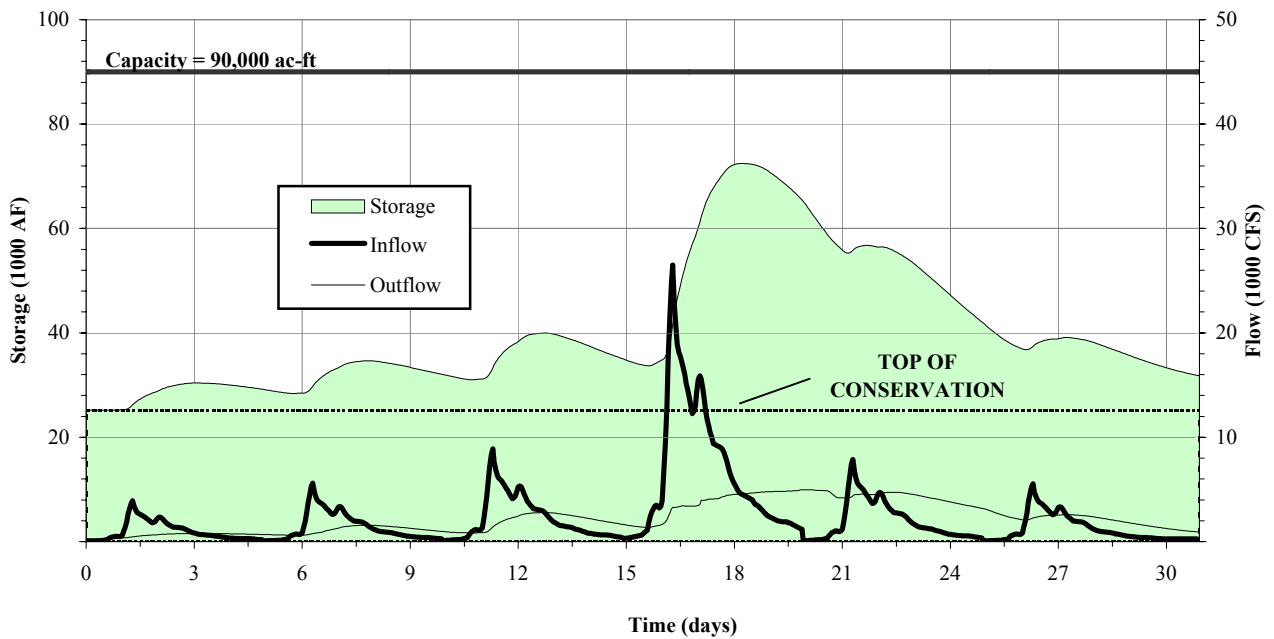
Hidden Inflow (2% Chance Exceedence Event)

Unregulated Inflow

Note: This reservoir has no major headwater reservoirs.



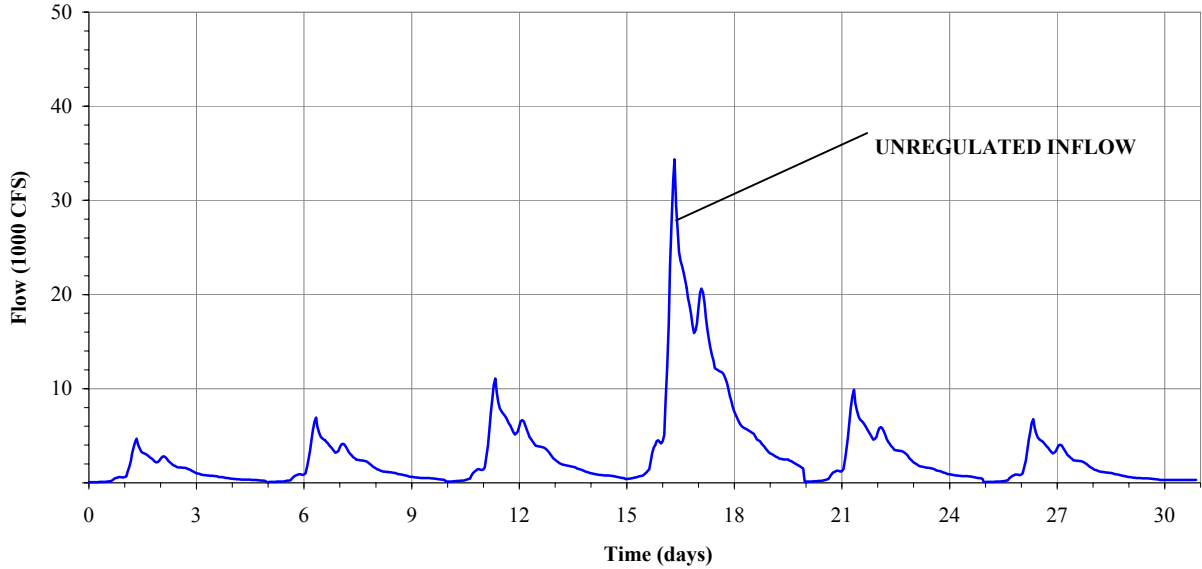
Hidden Operations (2% Chance Exceedence Event)



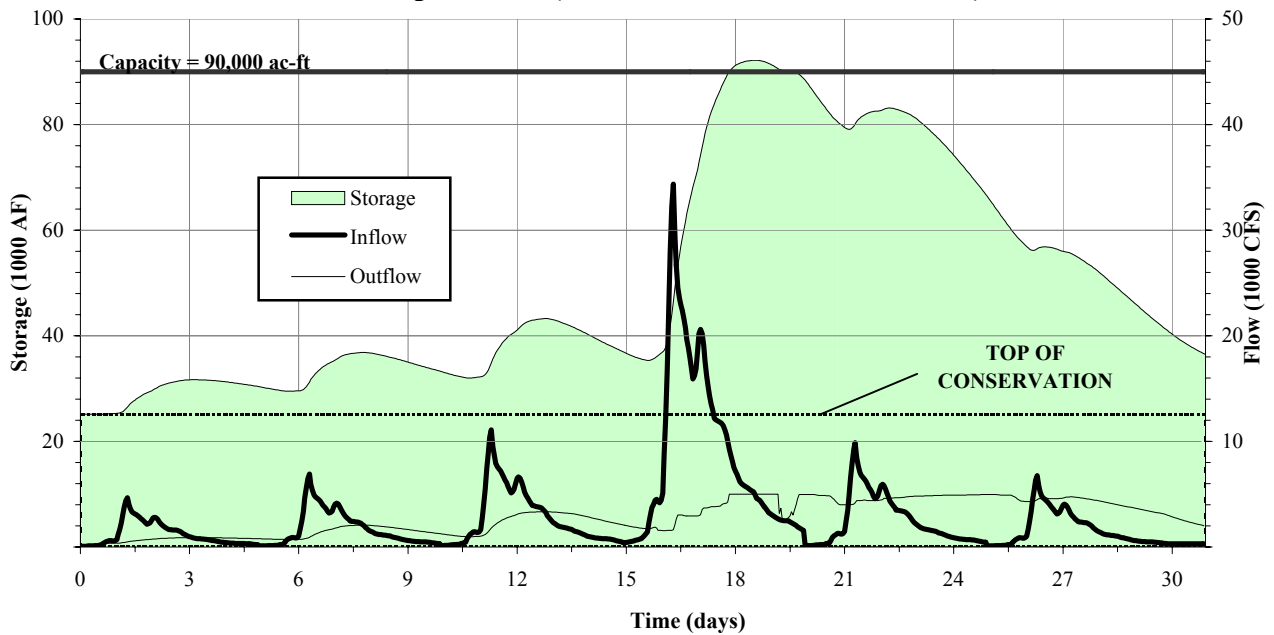
Sacramento & San Joaquin River Basins Comprehensive Study	
Figure C.1-9d Reservoir Simulation Hydrographs Hidden (2% Chance Exceedence Event)	
US Army Corps of Engineers The Reclamation Board, State of California December 2002	

FRESNO RIVER
Hidden Inflow (1% Chance Exceedence Event)
 Unregulated Inflow

Note: This reservoir has no major headwater reservoirs.



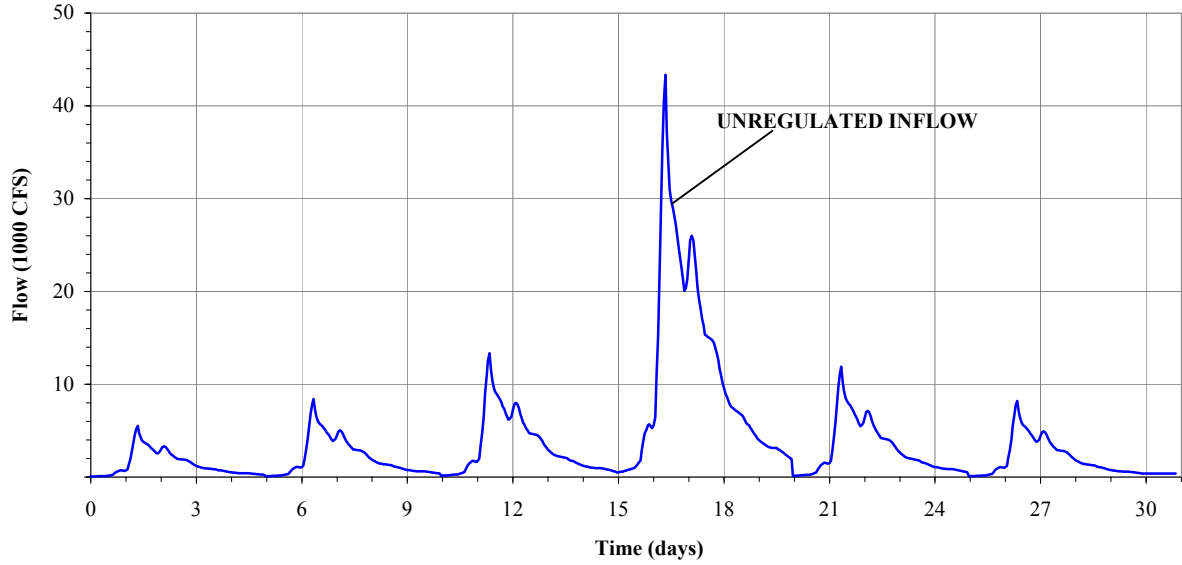
Hidden Operations (1% Chance Exceedence Event)



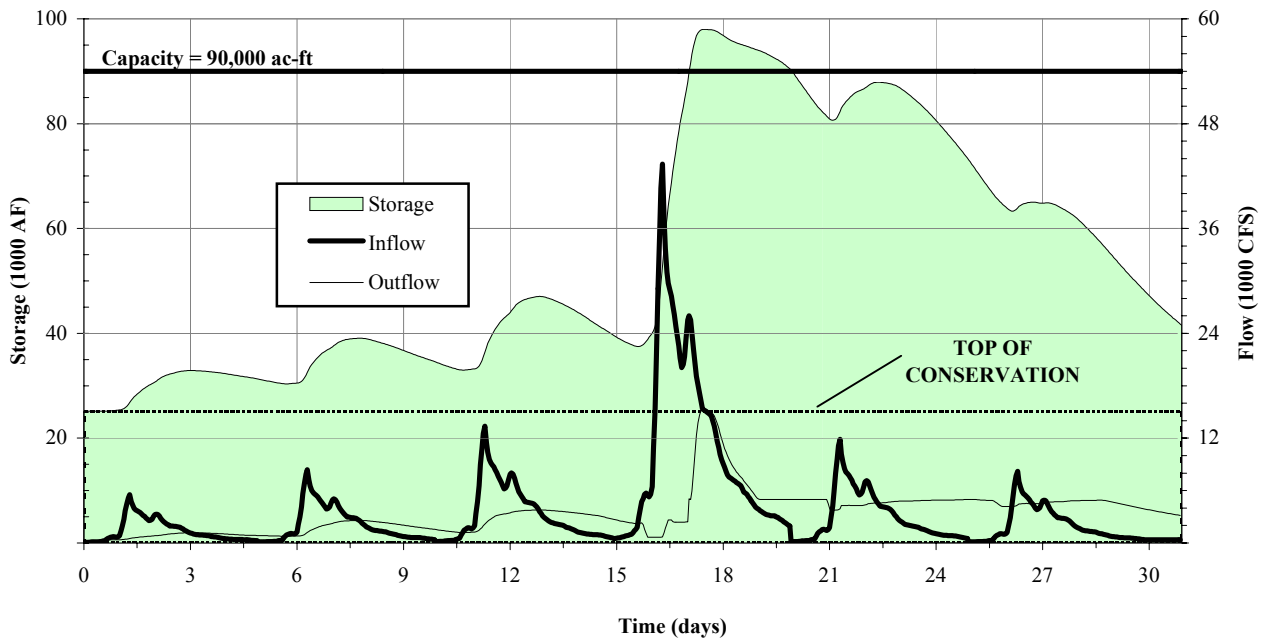
Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-9e Reservoir Simulation Hydrographs Hidden (1% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

FRESNO RIVER
Hidden Inflow (0.5% Chance Exceedence Event)
 Unregulated Inflow

Note: This reservoir has no major headwater reservoirs.



Hidden Operations (0.5% Chance Exceedence Event)

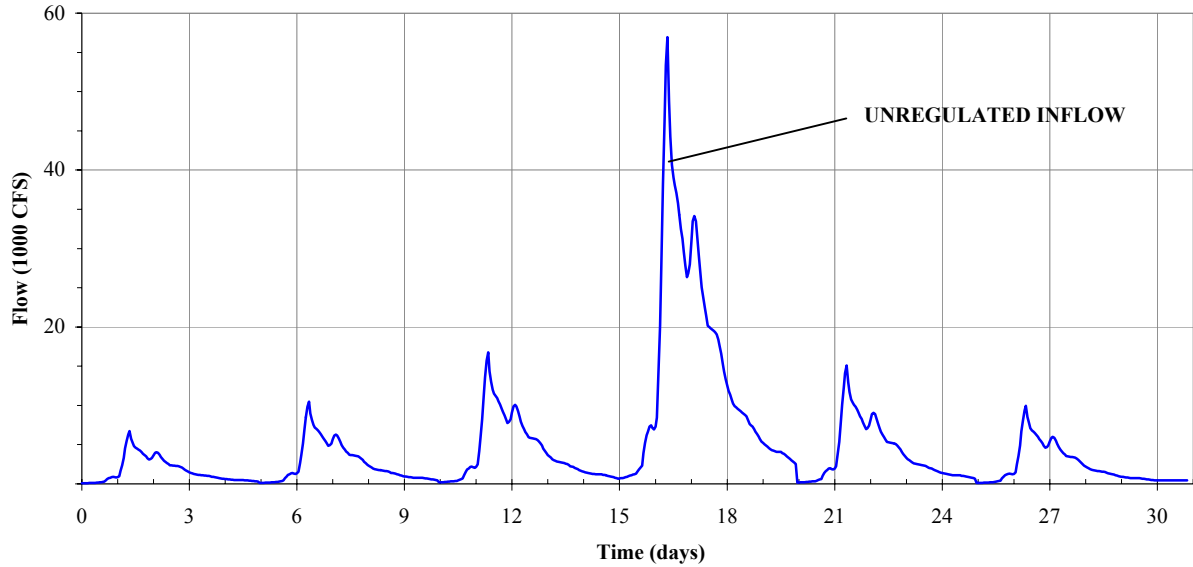


Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-9f Reservoir Simulation Hydrographs Hidden (0.5% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

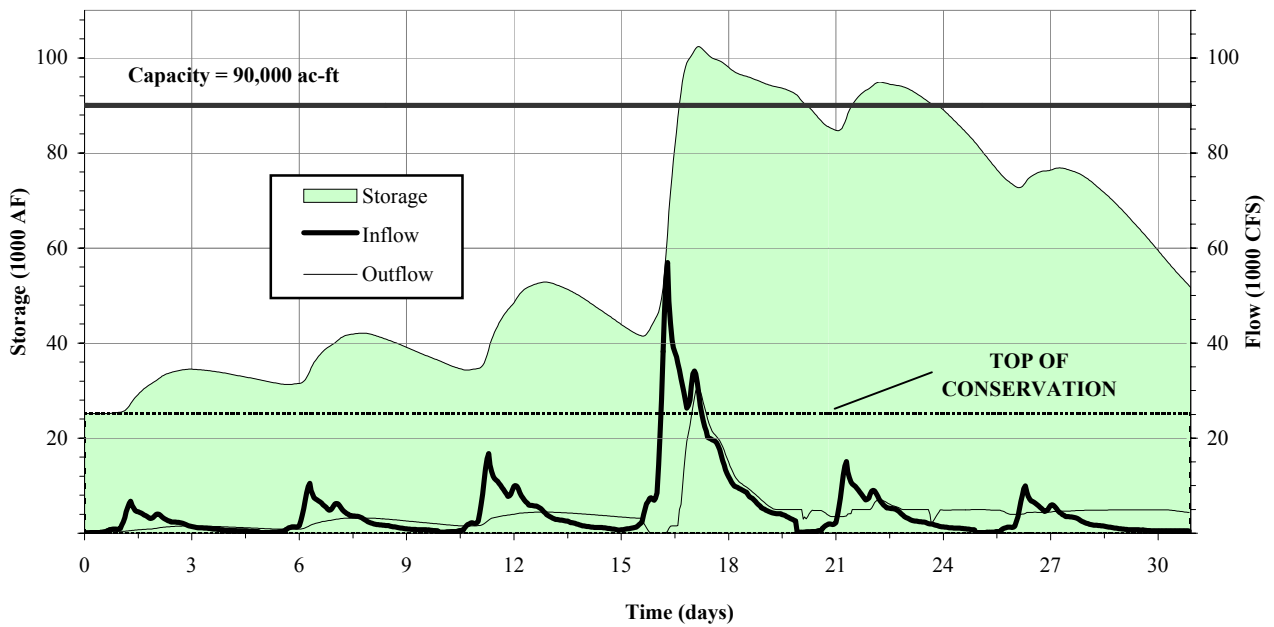
FRESNO RIVER
Hidden Inflow (0.2% Chance Exceedence Event)

Unregulated Inflow

Note: This reservoir has no major headwater reservoirs.



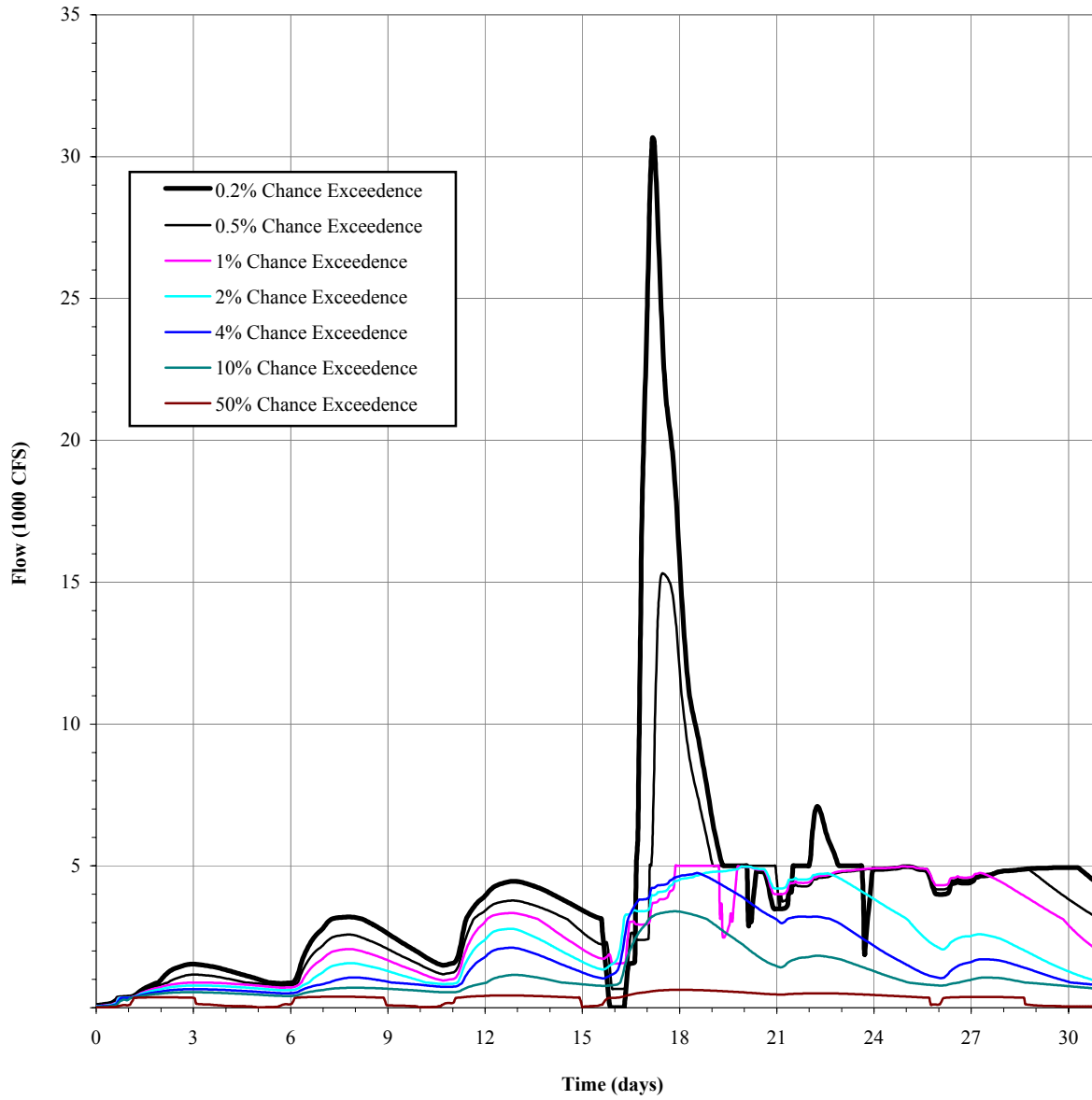
Hidden Operations (0.2% Chance Exceedence Event)



Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-9g Reservoir Simulation Hydrographs Hidden (0.2% Chance Exceedence Event)
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Hidden Outflow

Regulated Outflow Hydrographs



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Comprehensive Study

Figure C.1-9h
Reservoir Simulation Hydrographs
Regulated Outflow - Hidden

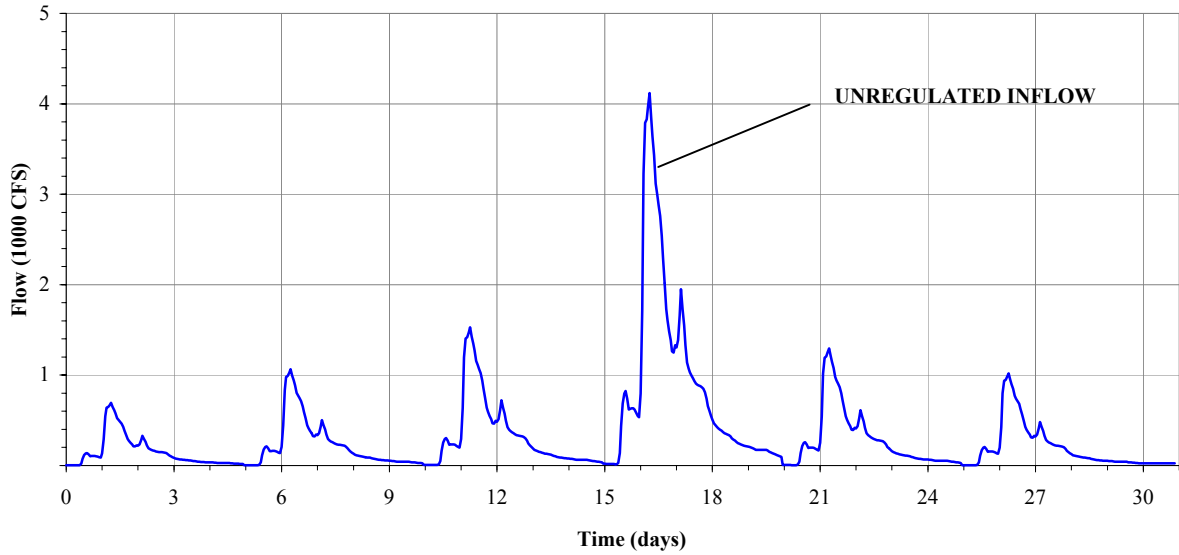
US Army Corps of Engineers
The Reclamation Board, State of California December 2002

CHOWCHILLA RIVER

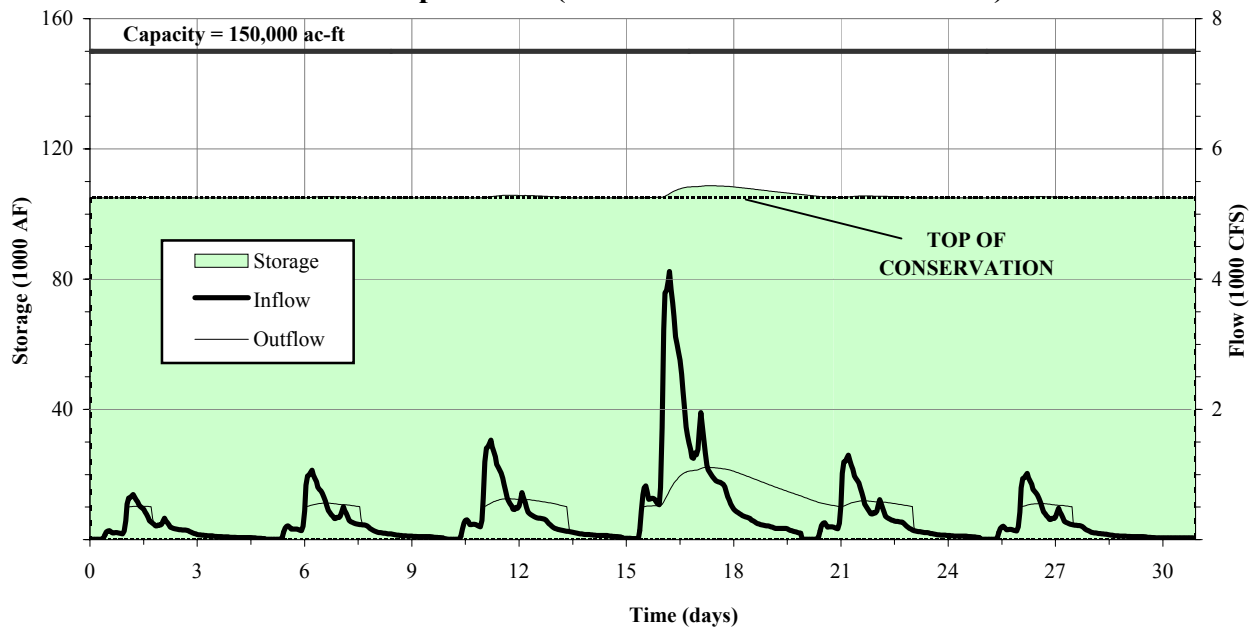
Buchanan Inflow (50% Chance Exceedence Event)

Unregulated Inflow

Note: This reservoir has no major headwater reservoirs.



Buchanan Operations (50% Chance Exceedence Event)



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Comprehensive Study

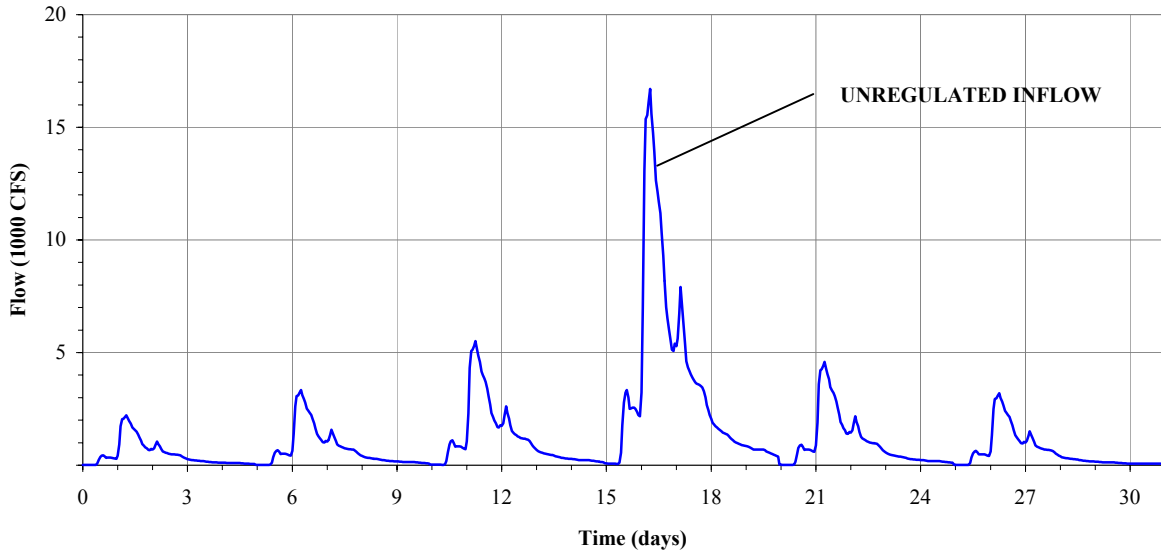
Figure C.1-10a
Reservoir Simulation Hydrographs
Buchanan
(50% Chance Exceedence Event)

US Army Corps of Engineers
The Reclamation Board, State of California December 2002

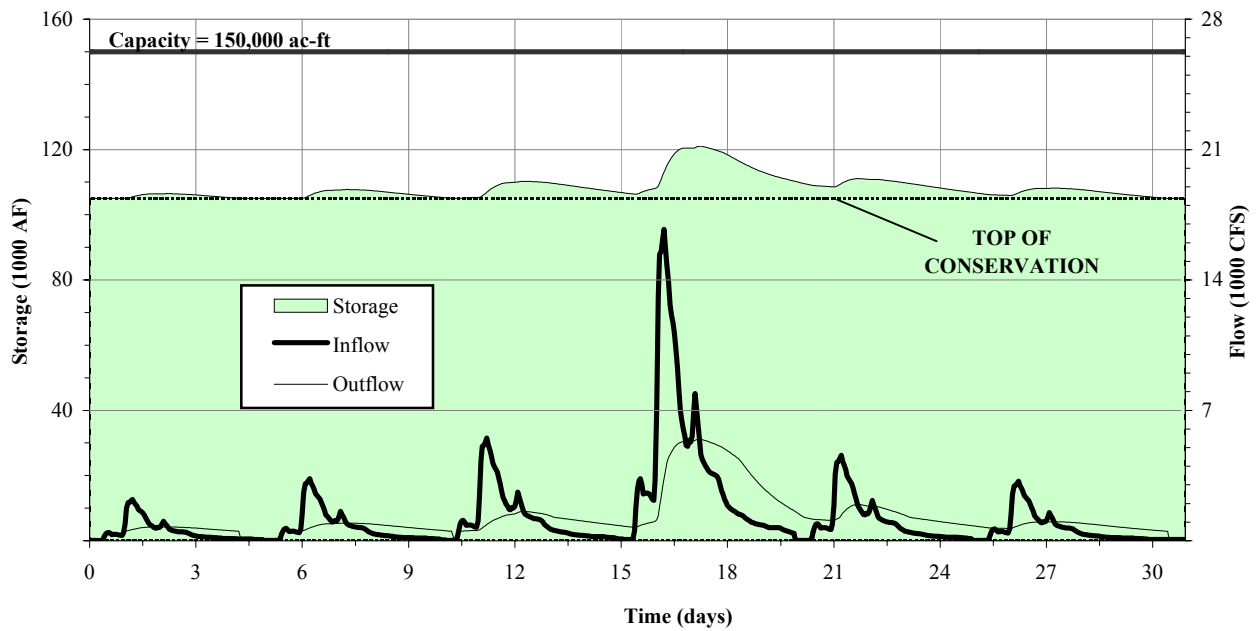
CHOWCHILLA RIVER
Buchanan Inflow (10% Chance Exceedence Event)

Unregulated Inflow

Note: This reservoir has no major headwater reservoirs.



Buchanan Operations (10% Chance Exceedence Event)



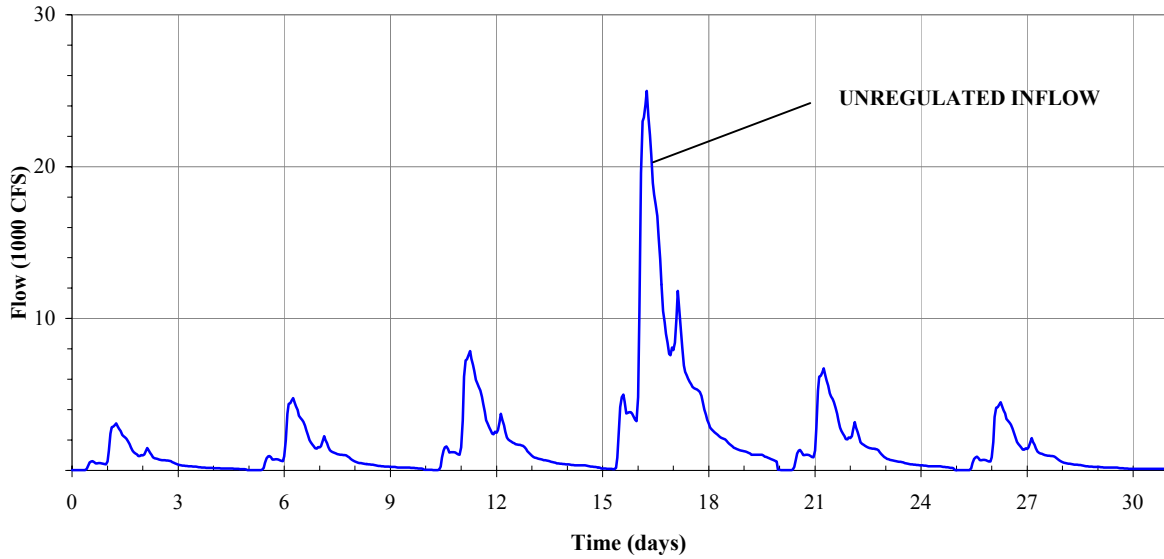
Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-10b Reservoir Simulation Hydrographs Buchanan (10% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

CHOWCHILLA RIVER

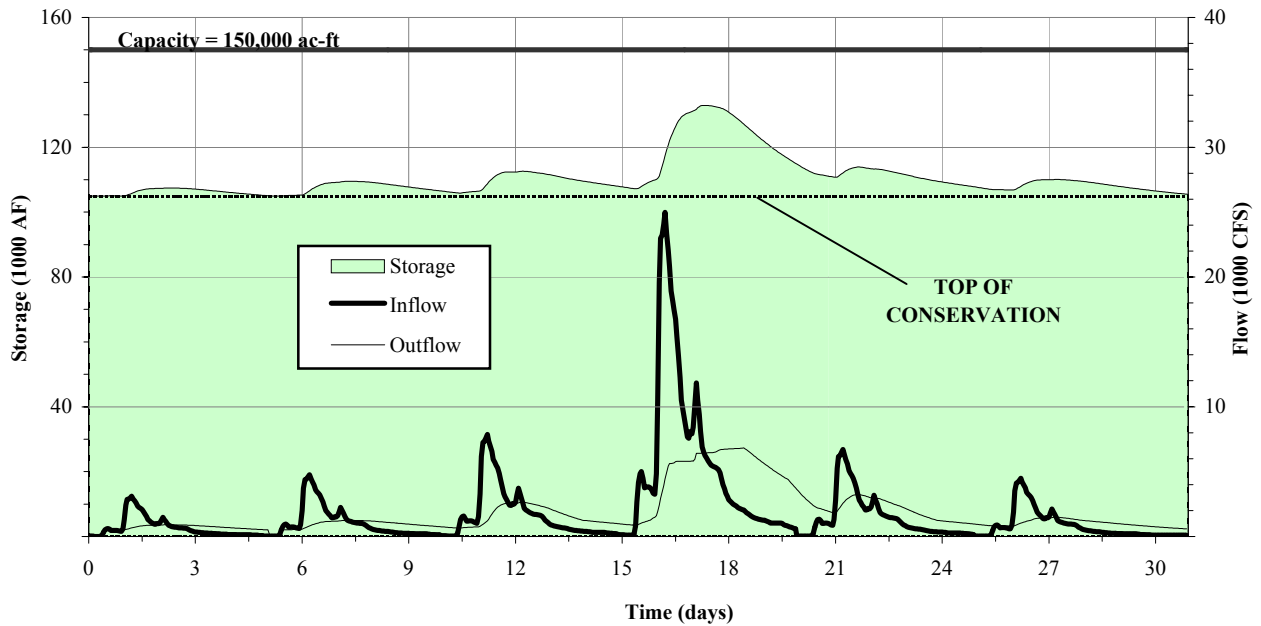
Buchanan Inflow (4% Chance Exceedence Event)

Unregulated Inflow

Note: This reservoir has no major headwater reservoirs.



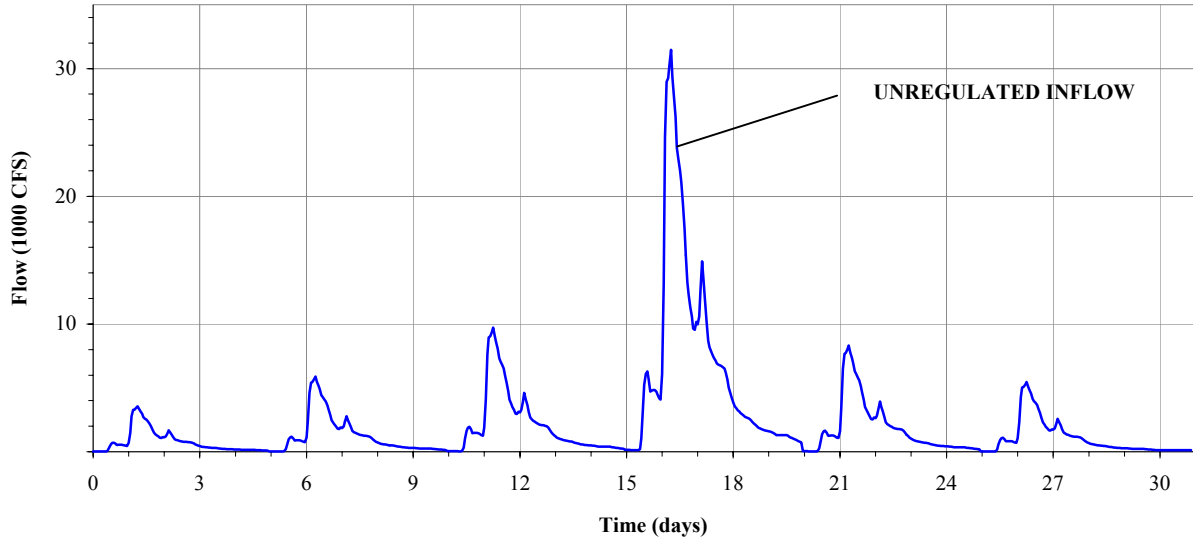
Buchanan Operations (4% Chance Exceedence Event)



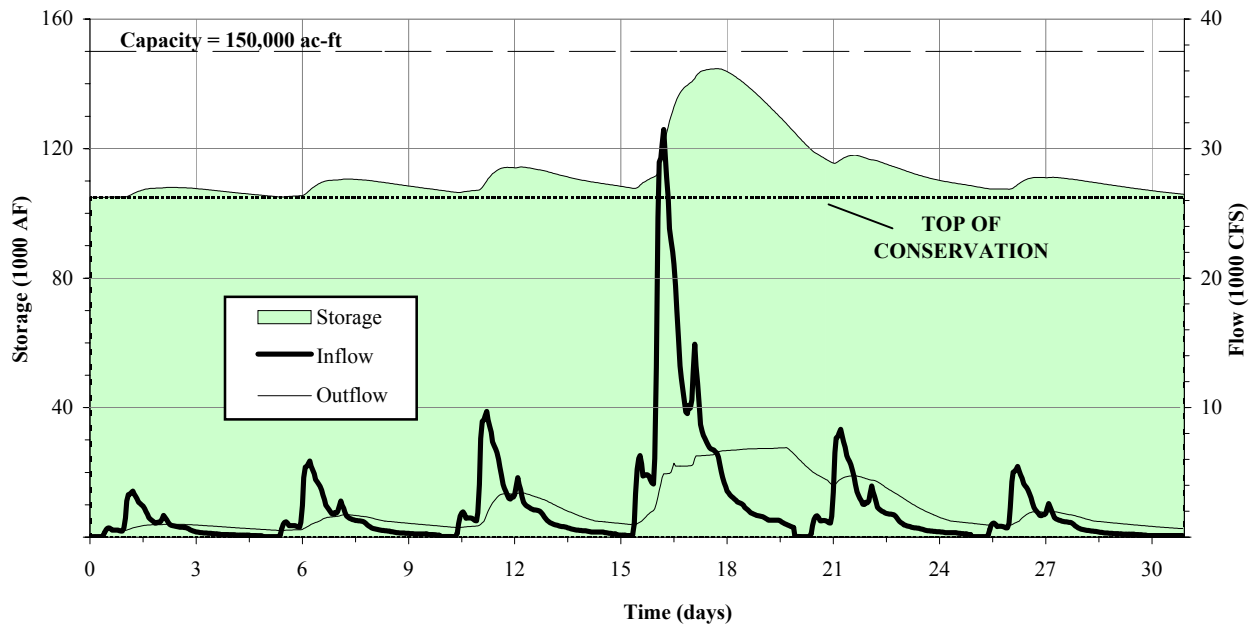
Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-10c Reservoir Simulation Hydrographs Buchanan (4% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

CHOWCHILLA RIVER
Buchanan Inflow (2% Chance Exceedence Event)
 Unregulated Inflow

Note: This reservoir has no major headwater reservoirs.



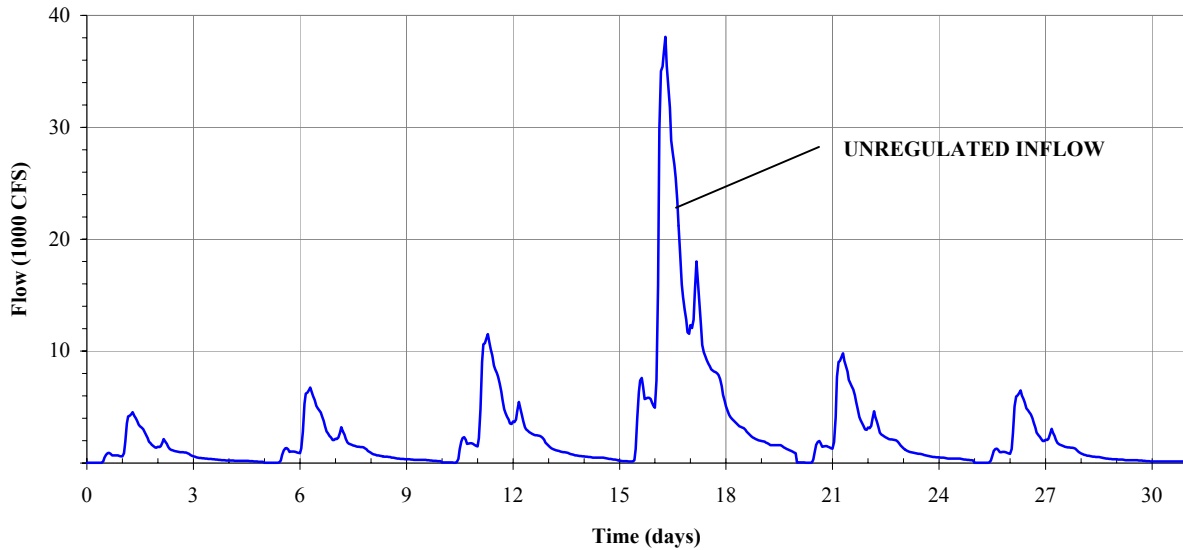
Buchanan Operations (2% Chance Exceedence Event)



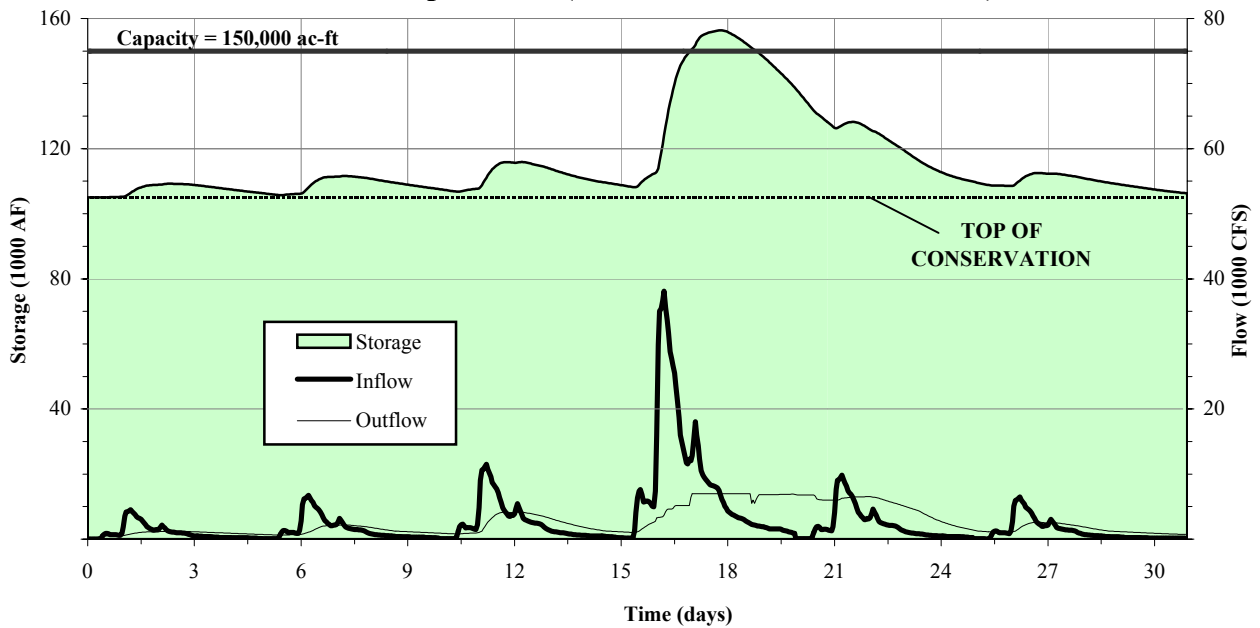
Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-10d Reservoir Simulation Hydrographs Buchanan (2% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

CHOWCHILLA RIVER
Buchanan Inflow (1% Chance Exceedence Event)
 Unregulated Inflow

Note: This reservoir has no major headwater reservoirs.



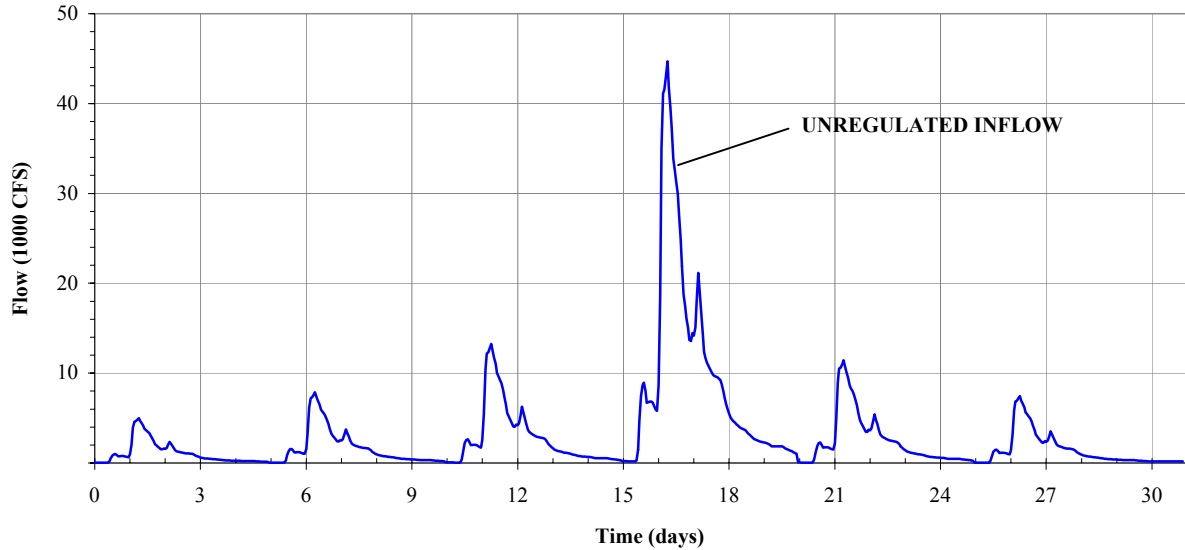
Buchanan Operations (1% Chance Exceedence Event)



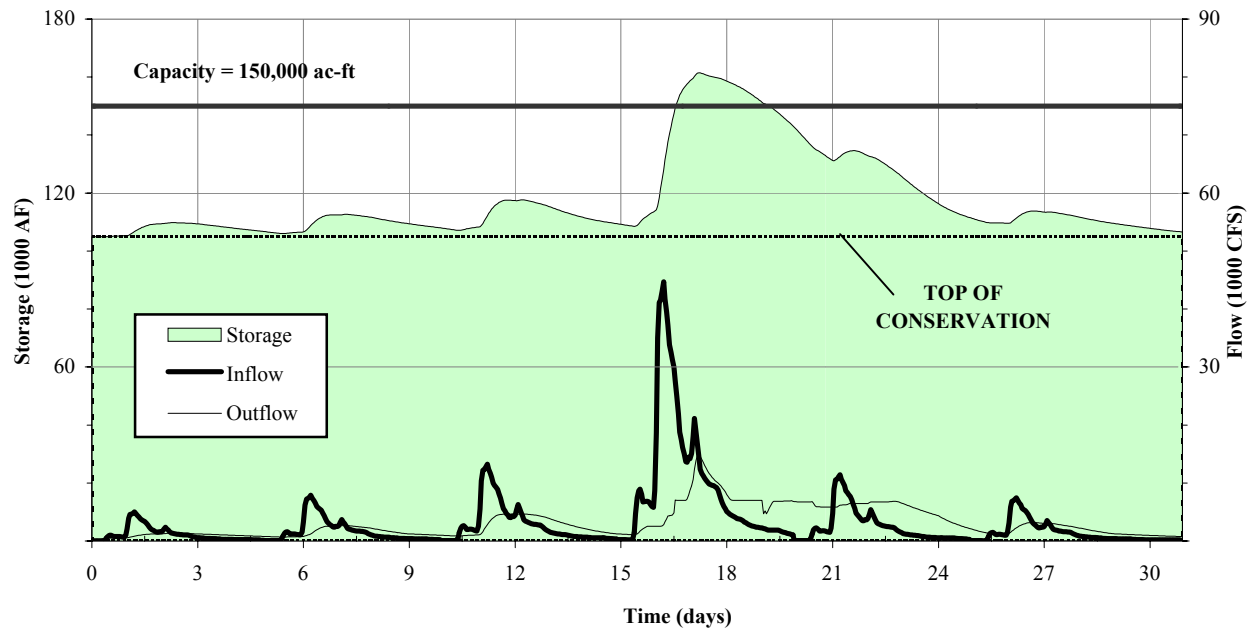
Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-10e Reservoir Simulation Hydrographs Buchanan (1% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

CHOWCHILLA RIVER
Buchanan Inflow (0.5% Chance Exceedence Event)
 Unregulated Inflow

Note: This reservoir has no major headwater reservoirs.



Buchanan Operations (0.5% Chance Exceedence Event)

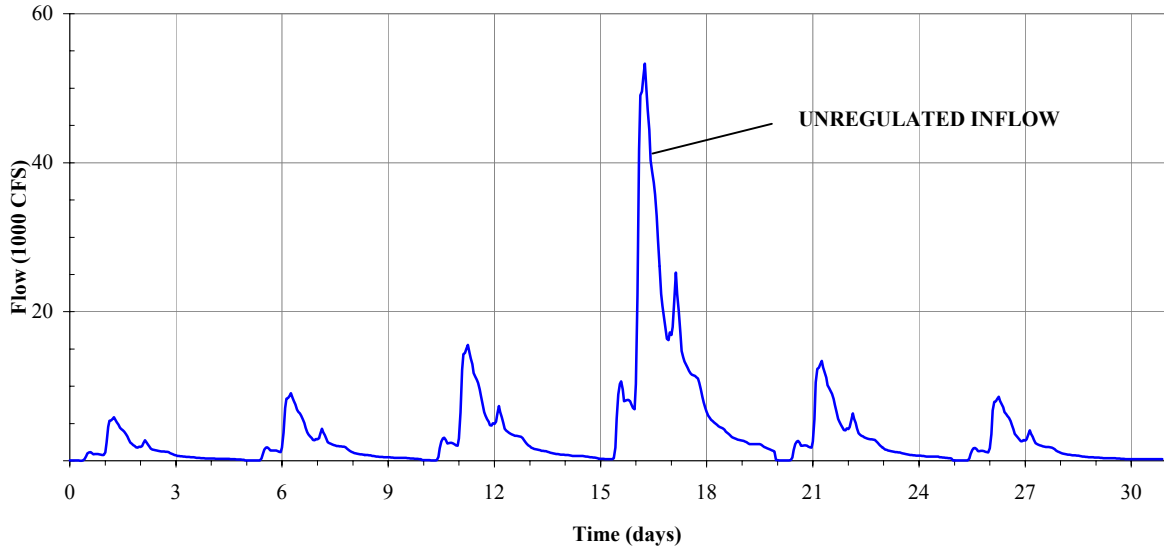


Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-10f Reservoir Simulation Hydrographs Buchanan (0.5% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

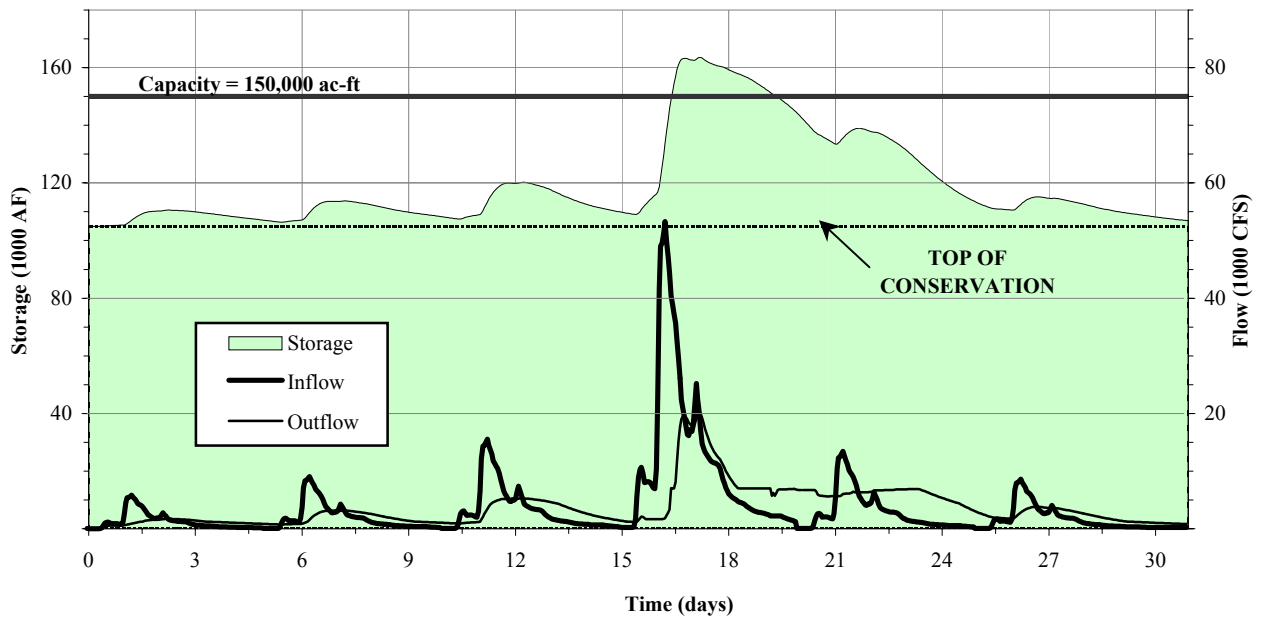
CHOWCHILLA RIVER
Buchanan Inflow (0.2% Chance Exceedence Event)

Unregulated Inflow

Note: This reservoir has no major headwater reservoirs.



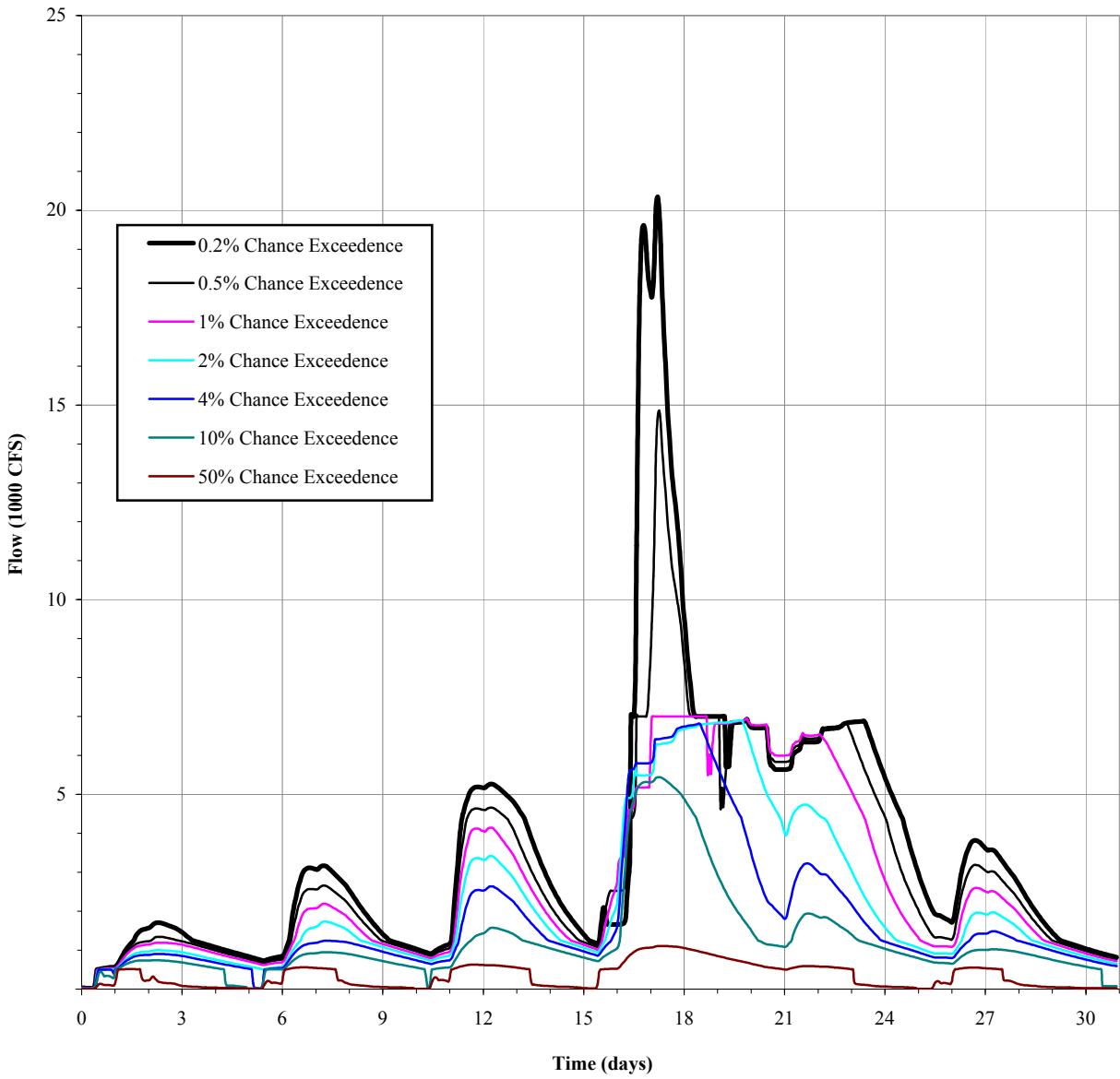
Buchanan Operations (0.2% Chance Exceedence Event)



Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-10g Reservoir Simulation Hydrographs Buchanan (0.2% Chance Exceedence Event)
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Buchanan Outflow

Regulated Outflow Hydrographs



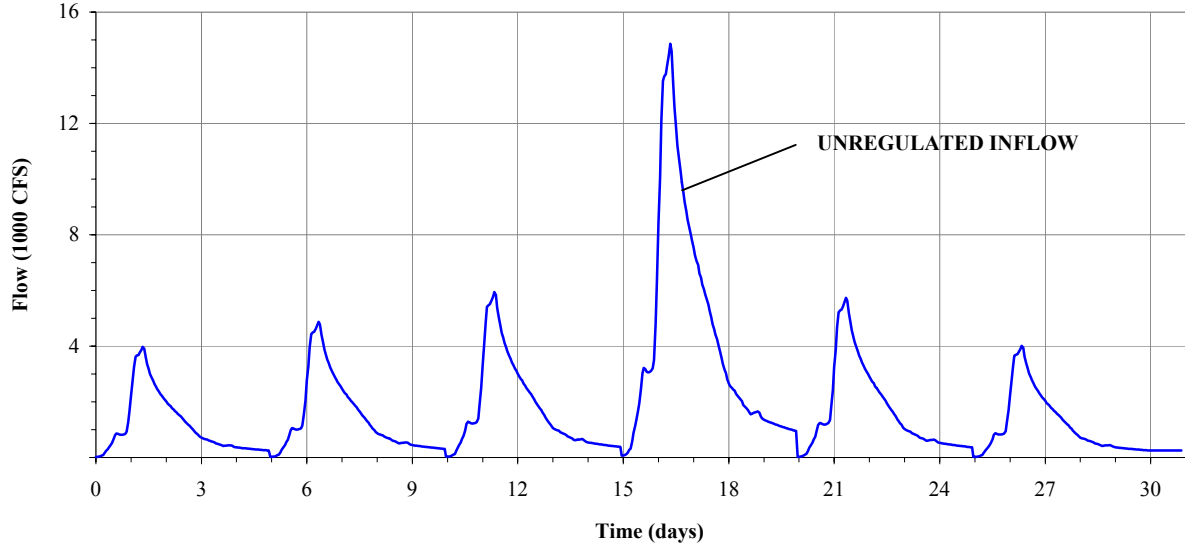
Sacramento & San Joaquin River Basins
Comprehensive Study

Figure C.1-10h
Reservoir Simulation Hydrographs
Regulated Outflow - Buchanan

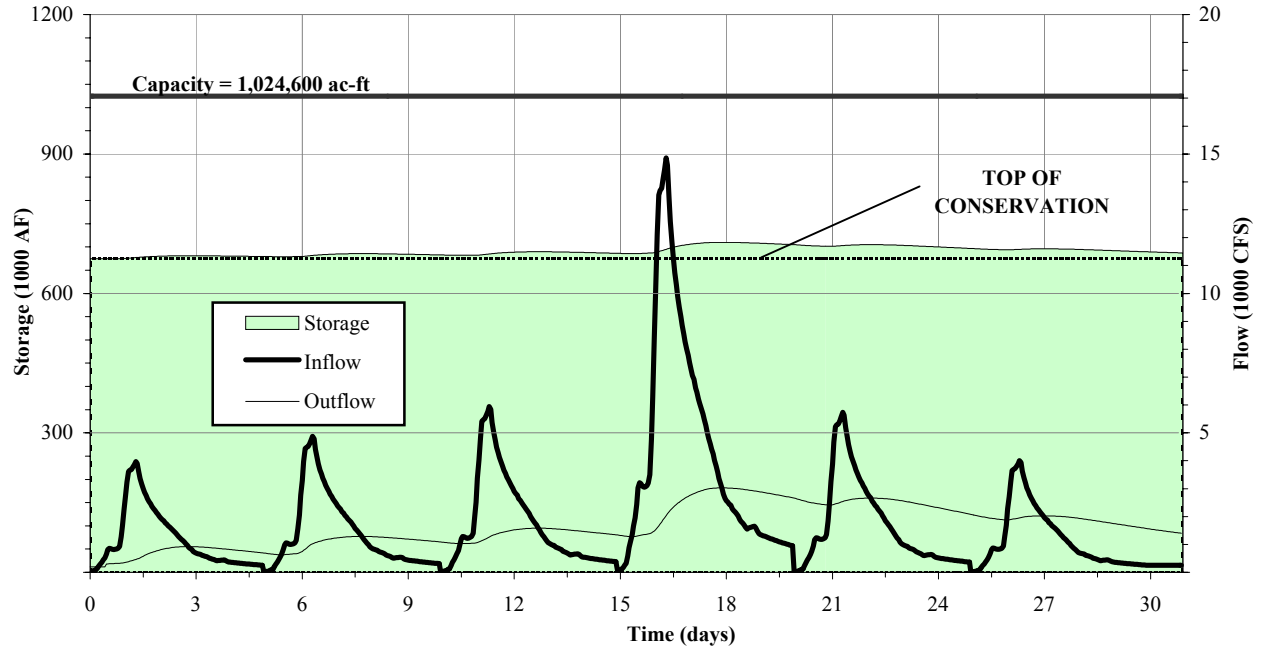
US Army Corps of Engineers
The Reclamation Board, State of California December 2002

MERCED RIVER
New Exchequer Inflow (50% Chance Exceedence Event)
 Unregulated Inflow

Note: This reservoir has no major headwater reservoirs.



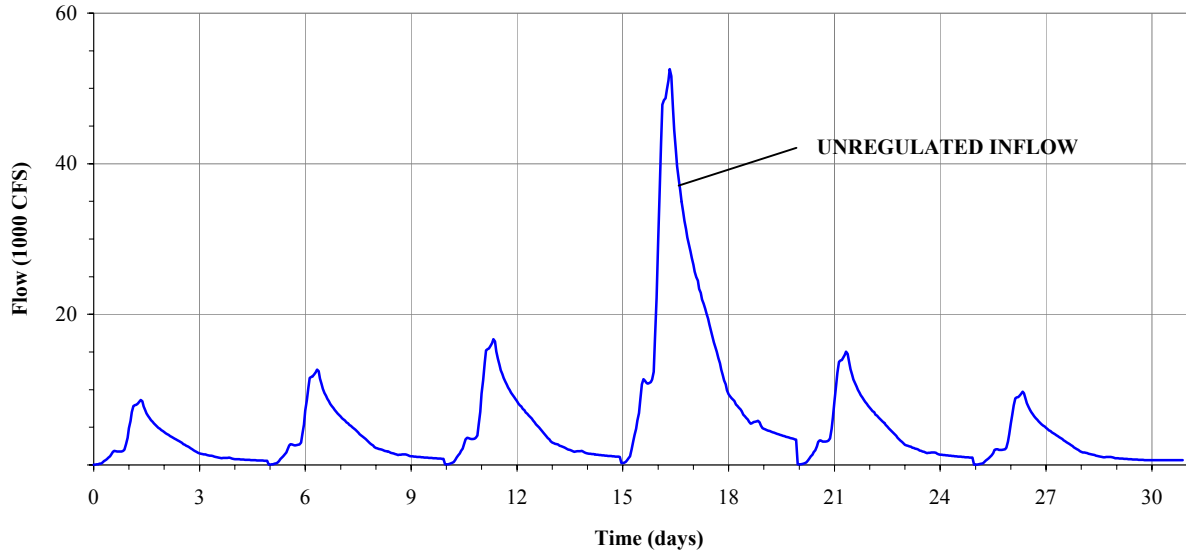
New Exchequer Operations (50% Chance Exceedence Event)



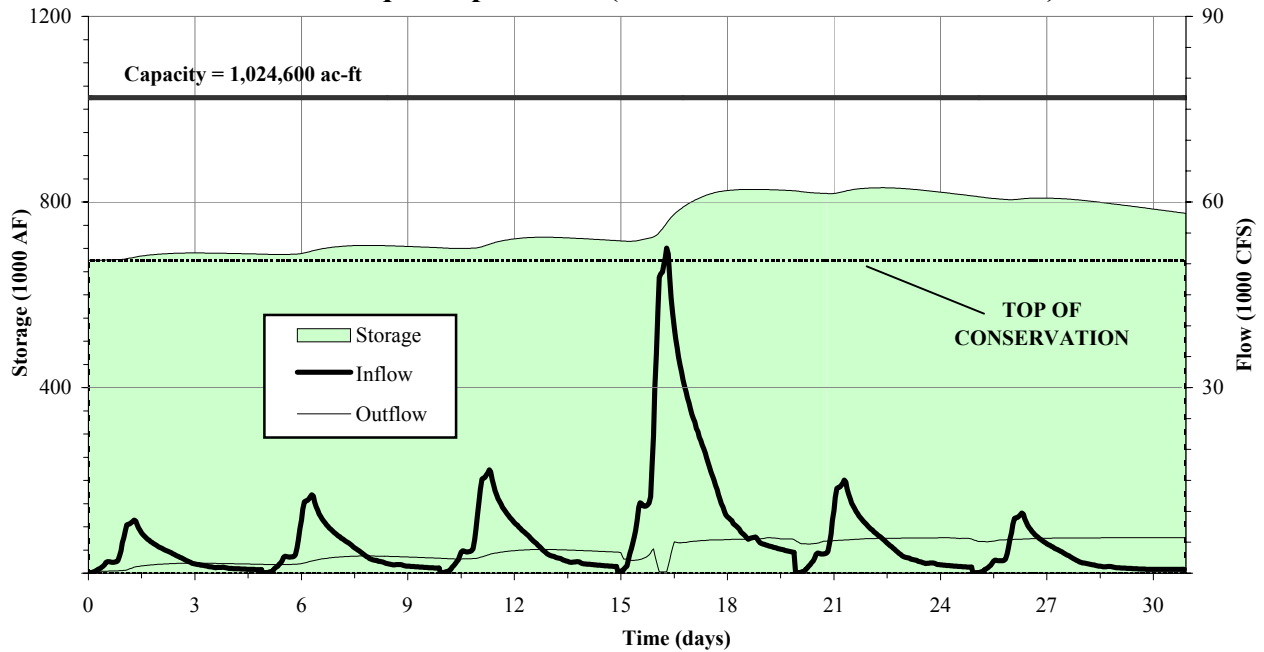
Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-11a Reservoir Simulation Hydrographs New Exchequer (50% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

MERCED RIVER
New Exchequer Inflow (10% Chance Exceedence Event)
 Unregulated Inflow

Note: This reservoir has no major headwater reservoirs.



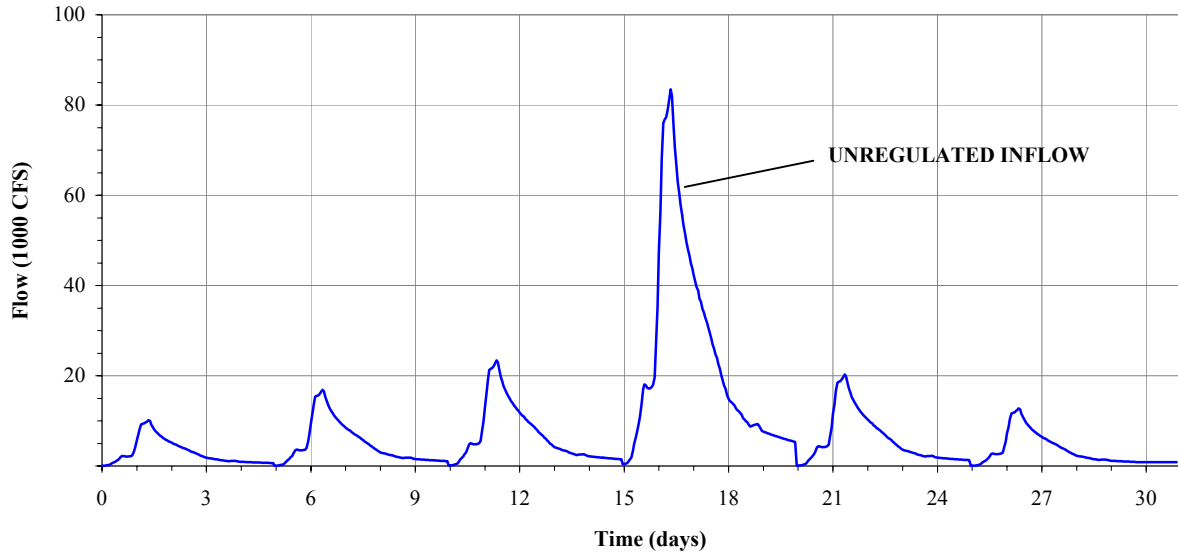
New Exchequer Operations (10% Chance Exceedence Event)



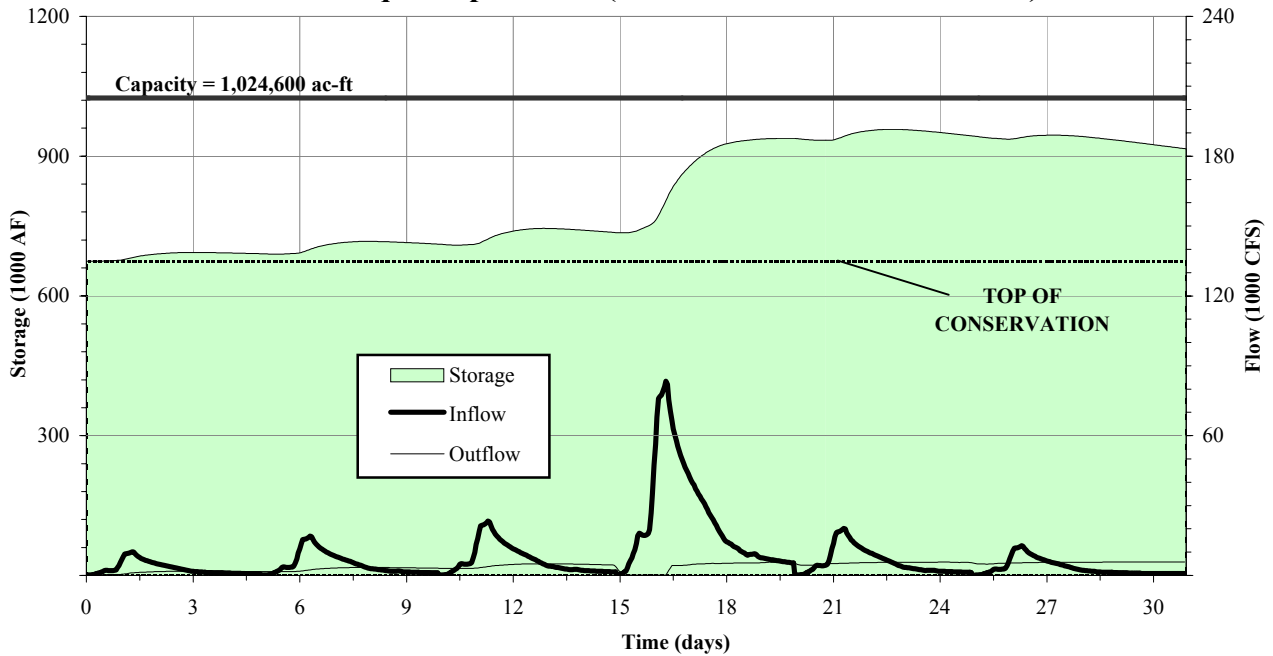
Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-11b Reservoir Simulation Hydrographs New Exchequer (10% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

MERCED RIVER
New Exchequer Inflow (4% Chance Exceedence Event)
 Unregulated Inflow

Note: This reservoir has no major headwater reservoirs.



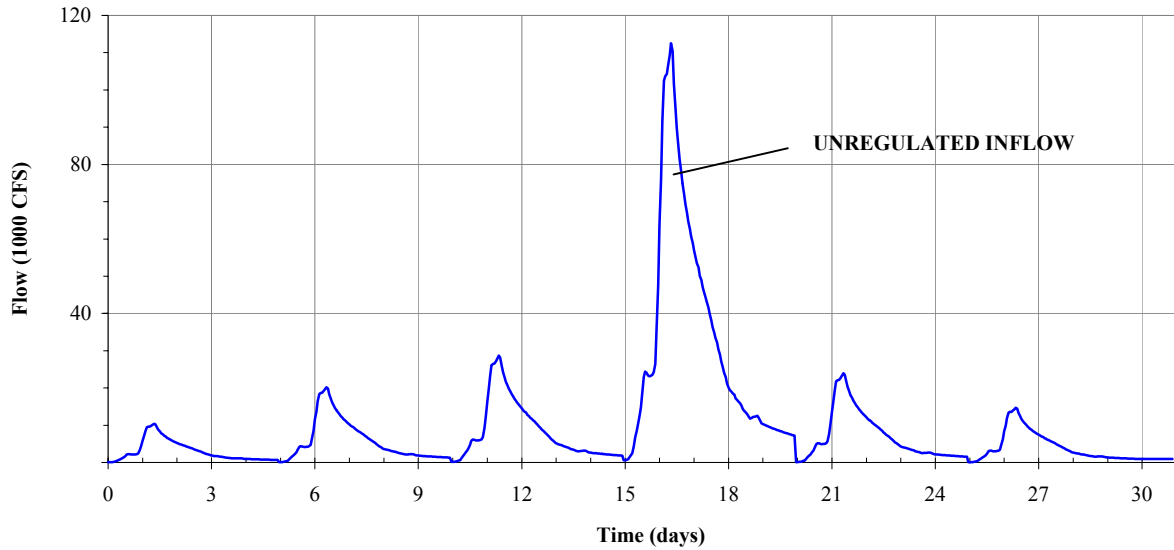
New Exchequer Operations (4% Chance Exceedence Event)



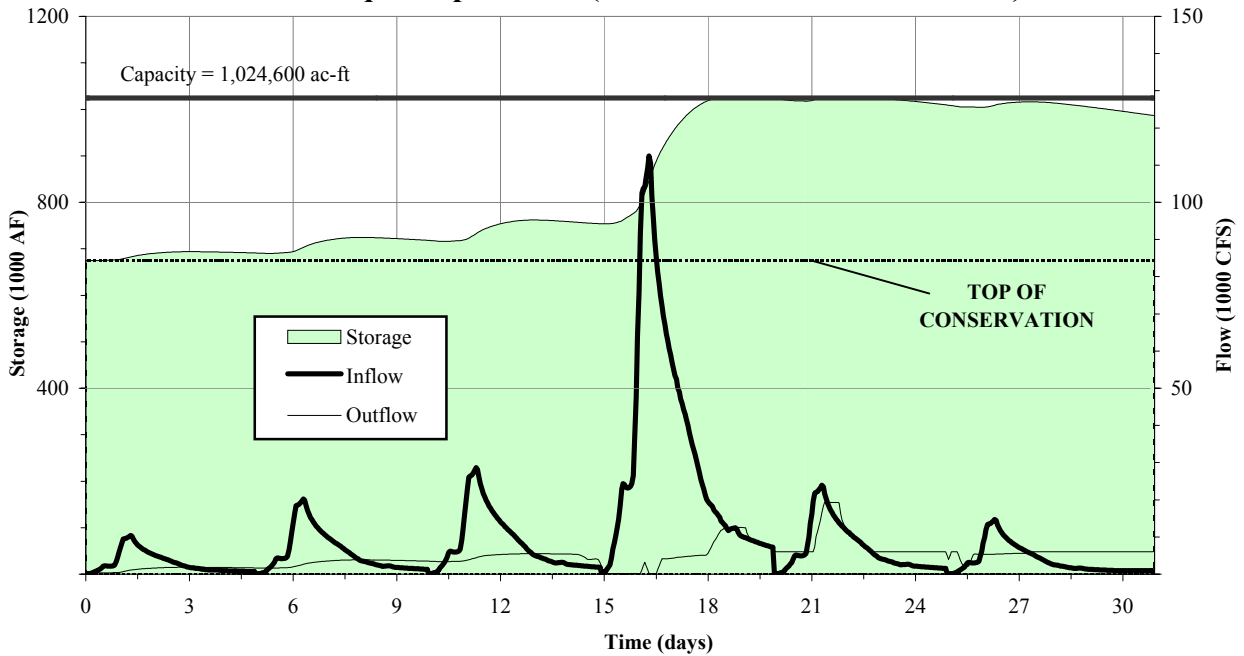
Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-11c Reservoir Simulation Hydrographs New Exchequer (4% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

MERCED RIVER
New Exchequer Inflow (2% Chance Exceedence Event)
 Unregulated Inflow

Note: This reservoir has no major headwater reservoirs.



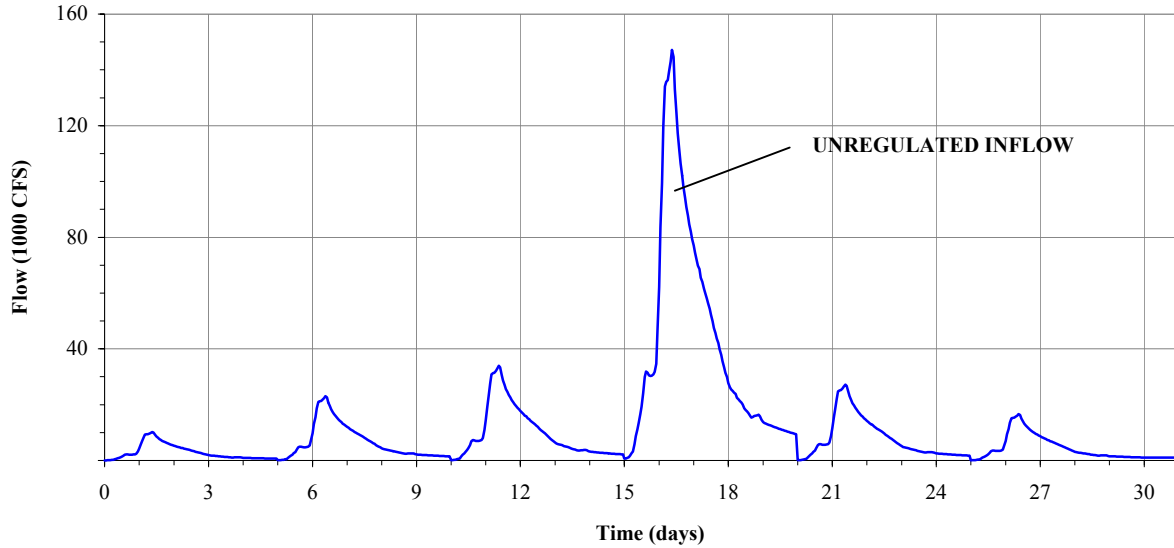
New Exchequer Operations (2% Chance Exceedence Event)



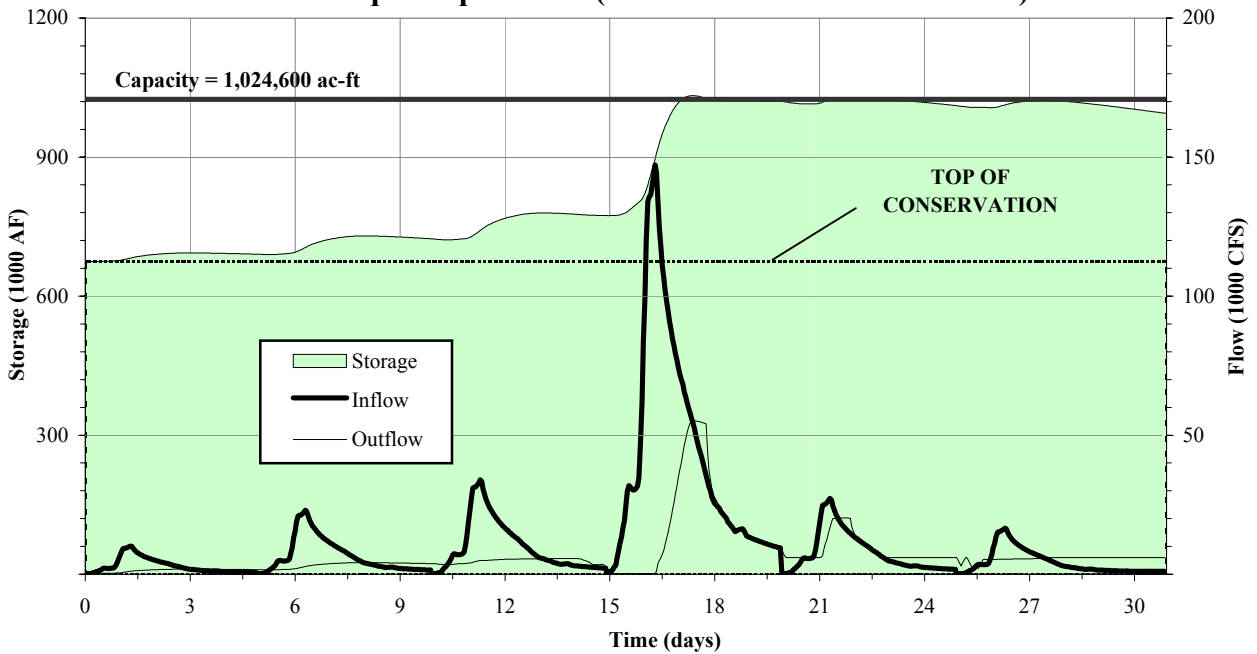
Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-11d Reservoir Simulation Hydrographs New Exchequer (2% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

MERCED RIVER
New Exchequer Inflow (1% Chance Exceedence Event)
 Unregulated Inflow

Note: This reservoir has no major headwater reservoirs.



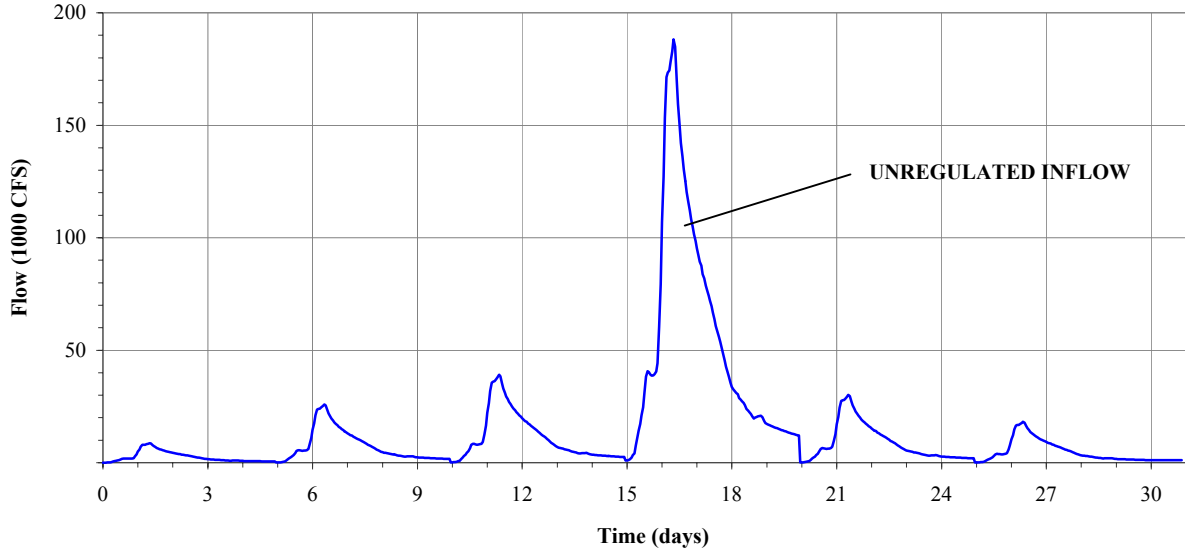
New Exchequer Operations (1% Chance Exceedence Event)



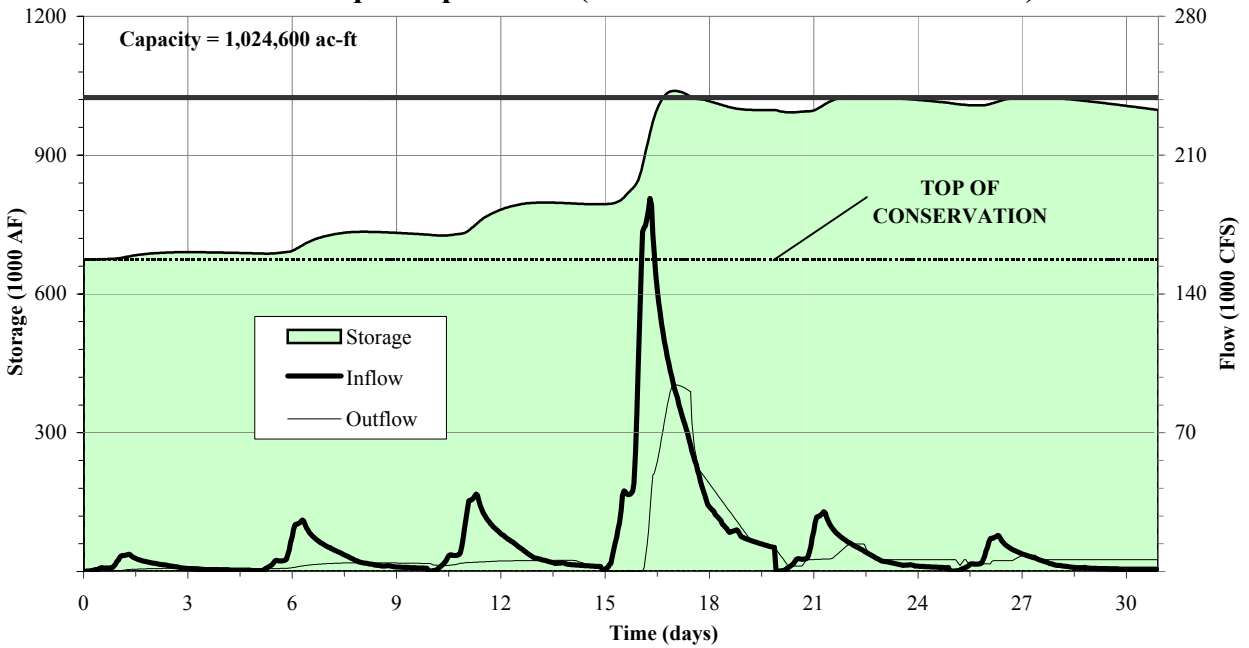
Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-11e Reservoir Simulation Hydrographs New Exchequer (1% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

MERCED RIVER
New Exchequer Inflow (0.5% Chance Exceedence Event)
 Unregulated Inflow

Note: This reservoir has no major headwater reservoirs.



New Exchequer Operations (0.5% Chance Exceedence Event)

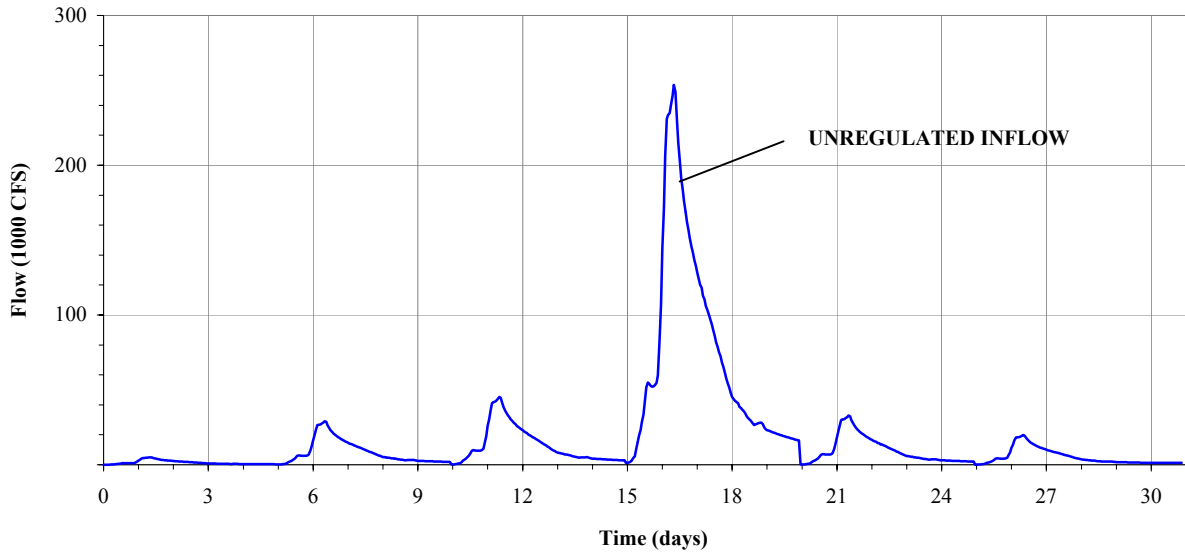


Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-11f Reservoir Simulation Hydrographs New Exchequer (0.5% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

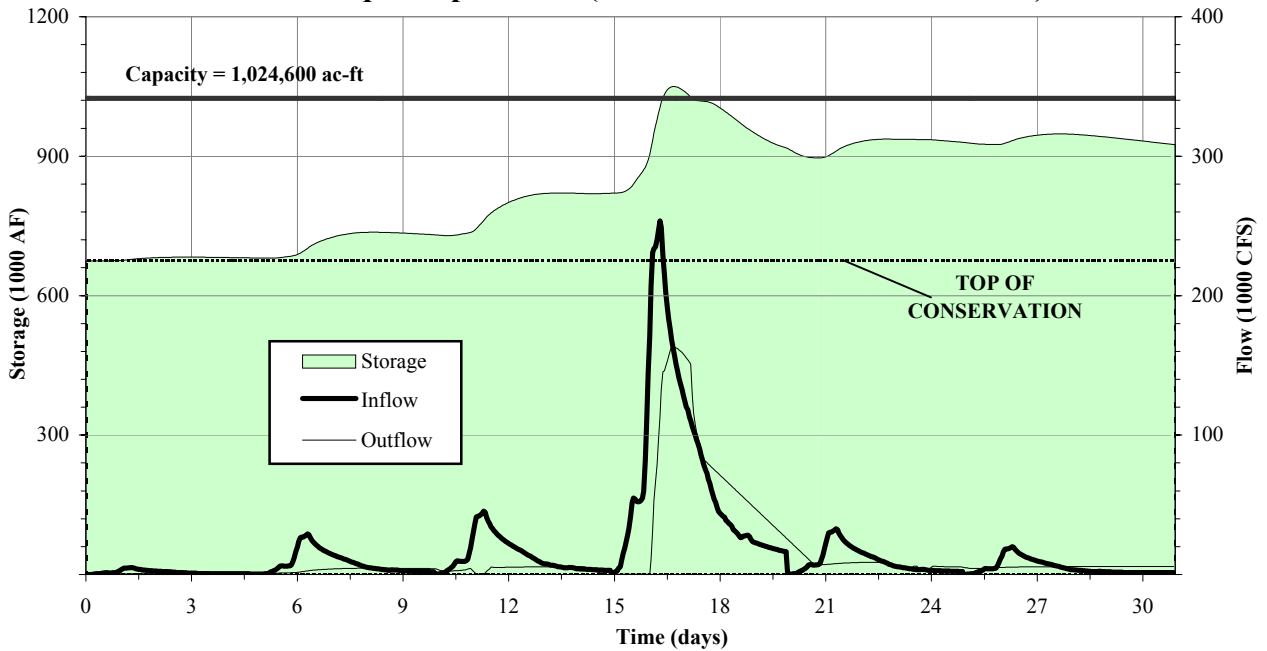
MERCED RIVER
New Exchequer Inflow (0.2% Chance Exceedence Event)

Unregulated Inflow

Note: This reservoir has no major headwater reservoirs.

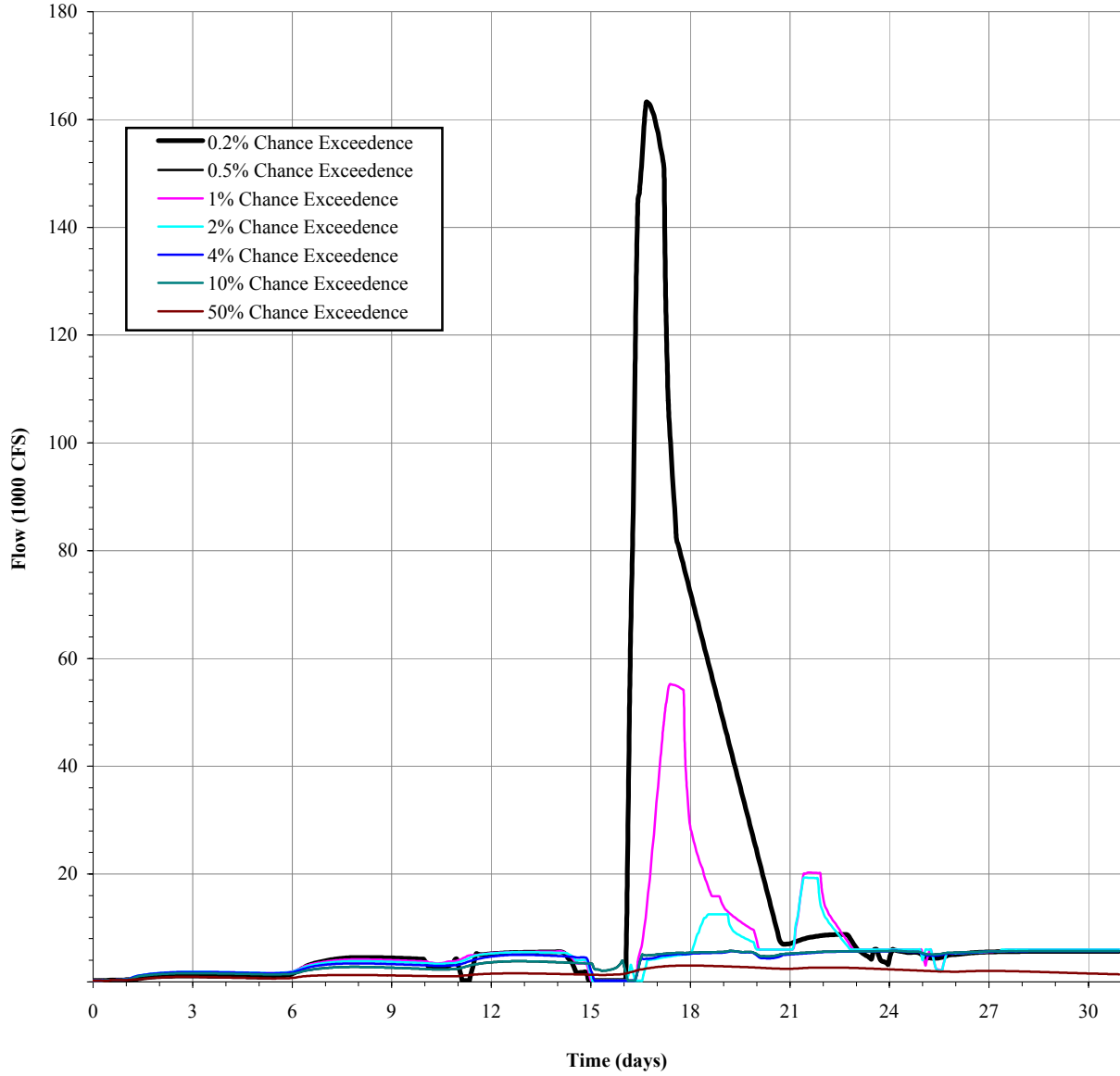


New Exchequer Operations (0.2% Chance Exceedence Event)



Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-11g Reservoir Simulation Hydrographs New Exchequer (0.2% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

New Exchequer Outflow
Regulated Outflow Hydrographs

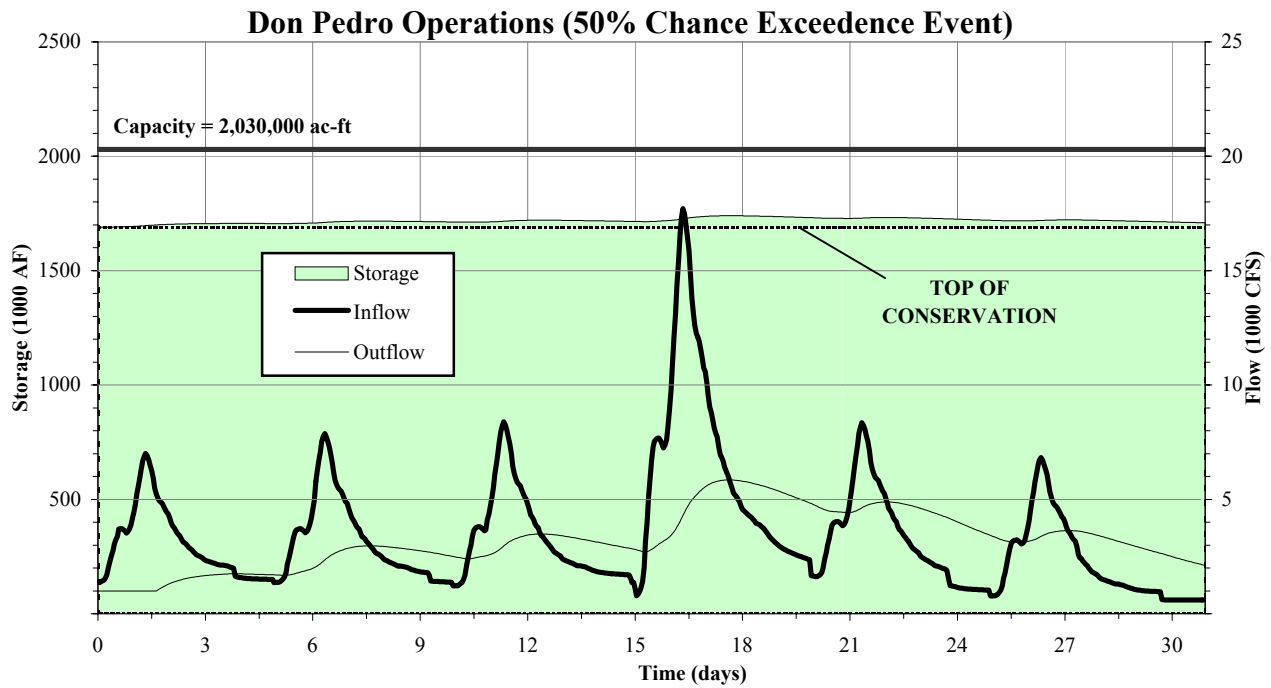
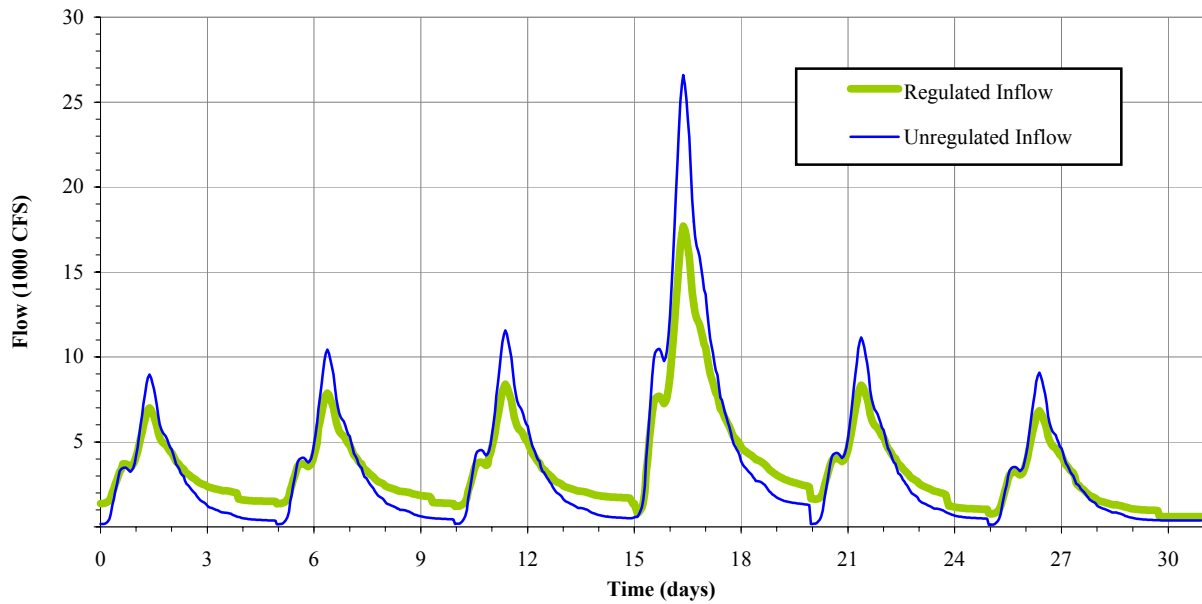


Sacramento & San Joaquin River Basins
Comprehensive Study

Figure C.1-11h
Reservoir Simulation Hydrographs
Regulated Outflow - New Exchequer

US Army Corps of Engineers
The Reclamation Board, State of California December 2002

TUOLUMNE RIVER
Don Pedro Inflow (50% Chance Exceedence Event)
 Regulated and Unregulated Inflow

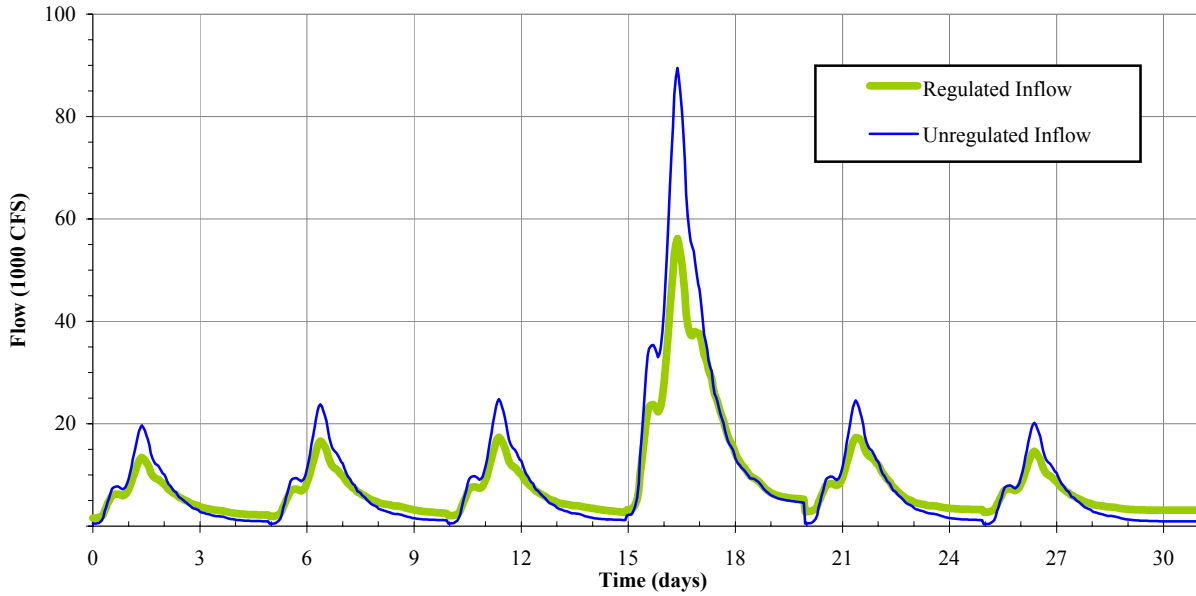


Sacramento & San Joaquin River Basins
 Comprehensive Study

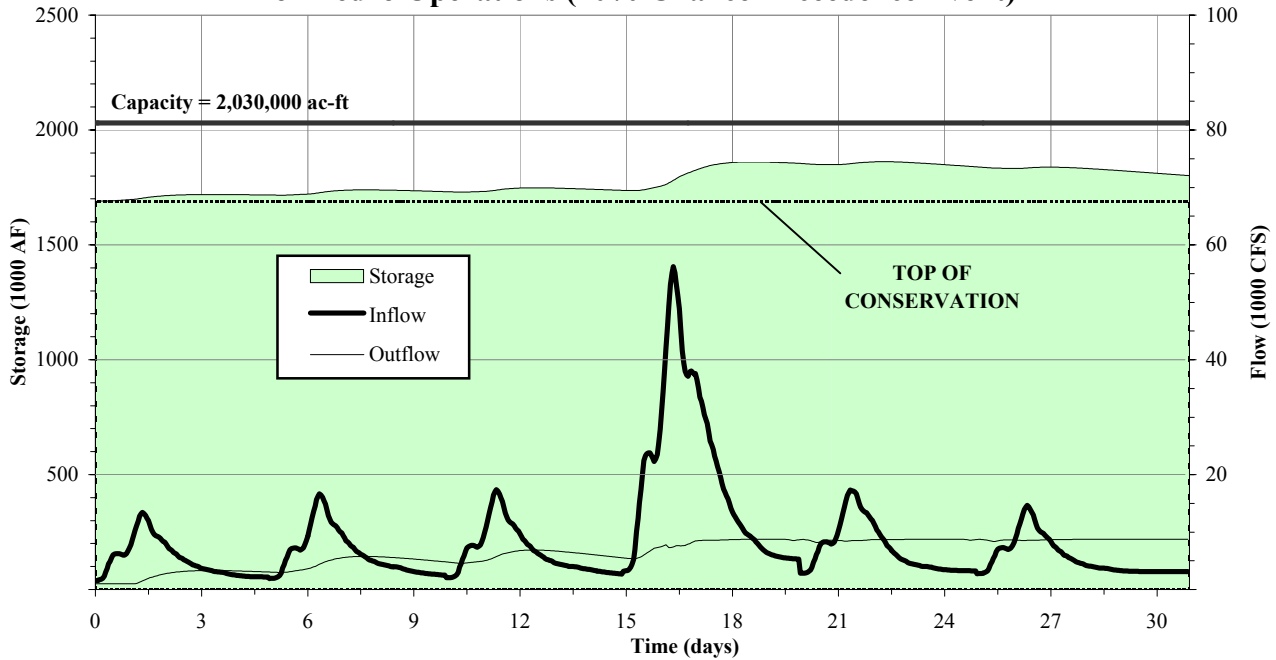
Figure C.1-12a
 Reservoir Simulation Hydrographs
 Don Pedro
 (50% Chance Exceedence Event)

US Army Corps of Engineers
 The Reclamation Board, State of California December 2002

TUOLUMNE RIVER
Don Pedro Inflow (10% Chance Exceedence Event)
 Regulated and Unregulated Inflow



Don Pedro Operations (10% Chance Exceedence Event)

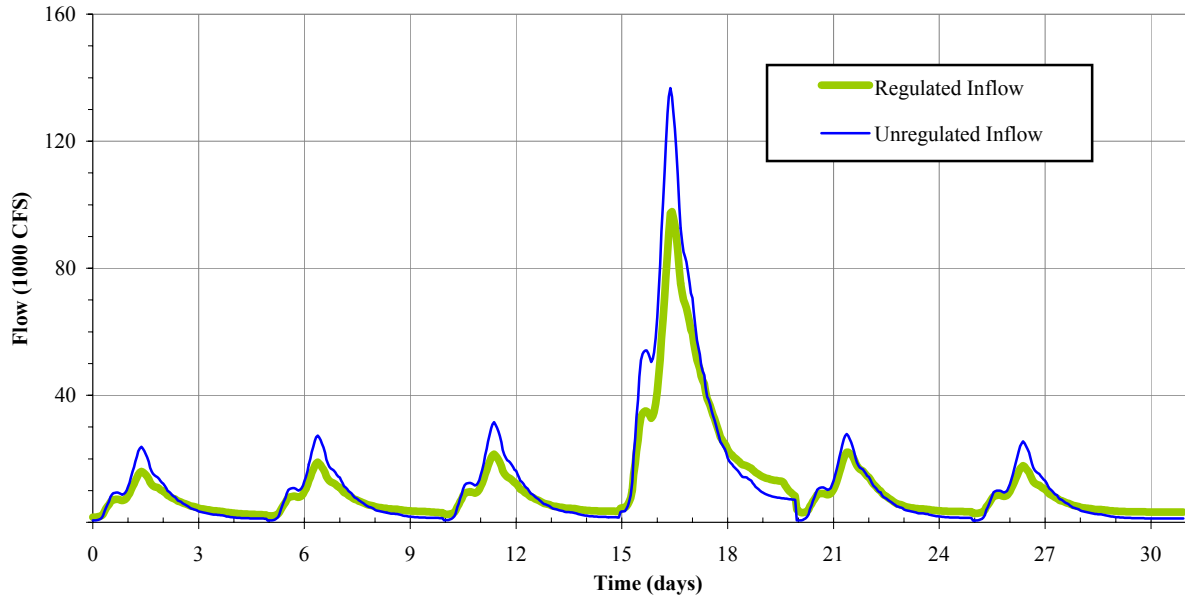


Sacramento & San Joaquin River Basins
 Comprehensive Study

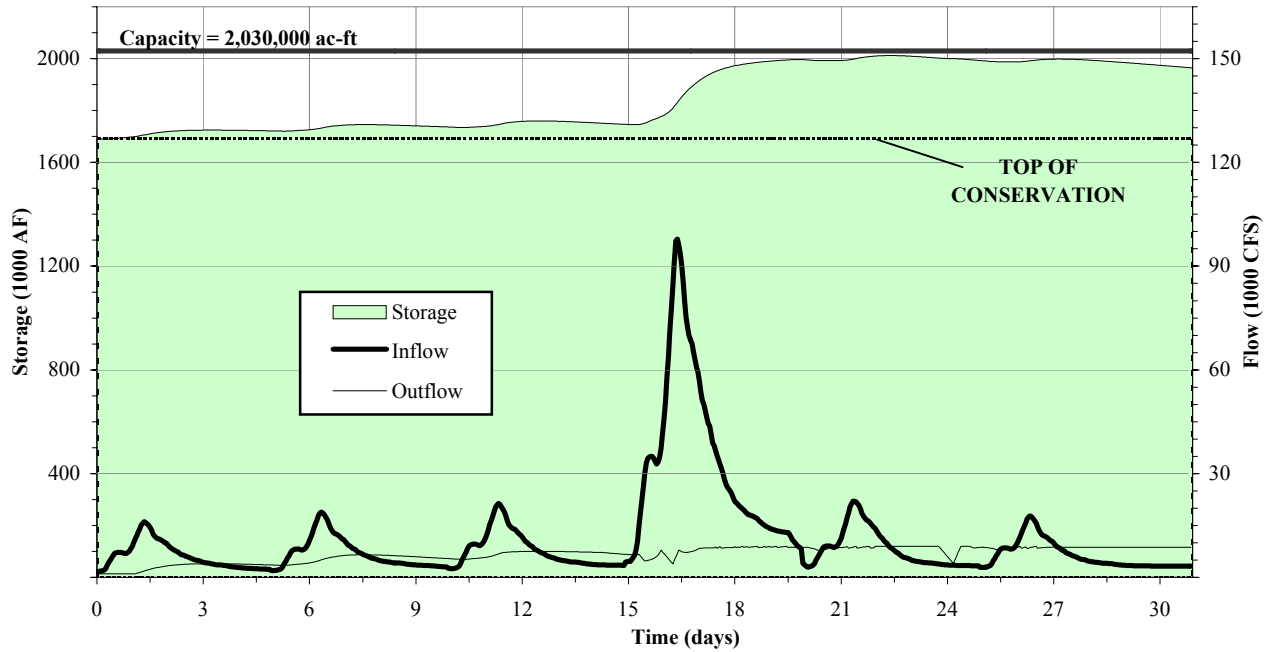
Figure C.1-12b
 Reservoir Simulation Hydrographs
 Don Pedro
 (10% Chance Exceedence Event)

US Army Corps of Engineers
 The Reclamation Board, State of California December 2002

TUOLUMNE RIVER
Don Pedro Inflow (4% Chance Exceedence Event)
 Regulated and Unregulated Inflow

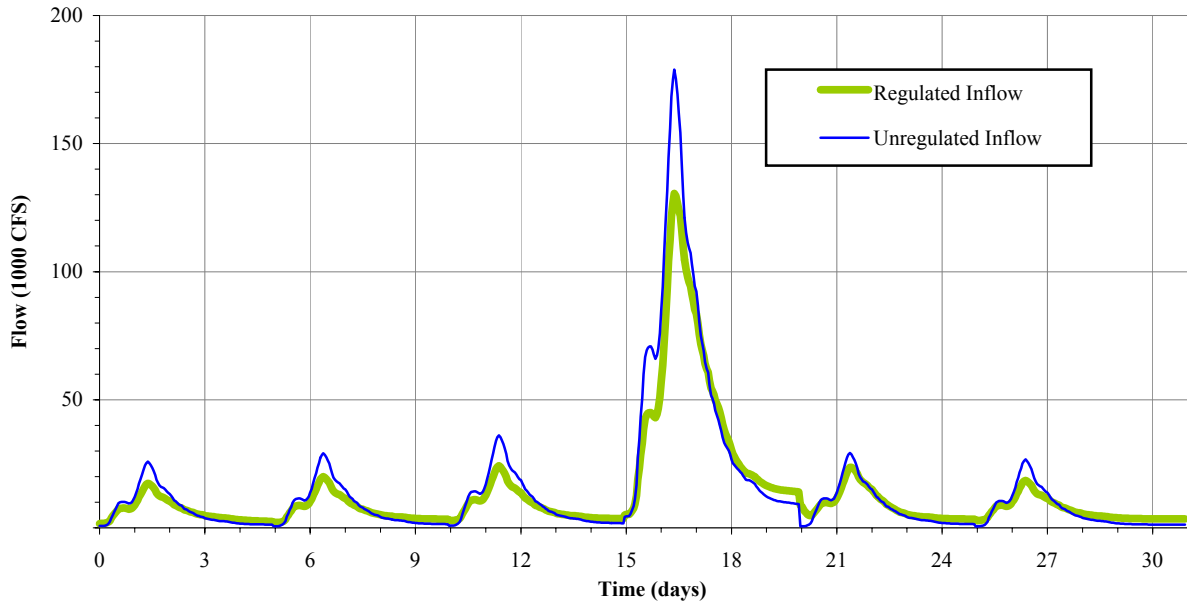


Don Pedro Operations (4% Chance Exceedence Event)

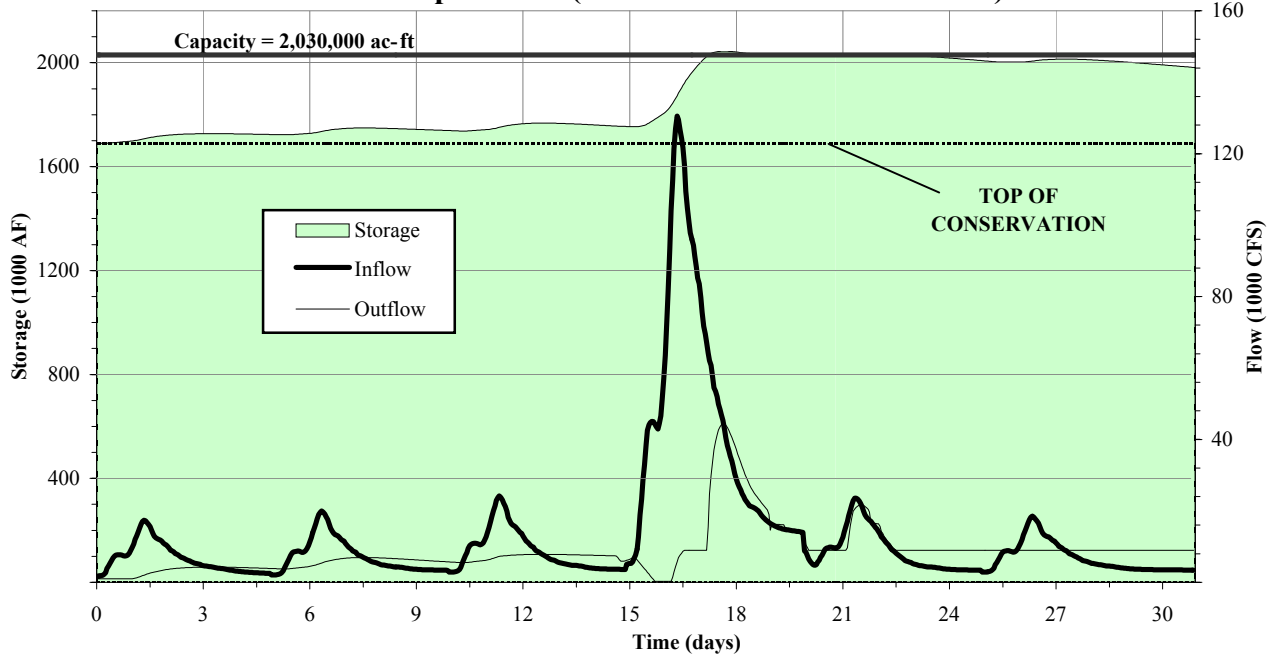


Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-12c Reservoir Simulation Hydrographs Don Pedro (4% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

TUOLUMNE RIVER
Don Pedro Inflow (2% Chance Exceedence Event)
 Regulated and Unregulated Inflow



Don Pedro Operations (2% Chance Exceedence Event)

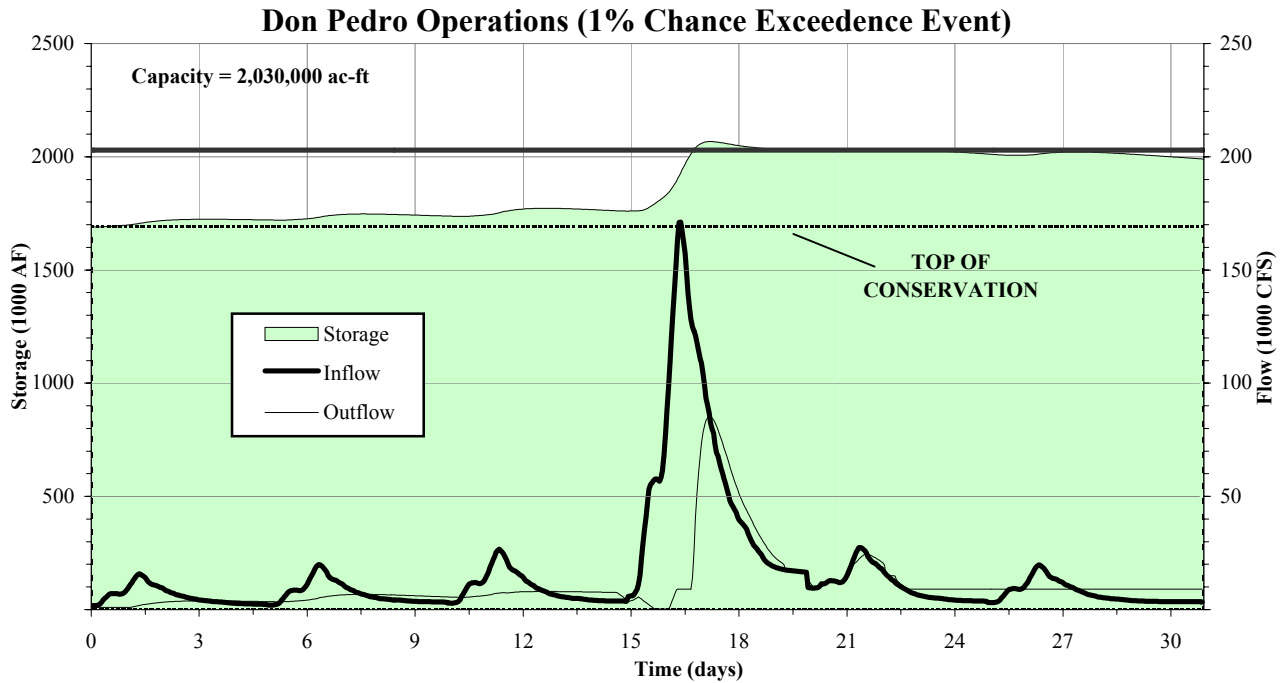
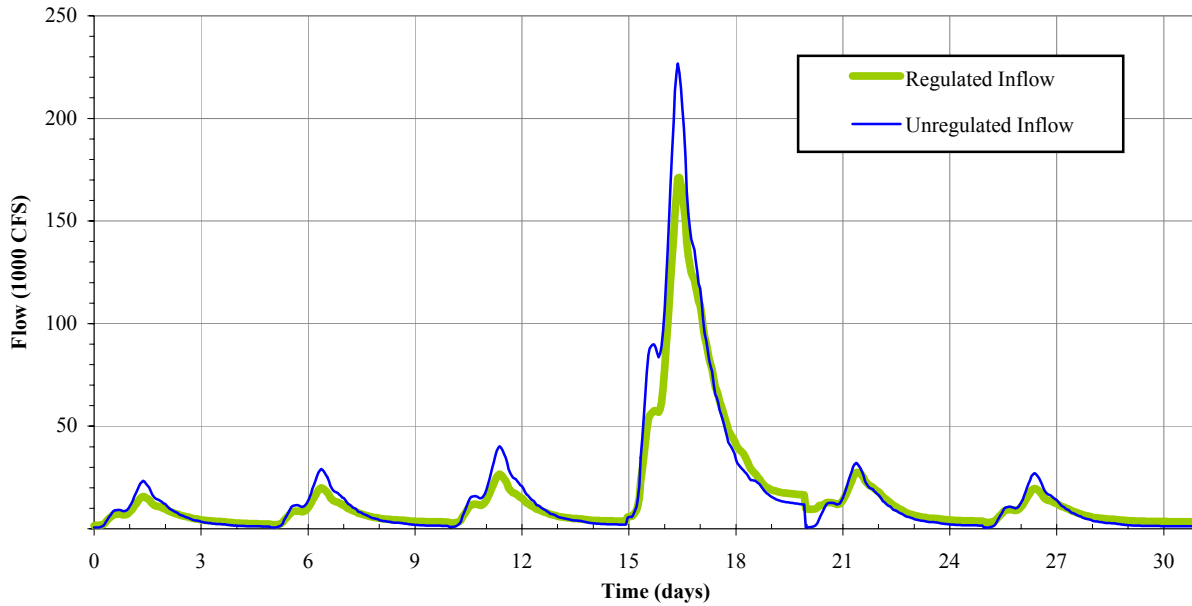


Sacramento & San Joaquin River Basins
 Comprehensive Study

Figure C.1-12d
 Reservoir Simulation Hydrographs
 Don Pedro
 (2% Chance Exceedence Event)

US Army Corps of Engineers
 The Reclamation Board, State of California December 2002

TUOLUMNE RIVER
Don Pedro Inflow (1% Chance Exceedence Event)
 Regulated and Unregulated Inflow

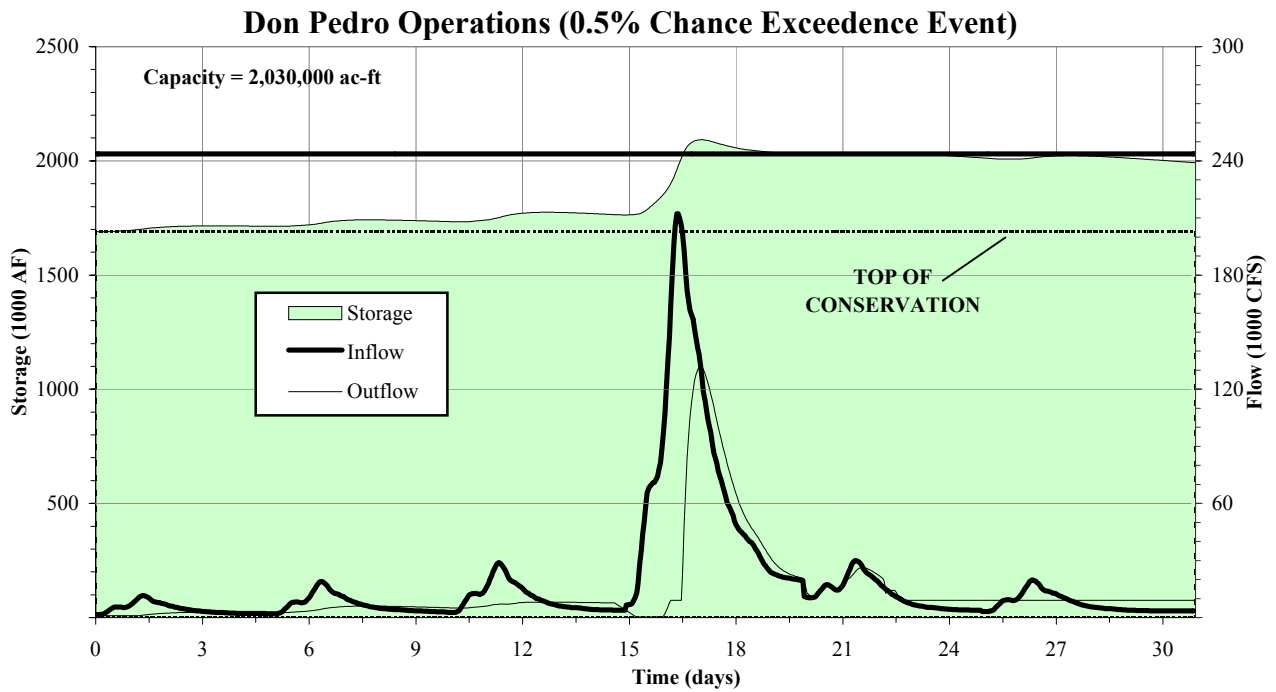
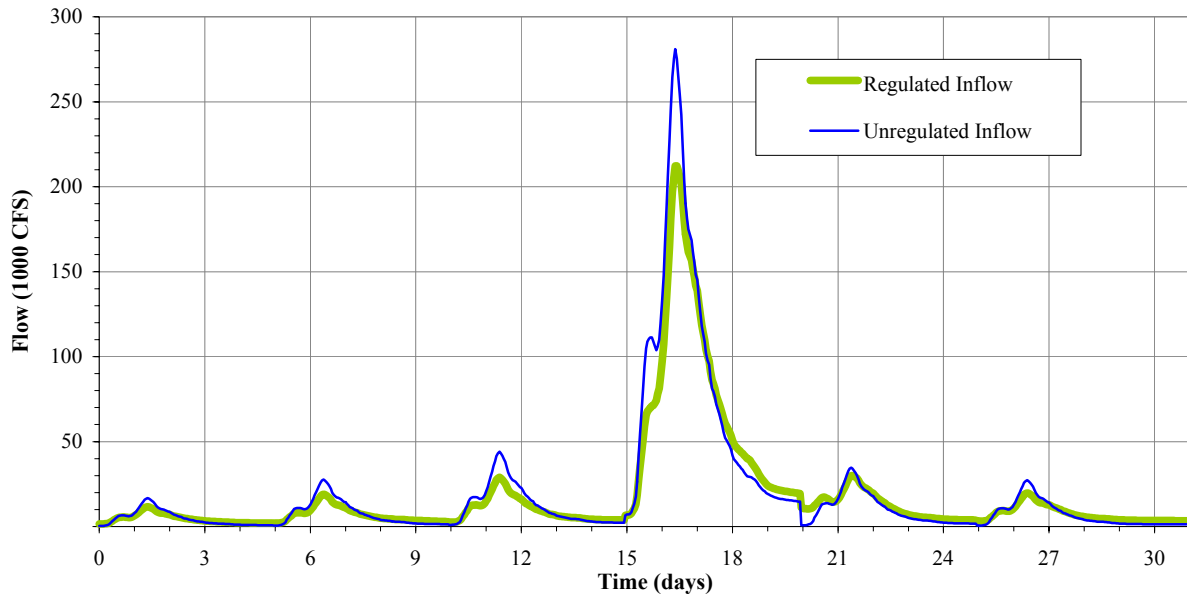


Sacramento & San Joaquin River Basins
 Comprehensive Study

Figure C.1-12e
 Reservoir Simulation Hydrographs
 Don Pedro
 (1% Chance Exceedence Event)

US Army Corps of Engineers
 The Reclamation Board, State of California December 2002

TUOLUMNE RIVER
Don Pedro Inflow (0.5% Chance Exceedence Event)
 Regulated and Unregulated Inflow

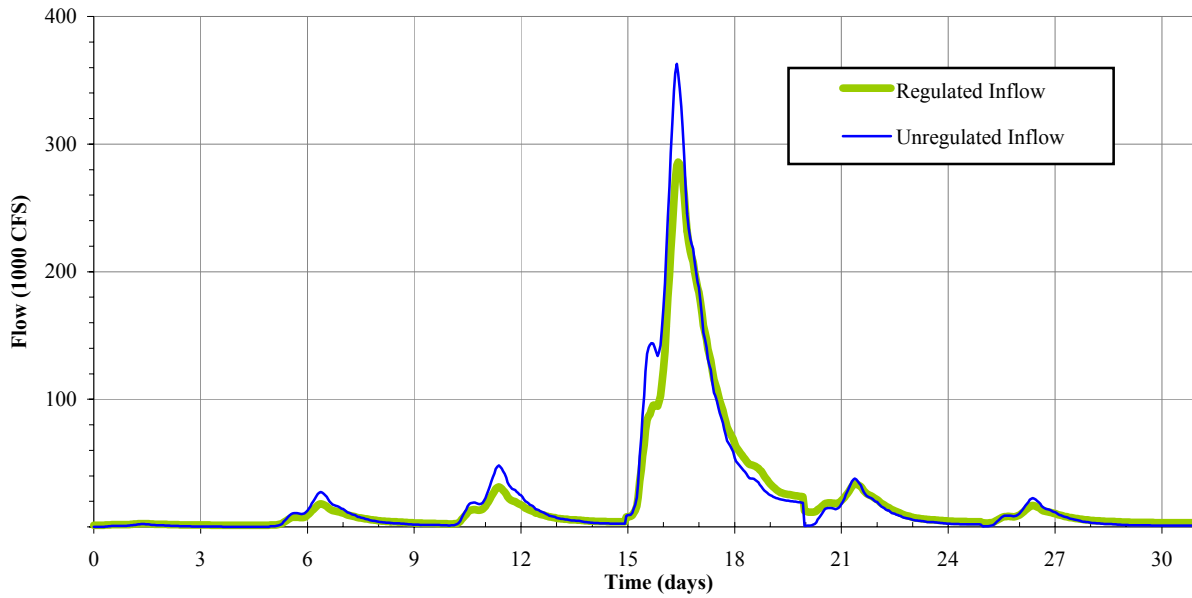


Sacramento & San Joaquin River Basins
 Comprehensive Study

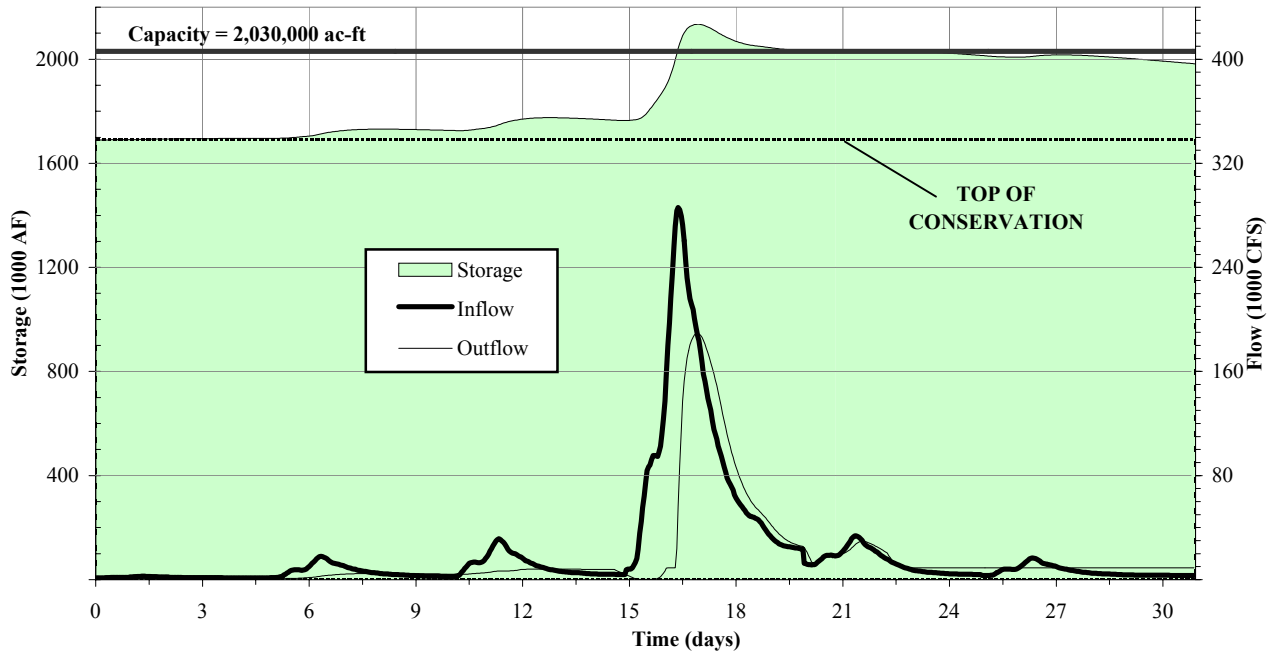
Figure C.1-12f
 Reservoir Simulation Hydrographs
 Don Pedro
 (0.5% Chance Exceedence Event)

US Army Corps of Engineers
 The Reclamation Board, State of California December 2002

TUOLUMNE RIVER
Don Pedro Inflow (0.2% Chance Exceedence Event)
 Regulated and Unregulated Inflow



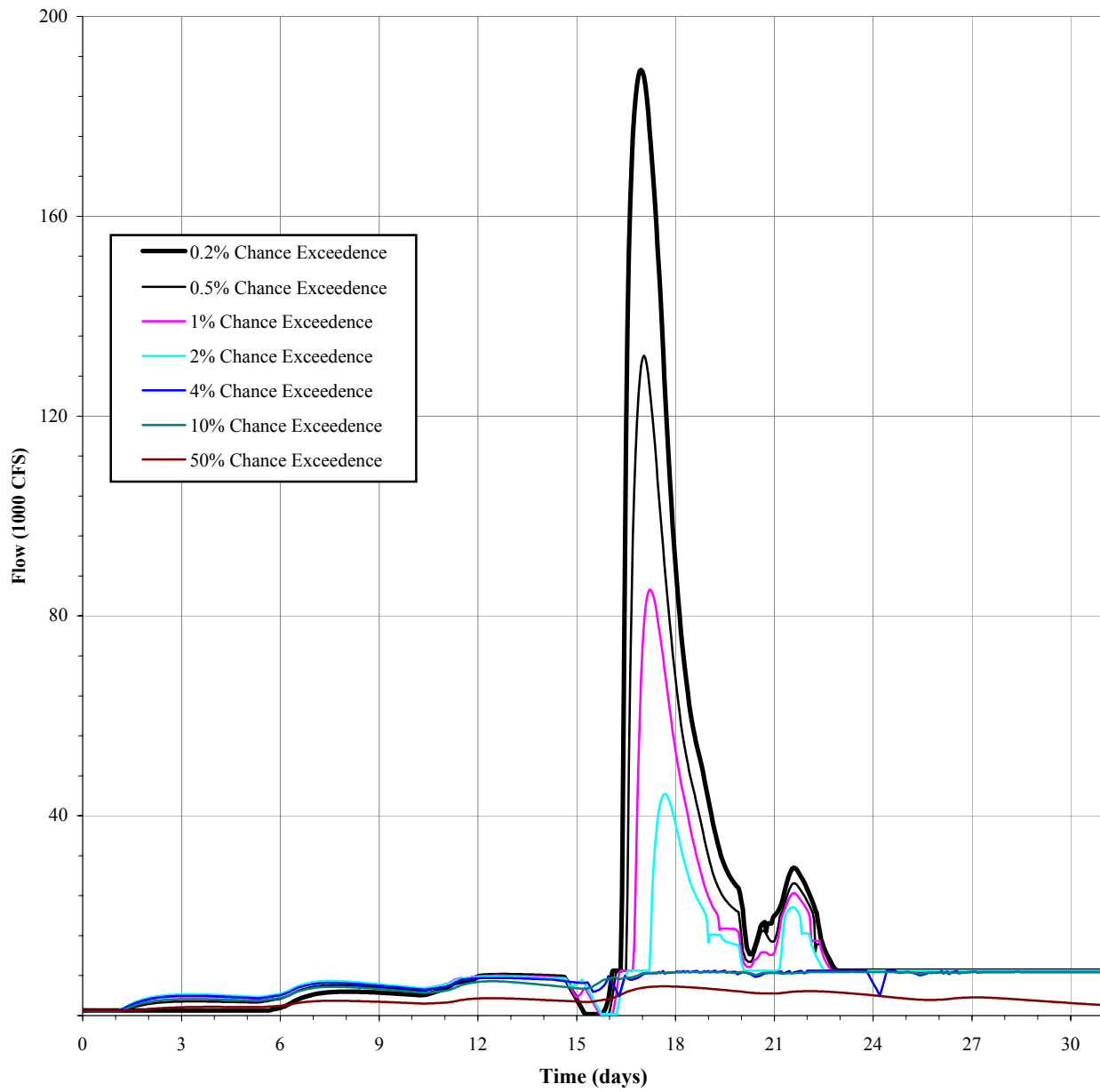
Don Pedro Operations (0.2% Chance Exceedence Event)



Sacramento & San Joaquin River Basins Comprehensive Study	
Figure C.1-12g Reservoir Simulation Hydrographs Don Pedro (0.2% Chance Exceedence Event)	
US Army Corps of Engineers The Reclamation Board, State of California December 2002	

Don Pedro Outflow

Regulated Outflow Hydrographs

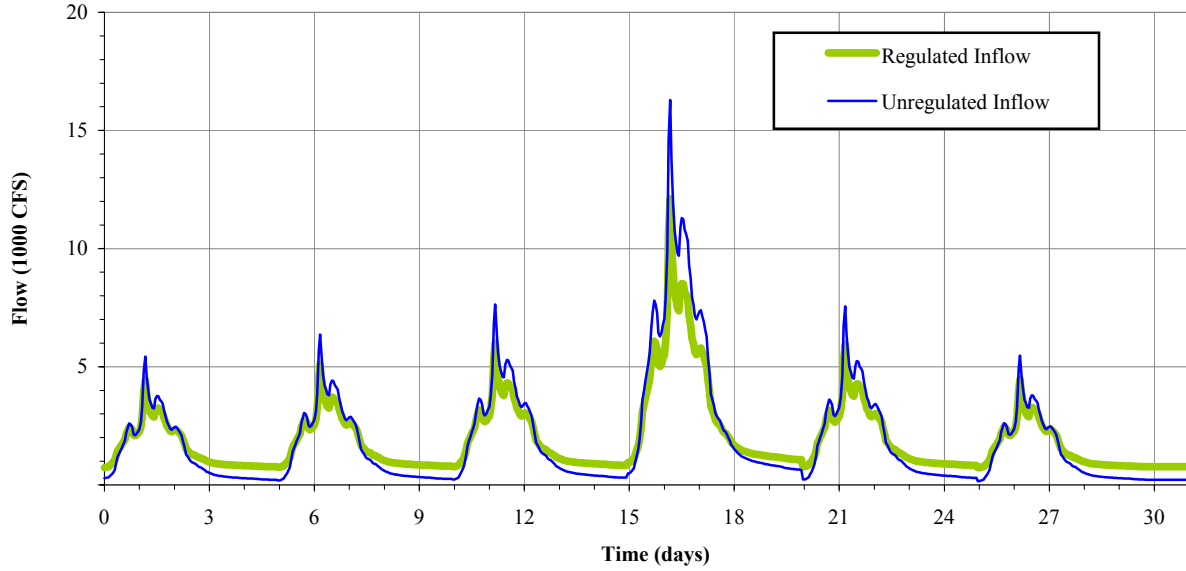


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Comprehensive Study

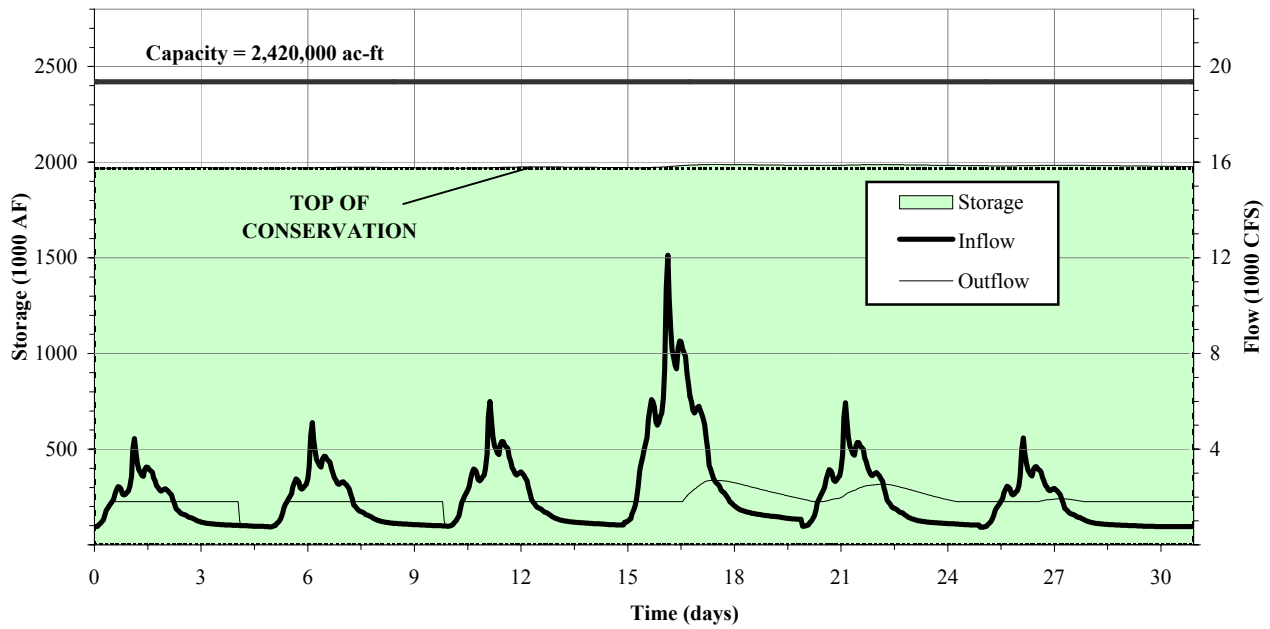
Figure C.1-12h
Reservoir Simulation Hydrographs
Regulated Outflow - Don Pedro

US Army Corps of Engineers
The Reclamation Board, State of California December 2002

STANISLAUS RIVER
New Melones Inflow (50% Chance Exceedence Event)
 Regulated and Unregulated Inflow



New Melones Operations (50% Chance Exceedence Event)

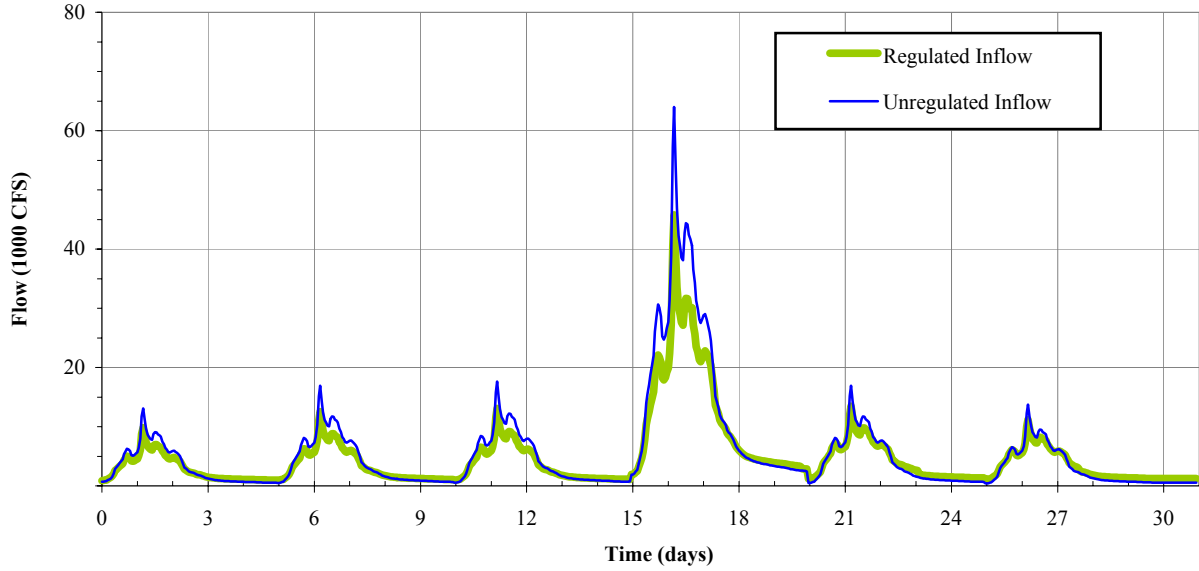


Sacramento & San Joaquin River Basins
 Comprehensive Study

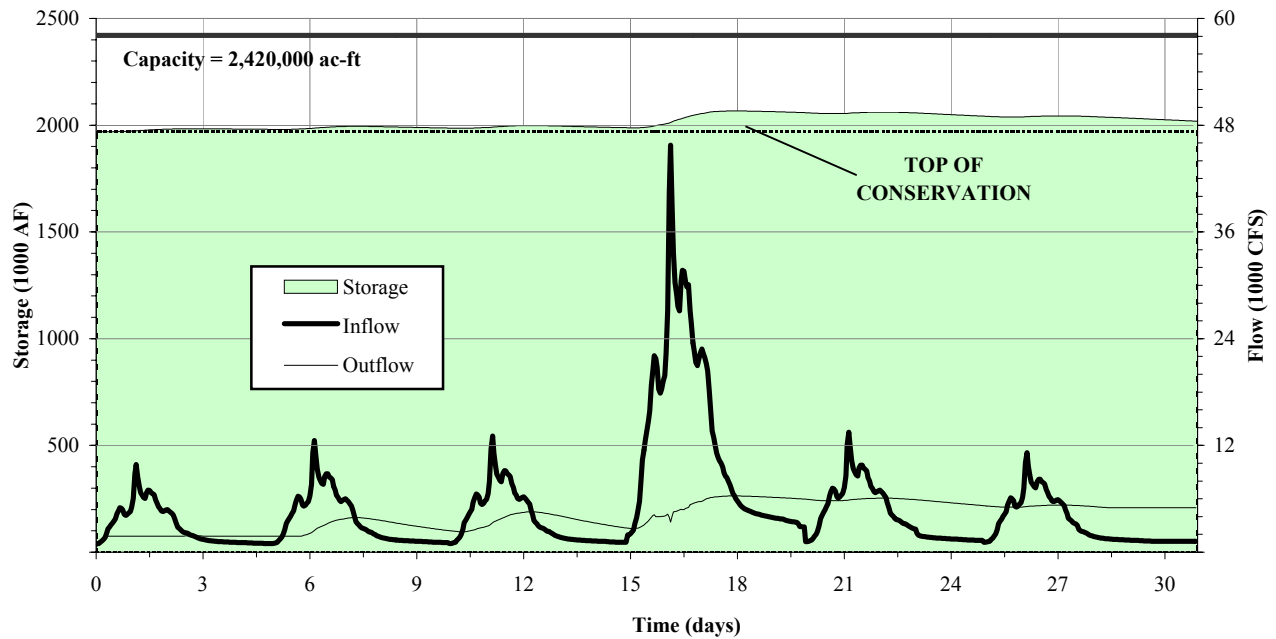
Figure C.1-13a
 Reservoir Simulation Hydrographs
 New Melones
 (50% Chance Exceedence Event)

US Army Corps of Engineers
 The Reclamation Board, State of California December 2002

STANISLAUS RIVER
New Melones Inflow (10% Chance Exceedence Event)
 Regulated and Unregulated Inflow

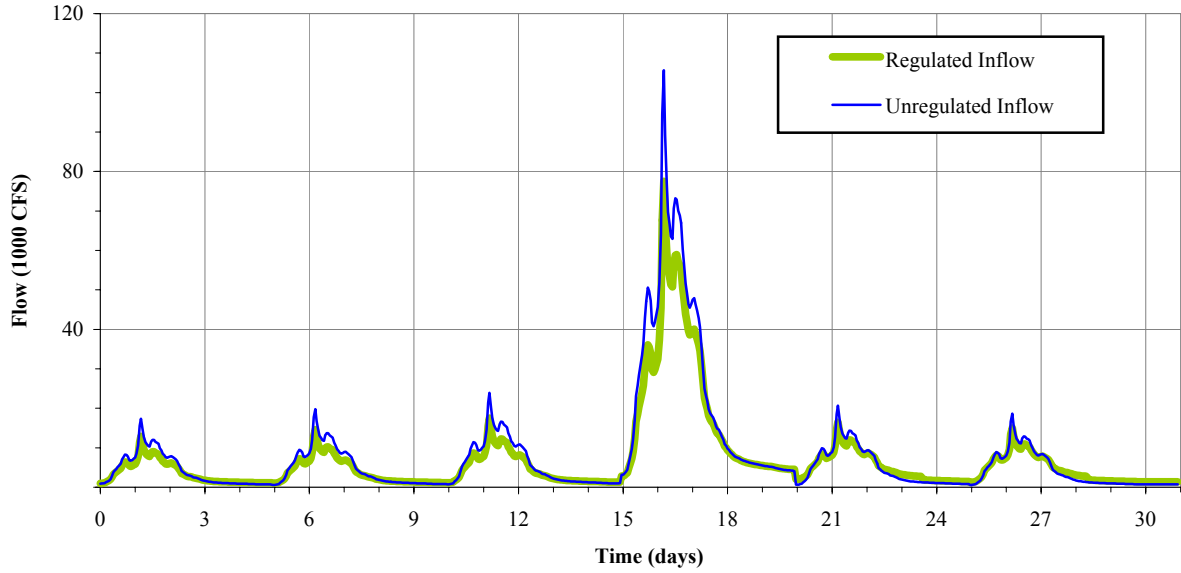


New Melones Operations (10% Chance Exceedence Event)

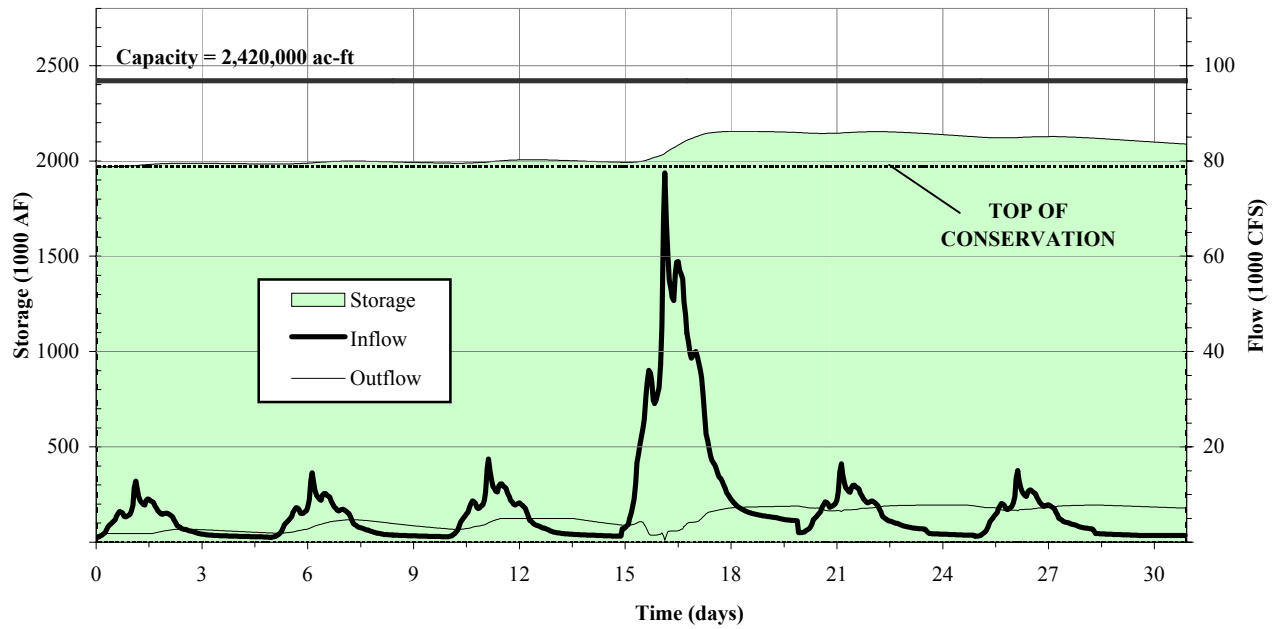


Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-13b Reservoir Simulation Hydrographs New Melones (10% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

STANISLAUS RIVER
New Melones Inflow (4% Chance Exceedence Event)
 Regulated and Unregulated Inflow

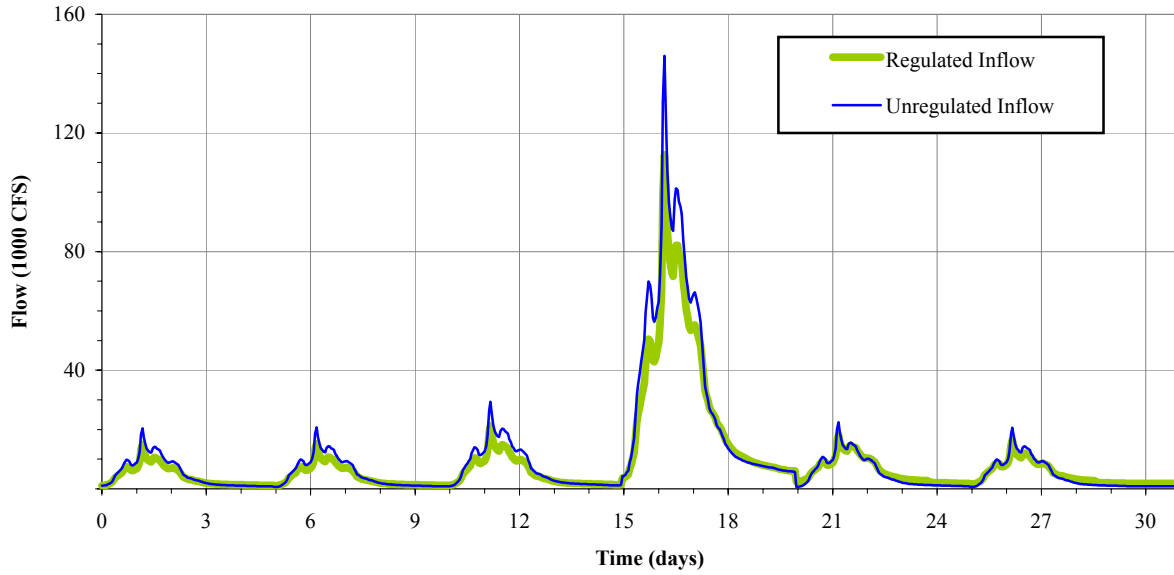


New Melones Operations (4% Chance Exceedence Event)

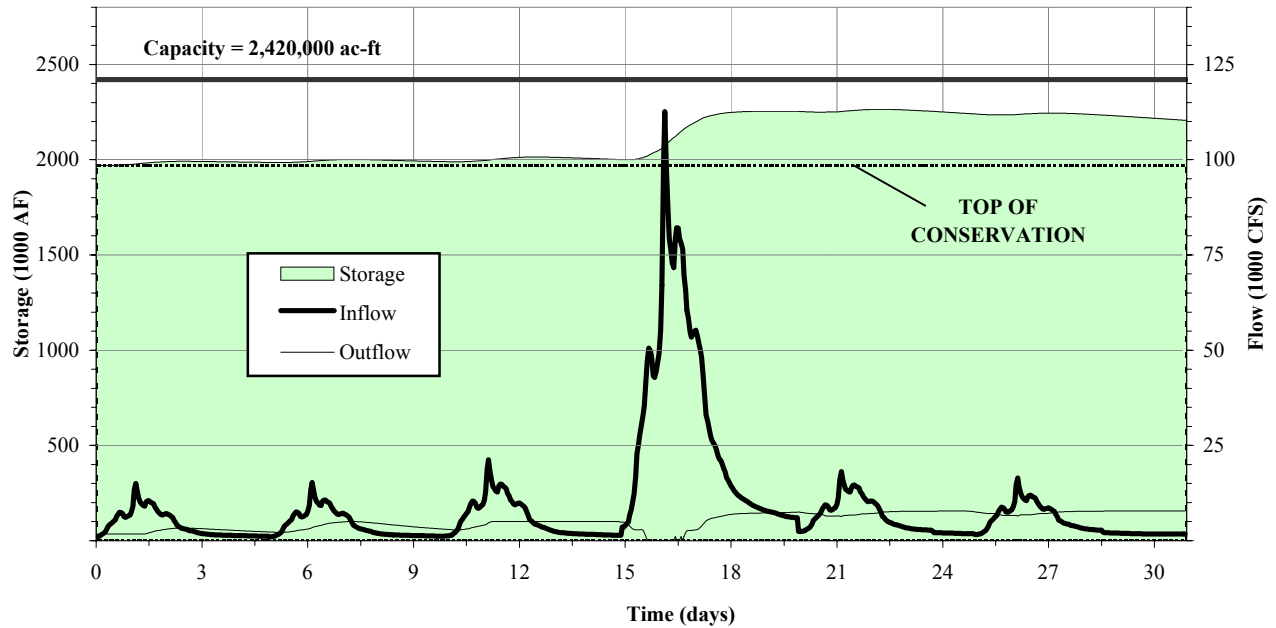


Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-13c Reservoir Simulation Hydrographs New Melones (4% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

STANISLAUS RIVER
New Melones Inflow (2% Chance Exceedence Event)
 Regulated and Unregulated Inflow

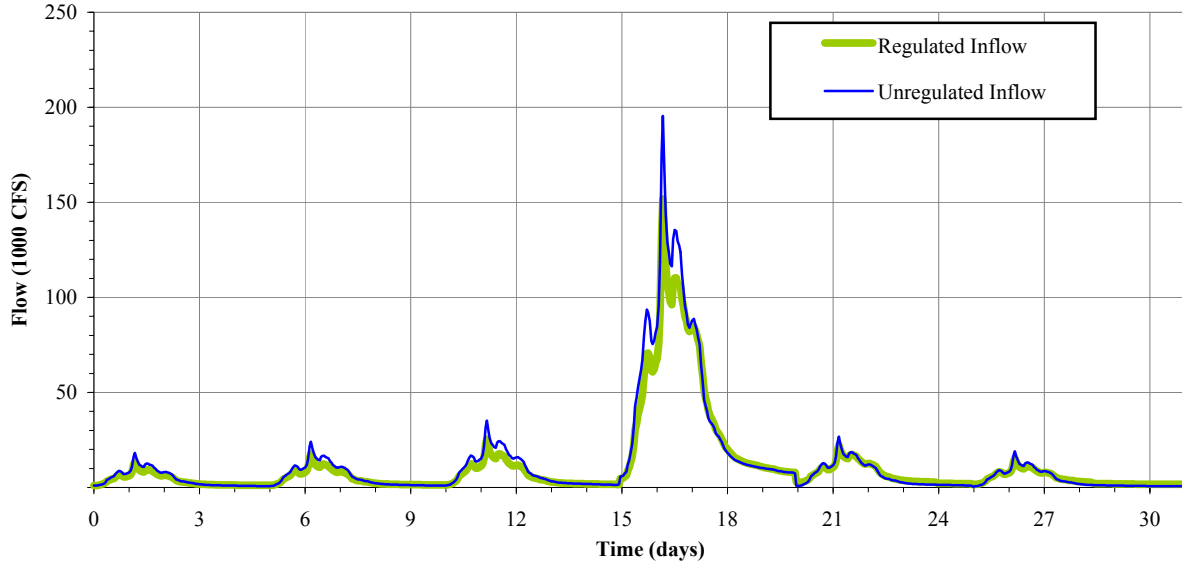


New Melones Operations (2% Chance Exceedence Event)

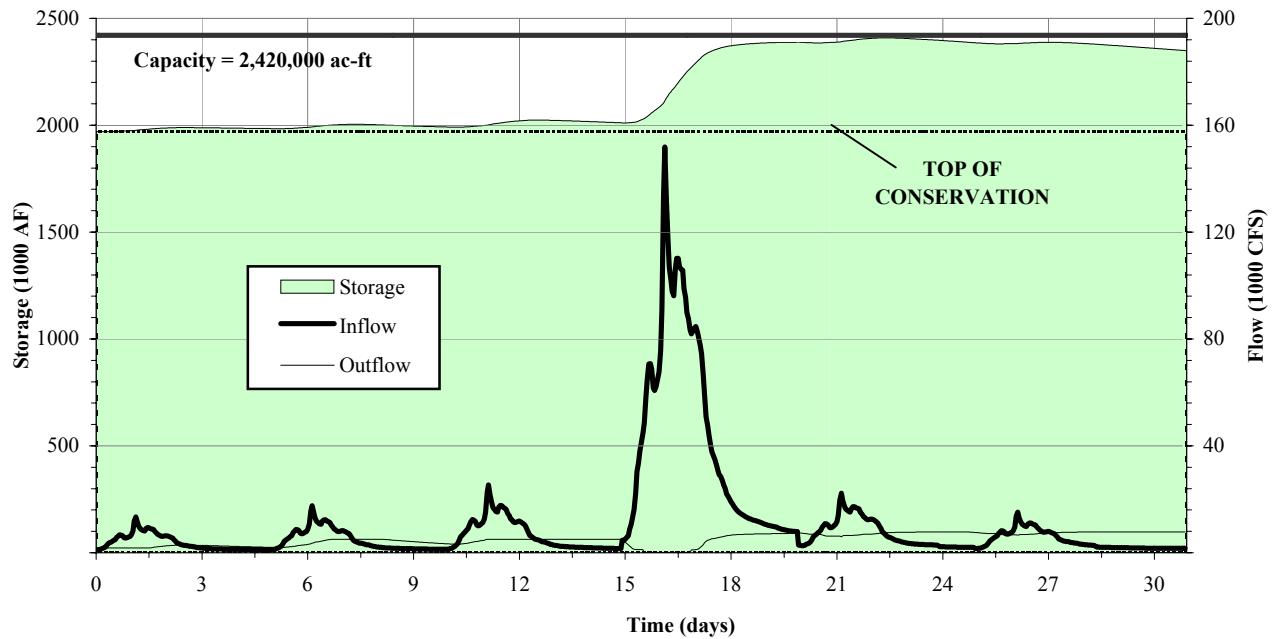


Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-13d Reservoir Simulation Hydrographs New Melones (2% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

STANISLAUS RIVER
New Melones Inflow (1% Chance Exceedence Event)
 Regulated and Unregulated Inflow

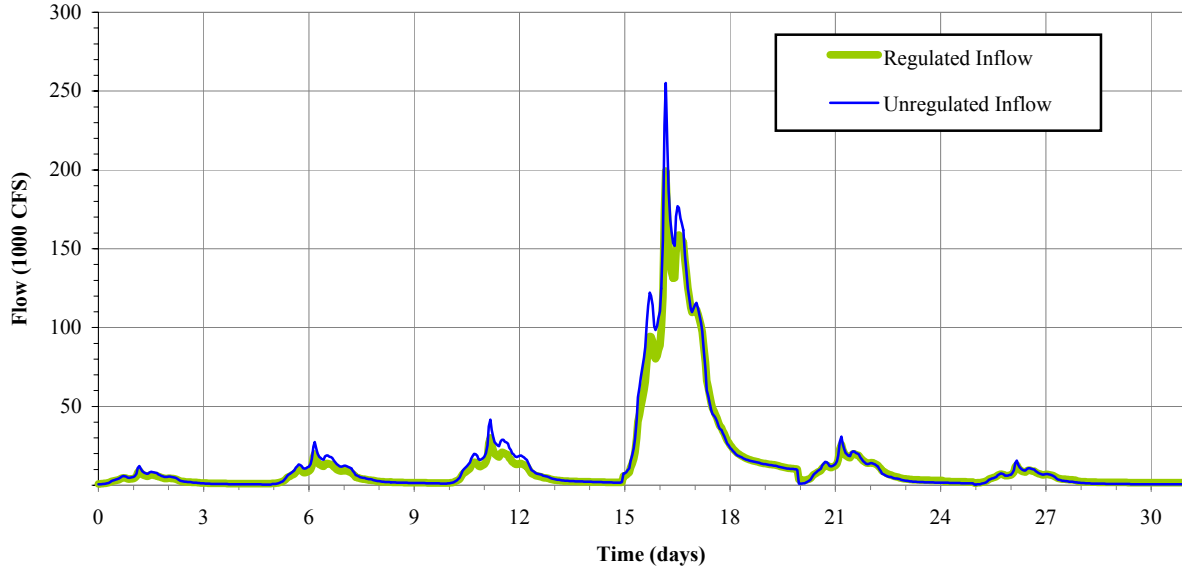


New Melones Operations (1% Chance Exceedence Event)

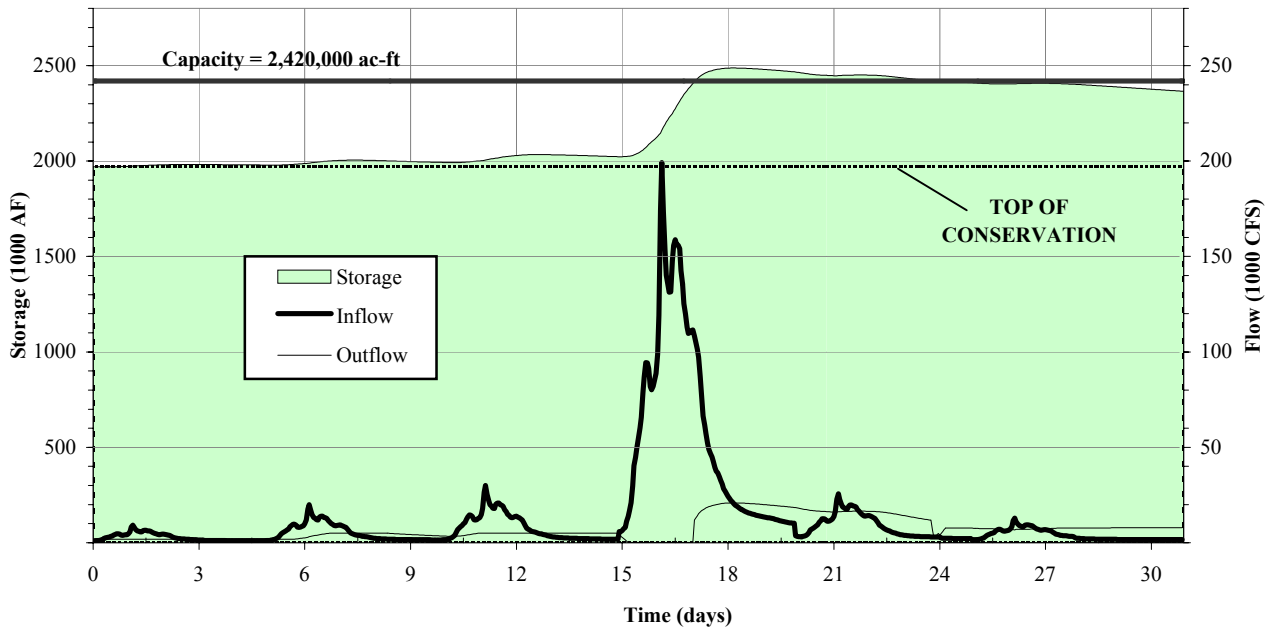


Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.1-13e Reservoir Simulation Hydrographs New Melones (1% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

Stanislaus River
New Melones Inflow (0.5% Chance Exceedence Event)
 Regulated and Unregulated Inflow



New Melones Operations (0.5% Chance Exceedence Event)

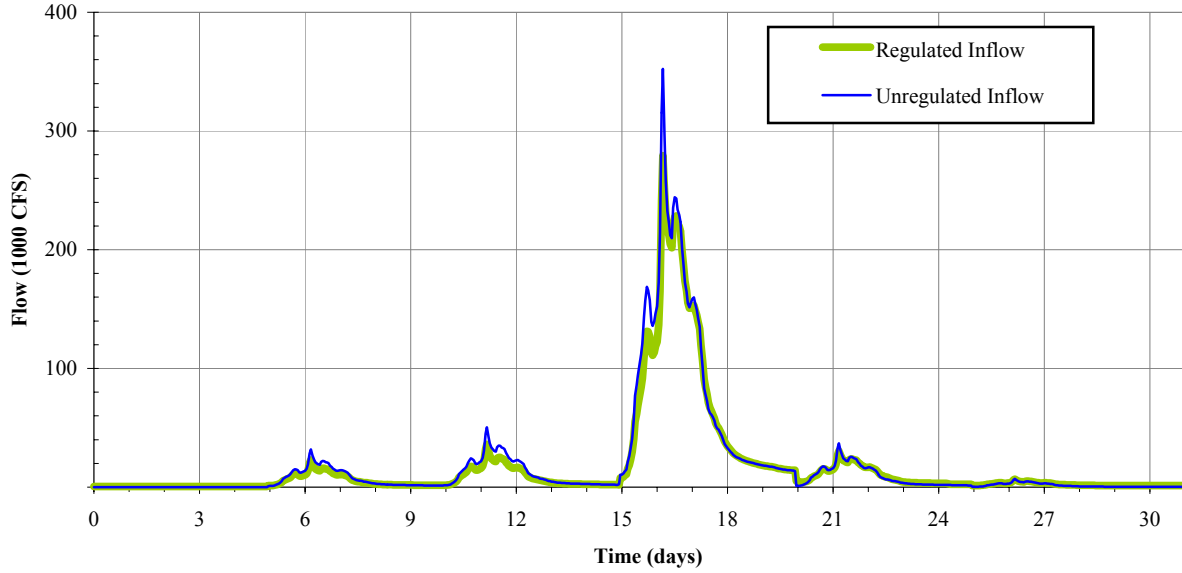


Sacramento & San Joaquin River Basins
 Comprehensive Study

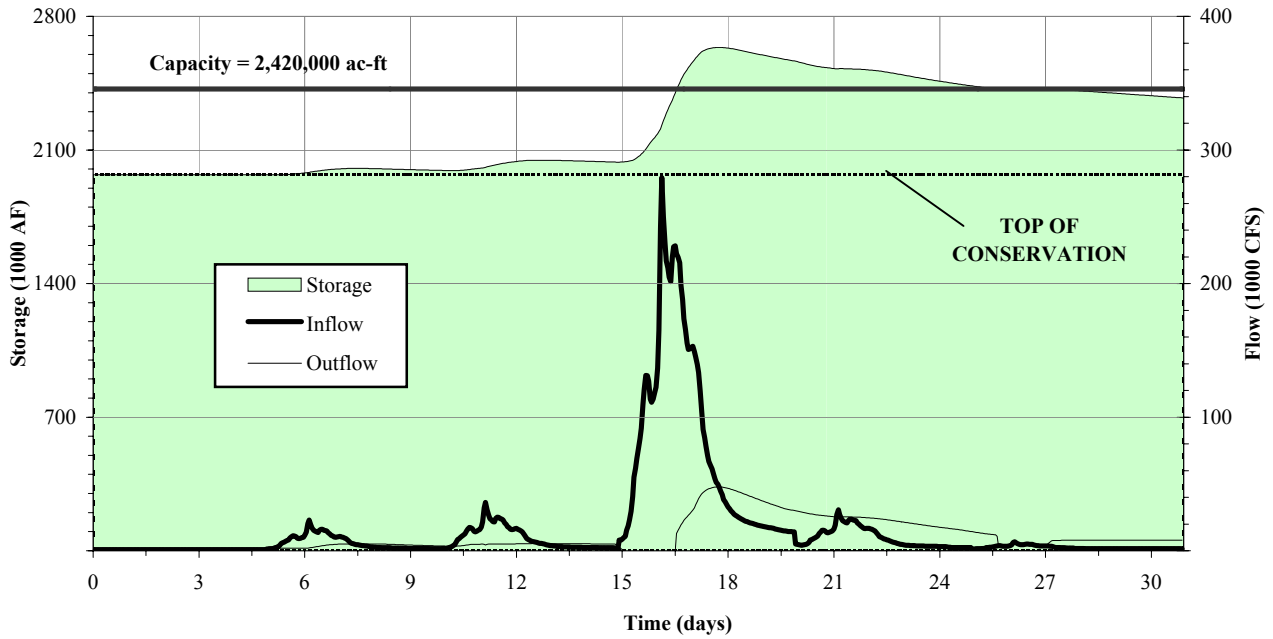
Figure C.1-13f
 Reservoir Simulation Hydrographs
 New Melones
 (0.5% Chance Exceedence Event)

US Army Corps of Engineers
 The Reclamation Board, State of California December 2002

STANISLAUS RIVER
New Melones Inflow (0.2% Chance Exceedence Event)
 Regulated and Unregulated Inflow



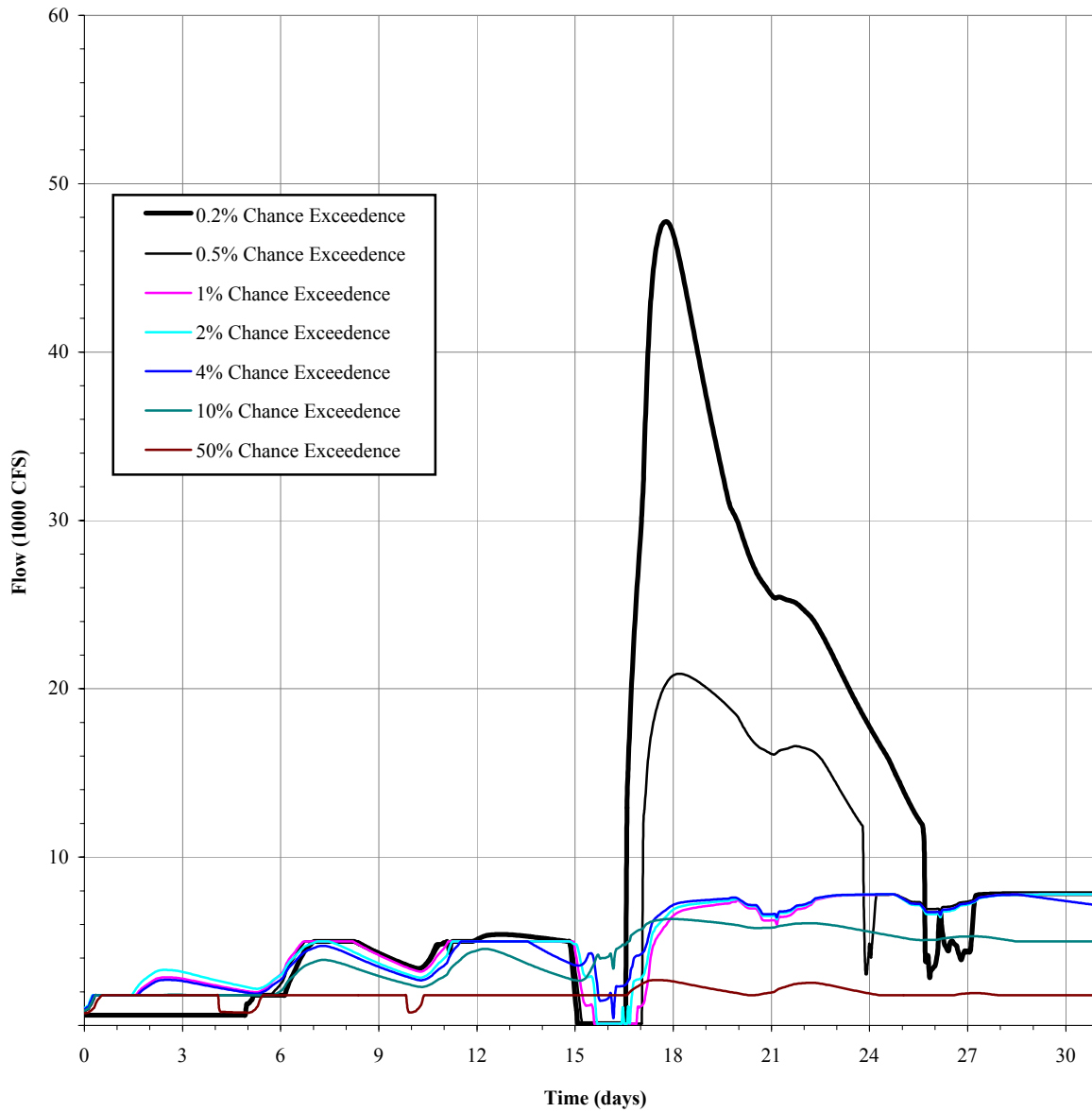
New Melones Operations (0.2% Chance Exceedence Event)



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Figure C.1-13g Reservoir Simulation Hydrographs New Melones (0.2% Chance Exceedence Event)
US Army Corps of Engineers The Reclamation Board, State of California December 2002

New Melones Outflow

Regulated Outflow Hydrographs



Sacramento & San Joaquin River Basins
Comprehensive Study

Figure C.1-13h
Reservoir Simulation Hydrographs
Regulated Outflow - New Melones

US Army Corps of Engineers
The Reclamation Board, State of California December 2002

ATTACHMENT C.2

RESERVOIR OPERATION HYDROGRAPHS AT DOWNSTREAM CONTROL POINTS

FIGURES – SACRAMENTO RIVER BASIN

- Figure C.2-1 Shasta Dam Storm Centering at Bend Bridge Index Point
Black Butte Dam Storm Centering at Ord Ferry Index Point
- Figure C.2-2 Oroville Dam Storm Centering at Gridley Index Point
Oroville Dam Storm Centering at Yuba City Index Point
- Figure C.2-3 Oroville Dam Storm Centering at Marysville Index Point
Oroville Dam Storm Centering at Nicolaus Index Point
- Figure C.2-4 New Bullards Bar Dam Storm Centering at Marysville (Yuba River) Index Point
New Bullards Bar Dam Storm Centering at Marysville (Feather River) Index Point
- Figure C.2-5 New Bullards Bar Dam Storm Centering at Nicolaus (Feather River) Index Point
Indian Valley Dam Storm Centering at Rumsey Index Point

FIGURES – SAN JOAQUIN RIVER BASIN

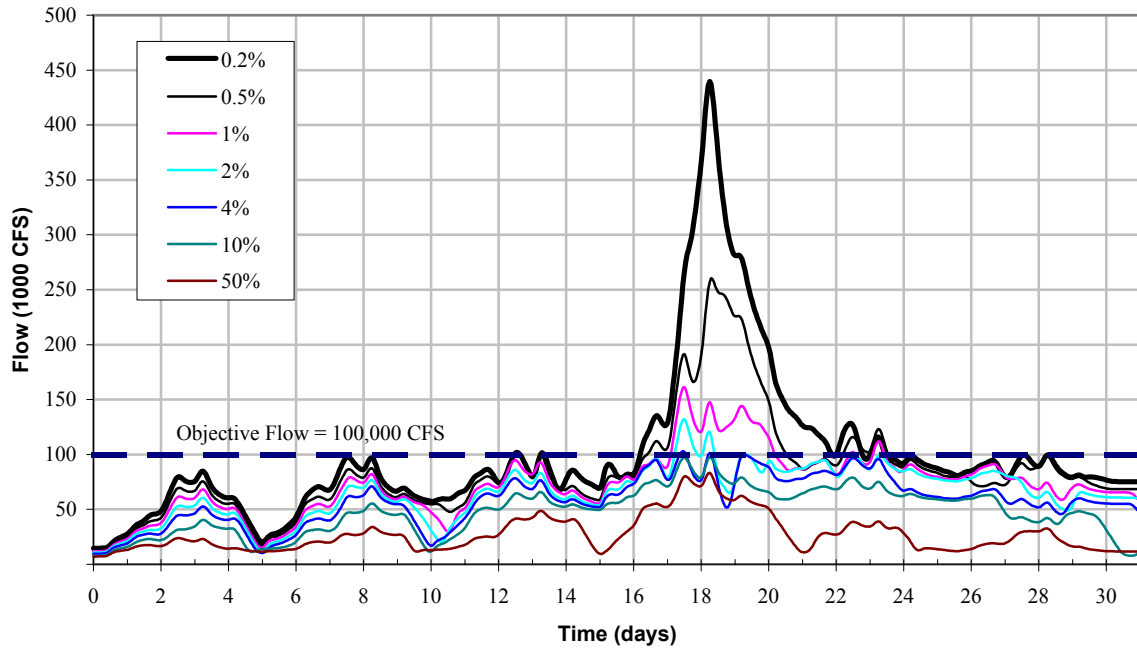
- Figure C.2-6 Pine Flat Dam Storm Centering at Friant Kern Canal Index Point
Friant Dam Storm Centering at Mendota Gage Index Point
- Figure C.2-7 Hidden Dam Storm Centering at Madera Canal Index Point
Buchanan Dam Storm Centering at Madera Canal Index Point
- Figure C.2-8 New Exchequer Storm Centering at Cressey Index Point
Don Pedro Dam Storm Centering at Modesto Index Point
- Figure C.2-9 New Melones Dam Storm Centering at Orange Blossom Index Point
Los Banos Detention Dam Storm Centering at Los Banos Index Point

Note on Figures:

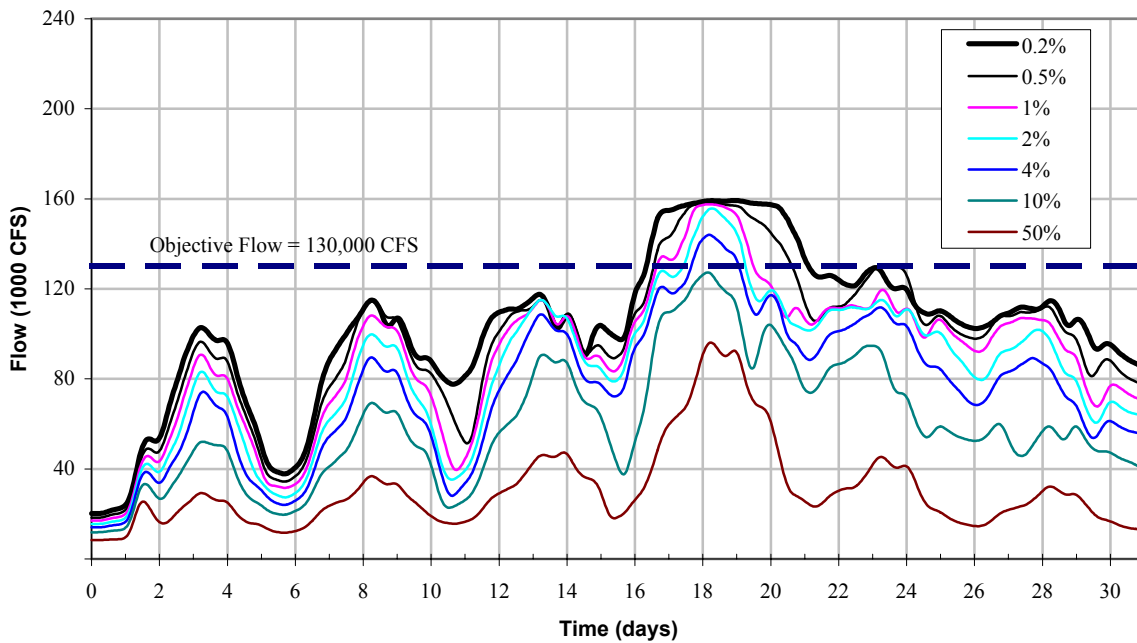
Figures present HEC-5 results at downstream control points during simulations of tributary centerings. For example, Figure C.2-3 (Oroville at Nicolaus) plots the simulated hydrograph at Nicolaus for the Feather River at Oroville flood centering. In some cases, points occur below the interface between HEC-5 and the hydraulic models (i.e. Friant Dam at Mendota). At these locations, final regulated hydrographs will be determined by the hydraulic models, but HEC-5 results have been included in this attachment to display model dynamics.

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Shasta Dam Storm Centering at Bend Bridge Index Point
Regulated Outflow Hydrographs

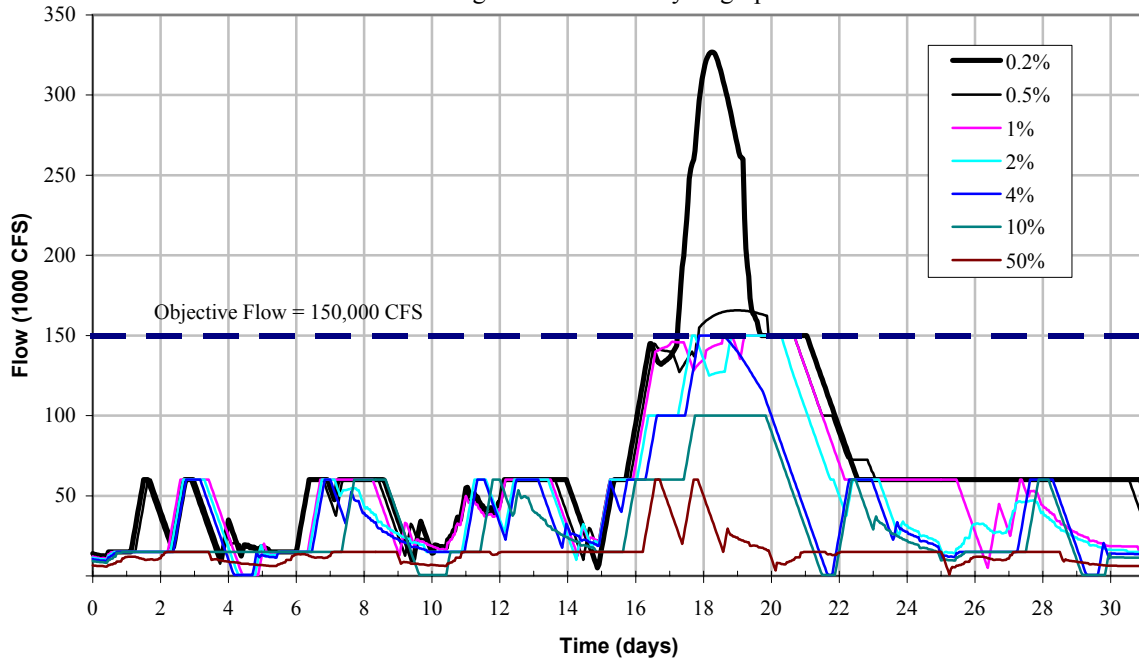


Black Butte Dam Storm Centering at Ord Ferry Index Point
Regulated Outflow Hydrographs

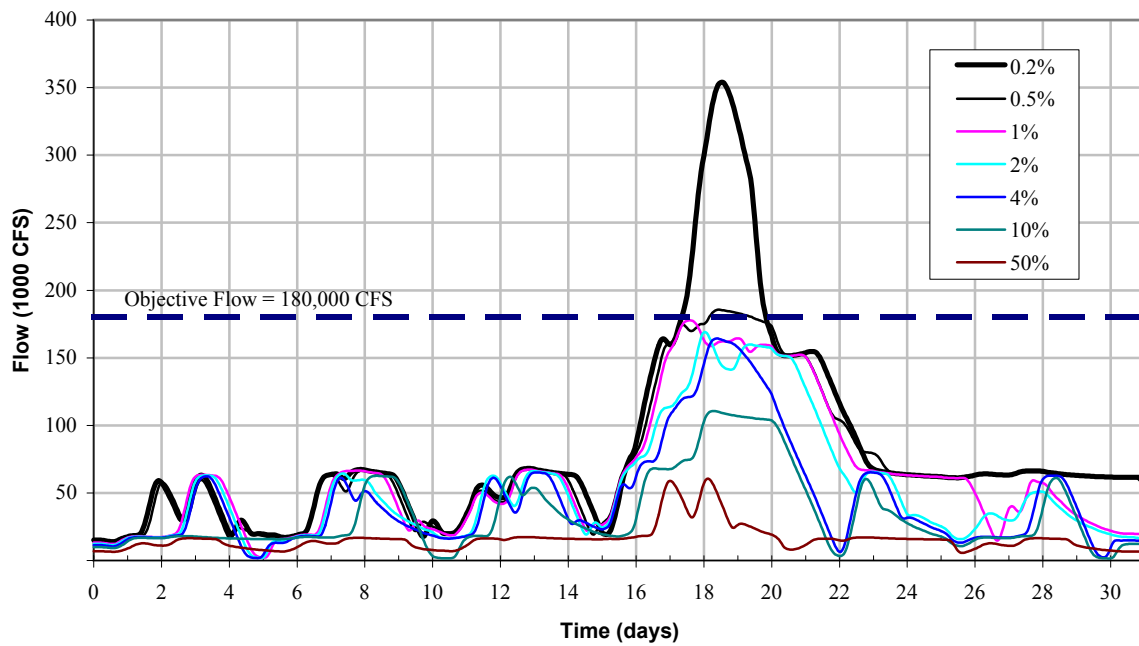


Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.2-1 Reservoir Simulation Hydrographs at Downstream Index Points
US Army Corps of Engineers The Reclamation Board, State of California
December 2002

Oroville Dam Storm Centering at Gridley Index Point
Regulated Outflow Hydrographs



Oroville Dam Storm Centering at Yuba City Index Point
Regulated Outflow Hydrographs



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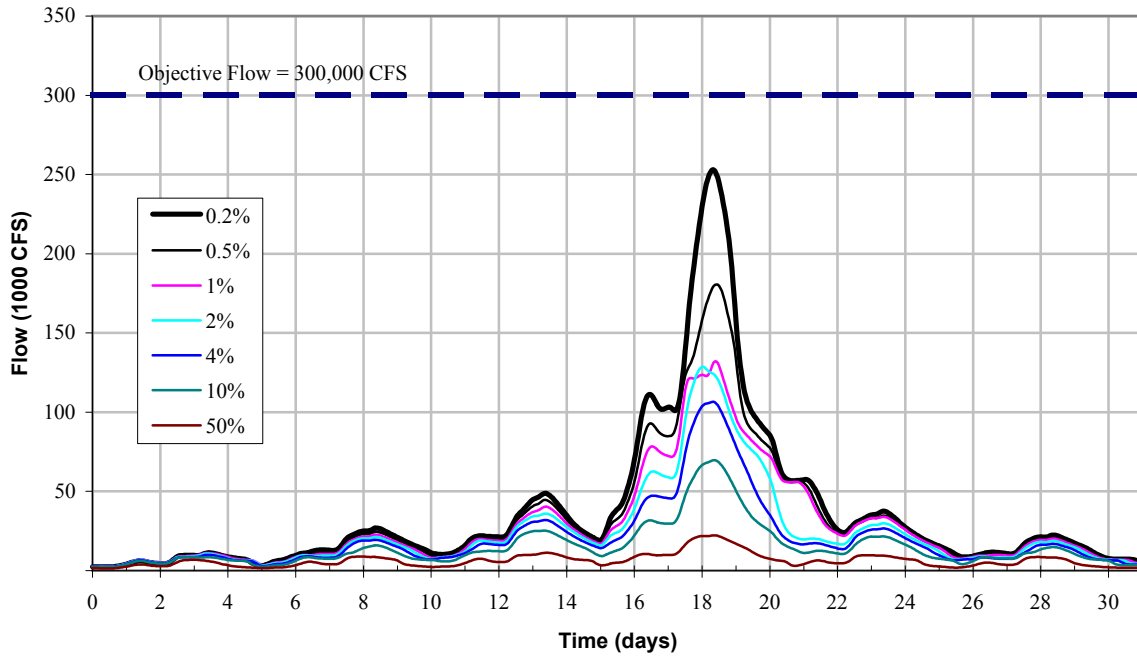
Figure C.2-2
Reservoir Simulation Hydrographs
at Downstream Index Points

US Army Corps of Engineers

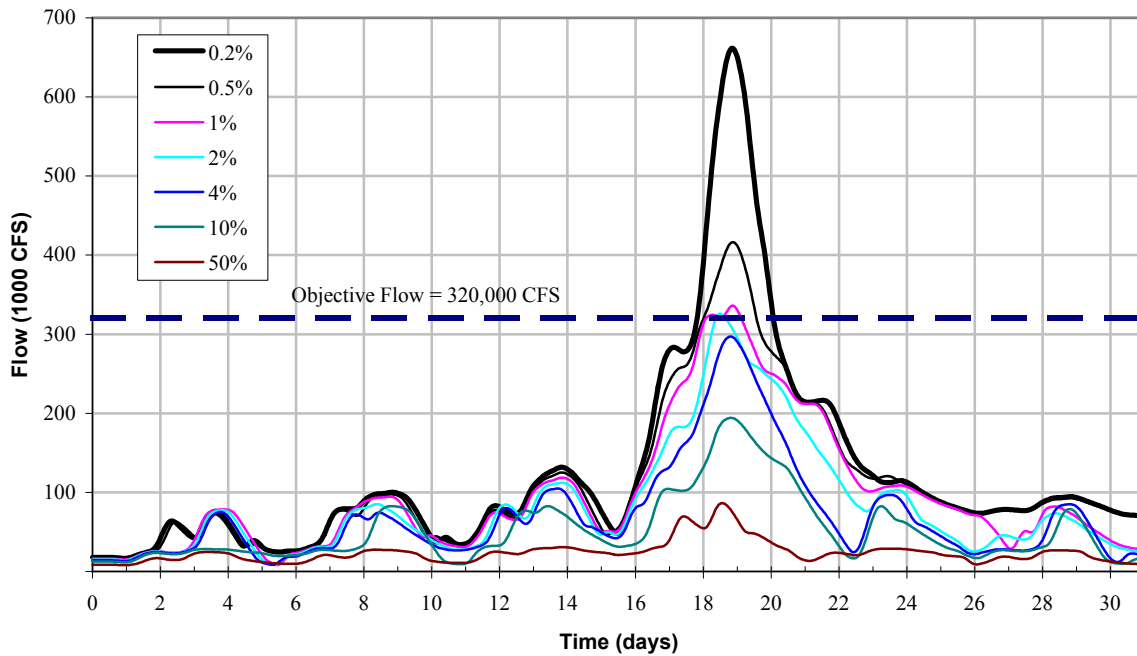
The Reclamation Board, State of California

December 2002

Oroville Dam Storm Centering at Marysville Index Point
Regulated Outflow Hydrographs

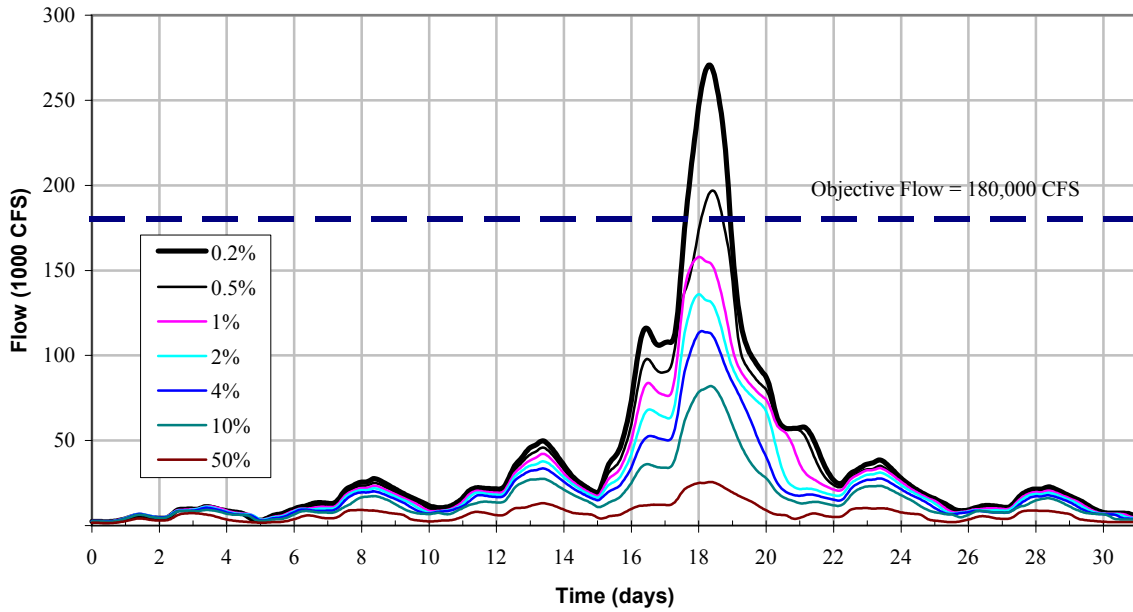


Oroville Dam Storm Centering at Nicolaus Index Point
Regulated Outflow Hydrographs

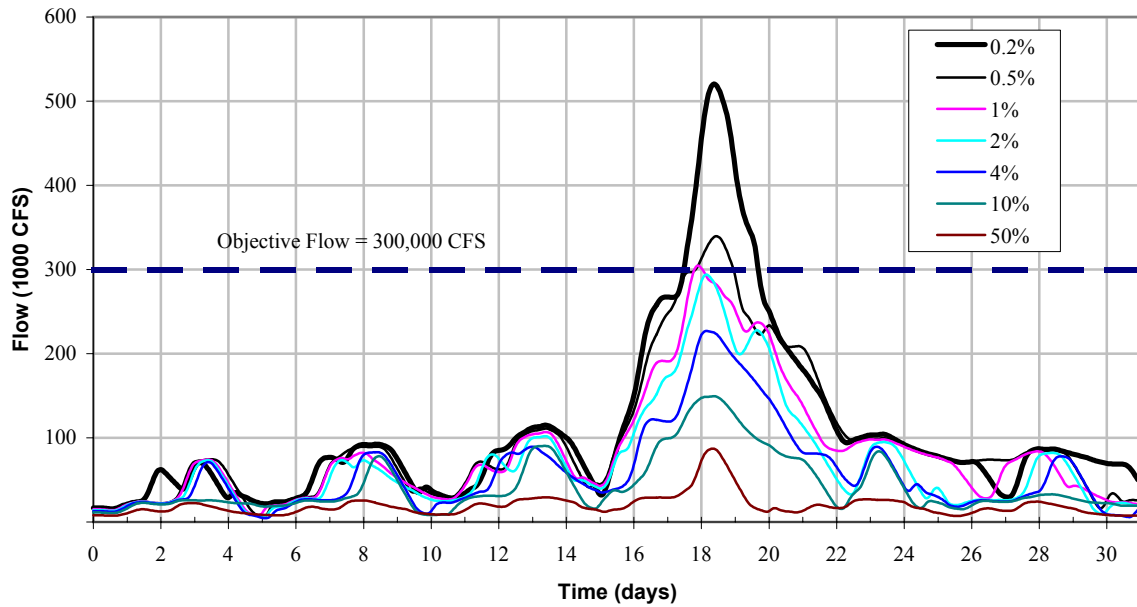


Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.2-3 Reservoir Simulation Hydrographs at Downstream Index Points
US Army Corps of Engineers The Reclamation Board, State of California December 2002

**New Bullards Bar Dam Storm Centering at
Marysville (Yuba River) Index Point**
Regulated Outflow Hydrographs

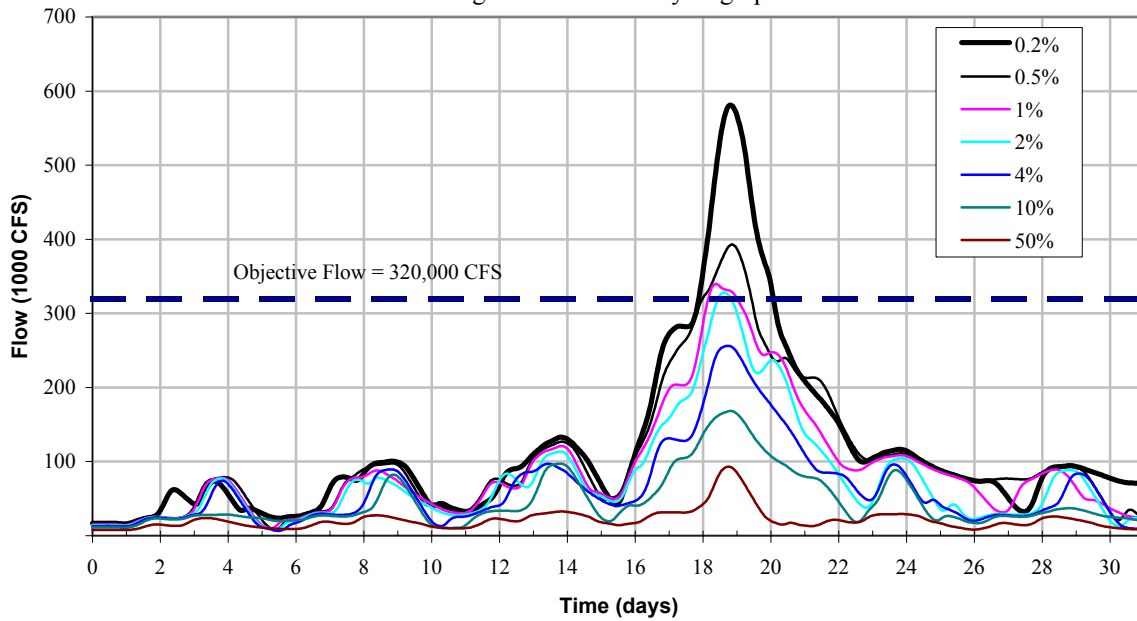


**New Bullards Bar Dam Storm Centering at Marysville
(Feather River) Index Point**
Regulated Outflow Hydrographs

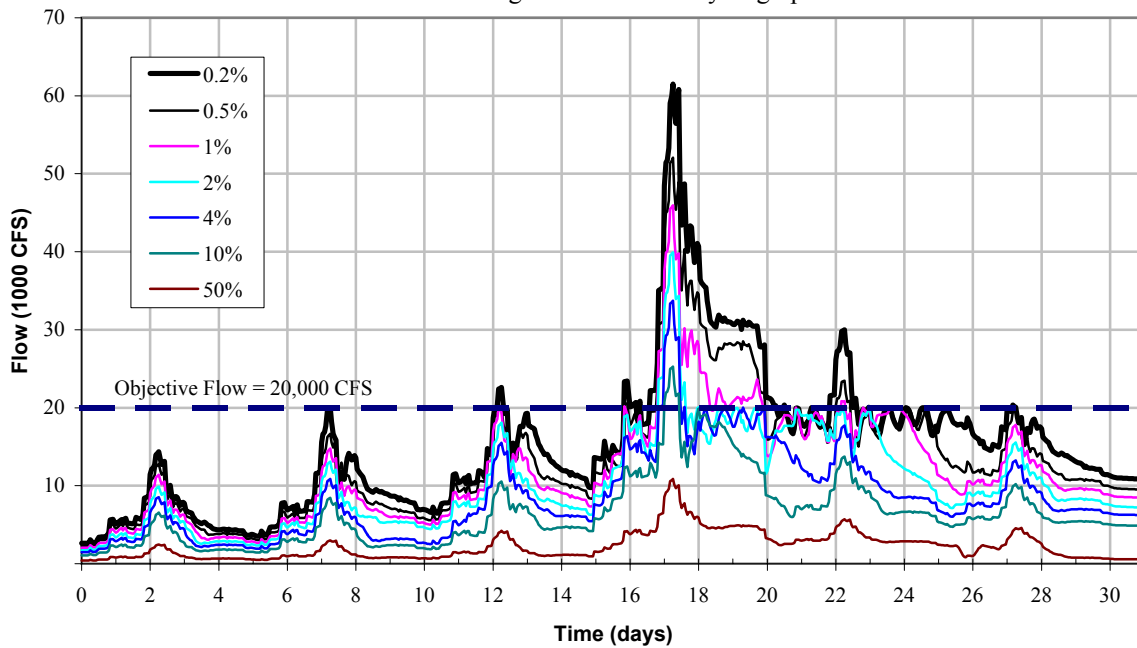


Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.2-4 Reservoir Simulation Hydrographs at Downstream Index Points
US Army Corps of Engineers The Reclamation Board, State of California
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**New Bullards Bar Dam Storm Centering at Nicolaus
(Feather River) Index Point**
Regulated Outflow Hydrographs

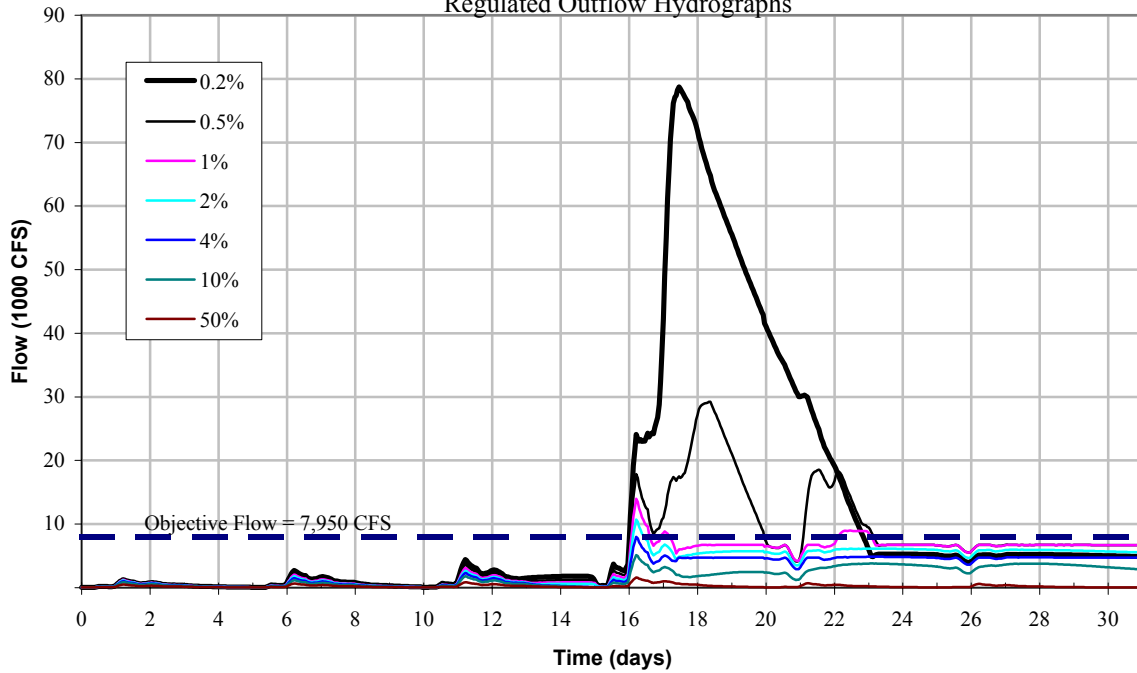


Indian Valley Storm Centering at Rumsey Index Point
Regulated Outflow Hydrographs

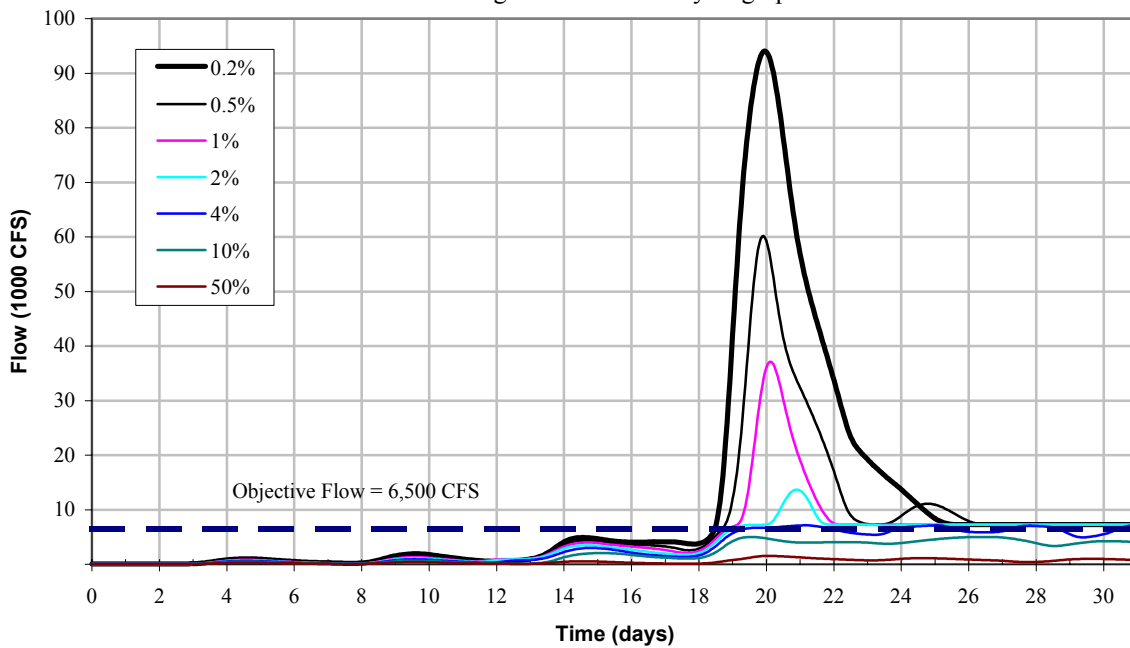


Sacramento & San Joaquin River Basins Comprehensive Study	
Figure C.2-5 Reservoir Simulation Hydrographs at Downstream Index Points	
US Army Corps of Engineers The Reclamation Board, State of California	December 2002

Pine Flat Dam Storm Centering at Friant Kern Canal Index Point
Regulated Outflow Hydrographs

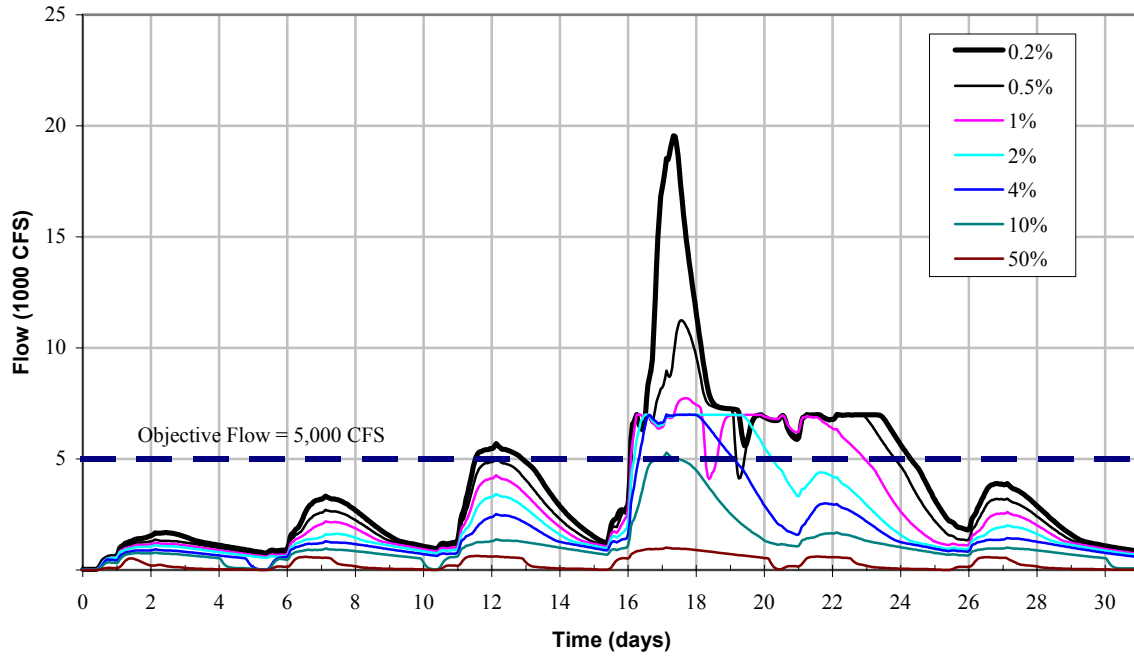


Friant Dam Storm Centering at Mendota Gage Index Point
Regulated Outflow Hydrographs

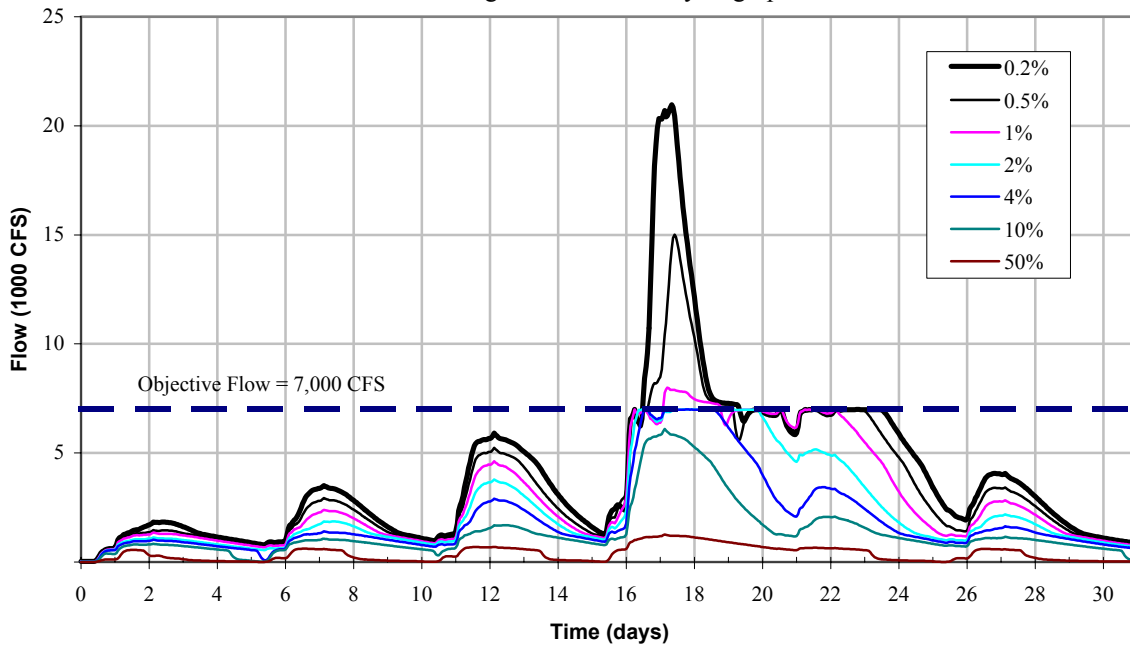


Sacramento & San Joaquin River Basins Comprehensive Study	
Figure C.2-6 Reservoir Simulation Hydrographs at Downstream Index Points	
US Army Corps of Engineers The Reclamation Board, State of California	December 2002

Hidden Dam Storm Centering at Madera Canal Index Point Regulated Outflow Hydrographs



Buchanan Dam Storm Centering at Madera Canal Index Point Regulated Outflow Hydrographs

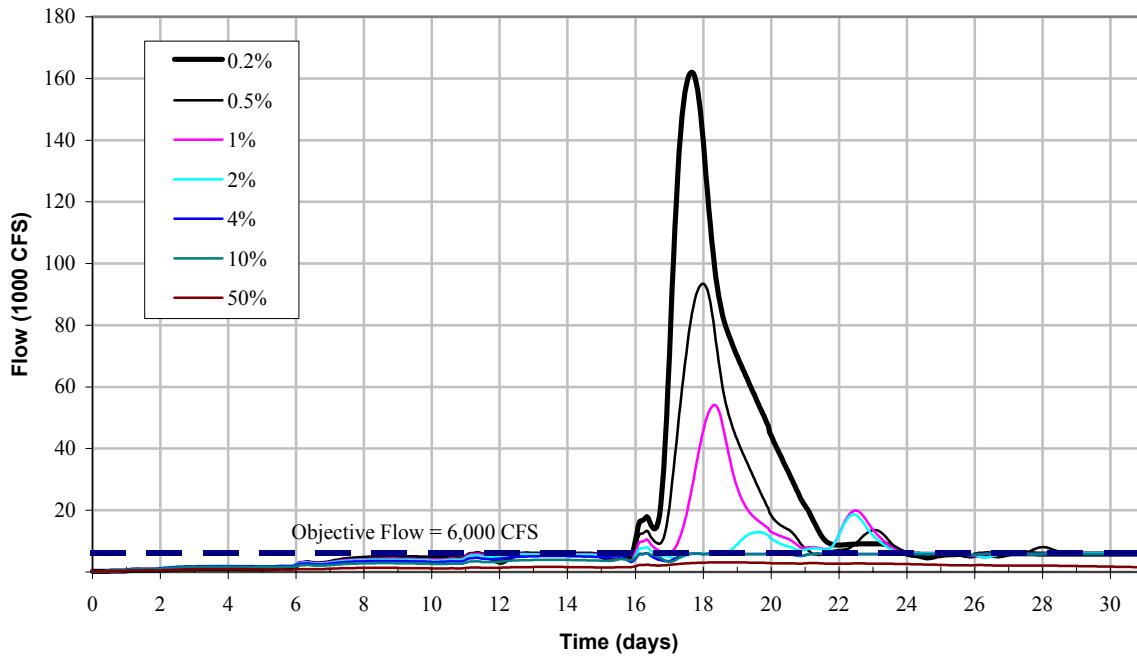


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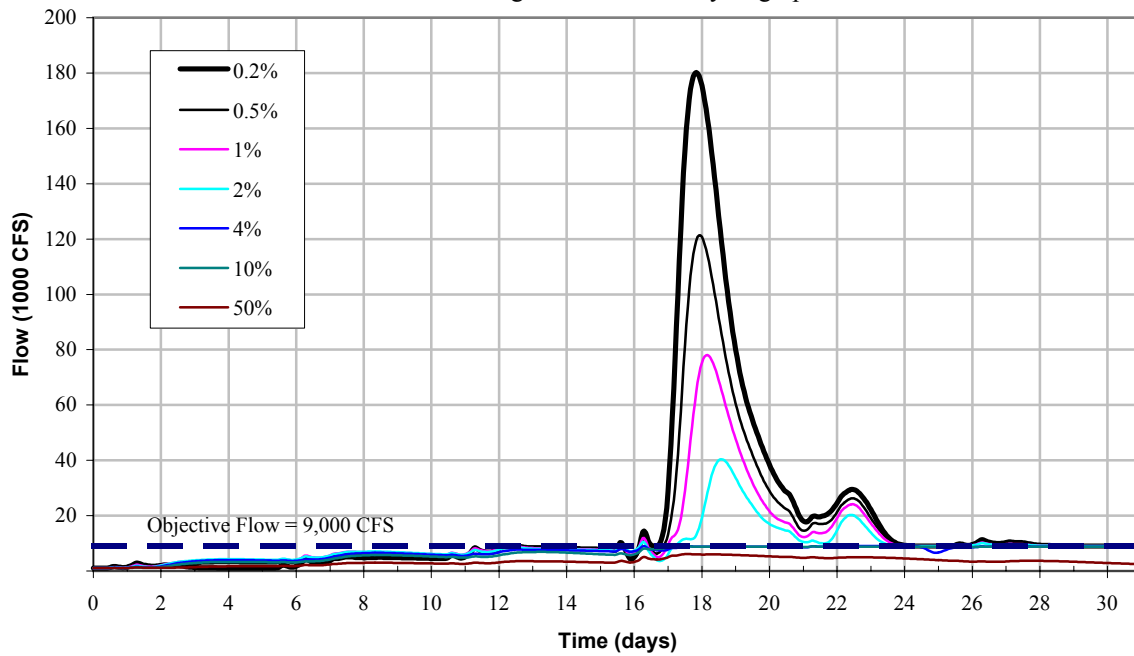
Figure C.2-7
Reservoir Simulation Hydrographs
at Downstream Index Points

US Army Corps of Engineers
The Reclamation Board, State of California December 2002

New Exchequer Dam Storm Centering at Cressey Index Point
Regulated Outflow Hydrographs

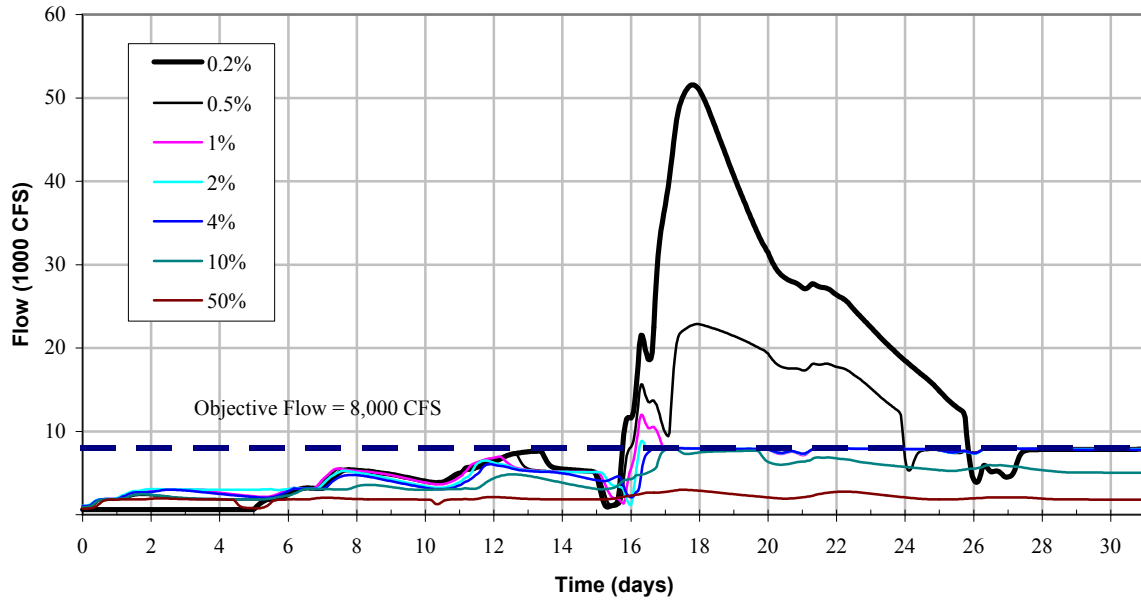


Don Pedro Dam Storm Centering at Modesto Index Point
Regulated Outflow Hydrographs

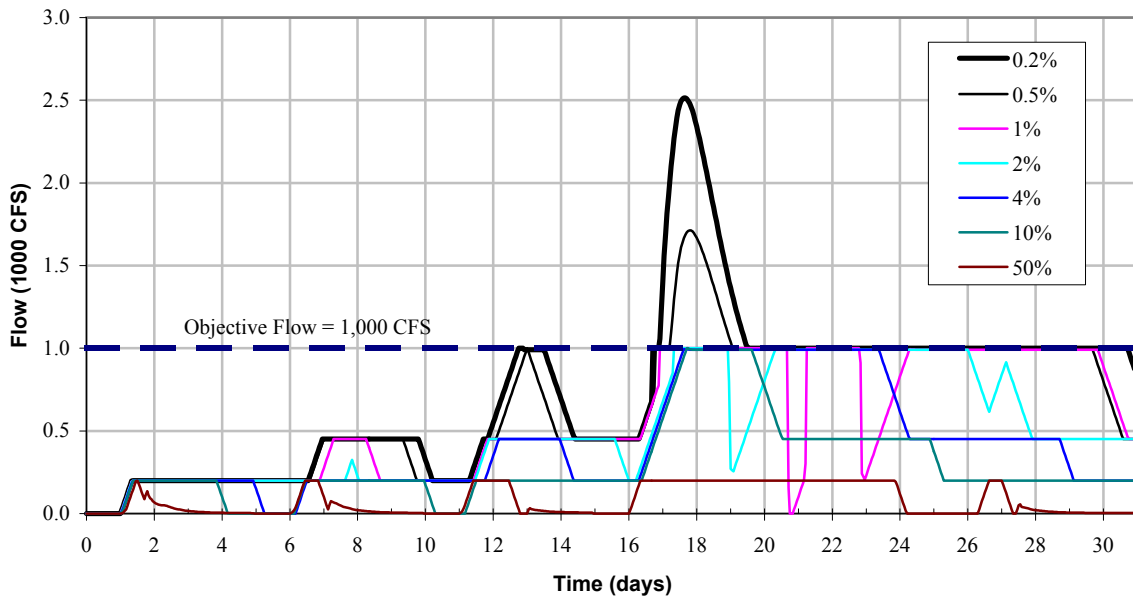


Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.2-8 Reservoir Simulation Hydrographs at Downstream Index Points
US Army Corps of Engineers The Reclamation Board, State of California December 2002

**New Melones Dam Storm Centering at
Orange Blossom Index Point**
Regulated Outflow Hydrographs



**Los Banos Detention Dam Storm Centering at
Los Banos Index Point**
Regulated Outflow Hydrographs



Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.2-9 Reservoir Simulation Hydrographs at Downstream Index Points
US Army Corps of Engineers The Reclamation Board, State of California December 2002

ATTACHMENT C.3

GRID ANALYSIS – CHANGES IN OBJECTIVE FLOW VS. CHANGES IN FLOOD STORAGE

FIGURES – SACRAMENTO RIVER BASIN

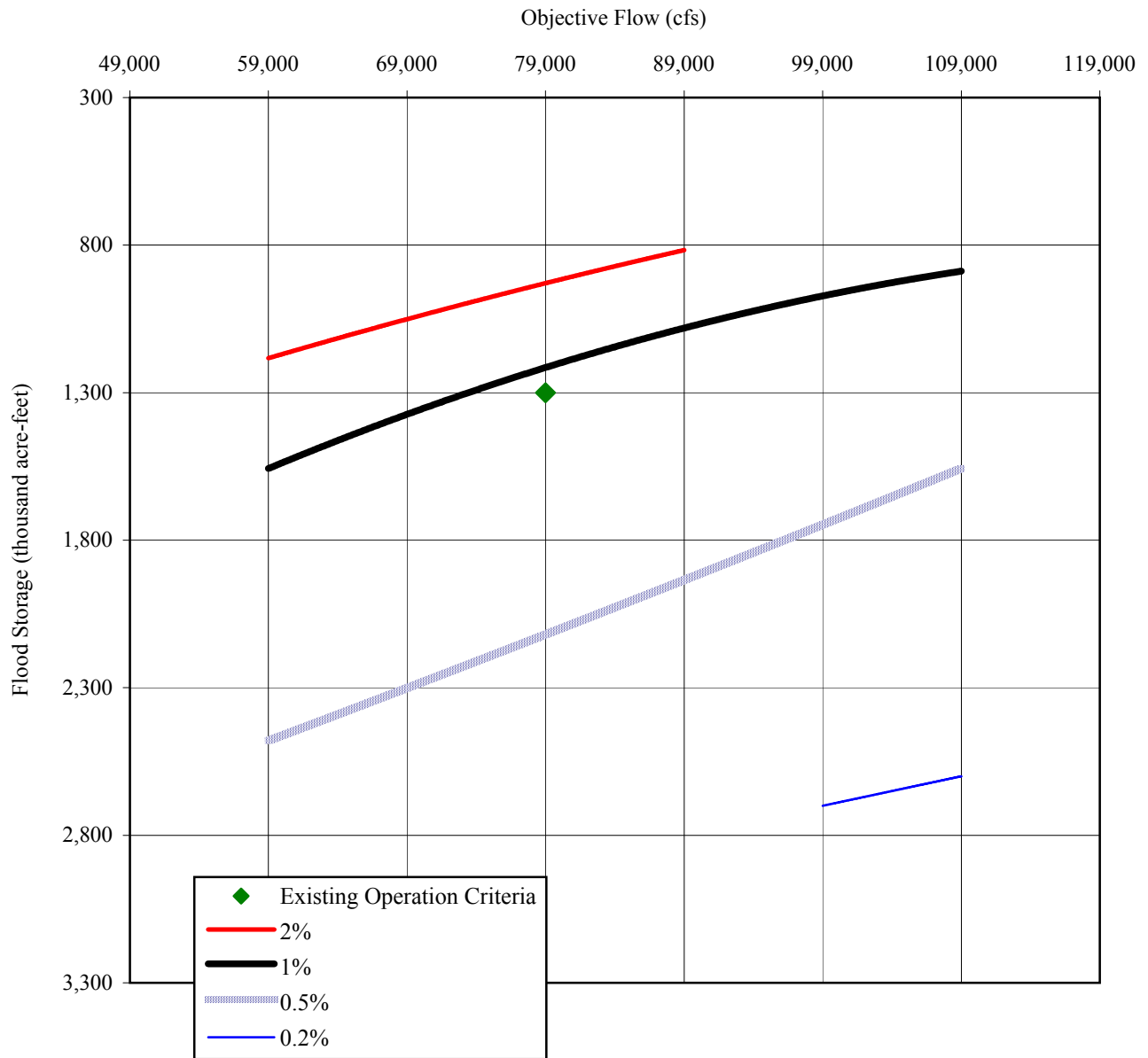
- Figure C.3-1 Shasta Dam and Reservoir
- Figure C.3-2 Black Butte Dam and Reservoir
- Figure C.3-3 Oroville Dam and Reservoir
- Figure C.3-4 New Bullards Bar Dam and Reservoir

FIGURES – SAN JOAQUIN RIVER BASIN

- Figure C.3-5 Pine Flat Dam and Reservoir
- Figure C.3-6 Friant Dam and Reservoir
- Figure C.3-7 Hidden Dam and Reservoir
- Figure C.3-8 Buchanan Dam and Reservoir
- Figure C.3-9 New Exchequer Dam and Reservoir
- Figure C.3-10 Don Pedro Dam and Reservoir
- Figure C.3-11 New Melones Dam and Reservoir

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Shasta Objective Flow vs. Flood Storage

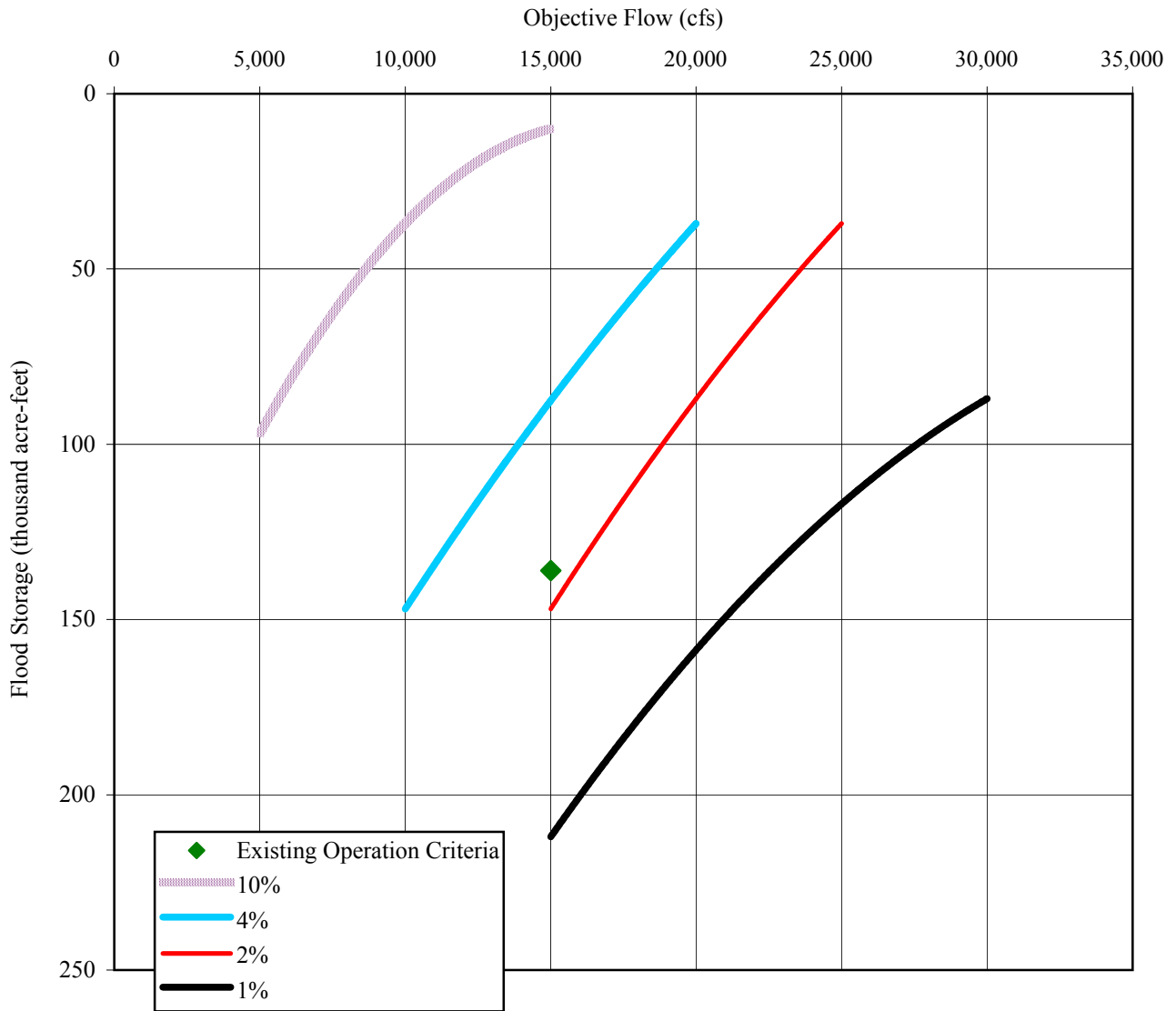


Notes:

1. Data representing the 50% and 10% chance exceedence events are not plotted because Shasta is capable of completely detaining inflows generated by events of these magnitudes.
2. Points above a curve indicate objective flows have been exceeded and values below a curve indicate objective flows have not been exceeded for a particular event.
3. Current objective flow = 79,000 cfs
4. Current maximum flood control storage = 1,300 TAF

Sacramento & San Joaquin River Basins Comprehensive Study	
Figure C.3-1 Grid Analysis Results Shasta Dam and Reservoir	
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Black Butte Objective Flow vs. Flood Storage

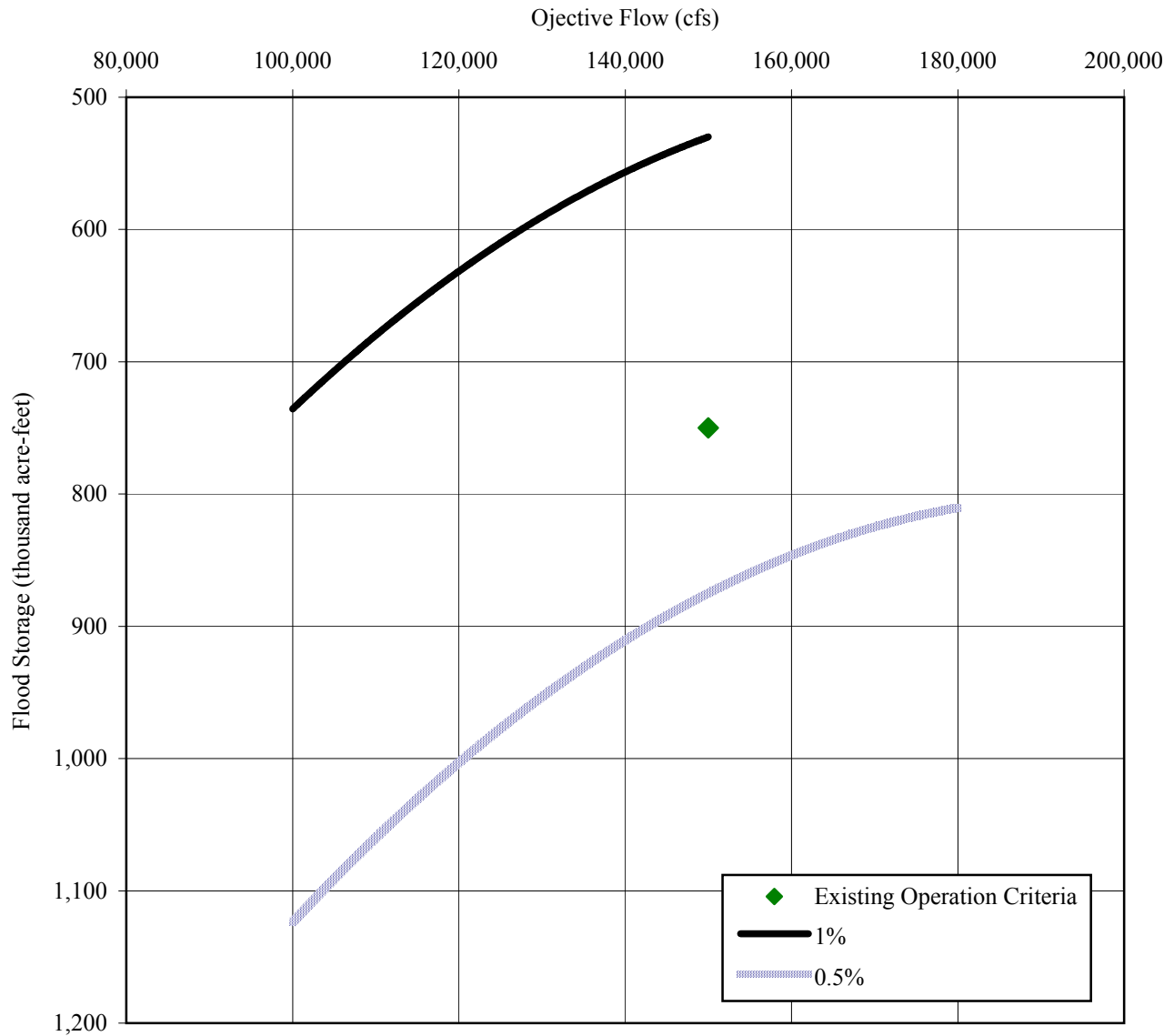


Notes:

1. Data representing the 50% chance exceedence events is not plotted because Black Butte is capable of completely detaining inflows generated by events of this magnitude.
2. Data representing the 0.5% and 0.2% chance exceedence events is not plotted because Black Butte is incapable of completely detaining inflows generated by events of these magnitudes.
3. Points above a curve indicate objective flows have been exceeded and values below a curve indicate objective flows have not been exceeded for a particular event.
4. Current objective flow = 15,000 cfs
5. Current maximum flood storage = 136 TAF

Sacramento & San Joaquin River Basins Comprehensive Study	
Figure C.3-2 Grid Analysis Results Black Butte Dam and Reservoir	
US Army Corps of Engineers The Reclamation Board, State of California	December 2002

Oroville Objective Flow vs. Flood Storage

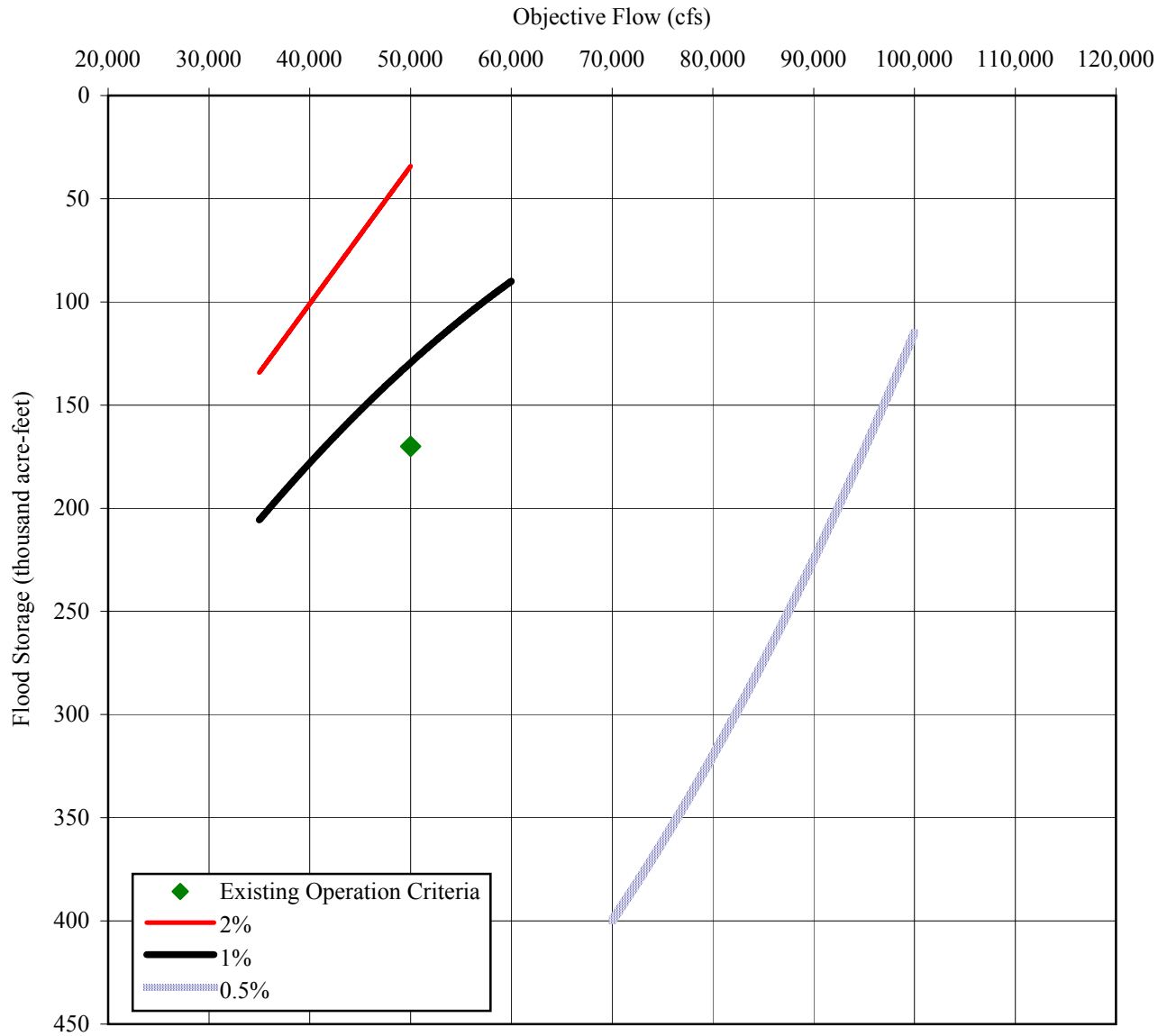


Notes:

1. Data representing the 50%, 10%, 4%, and 2% chance exceedence events is not plotted because Oroville is capable of completely detaining inflows generated by events of these magnitudes.
2. Data representing the 0.2% chance exceedence event is not plotted because Oroville is incapable of completely detaining inflows generated by events of this magnitude.
3. Points above a curve indicate objective flows have been exceeded and values below a curve indicate objective flows have not been exceeded for a particular event.
4. Current objective flow = 150,000 cfs
5. Current maximum flood storage = 750 TAF

Sacramento & San Joaquin River Basins Comprehensive Study	
Figure C.3-3 Grid Analysis Results Oroville Dam and Reservoir	
US Army Corps of Engineers	The Reclamation Board, State of California December 2002

New Bullards Objective Flow vs. Flood Storage

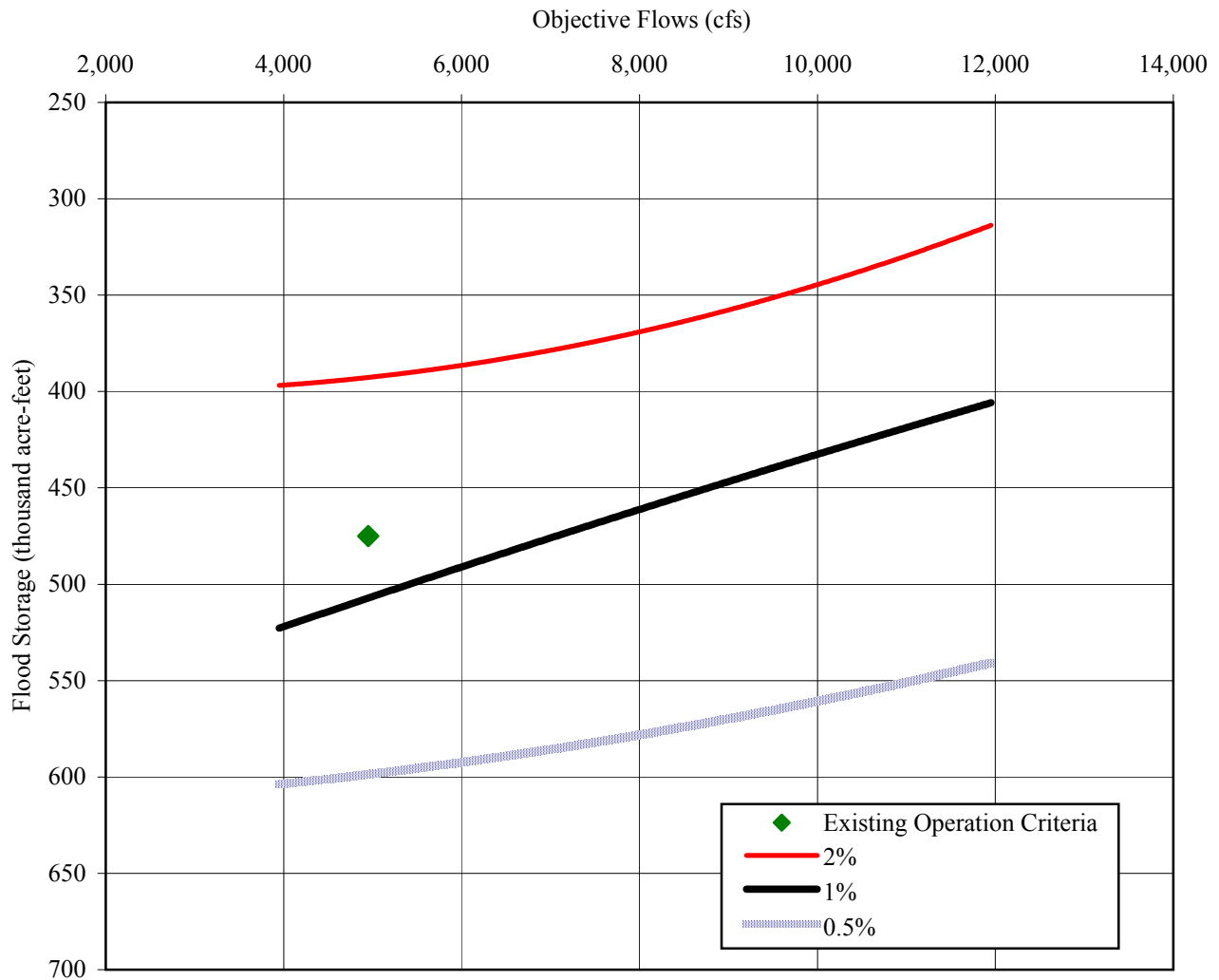


Notes:

1. Data representing the 50%, 10%, and 4% chance exceedence events is not plotted because New Bullards is capable of completely detaining inflows generated by events of these magnitudes.
2. Data representing the 0.2% chance exceedence event is not plotted because New Bullards is incapable of completely detaining inflows generated by events of this magnitude.
3. Points above a curve indicate objective flows have been exceeded and values below a curve indicate objective flows have not been exceeded for a particular event.
4. Current objective flow = 50,000 cfs
5. Current maximum flood storage = 170 TAF

Sacramento & San Joaquin River Basins Comprehensive Study	
Figure C.3-4 Grid Analysis Results New Bullards Dam and Reservoir	
US Army Corps of Engineers The Reclamation Board, State of California	December 2002

Pine Flat Objective Flow vs. Flood Storage

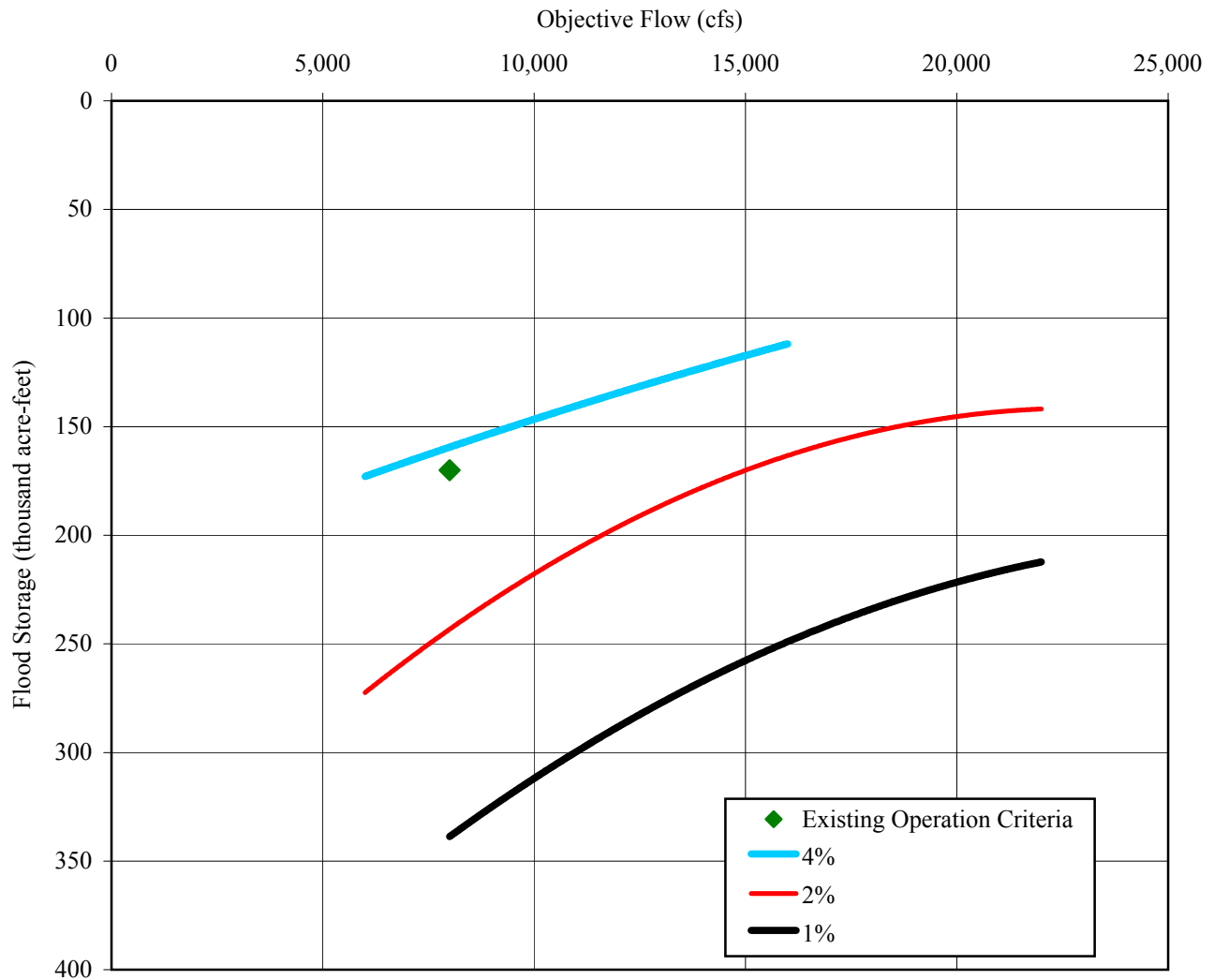


Notes:

1. Data representing the 50%, 10%, and 4% chance exceedance events is not plotted because Pine Flat is capable of completely detaining inflows generated by events of these magnitudes.
2. Data representing the 0.2% chance exceedance event is not plotted because Pine Flat is incapable of completely detaining inflows generated by events of this magnitude.
3. Points above a curve indicate objective flows have been exceeded and values below a curve indicate objective flows have not been exceeded for a particular event.
4. Current objective flow = 4,950 cfs
5. Current maximum flood storage = 475 TAF

Sacramento & San Joaquin River Basins Comprehensive Study	
Figure C.3-5 Grid Analysis Results Pine Flat Dam and Reservoir	
US Army Corps of Engineers The Reclamation Board, State of California	December 2002

Friant Objective Flow vs. Flood Storage

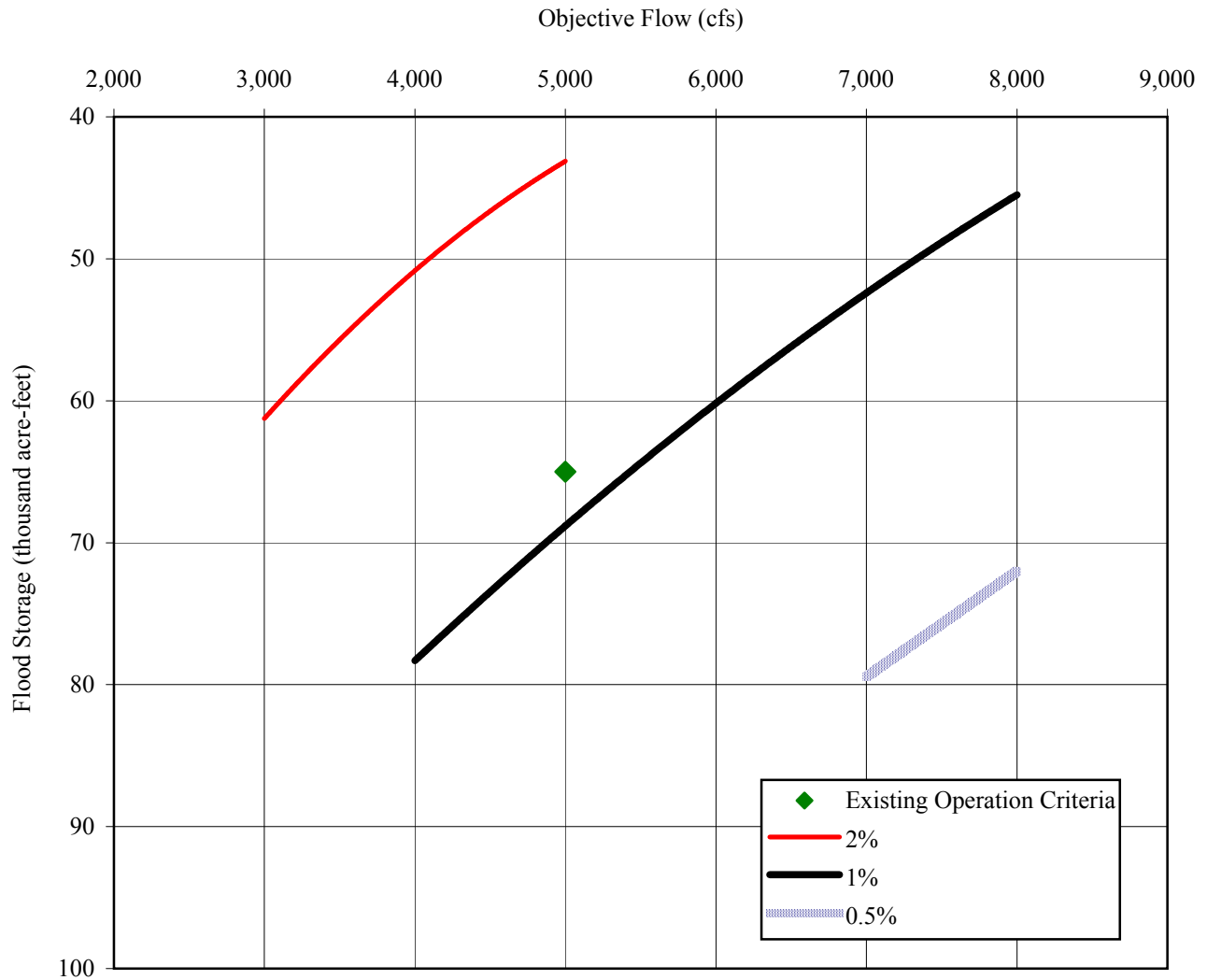


Notes:

1. Data representing the 50% and 10% chance exceedence events is not plotted because Friant is capable of completely detaining inflows generated by events of this magnitude.
2. Data representing the 0.5% and 0.2% chance exceedence events is not plotted because Friant is incapable of completely detaining inflows generated by events of these magnitudes.
3. Points above a curve indicate objective flows have been exceeded and values below a curve indicate objective flows have not been exceeded for a particular event.
4. Current objective flow = 8,000 cfs
5. Current maximum flood storage = 170 TAF

Sacramento & San Joaquin River Basins Comprehensive Study	
Figure C.3-6 Grid Analysis Results Friant Dam and Reservoir	
US Army Corps of Engineers The Reclamation Board, State of California	December 2002

Hidden Objective Flow vs. Flood Storage

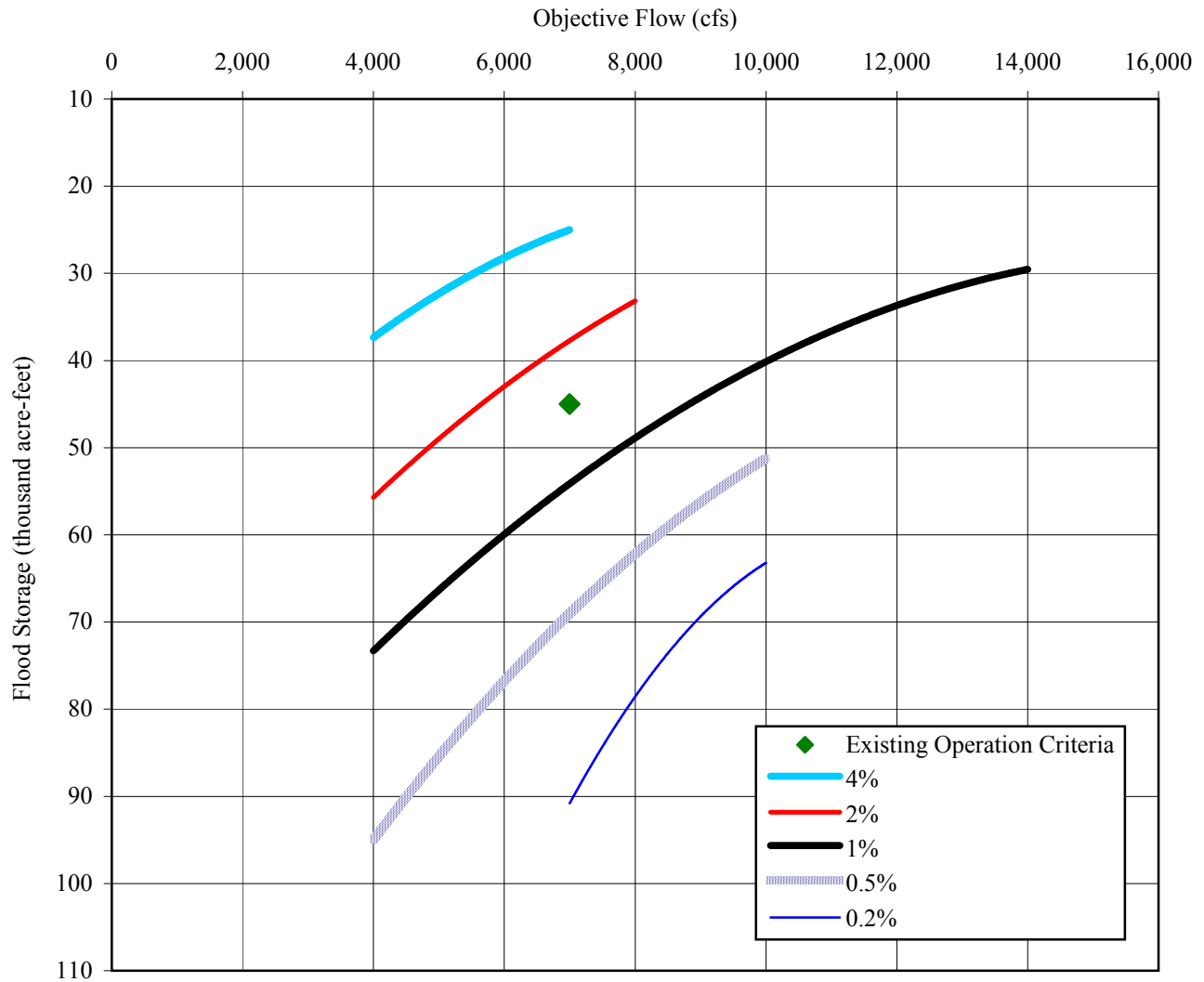


Notes:

1. Data representing the 50%, 10%, and 4% chance exceedence events is not plotted because Hidden Dam is capable of completely detaining inflows generated by events of these magnitudes.
2. Data representing the 0.2% chance exceedence event is not plotted because Hidden Dam is incapable of completely detaining inflows generated by events of this magnitude.
3. Points above a curve indicate objective flows have been exceeded and values below a curve indicate objective flows have not been exceeded for a particular event.
4. Current objective flow = 5,000 cfs
5. Current maximum flood storage = 65 TAF

Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.3-7 Grid Analysis Results Hidden Dam and Reservoir
US Army Corps of Engineers The Reclamation Board, State of California December 2002

Buchanan Objective Flow vs. Flood Storage

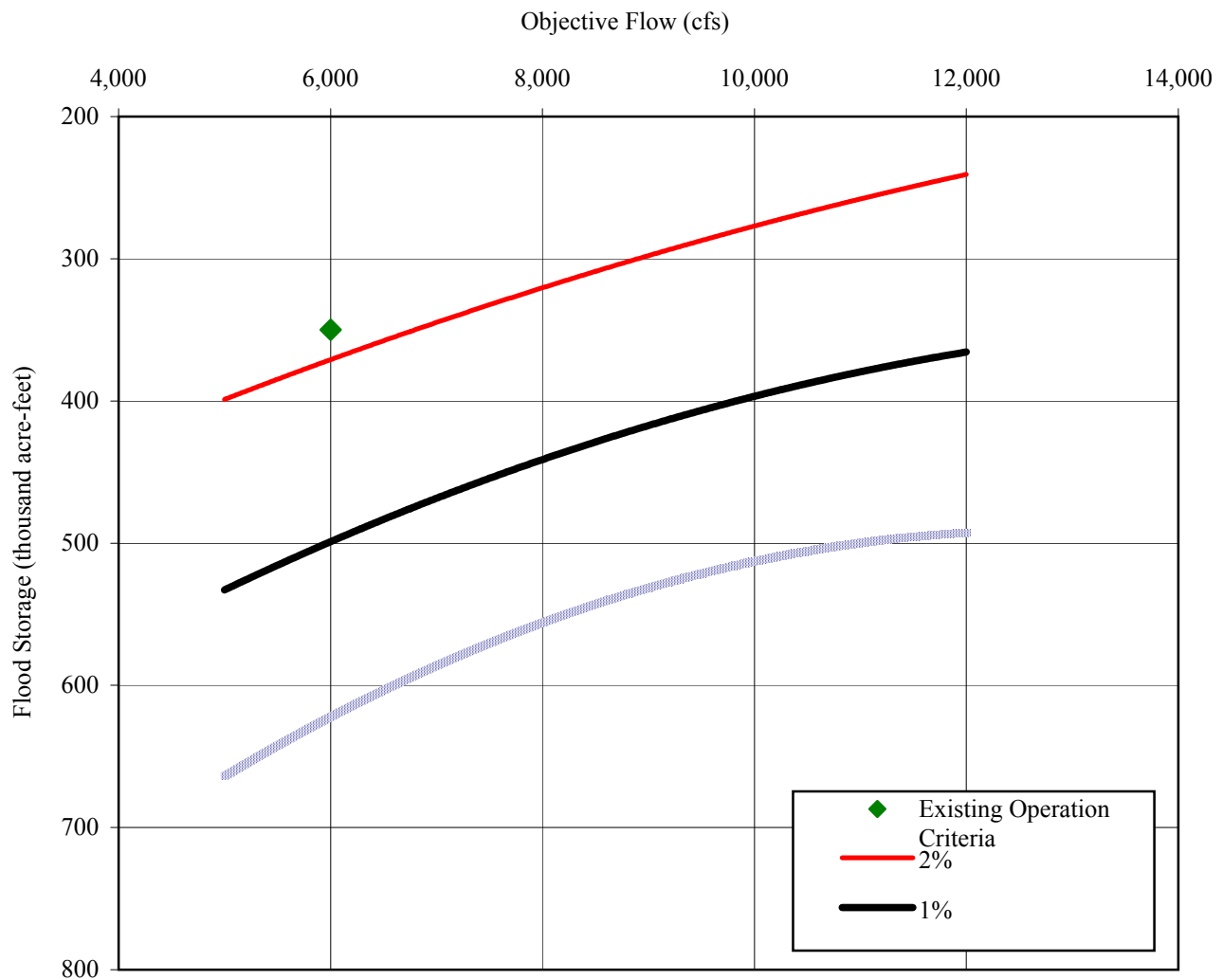


Notes:

1. Data representing the 50% and 10% chance exceedence events is not plotted because Buchanan is capable of completely detaining inflows generated by events of these magnitudes.
2. Points above a curve indicate objective flows have been exceeded and values below a curve indicate objective flows have not been exceeded for a particular event.
3. Current objective release = 7,000 cfs
4. Current maximum flood storage = 45 TAF

Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.3-8 Grid Analysis Results Buchanan Dam and Reservoir
US Army Corps of Engineers The Reclamation Board, State of California December 2002

New Exchequer Objective Flow vs. Flood Storage

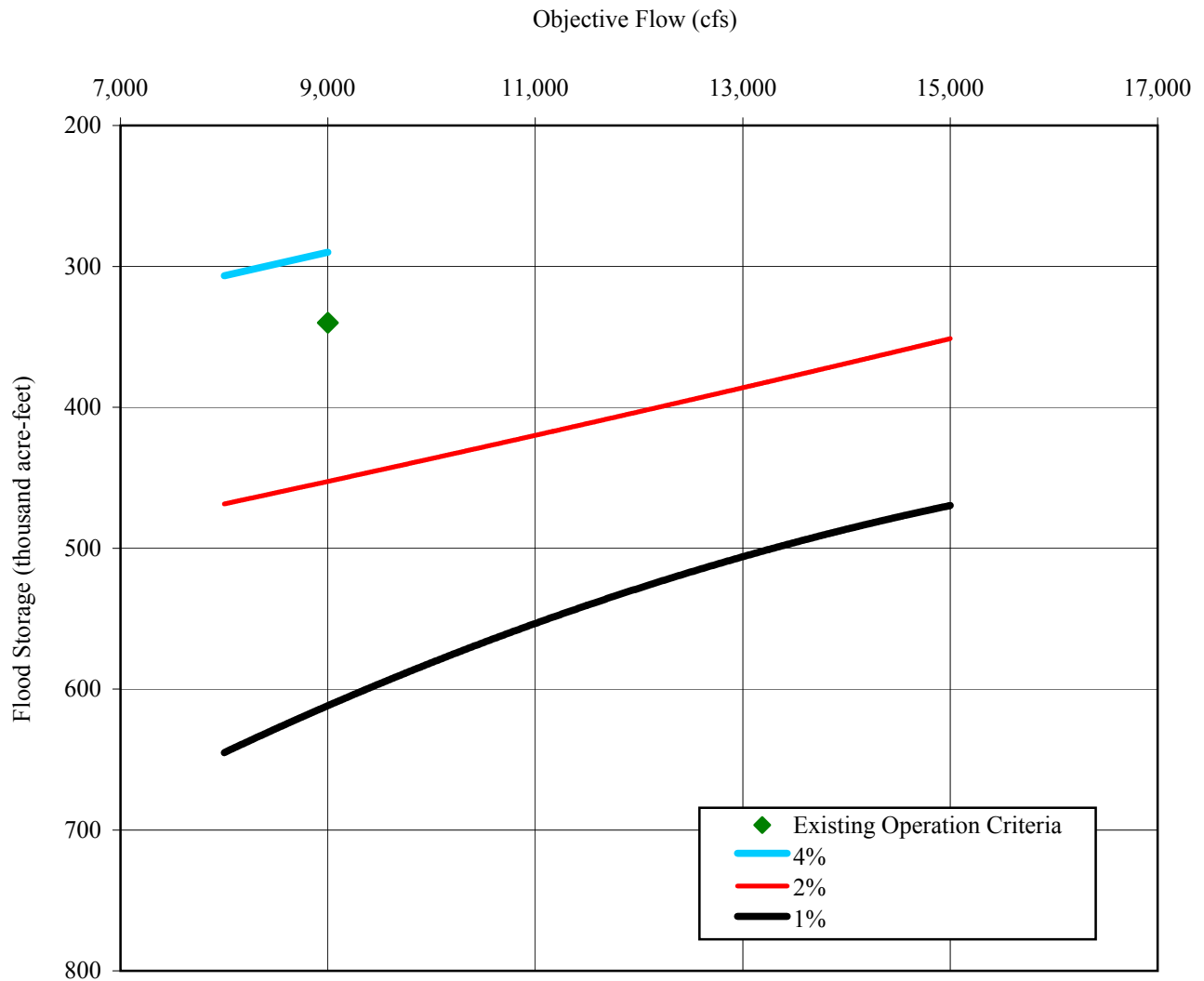


Notes:

1. Data representing the 50%, 10%, and 4% chance exceedence events is not plotted because New Exchequer is capable of completely detaining inflows generated by events of these magnitudes.
2. Data for the 0.2% chance exceedence event is not plotted because New Exchequer is incapable of completely detaining inflows generated by events of this magnitude.
3. Points above a curve indicate objective flows have been exceeded and values below a curve indicate objective flows have not been exceeded for a particular event.
4. Current objective flow = 6,000 cfs
5. Current maximum flood storage = 350 TAF

Sacramento & San Joaquin River Basins Comprehensive Study	
Figure C.3-9 Grid Analysis Results New Exchequer Dam and Reservoir	
US Army Corps of Engineers The Reclamation Board, State of California	December 2002

Don Pedro Objective Flow vs. Flood Storage

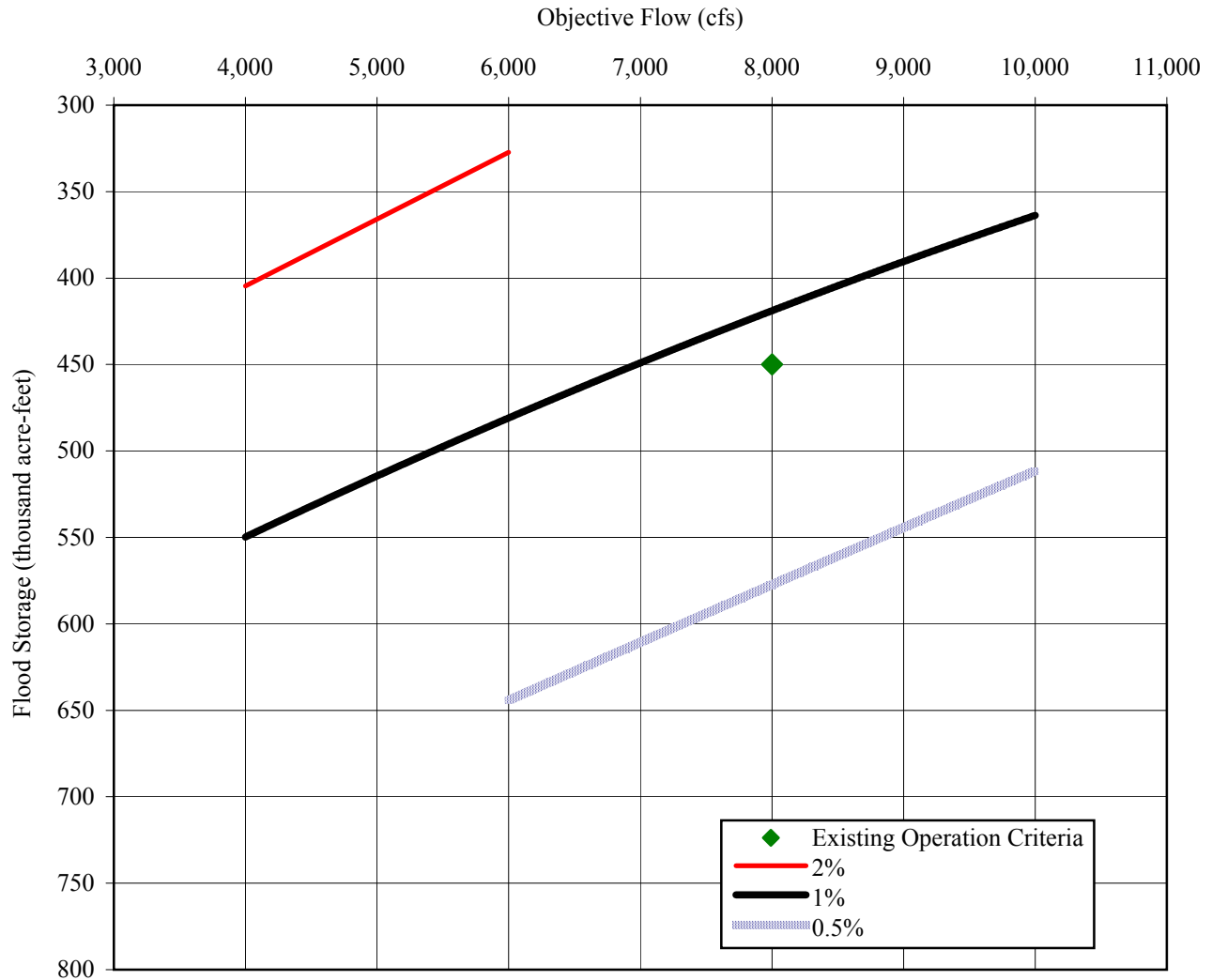


Notes:

1. Data representing the 50% and 10% chance exceedence events are not plotted because Don Pedro is capable of completely detaining inflows generated by events of these magnitudes.
2. Data representing the 0.5% and 0.2% chance exceedence events are not plotted because Don Pedro is incapable of completely detaining inflows generated by events of these magnitudes.
3. Points above a curve indicate objective flows have been exceeded and values below a curve indicate objective flows have not been exceeded for a particular event.
4. Current objective flow = 9,000 cfs
5. Current maximum flood storage = 340 TAF

Sacramento & San Joaquin River Basins Comprehensive Study	
Figure C.3-10 Grid Analysis Results Don Pedro Dam and Reservoir	
US Army Corps of Engineers The Reclamation Board, State of California	December 2002

New Melones Objective Flow vs. Flood Storage



Notes:

1. Data representing the 50%, 10%, and 4% chance exceedance events is not plotted because New Melones is capable of completely detaining inflows generated by events of these magnitudes.
2. Data representing the 0.2% chance exceedance event is not plotted because New Melones is incapable of completely detaining inflows generated by events of this magnitude.
3. Points above a curve indicate objective flows have been exceeded and values below a curve indicate objective flows have not been exceeded for a particular event.
4. Current objective flow = 8,000 cfs
5. Current maximum flood storage = 450 TAF

Sacramento & San Joaquin River Basins Comprehensive Study	
Figure C.3-11 Grid Analysis Results New Melones Dam and Reservoir	
US Army Corps of Engineers The Reclamation Board, State of California	December 2002

ATTACHMENT C.4

RESERVOIR SIMULATION TABLES AND REPRESENTATIVE RESERVOIR HYDROGRAPHS – ALTERNATIVE SCENARIOS

SACRAMENTO RIVER BASIN

Table C.4-1	Effects of Alternative Scenario SAC-B01A
Figure C.4-1a	Alternative SAC-B01A – Shasta Dam and Reservoir 50% and 10% Chance Exceedence Events
Figure C.4-1b	Alternative SAC-B01A – Shasta Dam and Reservoir 4% and 2% Chance Exceedence Events
Figure C.4-1c	Alternative SAC-B01A – Shasta Dam and Reservoir 1% and 0.5% Chance Exceedence Events
Figure C.4-1d	Alternative SAC-B01A – Shasta Dam and Reservoir 0.2% Chance Exceedence Events
Figure C.4-1e	Alternative SAC-B01A – Oroville Dam and Reservoir 50% and 10% Chance Exceedence Events
Figure C.4-1f	Alternative SAC-B01A – Oroville Dam and Reservoir 4% and 2% Chance Exceedence Events
Figure C.4-1g	Alternative SAC-B01A – Oroville Dam and Reservoir 1% and 0.5% Chance Exceedence Events
Figure C.4-1h	Alternative SAC-B01A – Oroville Dam and Reservoir 0.2% Chance Exceedence Events
Table C.4-2	Effects of Alternative Scenario SAC-B02A
Figure C.4-2a	Alternative SAC-B02A – Shasta Dam and Reservoir 50% and 10% Chance Exceedence Events
Figure C.4-2b	Alternative SAC-B02A – Shasta Dam and Reservoir 4% and 2% Chance Exceedence Events
Figure C.4-2c	Alternative SAC-B02A – Shasta Dam and Reservoir 1% and 0.5% Chance Exceedence Events
Figure C.4-2d	Alternative SAC-B02A – Shasta Dam and Reservoir 0.2% Chance Exceedence Events
Figure C.4-2e	Alternative SAC-B02A – Oroville Dam and Reservoir 50% and 10% Chance Exceedence Events
Figure C.4-2f	Alternative SAC-B02A – Oroville Dam and Reservoir 4% and 2% Chance Exceedence Events

Figure C.4-2g	Alternative SAC-B02A – Oroville Dam and Reservoir 1% and 0.5% Chance Exceedence Events
Figure C.4-2h	Alternative SAC-B02A – Oroville Dam and Reservoir 0.2% Chance Exceedence Events
Table C.4-3	Comparison of Peak Flows in the Sacramento Basin, Alternative SAC-B03A
Figure C.4-3a	Alternative SAC-B03A – Oroville Dam and Reservoir 50% and 10% Chance Exceedence Events
Figure C.4-3b	Alternative SAC-B03A – Oroville Dam and Reservoir 4% and 2% Chance Exceedence Events
Figure C.4-3c	Alternative SAC-B03A – Oroville Dam and Reservoir 1% and 0.5% Chance Exceedence Events
Figure C.4-3d	Alternative SAC-B03A – Oroville Dam and Reservoir 0.2% Chance Exceedence Events
Figure C.4-3e	Alternative SAC-B03A – New Bullards Bar Dam and Reservoir 50% and 10% Chance Exceedence Events
Figure C.4-3f	Alternative SAC-B03A – New Bullards Bar Dam and Reservoir 4% and 2% Chance Exceedence Events
Figure C.4-3g	Alternative SAC-B03A – New Bullards Bar Dam and Reservoir 100- and 200-yr
Figure C.4-3h	Alternative SAC-B03A – New Bullards Bar Dam and Reservoir 0.2% Chance Exceedence Events
Table C.4-4a	Peak Flow Comparisons for Folsom Dam
Table C.4-4b	Effects of Alternative Scenario SAC-B04A
Figure C.4-4a	Alternative SAC-B04A – Oroville Dam and Reservoir 50% and 10% Chance Exceedence Events
Figure C.4-4b	Alternative SAC-B04A – Oroville Dam and Reservoir 4% and 2% Chance Exceedence Events
Figure C.4-4c	Alternative SAC-B04A – Oroville Dam and Reservoir 1% and 0.5% Chance Exceedence Events
Figure C.4-4d	Alternative SAC-B04A – Oroville Dam and Reservoir 0.2% Chance Exceedence Events

SAN JOAQUIN RIVER BASIN

Table C.4-5a Comparison of Maximum Release of Baseline and Alternative Scenario (SJQ-B01A) Simulations for Specific Annual Percent Chance Exceedence Events

Table C.4-5b Effects of Alternative Scenario SJQ-B01A

Figure C.4-5a Alternative SJQ-B01A – Friant Dam and Reservoir 50% and 10% Chance Exceedence Events

Figure C.4-5b Alternative SJQ-B01A – Friant Dam and Reservoir 4% and 2% Chance Exceedence Events

Figure C.4-5c Alternative SJQ-B01A – Friant Dam and Reservoir 1% and 0.5% Chance Exceedence Events

Figure C.4-5d Alternative SJQ-B01A – Friant Dam and Reservoir 0.2% Chance Exceedence Events

Figure C.4-5e Alternative SJQ-B01A – Don Pedro Dam and Reservoir 50% and 10% Chance Exceedence Events

Figure C.4-5f Alternative SJQ-B01A – Don Pedro Dam and Reservoir 4% and 2% Chance Exceedence Events

Figure C.4-5g Alternative SJQ-B01A – Don Pedro Dam and Reservoir 1% and 0.5% Chance Exceedence Events

Figure C.4-5h Alternative SJQ-B01A – Don Pedro Dam and Reservoir 0.2% Chance Exceedence Events

Table C.4-6a Comparison of Maximum Release of Baseline and Alternative Scenario (SJQ-B02A) Simulations for Specific Annual Percent Chance Exceedence Events

Table C.4-6b Effects of Alternative Scenario SJQ-B02A

Figure C.4-6a Alternative SJQ-B02A – Friant Dam and Reservoir 50% and 10% Chance Exceedence Events

Figure C.4-6b Alternative SJQ-B02A – Friant Dam and Reservoir 4% and 2% Chance Exceedence Events

Figure C.4-6c Alternative SJQ-B02A – Friant Dam and Reservoir 1% and 0.5% Chance Exceedence Events

Figure C.4-6d Alternative SJQ-B02A – Friant Dam and Reservoir 0.2% Chance Exceedence Events

Figure C.4-6e Alternative SJQ-B02A – New Exchequer Dam and Reservoir 50% and 10% Chance Exceedence Events

Figure C.4-6f Alternative SJQ-B02A – New Exchequer Dam and Reservoir 4% and 2% Chance Exceedence Events

Figure C.4-6g Alternative SJQ-B02A – New Exchequer Dam and Reservoir 1% and 0.5% Chance Exceedence Events

Figure C.4-6h Alternative SJQ-B02A – New Exchequer Dam and Reservoir 0.2% Chance Exceedence Events

Figure C.4-6i	Alternative SJQ-B02A – Don Pedro Dam and Reservoir 50% and 10% Chance Exceedence Events
Figure C.4-6j	Alternative SJQ-B02A – Don Pedro Dam and Reservoir 4% and 2% Chance Exceedence Events
Figure C.4-6k	Alternative SJQ-B02A – Don Pedro Dam and Reservoir 1% and 0.5% Chance Exceedence Events
Figure C.4-6l	Alternative SJQ-B02A – Don Pedro Dam and Reservoir 0.2% Chance Exceedence Events
Table C.4-7a	Comparison of Maximum Release of Baseline and Alternative Scenario (SJQ-B03A) Simulations for Specific Annual Percent Chance Exceedence Events
Table C.4-7b	Effects of Alternative Scenario SJQ-B03A
Figure C.4-7a	Alternative SJQ-B03A – Don Pedro Dam and Reservoir 50% and 10% Chance Exceedence Events
Figure C.4-7b	Alternative SJQ-B03A – Don Pedro Dam and Reservoir 4% and 2% Chance Exceedence Events
Figure C.4-7c	Alternative SJQ-B03A – Don Pedro Dam and Reservoir 1% and 0.5% Chance Exceedence Events
Figure C.4-7d	Alternative SJQ-B03A – Don Pedro Dam and Reservoir 0.2% Chance Exceedence Events
Table C.4-8a	Comparison of Maximum Release of Baseline and Alternative Scenario (SJQ-B04A) Simulations for Specific Annual Percent Chance Exceedence Events
Table C.4-8b	Effects of Alternative Scenario SJQ-B04A
Figure C.4-8a	Alternative SJQ-B04A – Friant Dam and Reservoir 50% and 10% Chance Exceedence Events
Figure C.4-8b	Alternative SJQ-B04A – Friant Dam and Reservoir 4% and 2% Chance Exceedence Events
Figure C.4-8c	Alternative SJQ-B04A – Friant Dam and Reservoir 1% and 0.5% Chance Exceedence Events
Figure C.4-8d	Alternative SJQ-B04A – Friant Dam and Reservoir 0.2% Chance Exceedence Events
Figure C.4-8e	Alternative SJQ-B04A – New Exchequer Dam and Reservoir 50% and 10% Chance Exceedence Events
Figure C.4-8f	Alternative SJQ-B04A – New Exchequer Dam and Reservoir 4% and 2% Chance Exceedence Events
Figure C.4-8g	Alternative SJQ-B04A – New Exchequer Dam and Reservoir 1% and 0.5% Chance Exceedence Events
Figure C.4-8h	Alternative SJQ-B04A – New Exchequer Dam and Reservoir 0.2% Chance Exceedence Events

Figure C.4-8i	Alternative SJQ-B04A – Don Pedro Dam and Reservoir 50% and 10% Chance Exceedence Events
Figure C.4-8j	Alternative SJQ-B04A – Don Pedro Dam and Reservoir 4% and 2% Chance Exceedence Events
Figure C.4-8k	Alternative SJQ-B04A – Don Pedro Dam and Reservoir 1% and 0.5% Chance Exceedence Events
Figure C.4-8l	Alternative SJQ-B04A – Don Pedro Dam and Reservoir 0.2% Chance Exceedence Events
Table C.4-9a	Comparison of Maximum Release of Baseline and Alternative Scenario (SJQ-B05A) Simulations for Specific Annual Percent Chance Exceedence Events
Table C.4-9b	Effects of Alternative Scenario SJQ-B05A
Figure C.4-9a	Alternative SJQ-B05A – Friant Dam and Reservoir 50% and 10% Chance Exceedence Events
Figure C.4-9b	Alternative SJQ-B05A – Friant Dam and Reservoir 4% and 2% Chance Exceedence Events
Figure C.4-9c	Alternative SJQ-B05A – Friant Dam and Reservoir 1% and 0.5% Chance Exceedence Events
Figure C.4-9d	Alternative SJQ-B05A – Friant Dam and Reservoir 0.2% Chance Exceedence Events
Figure C.4-9e	Alternative SJQ-B05A – New Exchequer Dam and Reservoir 50% and 10% Chance Exceedence Events
Figure C.4-9f	Alternative SJQ-B05A – New Exchequer Dam and Reservoir 4% and 2% Chance Exceedence Events
Figure C.4-9g	Alternative SJQ-B05A – New Exchequer Dam and Reservoir 1% and 0.5% Chance Exceedence Events
Figure C.4-9h	Alternative SJQ-B05A – New Exchequer Dam and Reservoir 0.2% Chance Exceedence Events
Figure C.4-9i	Alternative SJQ-B05A – Don Pedro Dam and Reservoir 50% and 10% Chance Exceedence Events
Figure C.4-9j	Alternative SJQ-B05A – Don Pedro Dam and Reservoir 4% and 2% Chance Exceedence Events
Figure C.4-9k	Alternative SJQ-B05A – Don Pedro Dam and Reservoir 1% and 0.5% Chance Exceedence Events
Figure C.4-9l	Alternative SJQ-B05A – Don Pedro Dam and Reservoir 0.2% Chance Exceedence Events
Table C.4-10a	Comparison of Maximum Release of Baseline and Alternative Scenario (SJQ-B06A) Simulations for Specific Annual Percent Chance Exceedence Events
Table C.4-10b	Effects of Alternative Scenario SJQ-B06A

- Figure C.4-10a Alternative SJQ-B06A – Friant Dam and Reservoir 50% and 10% Chance Exceedence Events
- Figure C.4-10b Alternative SJQ-B06A – Friant Dam and Reservoir 4% and 2% Chance Exceedence Events
- Figure C.4-10c Alternative SJQ-B06A – Friant Dam and Reservoir 1% and 0.5% Chance Exceedence Events
- Figure C.4-10d Alternative SJQ-B06A – Friant Dam and Reservoir 0.2% Chance Exceedence Events
-
- Table C.4-11a Comparison of Maximum Release of Baseline and Alternative Scenario (SJQ-B07A) Simulations for Specific Annual Percent Chance Exceedence Events
- Table C.4-11b Effects of Alternative Scenario SJQ-B07A
-
- Figure C.4-11a Alternative SJQ-B07A – New Exchequer Dam and Reservoir 50% and 10% Chance Exceedence Events
- Figure C.4-11b Alternative SJQ-B07A – New Exchequer Dam and Reservoir 4% and 2% Chance Exceedence Events
- Figure C.4-11c Alternative SJQ-B07A – New Exchequer Dam and Reservoir 1% and 0.5% Chance Exceedence Events
- Figure C.4-11d Alternative SJQ-B07A – New Exchequer Dam and Reservoir 0.2% Chance Exceedence Events

TABLE C.4-1
EFFECTS OF ALTERNATIVE SCENARIO SAC-B01A

Shasta Storm Runoff Centering							
Percent Chance Exceedence	Mainstem gage location →	Bend Bridge ¹	Vina Bridge ¹	Ord Ferry ¹	Oroville ¹	Verona	Sacramento ¹
50%	% Peak Reduced	0.0	0.0	0.0	42.8	9.7	10.6
	Peak Attenuation (AF)	0	0	0	31,458	29,628	29,007
10%	% Peak Reduced	0.0	0.0	0.0	42.8	9.4	9.8
	Peak Attenuation (AF)	0	0	0	31,458	30,882	30,267
4%	% Peak Reduced	0.0	0.0	0.0	42.5	-1.3	4.7
	Peak Attenuation (AF)	0	0	0	45,851	-46,414	18,044
2%	% Peak Reduced	0.0	0.0	0.0	35.5	7.5	5.7
	Peak Attenuation (AF)	0	0	0	202,084	201,941	200,723
1%	% Peak Reduced	0.0	0.0	0.0	55.5	15.2	11.8
	Peak Attenuation (AF)	0	0	0	388,336	407,758	406,369
0.5%	% Peak Reduced	16.6	0.0	0.0	64.2	20.6	16.7
	Peak Attenuation (AF)	359,680	359,647	359,646	550,417	855,831	854,658
0.2%	% Peak Reduced	44.7	22.7	20.0	23.4	7.1	4.7
	Peak Attenuation (AF)	1,080,331	1,109,388	1,109,235	552,660	1,218,935	1,217,817

Ord Ferry Storm Runoff Centering							
Percent Chance Exceedence	Mainstem gage location →	Bend Bridge ¹	Vina Bridge ¹	Ord Ferry ¹	Oroville ¹	Verona	Sacramento ¹
50%	% Peak Reduced	0.0	0.0	0.0	42.7	9.6	12.2
	Peak Attenuation (AF)	0	0	0	35,535	33,954	33,430
10%	% Peak Reduced	0.0	0.0	0.0	36.1	8.5	6.4
	Peak Attenuation (AF)	0	0	0	301,135	205,271	204,407
4%	% Peak Reduced	0.0	0.0	0.0	55.0	16.8	13.3
	Peak Attenuation (AF)	0	0	0	387,149	383,016	381,421
2%	% Peak Reduced	0.0	0.0	0.0	53.6	15.7	12.4
	Peak Attenuation (AF)	0	0	0	402,664	398,472	396,810
1%	% Peak Reduced	0.0	0.0	0.0	60.9	21.2	17.0
	Peak Attenuation (AF)	0	0	0	574,693	580,065	579,045
0.5%	% Peak Reduced	10.2	0.0	0.0	30.0	8.4	6.9
	Peak Attenuation (AF)	325,092	324,995	324,983	439,164	873,773	872,268
0.2%	% Peak Reduced	38.6	18.7	20.0	0.0	0.8	0.5
	Peak Attenuation (AF)	945,916	966,621	966,248	80,339	10,098	10,548

	Maximum peak flow reduction %
	Maximum peak volume attenuation

Notes:

- 1) Flow at mainstem points are estimated by HEC-5, which assumes all flows remain in channel (bypasses were treated as channels).
Flows at mainstem points are taken "at latitude" (See Chapter III of Appendix B).
- 2) % Peak Reduced = ((Maximum Regulated Baseline Inflow)-(Maximum Regulated Alternative Inflow))/(Maximum Regulated Baseline Inflow) X 100%
- 3) Peak Attenuation = (Σ attenuated peak volume)*(0.08265 ac-ft/cfs)

**TABLE C.4-1 (CONT.)
EFFECTS OF ALTERNATIVE SCENARIO SAC-B01A**

Oroville Storm Runoff Centering							
Percent Chance Exceedence	Mainstem gage location →	Bend Bridge ¹	Vina Bridge ¹	Ord Ferry ¹	Oroville ¹	Verona	Sacramento ¹
50%	% Peak Reduced	0.0	0.0	0.0	42.5	6.0	8.7
	Peak Attenuation (AF)	0	0	0	45,851	19,150	18,340
10%	% Peak Reduced	0.0	0.0	0.0	55.5	20.1	15.0
	Peak Attenuation (AF)	0	0	1,550	388,336	385,352	384,016
4%	% Peak Reduced	0.1	0.0	0.0	56.1	23.1	17.8
	Peak Attenuation (AF)	179,463	0	0	594,312	597,112	595,809
2%	% Peak Reduced	0.0	0.0	0.0	23.4	9.2	8.0
	Peak Attenuation (AF)	0	0	0	555,378	562,723	584,536
1%	% Peak Reduced	0.0	0.0	0.0	0.2	-0.7	-0.6
	Peak Attenuation (AF)	0	0	0	311,041	-5,812	-6,369
0.5%	% Peak Reduced	0.0	0.0	0.0	9.1	6.8	5.2
	Peak Attenuation (AF)	0	0	0	344,046	700,043	694,711
0.2%	% Peak Reduced	33.4	9.9	6.7	41.1	16.2	10.8
	Peak Attenuation (AF)	764,596	764,557	797,728	607,595	631,714	628,992

Yuba Storm Runoff Centering							
Percent Chance Exceedence	Mainstem gage location →	Bend Bridge ¹	Vina Bridge ¹	Ord Ferry ¹	Oroville ¹	Verona	Sacramento ¹
50%	% Peak Reduced	0.0	0.0	0.0	42.8	12.9	12.9
	Peak Attenuation (AF)	0	0	0	33,474	31,895	31,385
10%	% Peak Reduced	0.0	0.0	0.0	35.8	8.7	6.2
	Peak Attenuation (AF)	4,235	3,891	3,802	311,547	208,431	207,469
4%	% Peak Reduced	0.2	0.0	0.0	51.7	14.9	11.2
	Peak Attenuation (AF)	156,752	0	0	414,510	437,343	435,806
2%	% Peak Reduced	0.0	0.0	0.0	52.7	17.5	14.2
	Peak Attenuation (AF)	0	0	0	582,124	580,203	578,791
1%	% Peak Reduced	0.0	0.0	0.0	19.9	2.3	1.6
	Peak Attenuation (AF)	0	0	0	96,395	549,746	548,383
0.5%	% Peak Reduced	0.0	0.0	0.0	0.0	5.0	3.3
	Peak Attenuation (AF)	0	0	0	63,396	281,624	281,569
0.2%	% Peak Reduced	13.8	0.0	0.0	33.6	12.1	7.0
	Peak Attenuation (AF)	369,604	369,413	369,379	538,884	848,405	846,058

	Maximum peak flow reduction %
	Maximum peak volume attenuation

Notes:

1) Flow at mainstem points are estimated by HEC-5, which assumes all flows remain in channel (bypasses were treated as channels).

Flows at mainstem points are taken "at latitude" (See Chapter III of Appendix B).

2) % Peak Reduced = ((Maximum Regulated Baseline Inflow)-(Maximum Regulated Alternative Inflow))/(Maximum Regulated Baseline Inflow) X 100%

3) Peak Attenuation = (Σ attenuated peak volume)*(0.08265 ac-ft/cfs)

TABLE C.4-1 (CONT.)
EFFECTS OF ALTERNATIVE SCENARIO SAC-B01A

American Storm Runoff Centering							
Percent Chance Exceedence	Mainstem gage location →	Bend Bridge ¹	Vina Bridge ¹	Ord Ferry ¹	Oroville ¹	Verona	Sacramento ¹
50%	% Peak Reduced	0.0	0.0	0.0	42.8	13.4	13.3
	Peak Attenuation (AF)	0	0	0	33,474	31,894	31,407
10%	% Peak Reduced	0.0	0.0	0.0	35.8	9.4	6.8
	Peak Attenuation (AF)	0	0	0	210,156	206,272	205,369
4%	% Peak Reduced	0.0	0.0	0.0	51.7	15.4	11.6
	Peak Attenuation (AF)	0	0	2,105	414,510	412,013	410,593
2%	% Peak Reduced	0.0	0.0	0.0	52.7	19.6	15.7
	Peak Attenuation (AF)	0	0	0	591,138	593,385	591,951
1%	% Peak Reduced	0.0	0.0	0.0	19.9	3.4	2.5
	Peak Attenuation (AF)	0	0	0	508,224	553,214	551,862
0.5%	% Peak Reduced	0.0	0.0	0.0	0.0	3.3	1.8
	Peak Attenuation (AF)	0	0	0	79,033	272,755	33,484
0.2%	% Peak Reduced	0.0	0.0	0.0	33.2	12.4	6.6
	Peak Attenuation (AF)	0	0	0	525,394	523,128	521,980

Sacramento Storm Runoff Centering							
Percent Chance Exceedence	Mainstem gage location →	Bend Bridge ¹	Vina Bridge ¹	Ord Ferry ¹	Oroville ¹	Verona	Sacramento ¹
50%	% Peak Reduced	0.0	0.0	0.0	42.9	3.5	7.7
	Peak Attenuation (AF)	0	0	0	40,382	17,344	16,297
10%	% Peak Reduced	0.0	0.0	0.0	59.0	18.7	12.3
	Peak Attenuation (AF)	0	0	0	371,791	369,331	368,033
4%	% Peak Reduced	0.0	0.0	0.0	61.3	22.4	17.5
	Peak Attenuation (AF)	0	0	0	573,767	570,901	569,479
2%	% Peak Reduced	0.0	0.0	0.0	32.5	9.6	8.1
	Peak Attenuation (AF)	0	0	0	444,268	527,338	526,106
1%	% Peak Reduced	0.0	0.0	0.0	0.0	0.0	-0.1
	Peak Attenuation (AF)	0	0	0	163,472	-5,501	-6,454
0.5%	% Peak Reduced	0.0	0.0	0.0	0.0	6.1	4.4
	Peak Attenuation (AF)	0	0	0	147,944	301,782	300,703
0.2%	% Peak Reduced	23.5	0.2	0.3	43.0	15.6	9.7
	Peak Attenuation (AF)	679,164	679,121	680,119	623,675	638,735	636,503

	Maximum peak flow reduction %
	Maximum peak volume attenuation

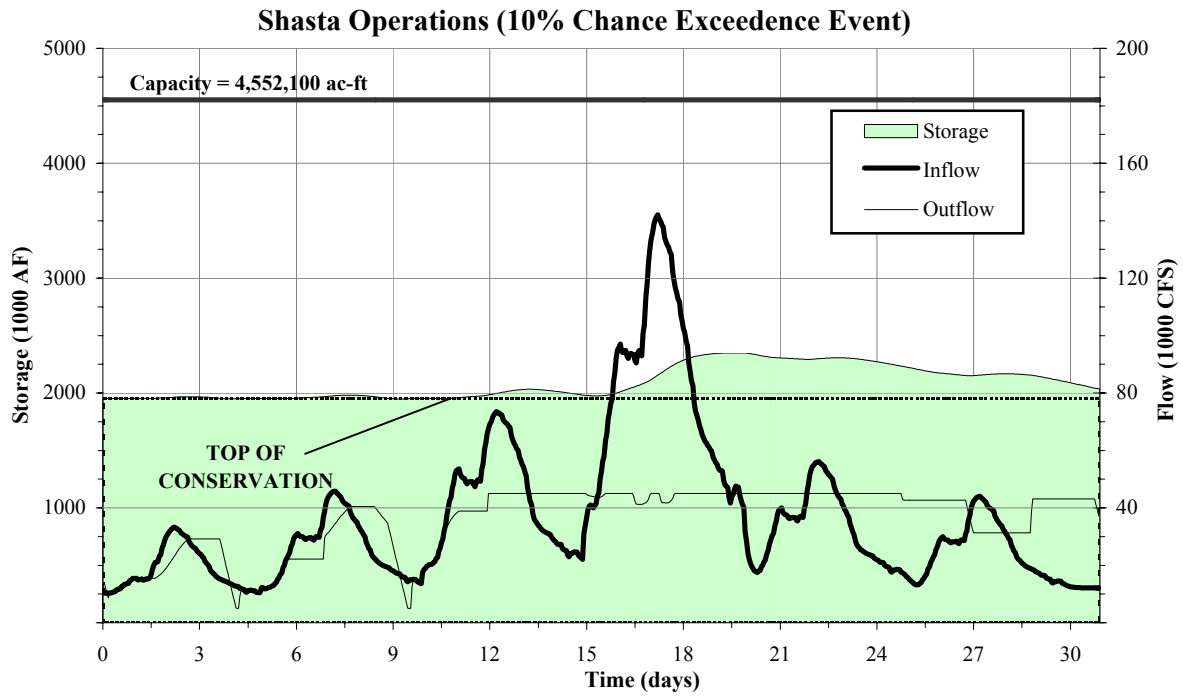
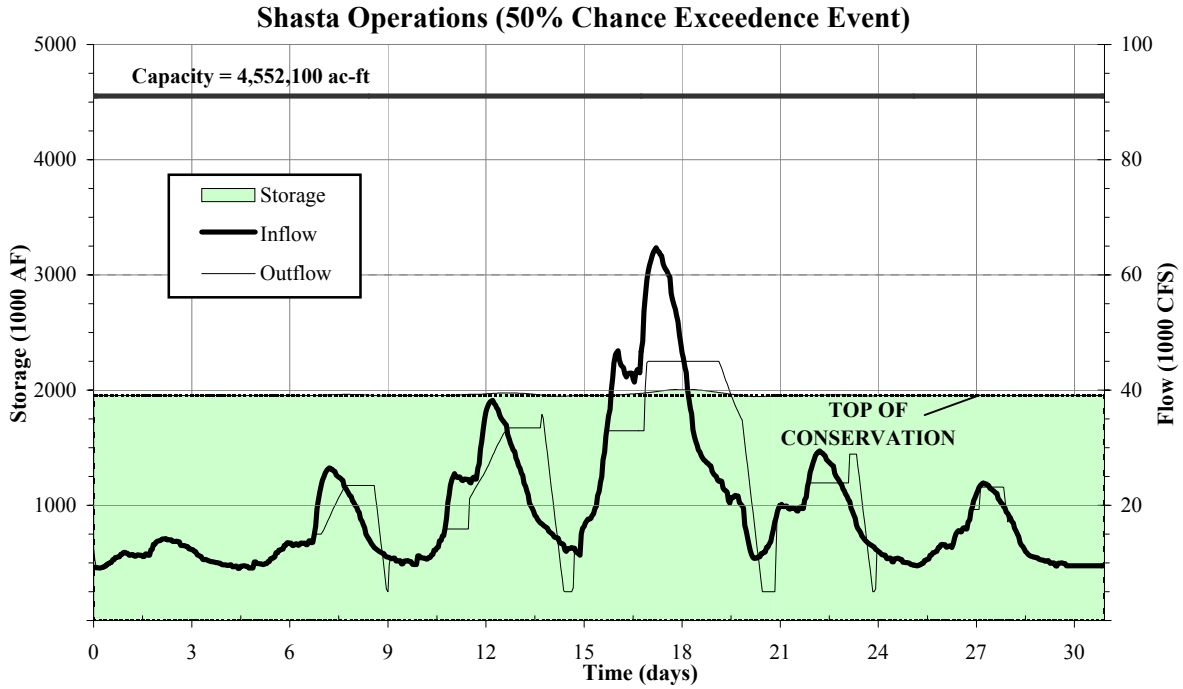
Notes:

1) Flow at mainstem points are estimated by HEC-5, which assumes all flows remain in channel (bypasses were treated as channels).

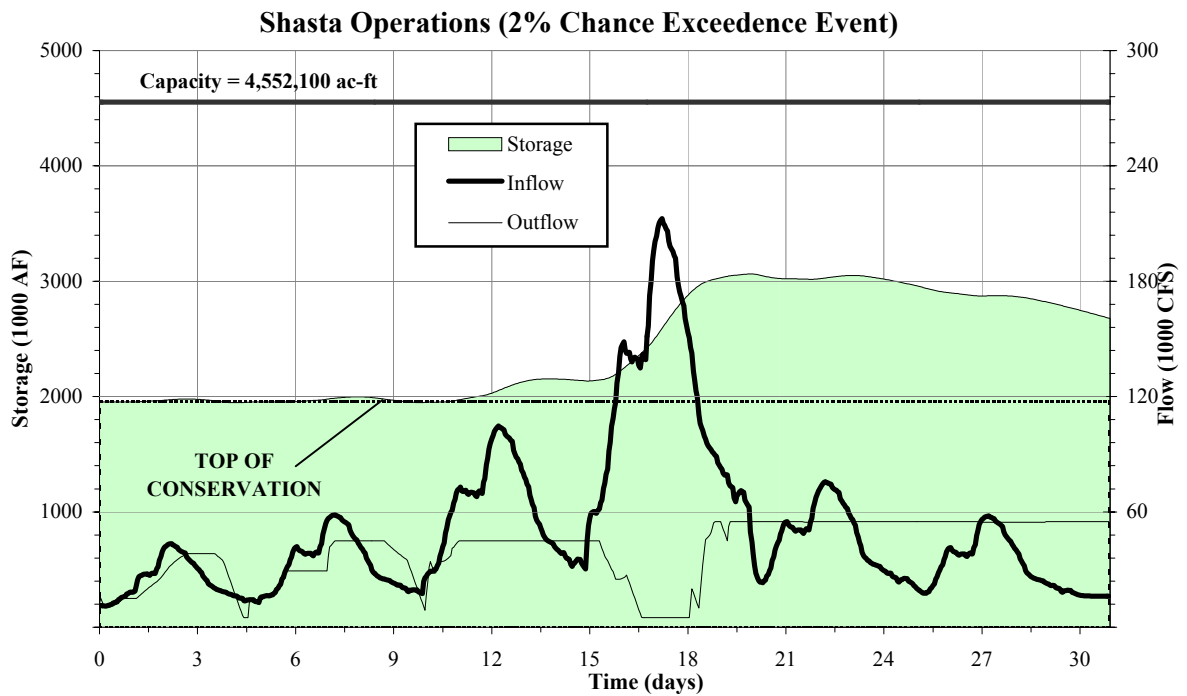
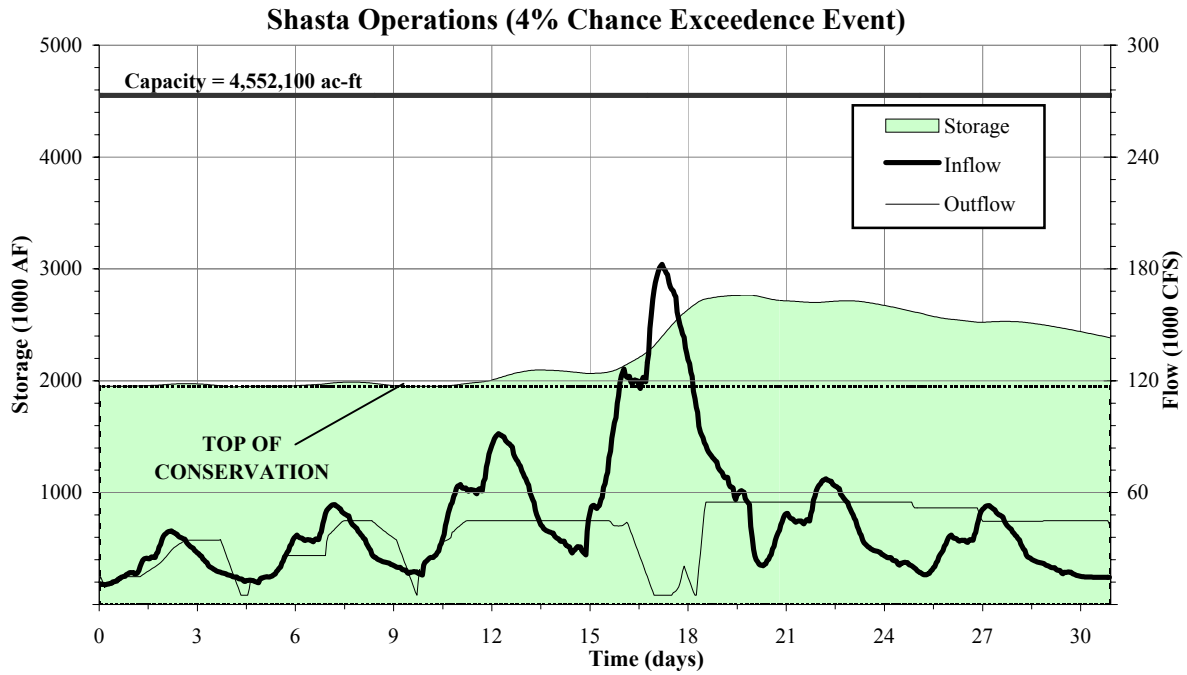
Flows at mainstem points are taken "at latitude" (See Chapter III of Appendix B).

2) % Peak Reduced = ((Maximum Regulated Baseline Inflow)-(Maximum Regulated Alternative Inflow))/(Maximum Regulated Baseline Inflow) X 100%

3) Peak Attenuation = (Σ attenuated peak volume)*(0.08265 ac-ft/cfs)



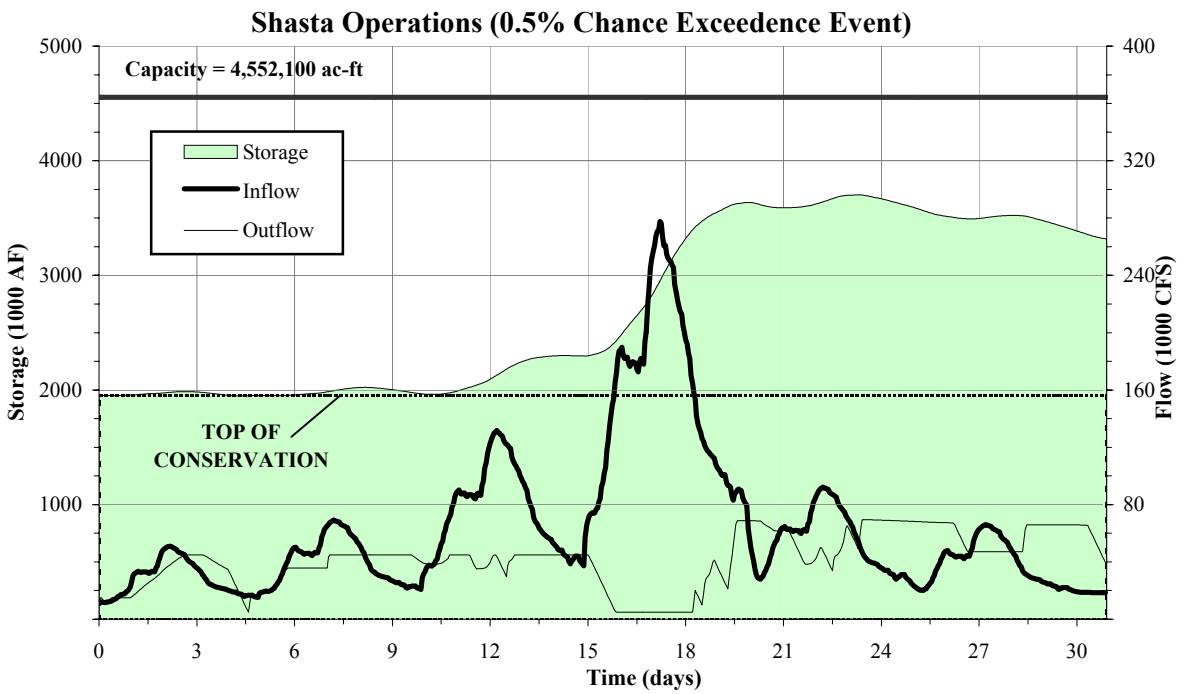
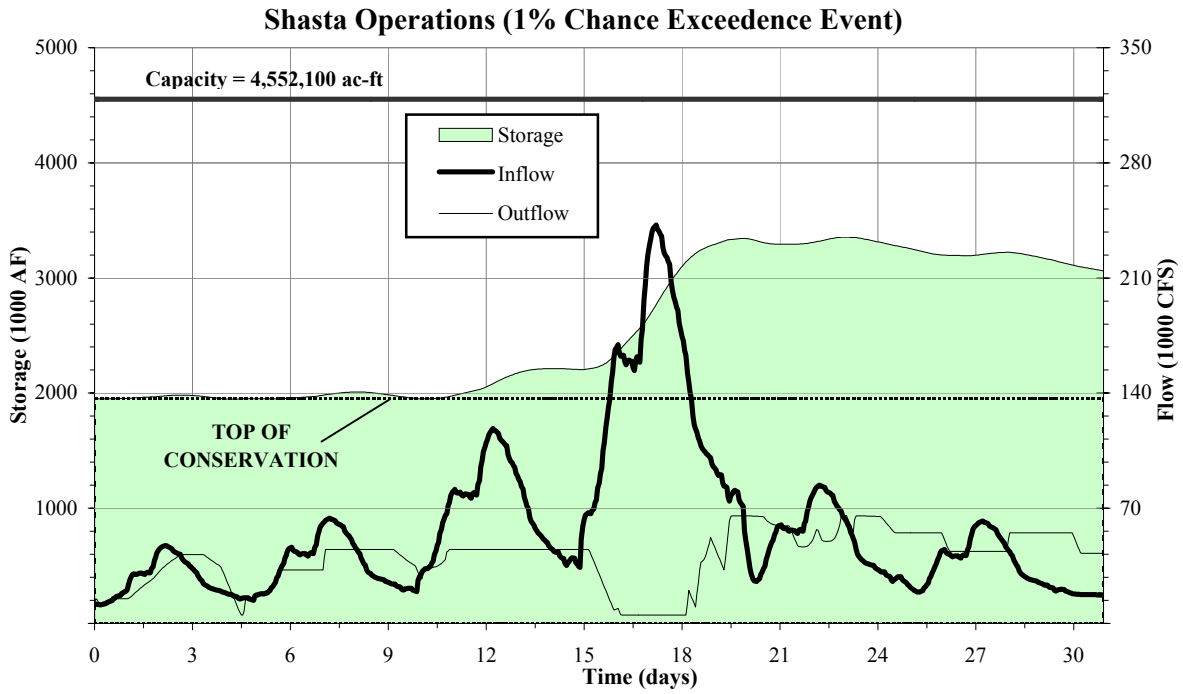
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Figure C.4-1a Reservoir Simulation Hydrographs Alternative Scenario SAC-B01A	
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Figure C.4-1b
Reservoir Simulation Hydrographs
Alternative Scenario SAC-B01A

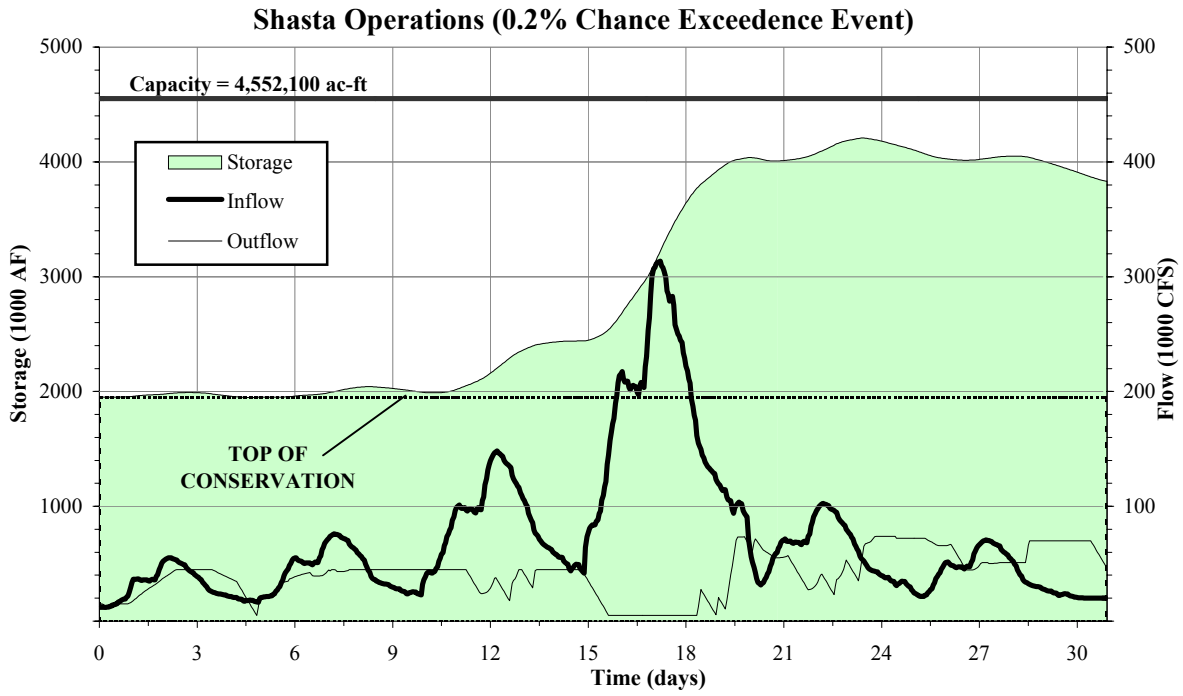
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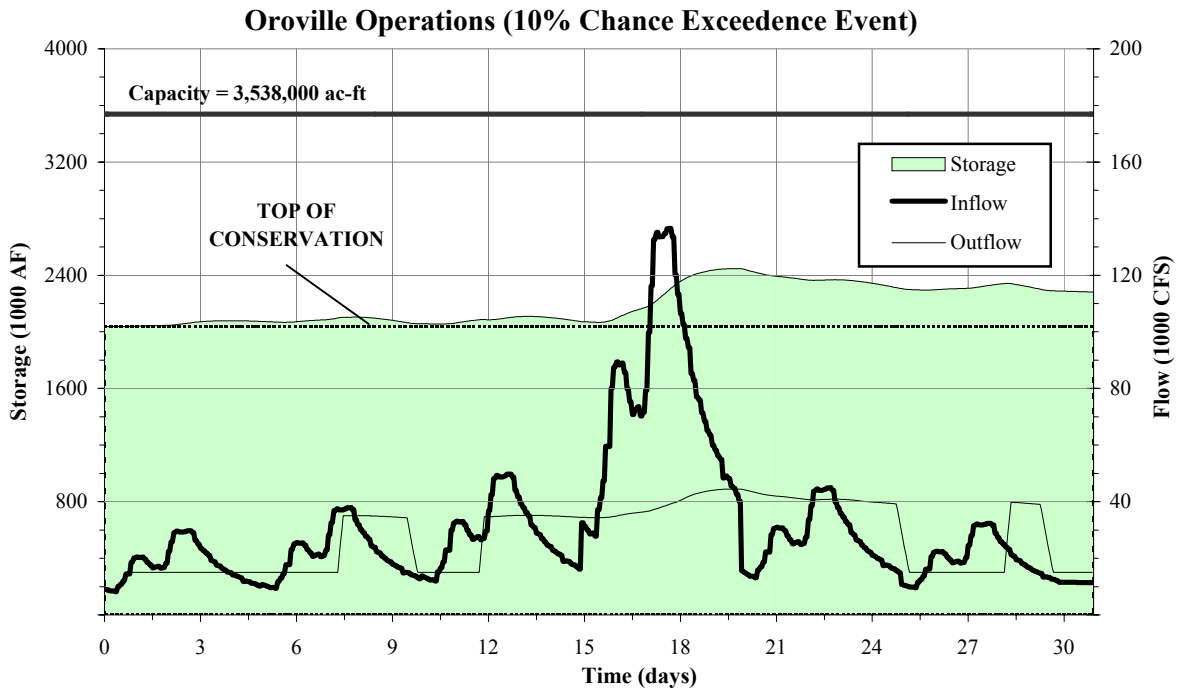
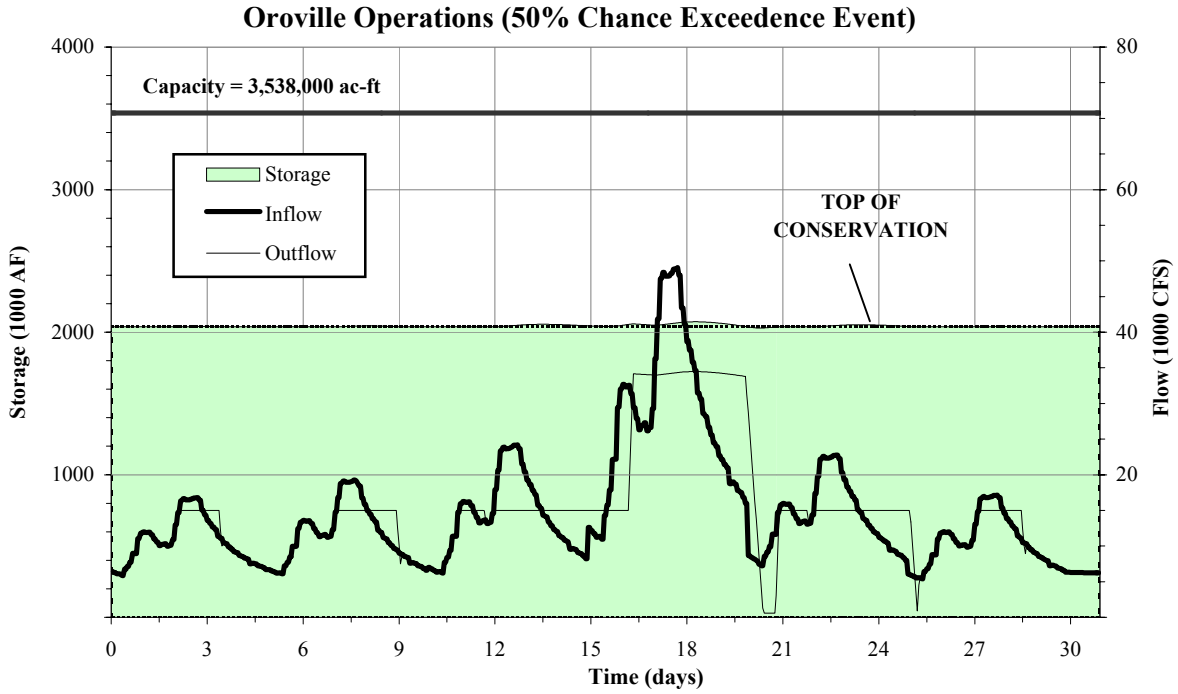
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Figure C.4-1c
Reservoir Simulation Hydrographs
Alternative Scenario SAC-B01A

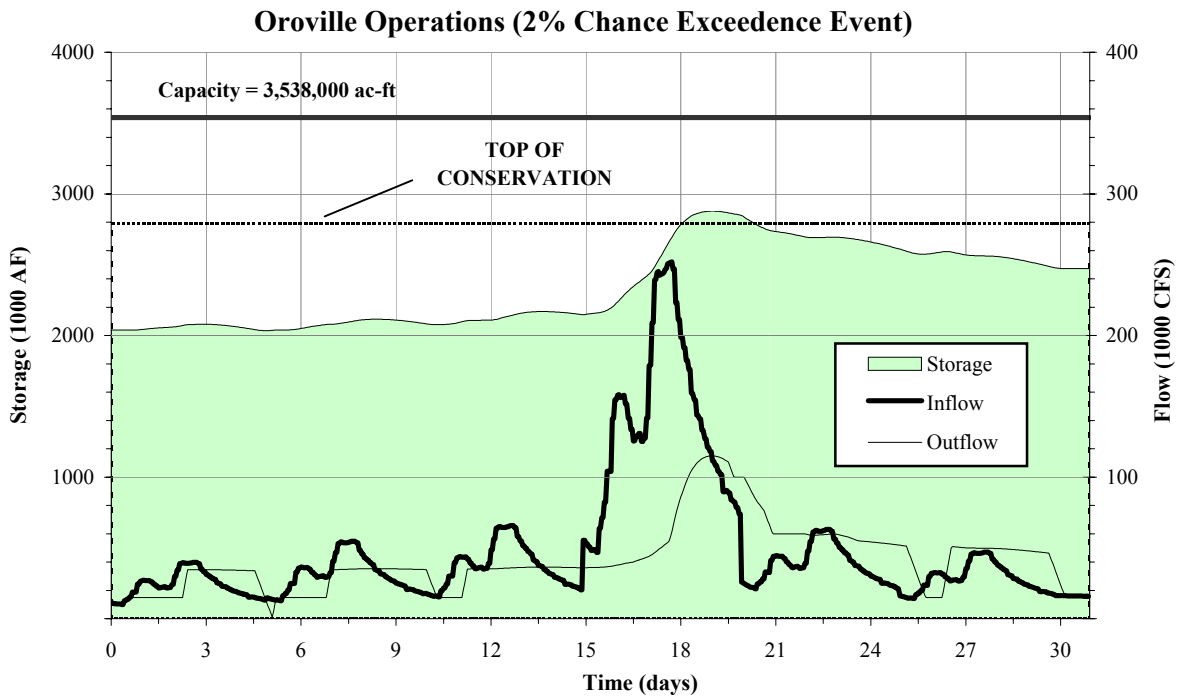
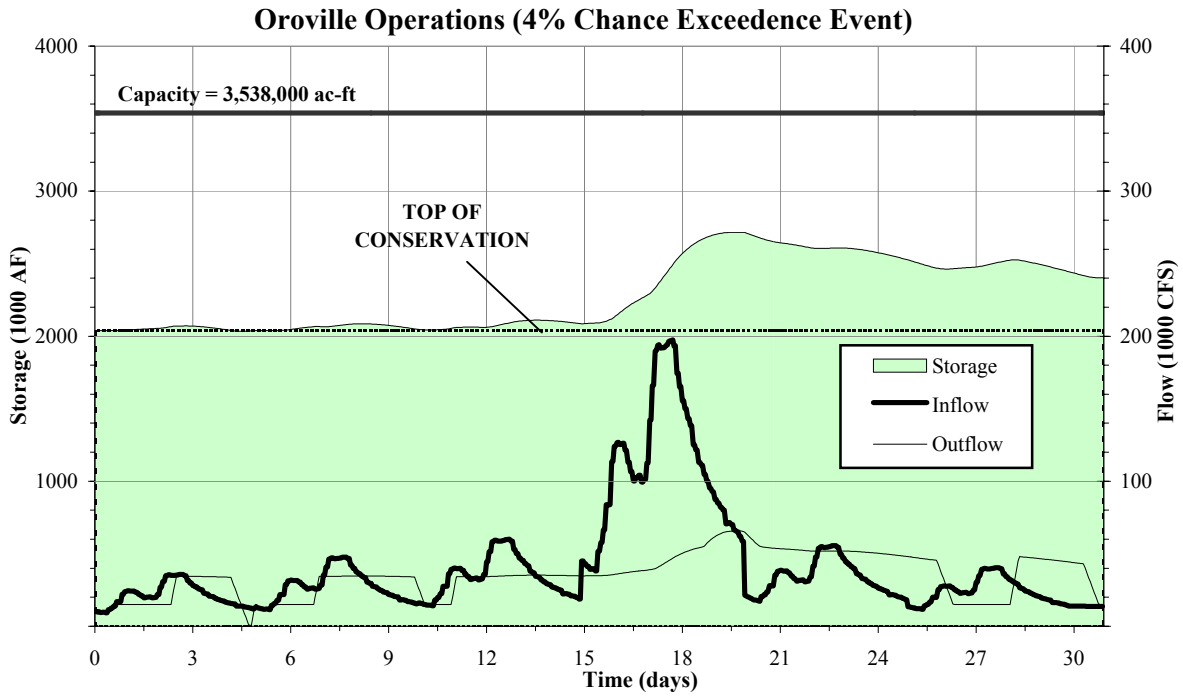
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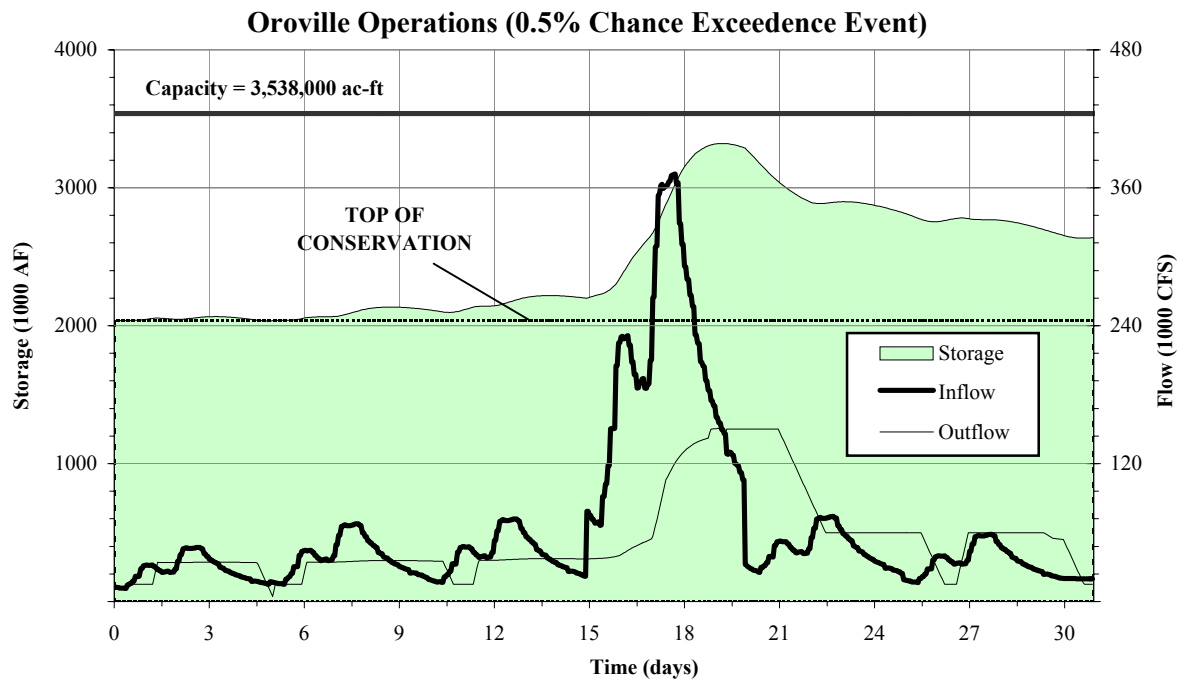
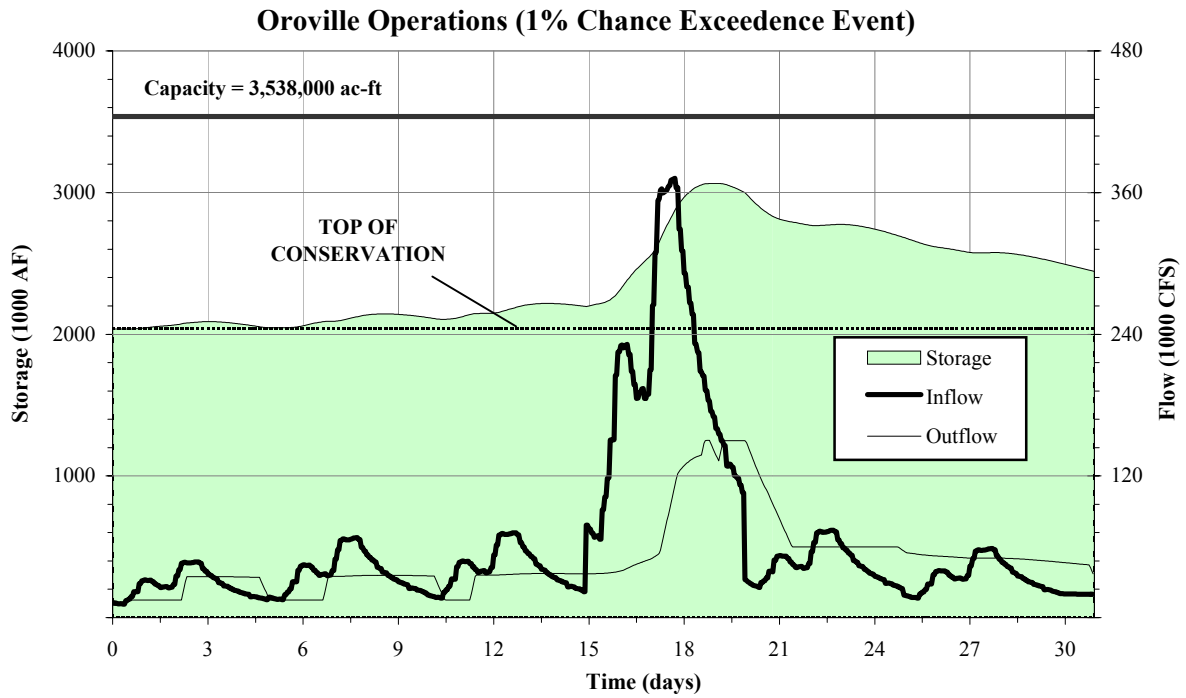
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Figure C.4-1d Reservoir Simulation Hydrographs Alternative Scenario SAC-B01A
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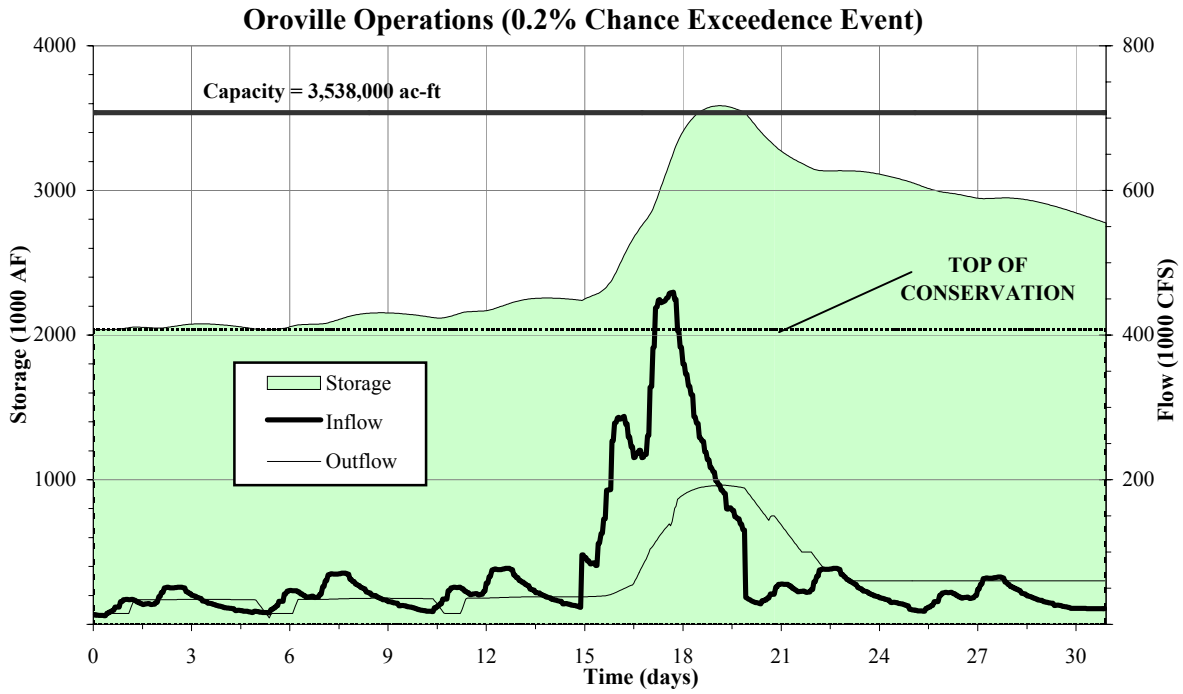
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Figure C.4-1e Reservoir Simulation Hydrographs Alternative Scenario SAC-B01A
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Figure C.4-1f Reservoir Simulation Hydrographs Alternative Scenario SAC-B01A
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Figure C.4-1g Reservoir Simulation Hydrographs Alternative Scenario SAC-B01A
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Figure C.4-1h Reservoir Simulation Hydrographs Alternative Scenario SAC-B01A
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TABLE C.4-2
EFFECTS OF ALTERNATIVE SCENARIO SAC-B02A

Shasta Storm Runoff Centering							
Percent Chance Exceedence	Mainstem gage location →	Bend Bridge ¹	Vina Bridge ¹	Ord Ferry ¹	Oroville ¹	Verona	Sacramento ¹
50%	% Peak Reduced	10.4	12.2	11.3	0.0	2.7	2.3
	Peak Attenuation (AF)	153,056	154,453	154,482	0	152,172	150,534
10%	% Peak Reduced	11.5	11.6	10.3	0.0	2.7	2.4
	Peak Attenuation (AF)	155,590	211,697	212,120	0	201,295	199,752
4%	% Peak Reduced	1.5	1.8	1.7	0.0	3.5	2.8
	Peak Attenuation (AF)	190,436	191,399	192,272	0	193,591	194,694
2%	% Peak Reduced	21.5	13.0	11.2	0.0	1.3	1.3
	Peak Attenuation (AF)	74,039	301,865	303,073	0	370,713	367,940
1%	% Peak Reduced	33.2	19.3	16.5	0.0	0.6	0.7
	Peak Attenuation (AF)	229,264	229,742	229,606	0	543,690	541,189
0.5%	% Peak Reduced	24.3	21.8	19.2	0.0	1.8	1.5
	Peak Attenuation (AF)	587,520	590,128	592,024	0	675,754	677,990
0.2%	% Peak Reduced	26.5	24.2	21.7	0.0	3.1	2.3
	Peak Attenuation (AF)	594,686	593,934	593,655	0	530,763	533,392

Ord Ferry Storm Runoff Centering							
Percent Chance Exceedence	Mainstem gage location →	Bend Bridge ¹	Vina Bridge ¹	Ord Ferry ¹	Oroville ¹	Verona	Sacramento ¹
50%	% Peak Reduced	12.1	13.6	14.2	0.0	3.0	2.4
	Peak Attenuation (AF)	189,160	189,214	189,251	0	187,580	186,414
10%	% Peak Reduced	4.5	3.6	3.3	0.0	3.3	2.1
	Peak Attenuation (AF)	198,310	204,515	205,391	0	328,503	329,755
4%	% Peak Reduced	20.8	13.7	11.9	0.0	1.2	1.2
	Peak Attenuation (AF)	468,608	468,713	467,590	0	449,845	446,571
2%	% Peak Reduced	31.2	20.6	18.0	0.0	0.5	0.8
	Peak Attenuation (AF)	129,753	129,329	129,152	0	445,591	442,229
1%	% Peak Reduced	34.9	23.6	21.1	0.0	1.4	1.1
	Peak Attenuation (AF)	500,969	503,304	505,077	0	602,363	600,982
0.5%	% Peak Reduced	30.7	23.9	21.6	0.0	3.0	1.8
	Peak Attenuation (AF)	633,024	635,836	637,911	0	779,986	775,372
0.2%	% Peak Reduced	32.0	29.0	26.3	0.0	2.6	1.9
	Peak Attenuation (AF)	665,142	682,588	682,265	0	611,062	613,737

	Maximum peak flow reduction %
	Maximum peak volume attenuation

Notes:

- 1) Flow at mainstem points are estimated by HEC-5, which assumes all flows remain in channel (bypasses were treated as channels).
Flows at mainstem points are taken "at latitude" (See Chapter III of Appendix B).
- 2) % Peak Reduced = ((Maximum Regulated Baseline Inflow)-(Maximum Regulated Alternative Inflow))/(Maximum Regulated Baseline Inflow) X 100%
- 3) Peak Attenuation = (Σ attenuated peak volume)*(0.08265 ac-ft/cfs)

**TABLE C.4-2 (CONT.)
EFFECTS OF ALTERNATIVE SCENARIO SAC-B02A**

Oroville Storm Runoff Centering							
Percent Chance Exceedence	Mainstem gage location →	Bend Bridge ¹	Vina Bridge ¹	Ord Ferry ¹	Oroville ¹	Verona	Sacramento ¹
50%	% Peak Reduced	7.8	7.6	8.1	0.0	1.9	1.7
	Peak Attenuation (AF)	113,263	113,292	113,312	0	112,536	111,696
10%	% Peak Reduced	9.5	10.5	9.3	0.0	1.5	1.0
	Peak Attenuation (AF)	171,090	171,163	171,312	0	166,282	165,022
4%	% Peak Reduced	0.3	1.3	1.0	0.0	1.5	1.2
	Peak Attenuation (AF)	66,559	225,426	225,483	0	220,031	218,082
2%	% Peak Reduced	11.1	7.4	6.5	0.0	1.1	0.9
	Peak Attenuation (AF)	201,307	203,173	204,203	0	331,780	329,264
1%	% Peak Reduced	28.1	16.3	13.5	0.0	0.4	0.3
	Peak Attenuation (AF)	135,356	134,768	134,567	0	350,038	351,699
0.5%	% Peak Reduced	27.2	20.5	17.8	0.0	1.0	0.8
	Peak Attenuation (AF)	508,022	510,376	512,050	0	587,803	586,955
0.2%	% Peak Reduced	30.5	26.6	24.5	0.0	0.8	0.4
	Peak Attenuation (AF)	492,071	491,493	591,676	0	694,311	690,963

Yuba Storm Runoff Centering							
Percent Chance Exceedence	Mainstem gage location →	Bend Bridge ¹	Vina Bridge ¹	Ord Ferry ¹	Oroville ¹	Verona	Sacramento ¹
50%	% Peak Reduced	8.7	8.4	9.2		2.2	1.7
	Peak Attenuation (AF)	116,599	116,629	116,650	0	116,178	115,304
10%	% Peak Reduced	12.7	11.0	9.5	0.0	1.8	1.0
	Peak Attenuation (AF)	187,770	187,823	187,859	0	184,211	182,973
4%	% Peak Reduced	4.4	5.2	3.5	0.0	1.8	1.3
	Peak Attenuation (AF)	206,119	5,372	207,916	0	273,955	271,399
2%	% Peak Reduced	9.8	5.8	5.2	0.0	1.5	1.2
	Peak Attenuation (AF)	218,817	219,892	220,848	0	350,586	349,524
1%	% Peak Reduced	28.3	15.0	12.6	0.0	0.5	0.4
	Peak Attenuation (AF)	114,163	113,855	113,764	0	422,818	420,218
0.5%	% Peak Reduced	35.3	19.2	16.5	0.0	0.9	0.6
	Peak Attenuation (AF)	175,504	458,878	460,659	0	509,562	507,458
0.2%	% Peak Reduced	28.7	20.5	16.7	0.0	1.4	0.8
	Peak Attenuation (AF)	668,404	671,288	673,431	0	592,961	595,481

	Maximum peak flow reduction %
	Maximum peak volume attenuation

Notes:

- 1) Flow at mainstem points are estimated by HEC-5, which assumes all flows remain in channel (bypasses were treated as channels).
Flows at mainstem points are taken "at latitude" (See Chapter III of Appendix B).
- 2) % Peak Reduced = ((Maximum Regulated Baseline Inflow)-(Maximum Regulated Alternative Inflow))/(Maximum Regulated Baseline Inflow) X 100%
- 3) Peak Attenuation = (Σ attenuated peak volume)*(0.08265 ac-ft/cfs)

**TABLE C.4-2 (CONT.)
EFFECTS OF ALTERNATIVE SCENARIO SAC-B02A**

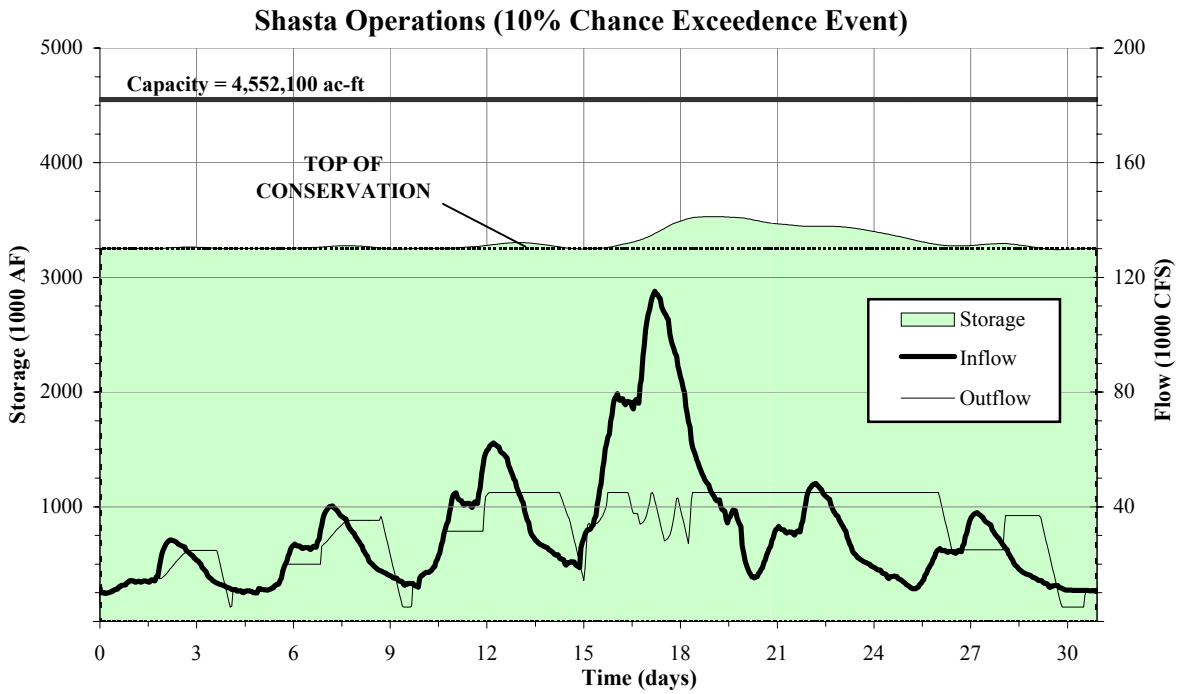
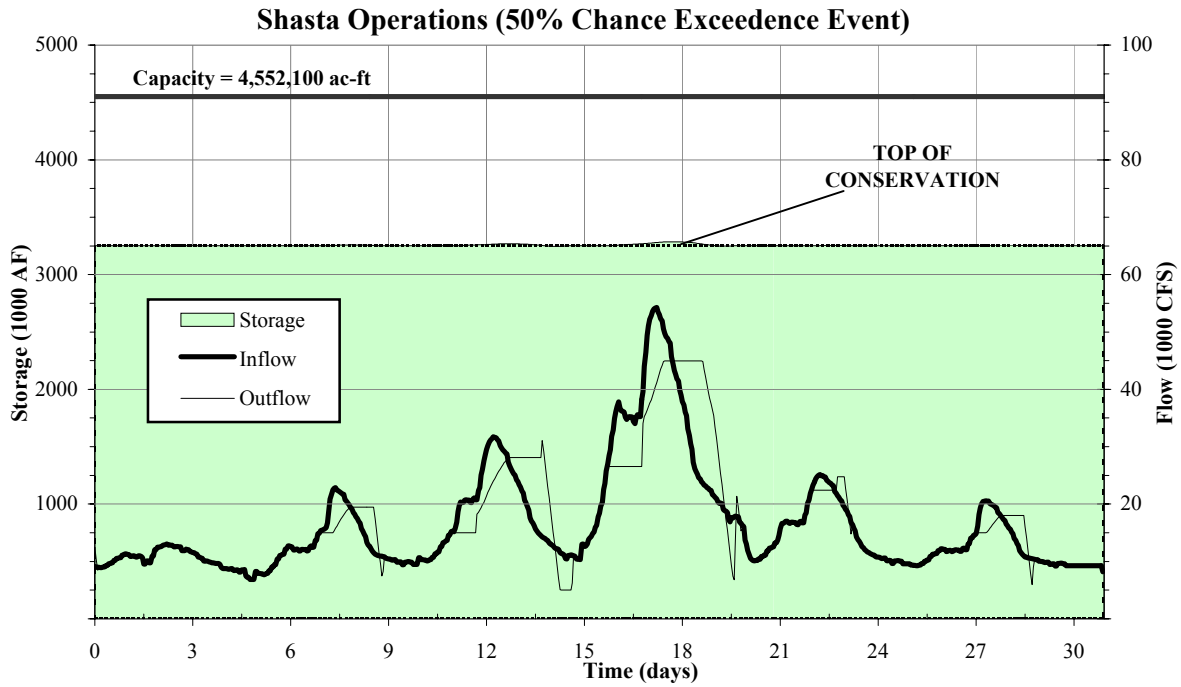
American Storm Runoff Centering							
Percent Chance Exceedence	Mainstem gage location →	Bend Bridge ¹	Vina Bridge ¹	Ord Ferry ¹	Oroville ¹	Verona	Sacramento ¹
50%	% Peak Reduced	8.5	8.3	8.5	0	2.1	1.6
	Peak Attenuation (AF)	108,815	108,842	108,861	0.0	108,472	107,982
10%	% Peak Reduced	9.1	10.0	8.9	0	1.7	1.0
	Peak Attenuation (AF)	148,850	148,890	148,918	0.0	146,352	145,042
4%	% Peak Reduced	1.8	2.9	2.2	0	1.3	1.0
	Peak Attenuation (AF)	117,638	224,316	224,849	0.0	218,844	217,191
2%	% Peak Reduced	0.5	2.1	2.0	0	1.2	1.0
	Peak Attenuation (AF)	165,737	166,467	167,158	0.0	167,521	168,507
1%	% Peak Reduced	22.4	11.9	9.9	0	0.6	0.4
	Peak Attenuation (AF)	83,571	83,140	228,336	0.0	407,589	404,839
0.5%	% Peak Reduced	31.4	17.0	15.2	0	0.6	0.4
	Peak Attenuation (AF)	140,156	139,791	139,640	0.0	448,630	445,639
0.2%	% Peak Reduced	33.8	19.3	15.8	0	1.1	0.6
	Peak Attenuation (AF)	575,505	578,150	580,058	0.0	501,642	590,343

Sacramento Storm Runoff Centering							
Percent Chance Exceedence	Mainstem gage location →	Bend Bridge ¹	Vina Bridge ¹	Ord Ferry ¹	Oroville ¹	Verona	Sacramento ¹
50%	% Peak Reduced	11.1	11.7	12.5	0	2.5	1.9
	Peak Attenuation (AF)	167,754	167,801	167,833	0.0	166,590	165,577
10%	% Peak Reduced	0.6	1.4	1.3	0	2.8	1.9
	Peak Attenuation (AF)	189,581	190,664	191,562	0.0	193,790	194,909
4%	% Peak Reduced	15.9	10.2	9.0	0	1.3	1.2
	Peak Attenuation (AF)	237,958	240,367	367,413	0.0	356,808	165,577
2%	% Peak Reduced	28.6	17.3	15.1	0	0.7	0.6
	Peak Attenuation (AF)	113,090	293,624	292,208	0.0	502,662	307,008
1%	% Peak Reduced	35.0	21.7	19.1	0	1.0	0.8
	Peak Attenuation (AF)	432,528	435,027	436,779	0.0	451,899	454,038
0.5%	% Peak Reduced	36.0	22.7	20.5	0	1.6	1.1
	Peak Attenuation (AF)	610,453	613,330	615,381	0.0	707,380	705,232
0.2%	% Peak Reduced	30.9	23.1	19.5	0	1.5	0.7
	Peak Attenuation (AF)	504,321	817,589	820,062	0.0	680,960	677,470

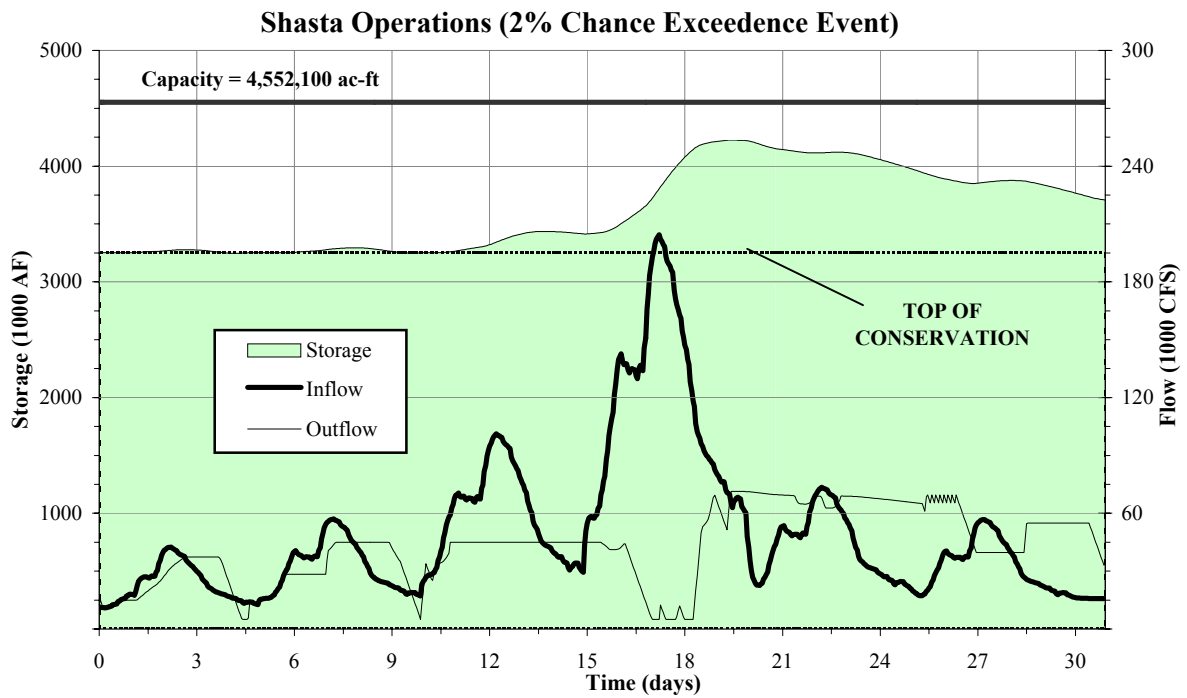
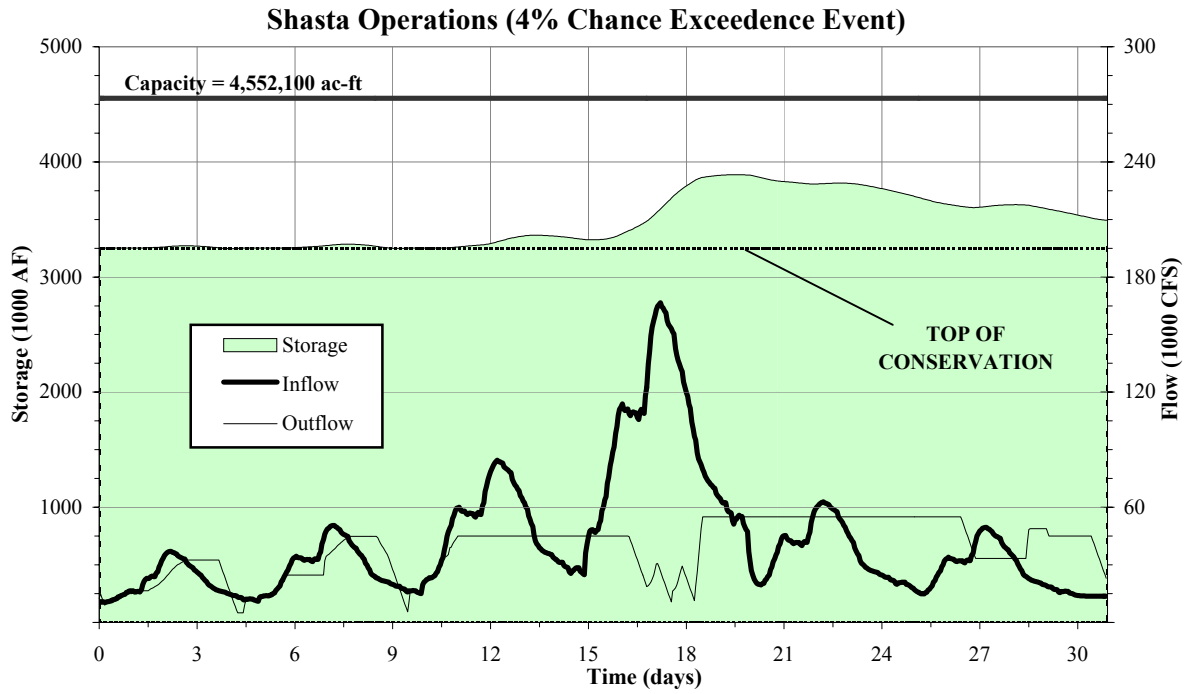
	Maximum peak flow reduction %
	Maximum peak volume attenuation

Notes:

- 1) Flow at mainstem points are estimated by HEC-5, which assumes all flows remain in channel (bypasses were treated as channels).
Flows at mainstem points are taken "at latitude" (See Chapter III of Appendix B).
- 2) % Peak Reduced = ((Maximum Regulated Baseline Inflow)-(Maximum Regulated Alternative Inflow))/(Maximum Regulated Baseline Inflow) X 100%
- 3) Peak Attenuation = (Σ attenuated peak volume)*(0.08265 ac-ft/cfs)



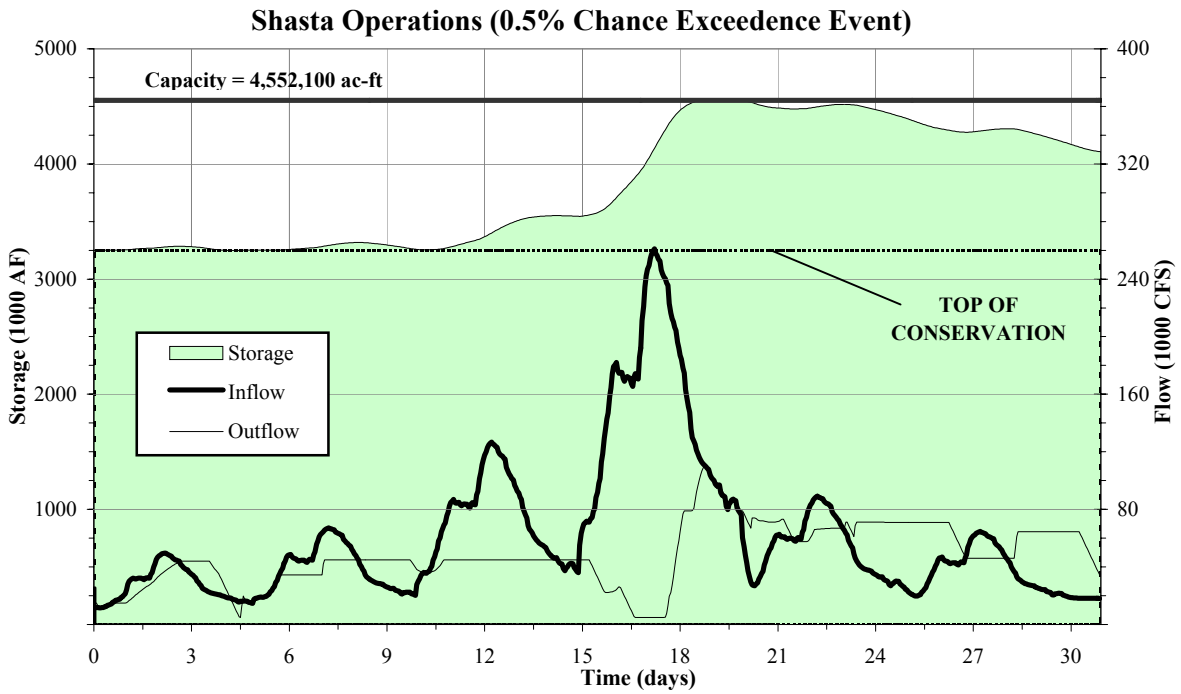
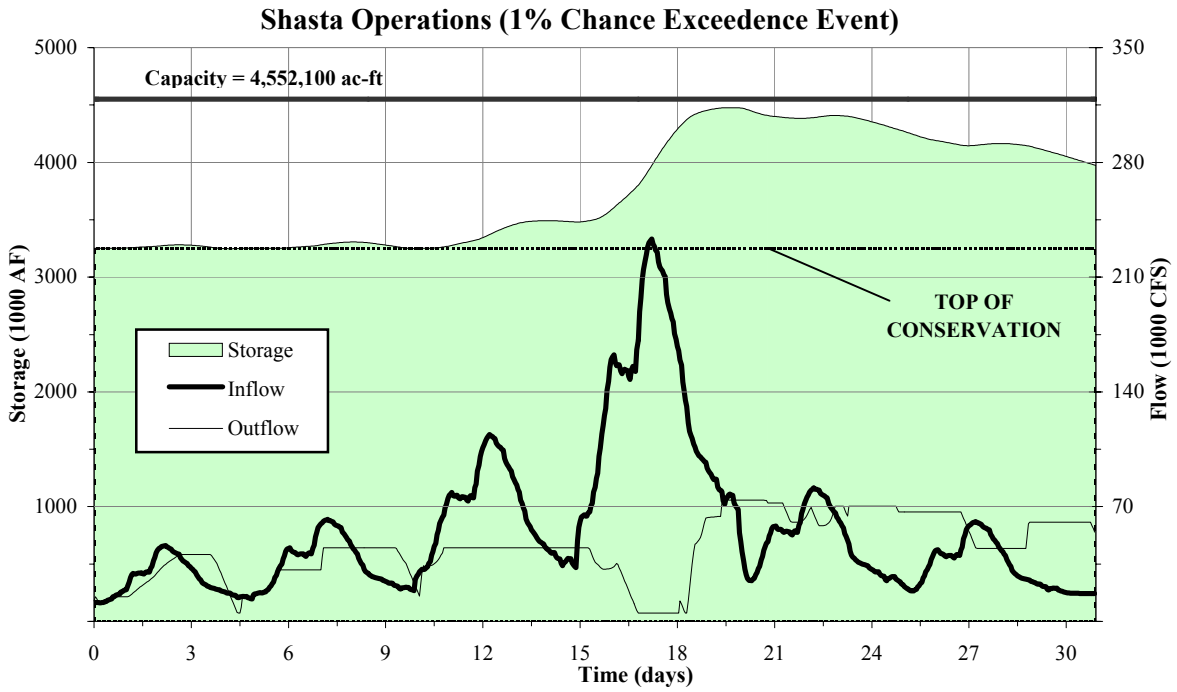
Sacramento & San Joaquin River Basins Comprehensive Study	
Figure C.4-2a Reservoir Simulation Hydrographs Alternative Scenario SAC-B02A	
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Figure C.4-2b
Reservoir Simulation Hydrographs
Alternative Scenario SAC-B02A

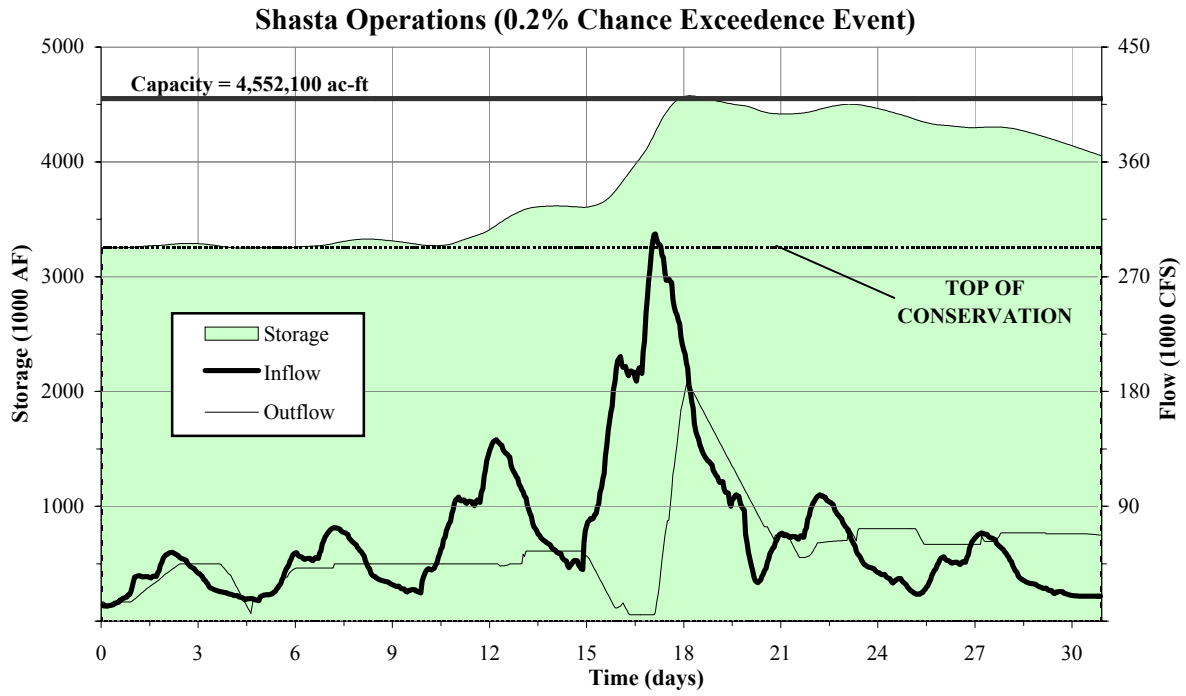
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Figure C.4-2c
Reservoir Simulation Hydrographs
Alternative Scenario SAC-B02A

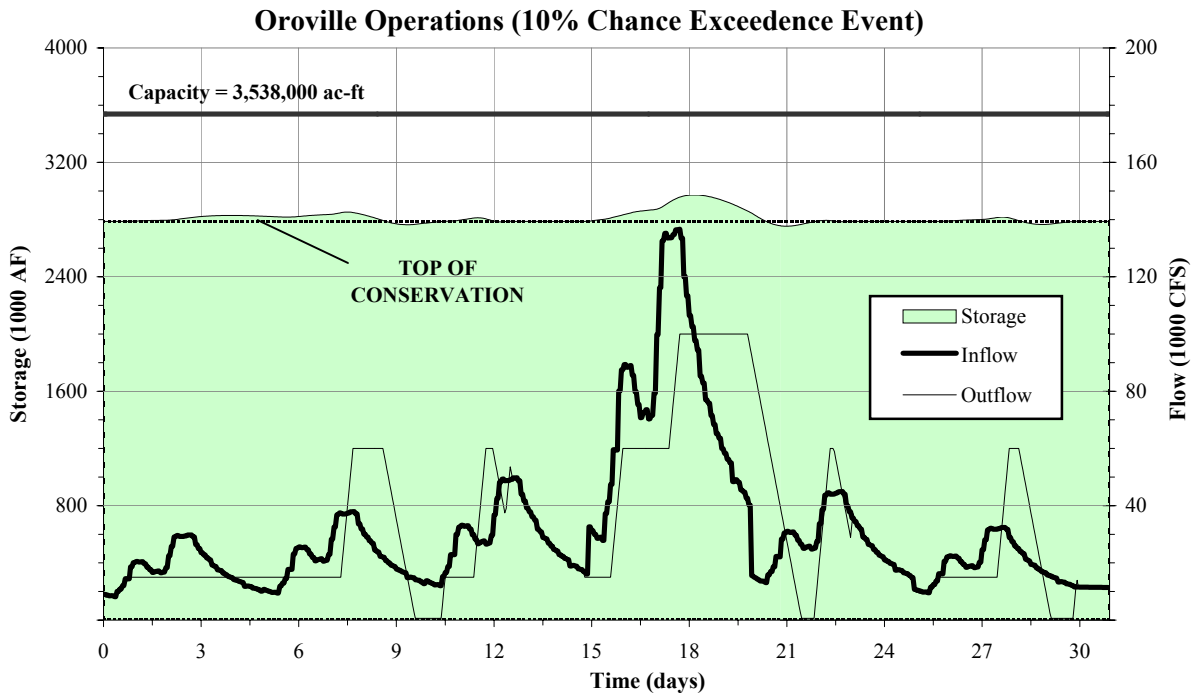
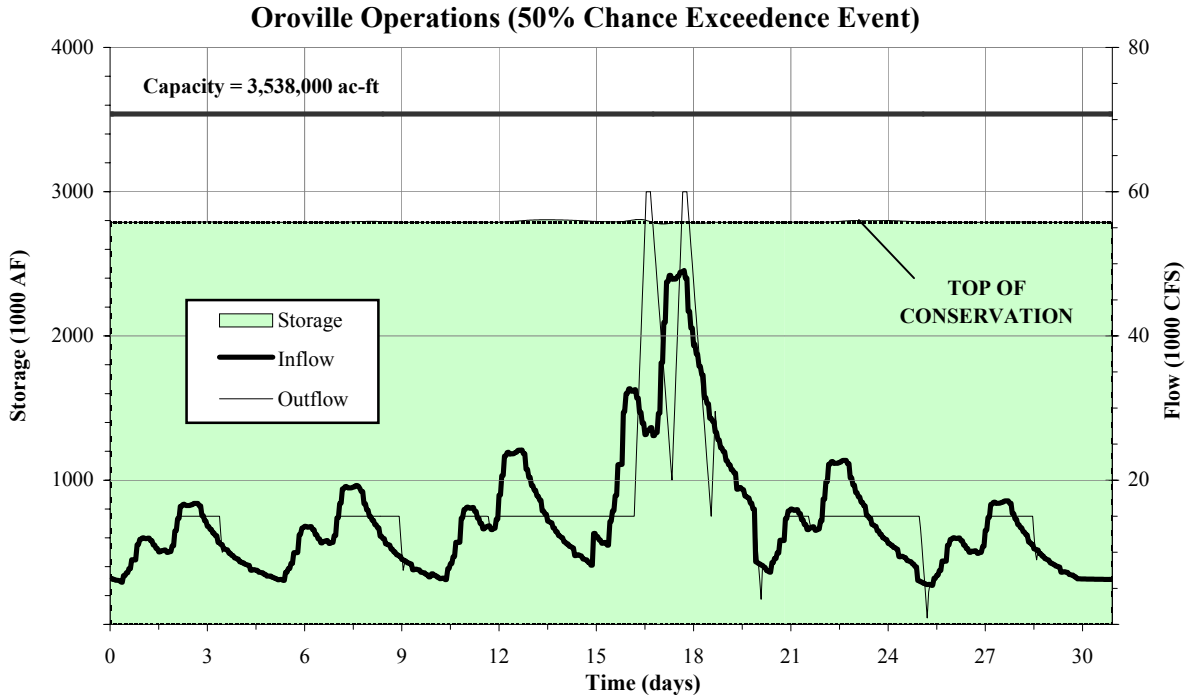
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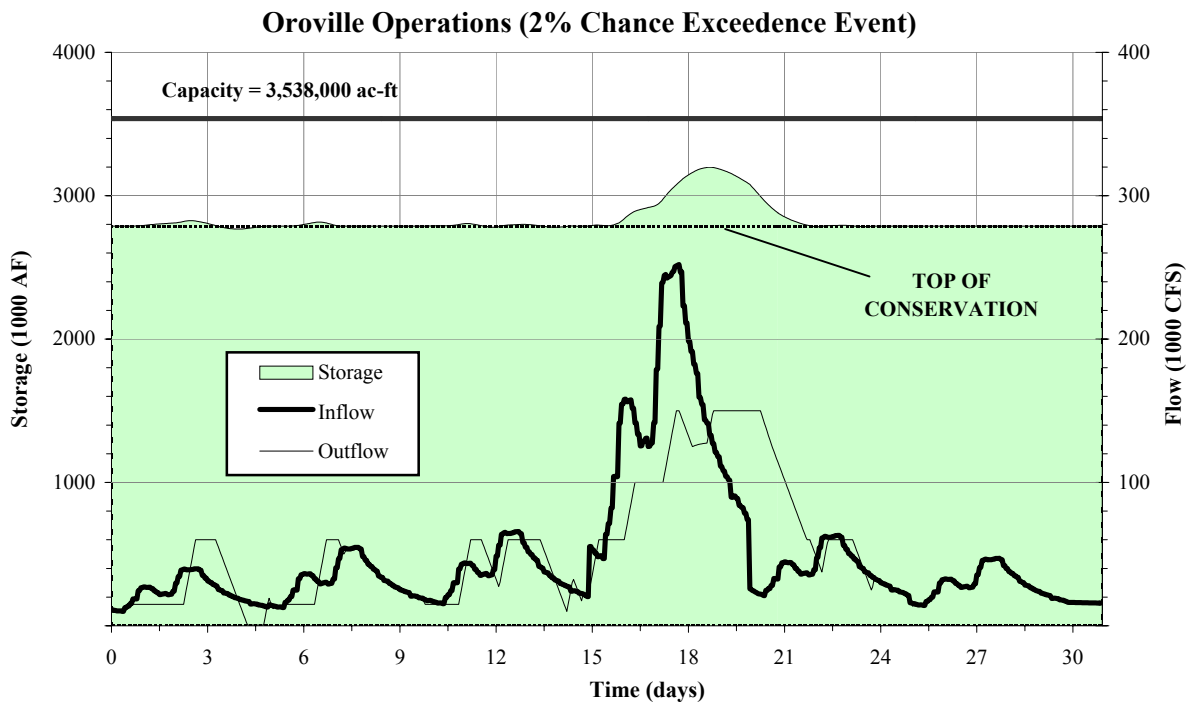
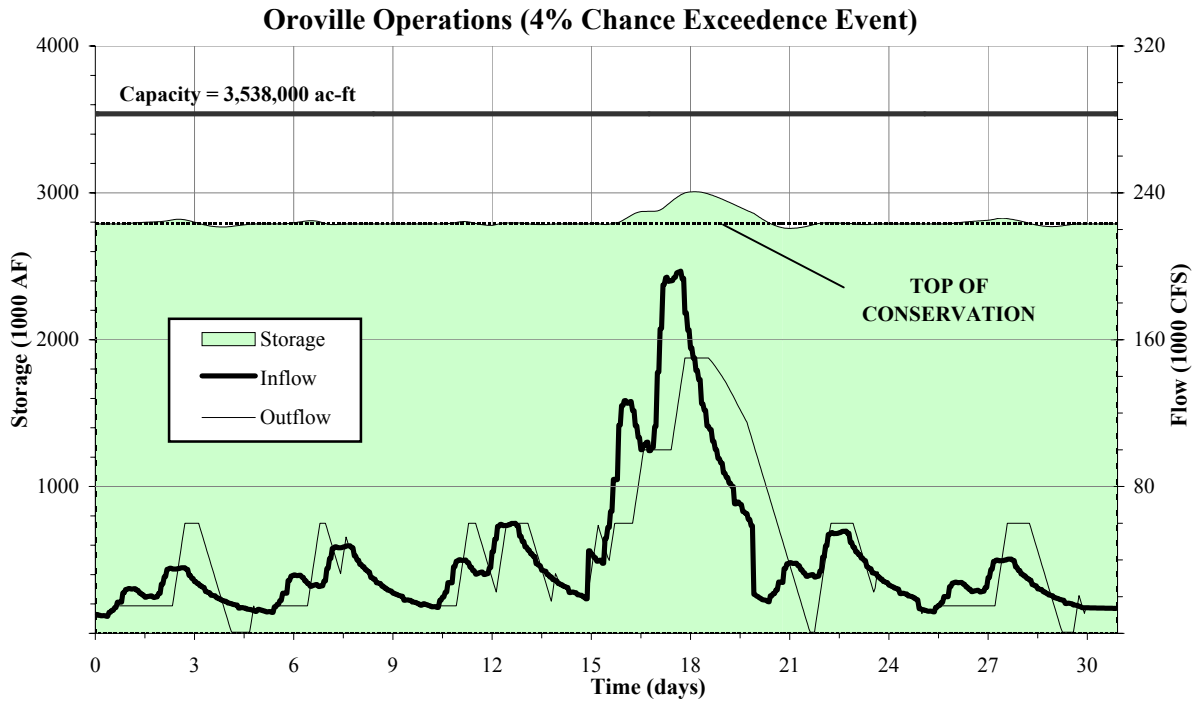
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Comprehensive Study

Figure C.4-2d
Reservoir Simulation Hydrographs
Alternative Scenario SAC-B02A

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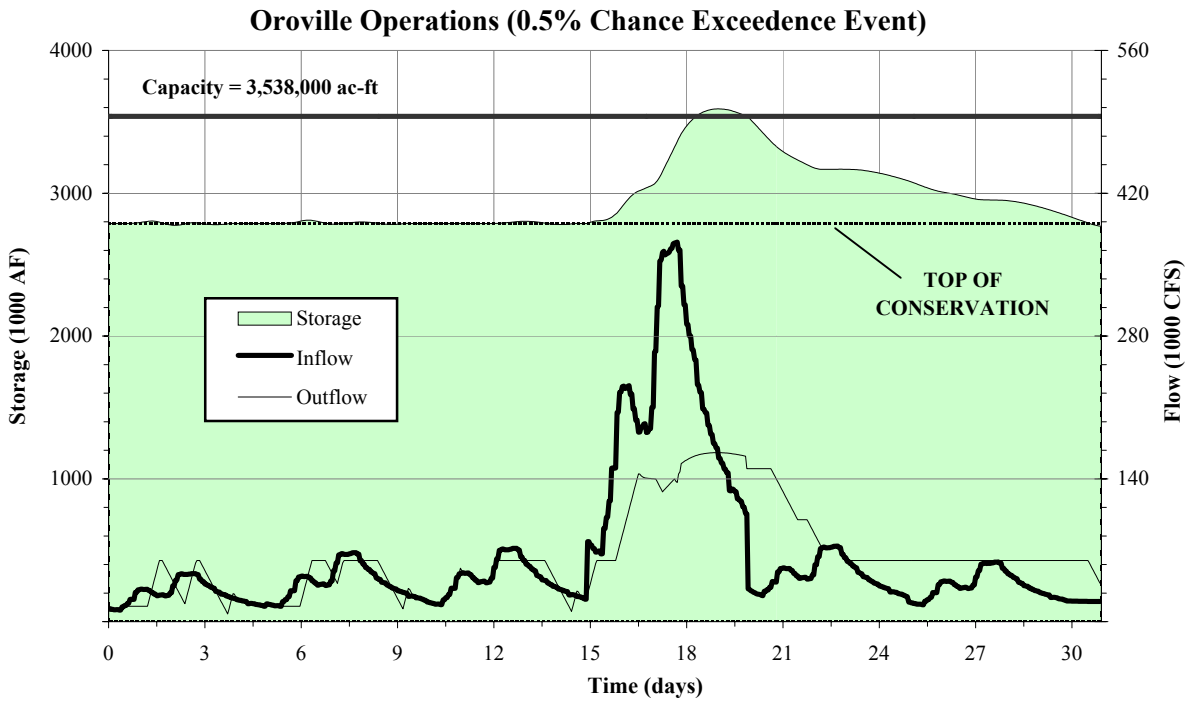
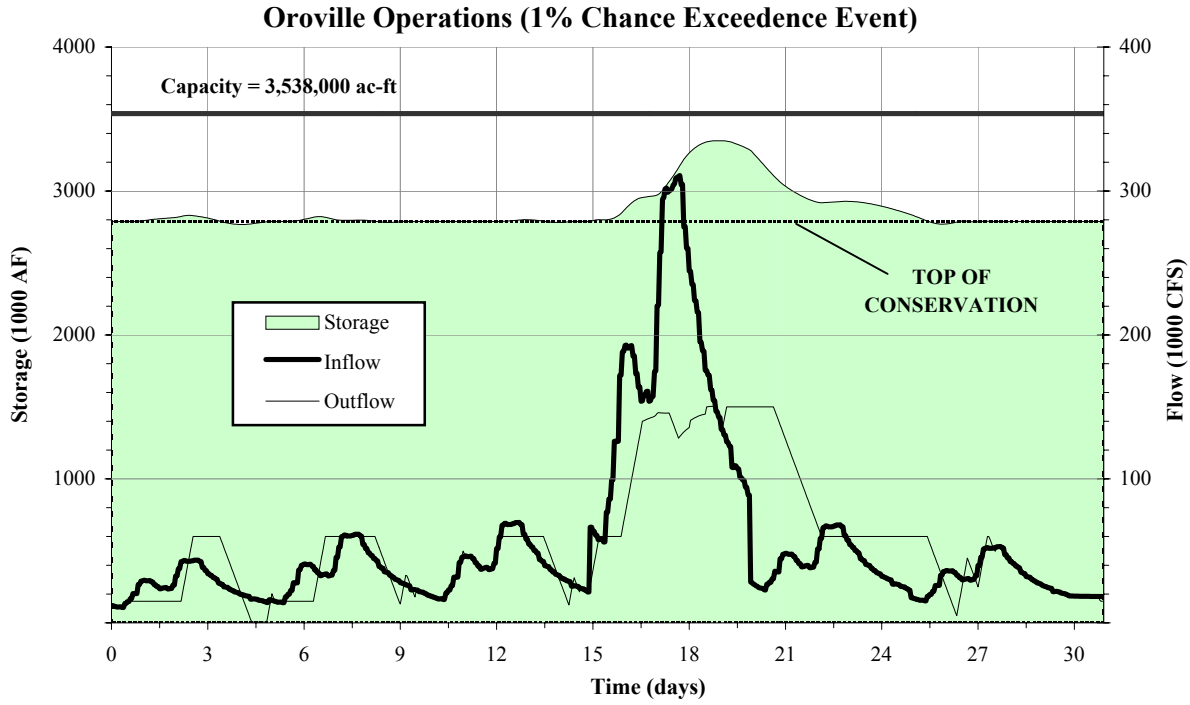
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Figure C.4-2e Reservoir Simulation Hydrographs Alternative Scenario SAC-B02A
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Figure C.4-2f
Reservoir Simulation Hydrographs
Alternative Scenario SAC-B02A

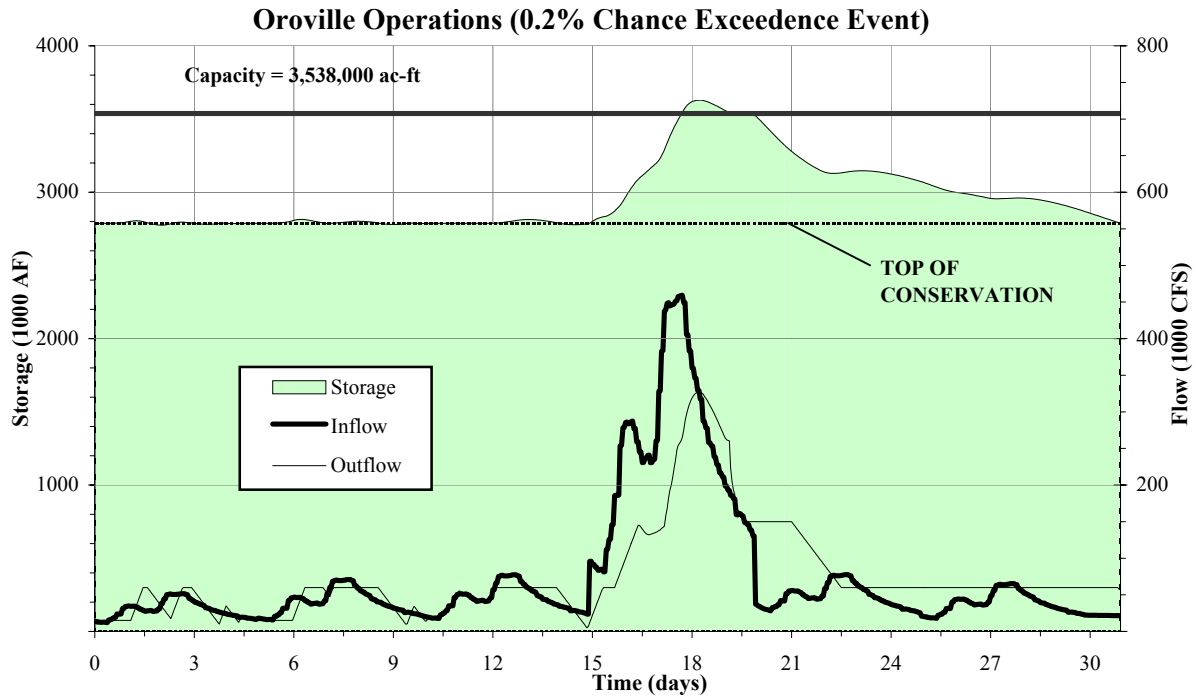
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Figure C.4-2g
Reservoir Simulation Hydrographs
Alternative Scenario SAC-B02A

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Figure C.4-2h
 Reservoir Simulation Hydrographs
 Alternative Scenario SAC-B02A

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TABLE C.4-3
COMPARISON OF PEAK FLOWS IN THE SACRAMENTO BASIN
(10% CHANCE EXCEEDENCE EVENT)
SAC-B03A

Key:
 Gray shaded values indicate that the alternative SAC-B03A re-operation objective flow operation criteria has been exceeded.
 White on black, italicized values indicate that the SAC-B03A objective (230,000 cfs) is exceeded.

Location <i>(Alternative Operational Criteria)</i>	Peak Regulated Flows (cfs) ²						
	Baseline ³	+ 0 ¹	+ 200	+ 400	+ 750	+ 850	+ 950
Feather Storm Runoff Centering							
Oroville Dam (90,000 cfs)	100,000	89,300	89,200	62,700	44,500	41,700	39,400
New Bullards Dam (50,000 cfs)	37,400	37,400	37,400	37,400	37,400	22,900	22,900
Yuba City (120,000 cfs)	110,600	100,500	98,500	68,600	53,200	51,800	50,300
Marysville (170,000/110,000 cfs)	69,800	69,800	69,800	69,800	69,800	69,800	69,800
Shanghai Bend (230,000 cfs)	180,000	169,400	168,100	134,500	120,700	100,100	98,700
Nicolaus (320, 000 cfs)	194,300	183,700	182,500	149,200	135,200	114,900	113,500
Yuba Storm Runoff Centering							
Oroville Dam (90,000 cfs)	60,000	60,000	60,000	50,200	38,500	36,900	35,400
New Bullards Dam (50,000 cfs)	41,900	41,900	41,900	41,900	41,900	30,100	30,100
Yuba City (120,000 cfs)	70,800	70,800	69,100	58,000	47,200	45,500	43,800
Marysville (170,000/110,000 cfs)	82,000	82,000	82,000	82,000	82,000	66,700	66,700
Shanghi Bend (230,000 cfs)	149,500	149,500	149,500	138,800	127,200	109,800	108,200
Nicolaus (320,000 cfs)	168,300	168,300	168,300	157,600	145,900	128,800	127,200
Notes:							
1) Volumes across top of table represent incremental increases in flood control space at Oroville in thousand acre-feet.							
2) Peak regulated flows at mainstem points are estimated by HEC-5, which assumes all flows remain in channel.							
3) Gray shaded cells at Baseline represent in-stream flows in excess of "Baseline" operational flow criteria.							

TABLE C.4-3 (CONT.)
COMPARISON OF PEAK FLOWS IN THE SACRAMENTO BASIN
(4% CHANCE EXCEEDENCE EVENT)
SAC-B03A

Key:
Gray shaded values indicate that the alternative SAC-B03A re-operation objective flow operation criteria has been exceeded.
White on black, italicized values indicate that the SAC-B03A objective (230,000 cfs) is exceeded.

Location <i>(Alternative Operational Criteria)</i>	Peak Regulated Flows (cfs) ²						
	Baseline ³	+ 0 ¹	+ 200	+ 400	+ 750	+ 850	+ 950
Feather Storm Runoff Centering							
Oroville Dam (90,000 cfs)	150,000	89,300	89,200	89,400	65,800	55,000	52,600
New Bullards Dam (50,000 cfs)	50,000	50,000	50,000	50,000	50,000	44,000	44,000
Yuba City (120,000 cfs)	164,300	110,600	110,000	103,100	71,800	62,700	60,400
Marysville (170,000/110,000 cfs)	106,600	106,600	106,600	106,600	106,600	106,600	106,600
Shanghai Bend (230,000 cfs)	270,800	212,300	212,300	209,400	171,900	159,700	156,800
Nicolaus (320, 000 cfs)	297,200	237,800	237,800	235,700	198,600	186,500	183,600
Yuba Storm Runoff Centering							
Oroville Dam (90,000 cfs)	100,000	89,300	89,200	75,700	48,300	45,700	41,700
New Bullards Dam (50,000 cfs)	50,000	50,000	50,000	50,000	50,000	48,800	48,800
Yuba City (120,000 cfs)	112,800	103,100	103,000	82,900	56,300	54,800	52,700
Marysville (170,000/110,000 cfs)	114,300	114,300	114,300	114,300	114,300	108,600	108,600
Shanghi Bend (230,000 cfs)	226,900	217,000	216,900	189,700	169,600	160,800	158,500
Nicolaus (320,000 cfs)	256,300	245,600	245,600	220,700	199,500	191,700	189,300
<i>Notes:</i>							
1) Volumes across top of table represent incremental increases in flood control space at Oroville in thousand acre-feet.							
2) Peak regulated flows at mainstem points are estimated by HEC-5, which assumes all flows remain in channel.							
3) Gray shaded cells at Baseline represent in-stream flows in excess of "Baseline" operational flow criteria.							

TABLE C.4-3 (CONT.)
COMPARISON OF PEAK FLOWS IN THE SACRAMENTO BASIN
(2% CHANCE EXCEEDENCE EVENT)
SAC-B03A

Key:
Gray shaded values indicate that the alternative SAC-B03A re-operation objective flow operation criteria has been exceeded.
White on black, italicized values indicate that the SAC-B03A objective (230,000 cfs) is exceeded.

Location (Alternative Operational Criteria)	Peak Regulated Flows (cfs) ²						
	Baseline ³	+ 0 ¹	+ 200	+ 400	+ 750	+ 850	+ 950
Feather Storm Runoff Centering							
Oroville Dam (90,000 cfs)	150,000	94,900	91,800	89,400	89,200	89,200	89,600
New Bullards Dam (50,000 cfs)	51,400	51,400	51,400	51,400	51,400	50,000	50,000
Yuba City (120,000 cfs)	169,100	115,800	115,800	111,800	105,000	102,600	99,300
Marysville (170,000/110,000 cfs)	128,600	128,600	128,600	128,600	128,600	125,200	125,200
Shanghai Bend (230,000 cfs)	297,600	236,700	236,600	236,500	227,600	216,300	197,900
Nicolaus (320, 000 cfs)	325,900	266,000	263,200	263,500	262,600	251,600	233,900
Yuba Storm Runoff Centering							
Oroville Dam (90,000 cfs)	150,000	89,700	89,300	89,300	70,900	61,200	53,900
New Bullards Dam (50,000 cfs)	53,600	53,600	53,600	53,600	53,600	51,700	51,700
Yuba City (120,000 cfs)	159,800	110,800	109,000	99,900	77,300	66,500	61,500
Marysville (170,000/110,000 cfs)	136,000	136,000	136,000	136,000	136,000	134,400	134,400
Shanghi Bend (230,000 cfs)	294,000	238,300	238,100	232,000	202,700	198,000	195,100
Nicolaus (320,000 cfs)	328,100	267,000	266,900	269,500	237,400	233,300	230,400
Notes:							
1) Volumes across top of table represent incremental increases in flood control space at Oroville in thousand acre-feet.							
2) Peak regulated flows at mainstem points are estimated by HEC-5, which assumes all flows remain in channel.							
3) Gray shaded cells at Baseline represent in-stream flows in excess of "Baseline" operational flow criteria.							

TABLE C.4-3 (CONT.)
COMPARISON OF PEAK FLOWS IN THE SACRAMENTO BASIN
(1% CHANCE EXCEEDENCE EVENT)
SAC-B03A

Key:
Gray shaded values indicate that the alternative SAC-B03A re-operation objective flow operation criteria has been exceeded.
White on black, italicized values indicate that the SAC-B03A objective (230,000 cfs) is exceeded.

Location (Alternative Operational Criteria)	Peak Regulated Flows (cfs) ²						
	Baseline ³	+ 0 ¹	+ 200	+ 400	+ 750	+ 850	+ 950
Feather Storm Runoff Centering							
Oroville Dam (90,000 cfs)	150,500	113,400	92,800	93,500	93,000	90,300	89,300
New Bullards Dam (50,000 cfs)	50,000	52,600	52,600	52,600	53,900	52,900	53,000
Yuba City (120,000 cfs)	177,800	129,400	117,600	115,300	103,900	102,900	103,100
Marysville (170,000/110,000 cfs)	132,200	139,500	139,500	139,500	142,200	142,200	145,000
Shanghai Bend (230,000 cfs)	298,500	268,600	244,500	246,300	238,200	234,900	234,000
Nicolaus (320, 000 cfs)	336,200	311,600	280,500	275,300	276,800	276,300	275,900
Yuba Storm Runoff Centering							
Oroville Dam (90,000 cfs)	150,000	91,100	91,700	89,500	89,300	89,300	89,200
New Bullards Dam (50,000 cfs)	59,100	52,700	52,700	51,700	54,000	55,500	58,300
Yuba City (120,000 cfs)	157,200	115,000	114,400	101,600	100,500	100,100	99,800
Marysville (170,000/110,000 cfs)	157,900	144,000	144,000	146,100	153,600	154,700	157,000
Shanghi Bend (230,000 cfs)	304,600	244,000	244,000	237,600	232,900	233,000	230,700
Nicolaus (320,000 cfs)	339,800	287,300	283,200	275,700	278,300	278,300	276,700
<i>Notes:</i>							
1) Volumes across top of table represent incremental increases in flood control space at Oroville in thousand acre-feet.							
2) Peak regulated flows at mainstem points are estimated by HEC-5, which assumes all flows remain in channel.							
3) Gray shaded cells at Baseline represent in-stream flows in excess of "Baseline" operational flow criteria.							

TABLE C.4-3 (CONT.)
COMPARISON OF PEAK FLOWS IN THE SACRAMENTO BASIN
(0.5% CHANCE EXCEEDENCE EVENT)
SAC-B03A

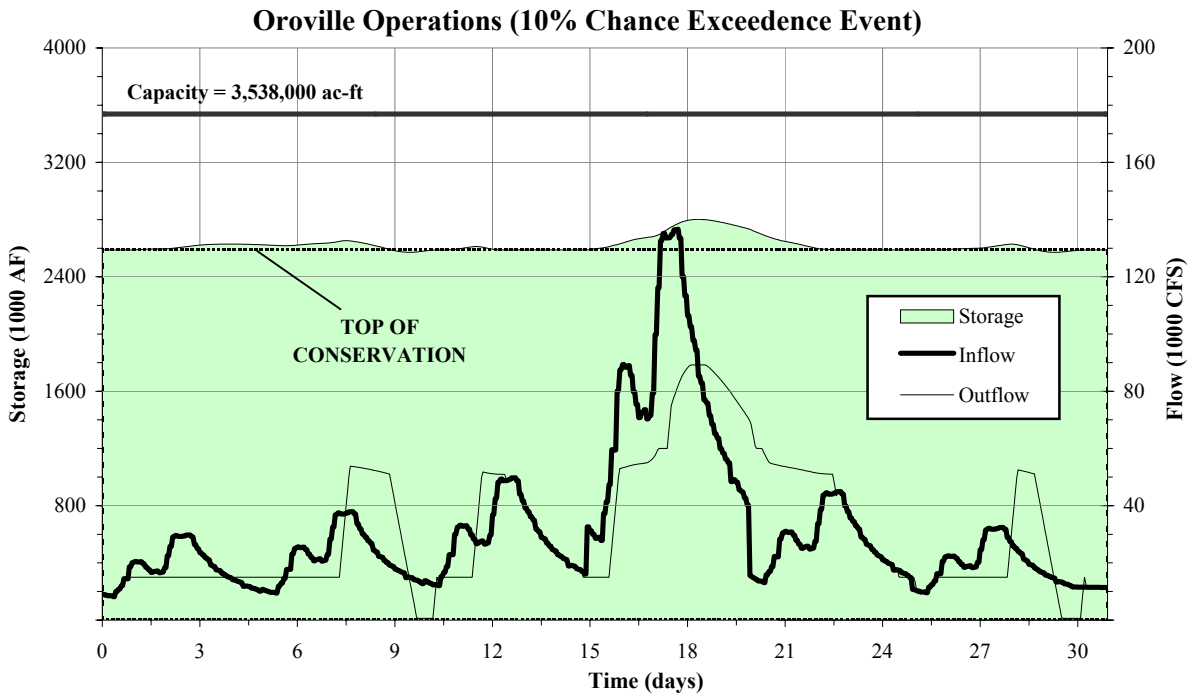
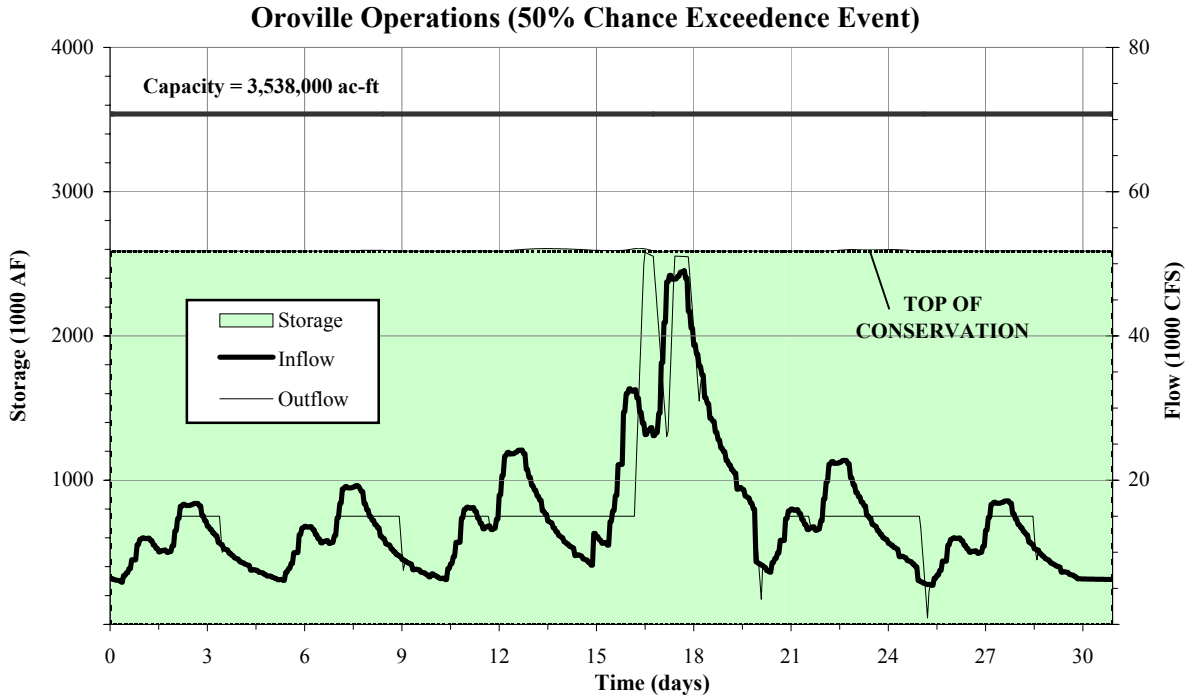
Key:
Gray shaded values indicate that the alternative SAC-B03A re-operation objective flow operation criteria has been exceeded.
White on black, italicized values indicate that the SAC-B03A objective (230,000 cfs) is exceeded.

Location (Alternative Operational Criteria)	Peak Regulated Flows (cfs) ²						
	Baseline ³	+ 0 ¹	+ 200	+ 400	+ 750	+ 850	+ 950
Feather Storm Runoff Centering							
Oroville Dam (90,000 cfs)	165,700	224,500	157,400	123,000	93,500	91,900	92,300
New Bullards Dam (50,000 cfs)	83,300	82,000	82,000	82,000	82,000	77,200	76,700
Yuba City (120,000 cfs)	185,700	241,400	176,500	139,500	103,400	103,200	103,500
Marysville (170,000/110,000 cfs)	180,600	177,300	177,300	177,300	176,100	169,400	168,800
Shanghai Bend (230,000 cfs)	366,000	<i>141,300</i>	<i>353,5000</i>	<i>316,400</i>	<i>277,800</i>	<i>251,800</i>	<i>240,800</i>
Nicolaus (320, 000 cfs)	416,400	464,700	404,000	366,900	328,300	302,700	291,700
Yuba Storm Runoff Centering							
Oroville Dam (90,000 cfs)	150,000	129,100	93,600	90,100	90,600	91,100	91,100
New Bullards Dam (50,000 cfs)	91,400	90,000	90,000	89,900	88,200	86,200	85,700
Yuba City (120,000 cfs)	171,000	146,100	105,900	101,200	100,500	101,000	100,800
Marysville (170,000/110,000 cfs)	196,900	194,800	194,800	194,600	192,100	186,000	185,400
Shanghi Bend (230,000 cfs)	339,600	<i>340,600</i>	<i>295,200</i>	<i>268,400</i>	<i>237,700</i>	<i>236,600</i>	<i>240,200</i>
Nicolaus (320,000 cfs)	392,800	393,800	348,500	321,700	291,600	287,400	291,600
Notes:							
1) Volumes across top of table represent incremental increases in flood control space at Oroville in thousand acre-feet.							
2) Peak regulated flows at mainstem points are estimated by HEC-5, which assumes all flows remain in channel.							
3) Gray shaded cells at Baseline represent in-stream flows in excess of "Baseline" operational flow criteria.							

TABLE C.4-3 (CONT.)
COMPARISON OF PEAK FLOWS IN THE SACRAMENTO BASIN
(0.2% CHANCE EXCEEDENCE EVENT)
SAC-B03A

Key:
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White on black, italicized values indicate that the SAC-B03A objective (230,000 cfs) is exceeded..

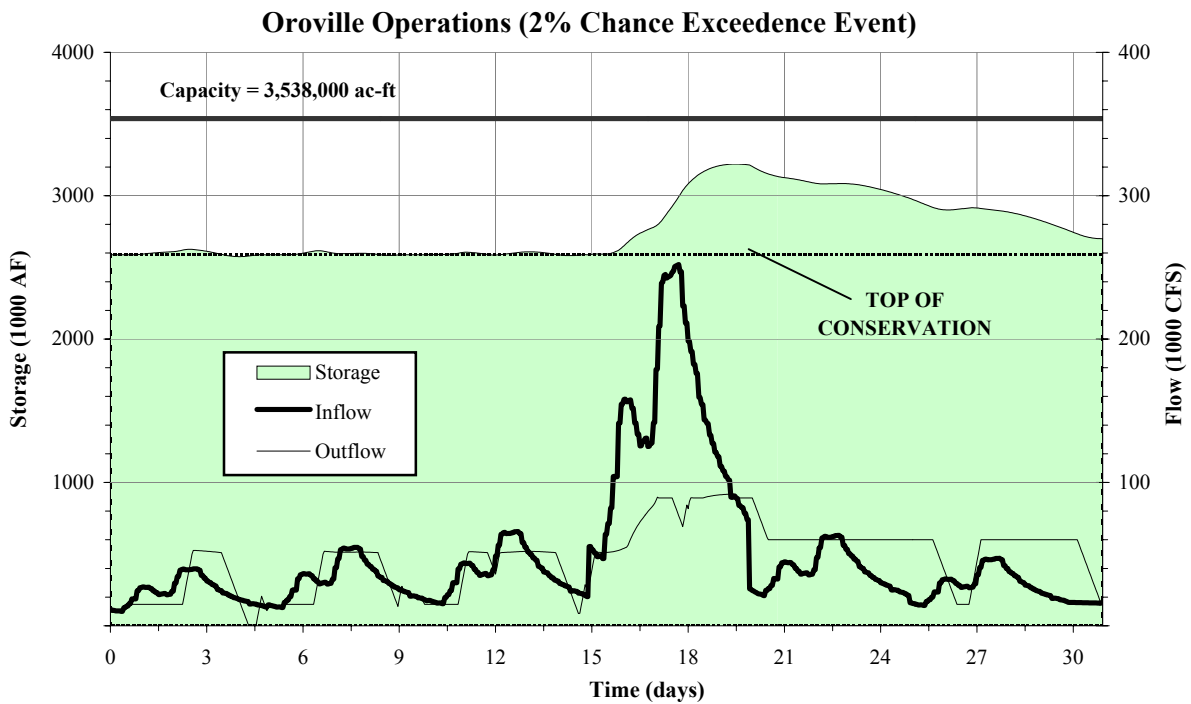
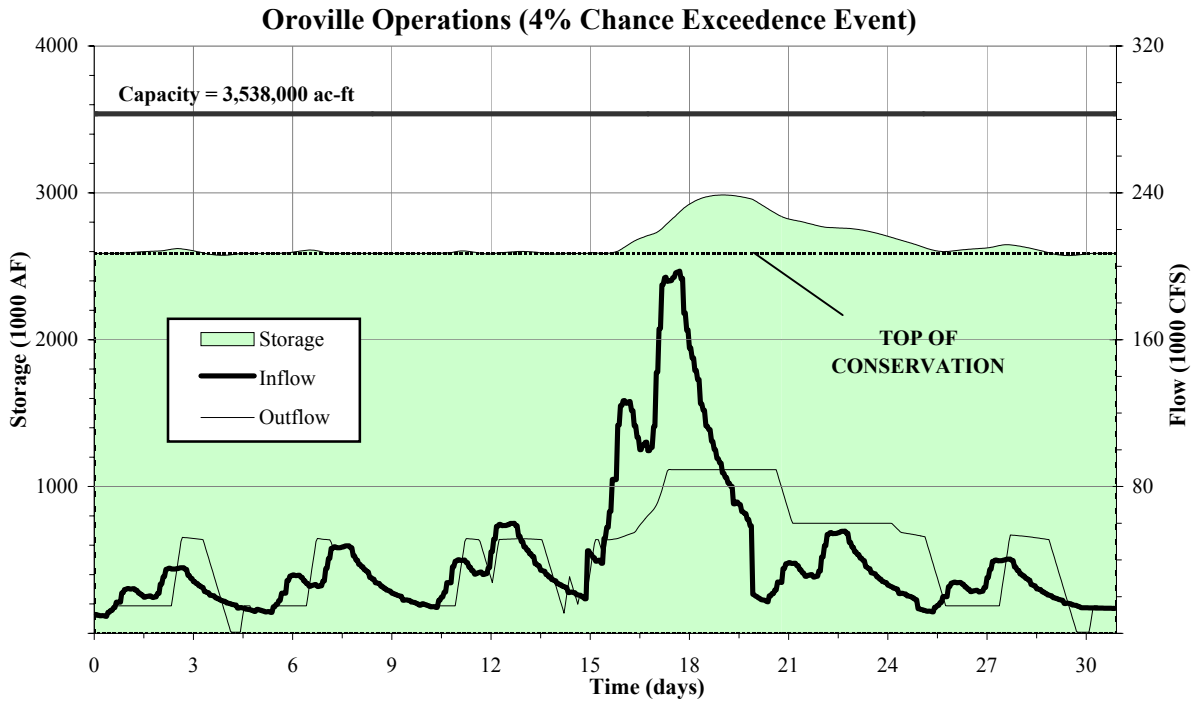
Location (Alternative Operational Criteria)	Peak Regulated Flows (cfs) ²						
	Baseline ³	+ 0 ¹	+ 200	+ 400	+ 750	+ 850	+ 950
Feather Storm Runoff Centering							
Oroville Dam (90,000 cfs)	326,800	357,300	296,900	257,700	216,400	198,400	180,800
New Bullards Dam (50,000 cfs)	116,900	116,900	116,900	116,900	116,900	112,700	112,400
Yuba City (120,000 cfs)	354,000	386,500	323,700	284,300	234,100	219,900	201,000
Marysville (170,000/110,000 cfs)	253,000	252,300	252,300	252,300	252,300	247,000	246,600
Shanghai Bend (230,000 cfs)	603,700	638,300	572,000	535,800	485,200	465,900	446,400
Nicolaus (320, 000 cfs)	661,500	695,300	630,600	594,100	543,500	524,100	504,600
Yuba Storm Runoff Centering							
Oroville Dam (90,000 cfs)	226,000	285,700	206,500	163,500	128,400	114,400	105,400
New Bullards Dam (50,000 cfs)	126,400	128,600	128,600	128,600	128,600	122,600	122,600
Yuba City (120,000 cfs)	250,600	306,500	224,700	182,800	144,900	129,900	117,400
Marysville (170,000/110,000 cfs)	270,600	273,000	273,000	273,000	273,000	266,000	266,000
Shanghi Bend (230,000 cfs)	520,500	571,100	496,800	454,800	417,000	395,100	382,700
Nicolaus (320,000 cfs)	581,000	632,800	557,500	515,600	447,800	456,100	443,600
Notes:							
1) Volumes across top of table represent incremental increases in flood control space at Oroville in thousand acre-feet.							
2) Peak regulated flows at mainstem points are estimated by HEC-5, which assumes all flows remain in channel.							
3) Gray shaded cells at Baseline represent in-stream flows in excess of "Baseline" operational flow criteria.							



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Figure C.4-3a
Reservoir Simulation Hydrographs
Alternative Scenario SAC-B03A

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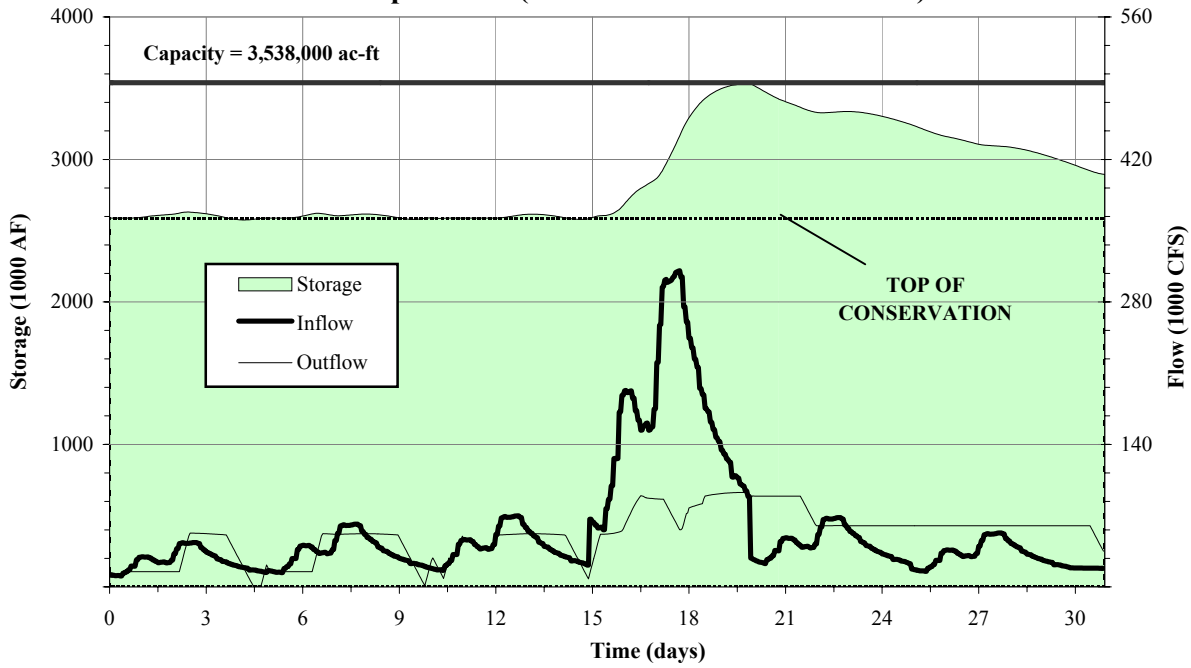


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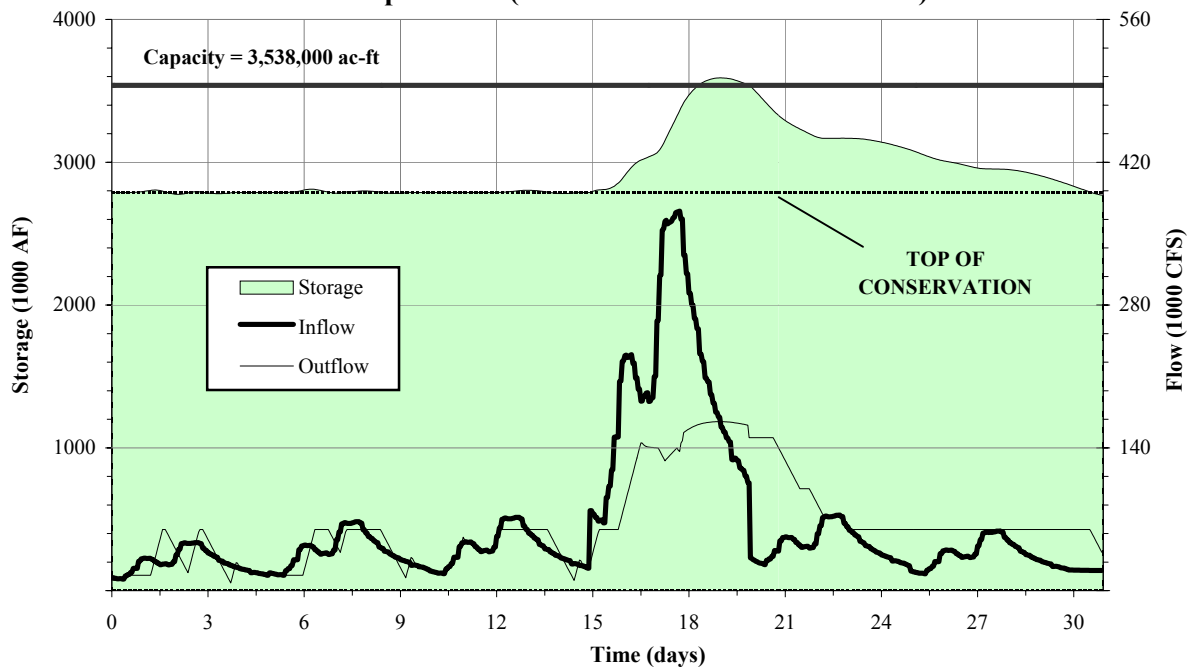
Figure C.4-3b
Reservoir Simulation Hydrographs
Alternative Scenario SAC-B03A

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Oroville Operations (1% Chance Exceedence Event)



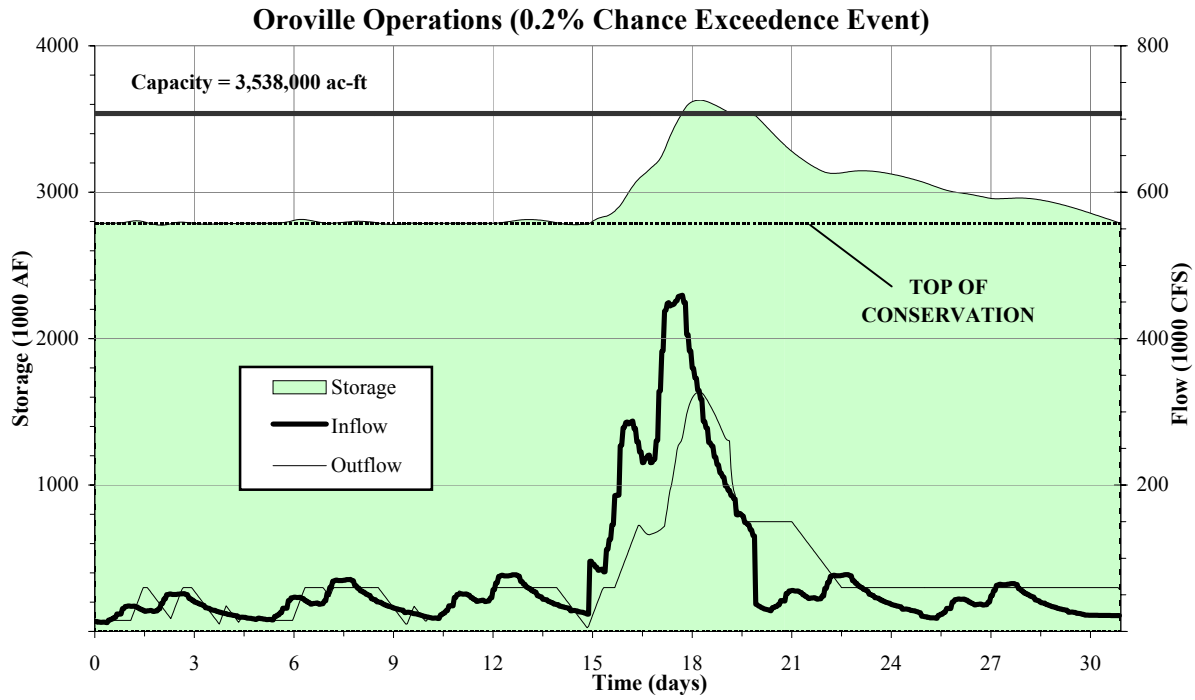
Oroville Operations (0.5% Chance Exceedence Event)



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Figure C.4-3c
Reservoir Simulation Hydrographs
Alternative Scenario SAC-B03A

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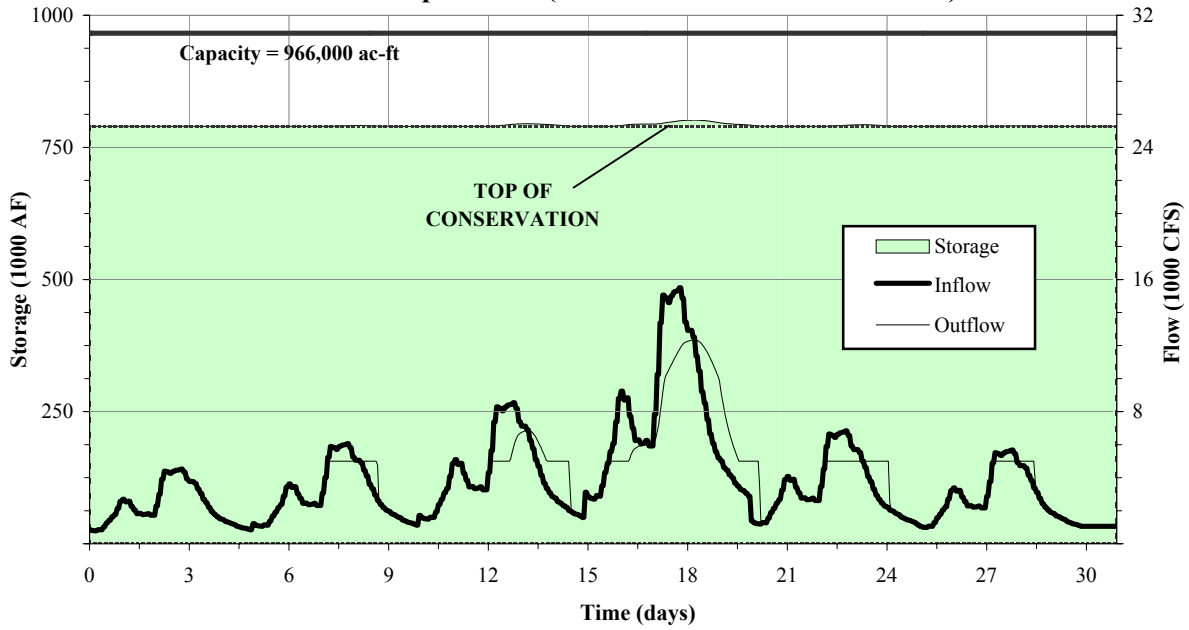


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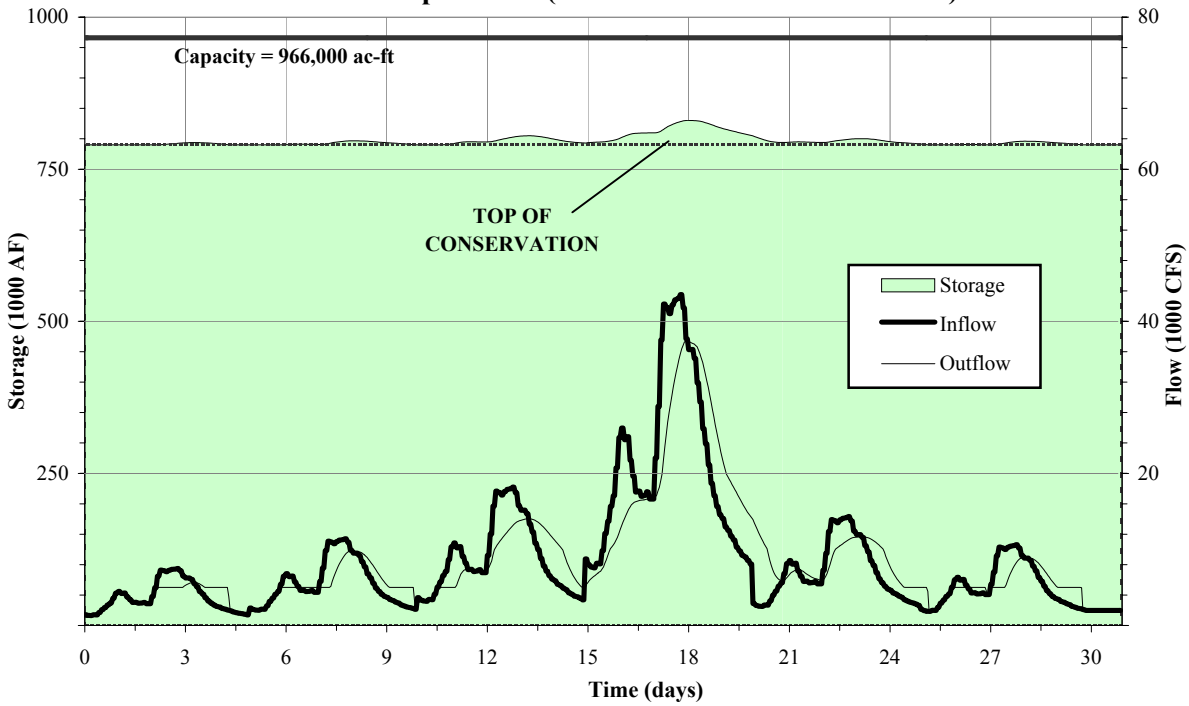
Figure C.4-3d
Reservoir Simulation Hydrographs
Alternative Scenario SAC-B03A

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Bullards Bar Operations (50% Chance Exceedence Event)



Bullards Bar Operations (10% Chance Exceedence Event)

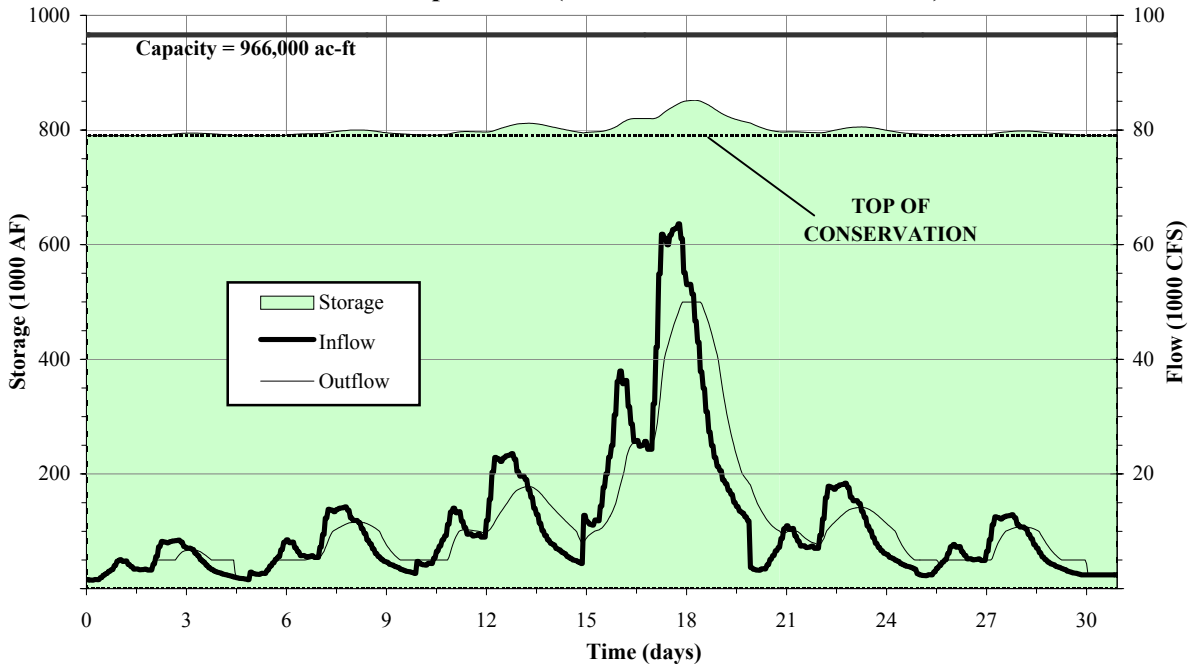


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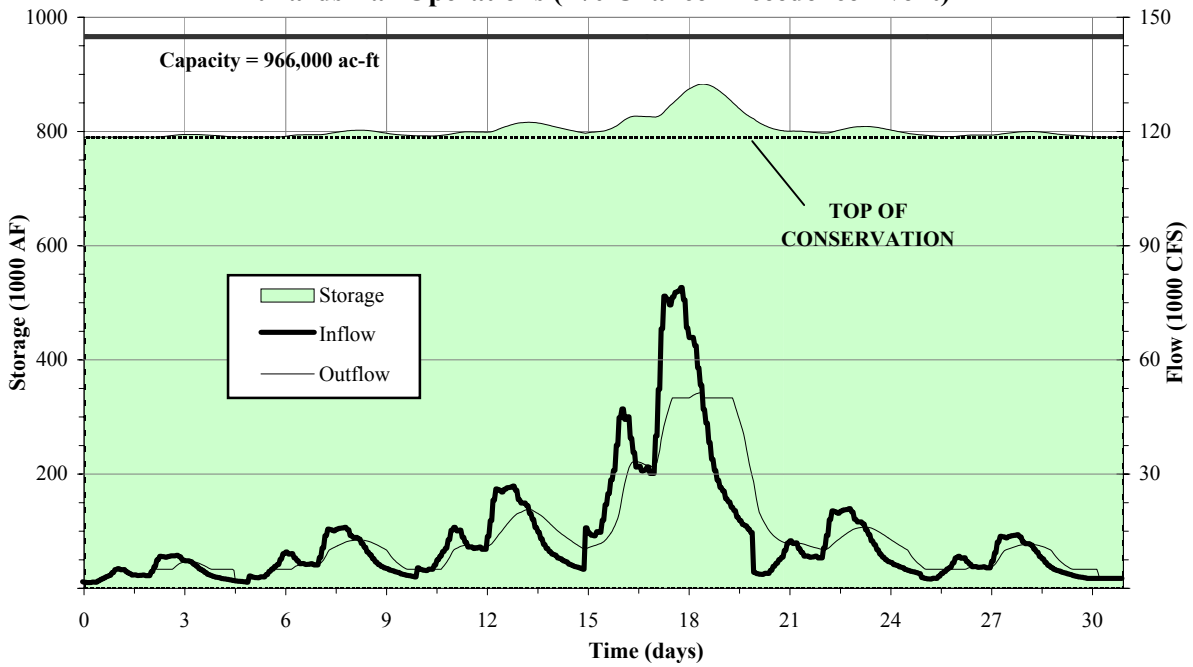
Figure C.4-3e
Reservoir Simulation Hydrographs
Alternative Scenario SAC-B03A

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Bullards Bar Operations (4% Chance Exceedence Event)



Bullards Bar Operations (2% Chance Exceedence Event)

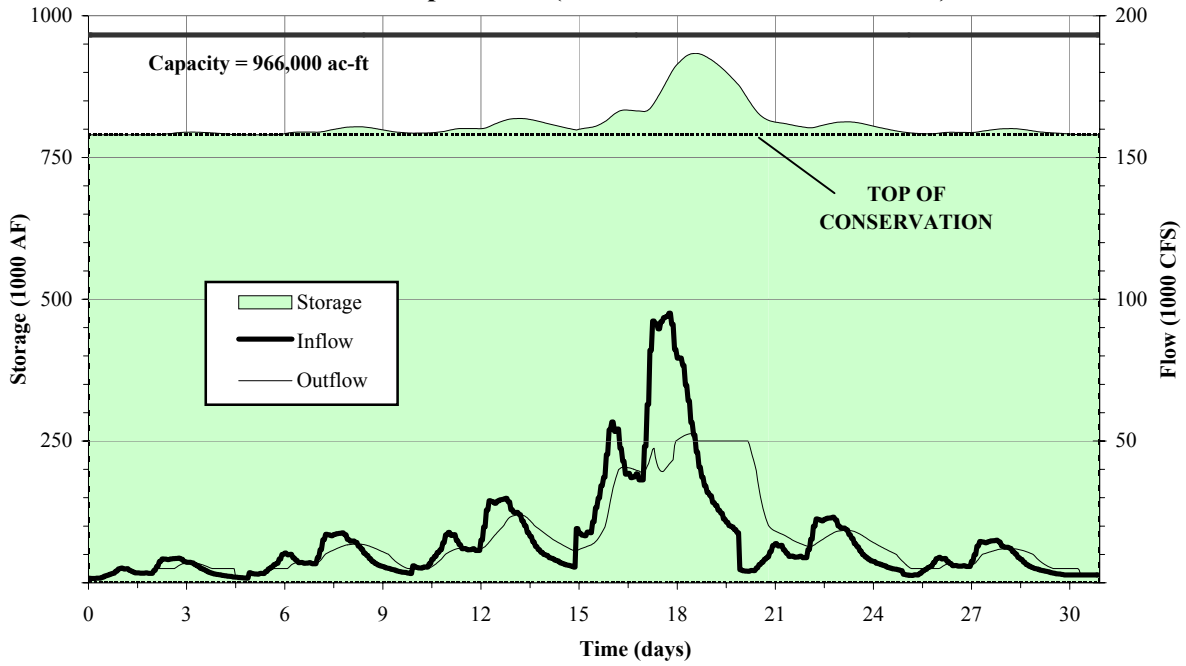


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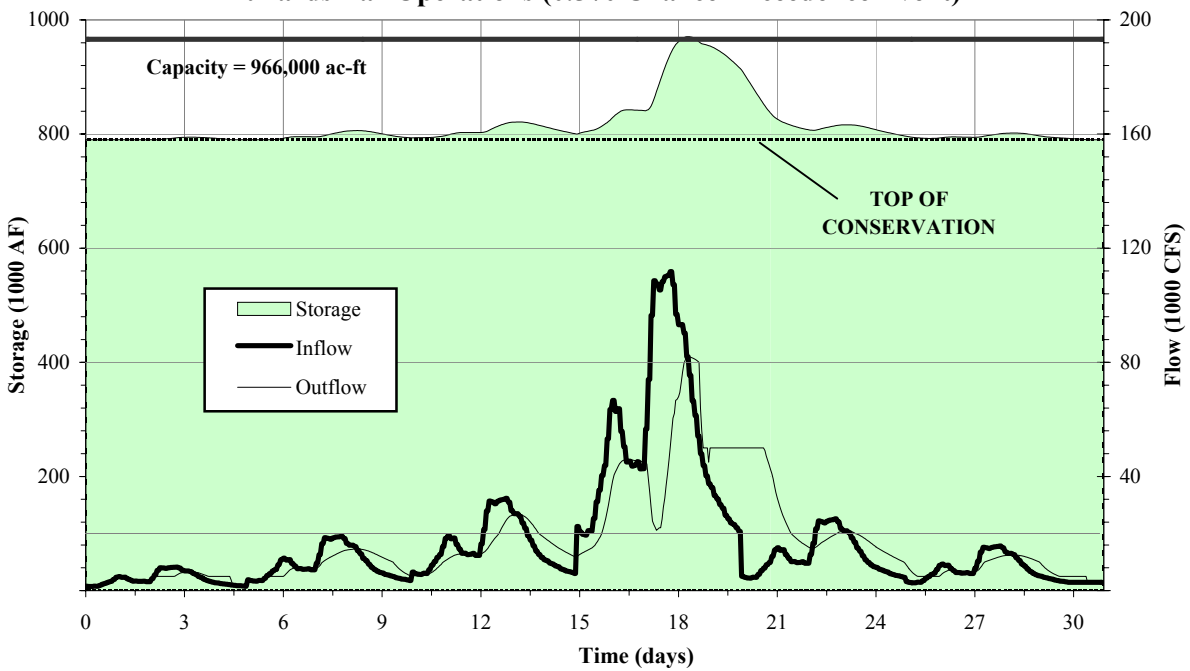
Figure C.4-3f
Reservoir Simulation Hydrographs
Alternative Scenario SAC-B03A

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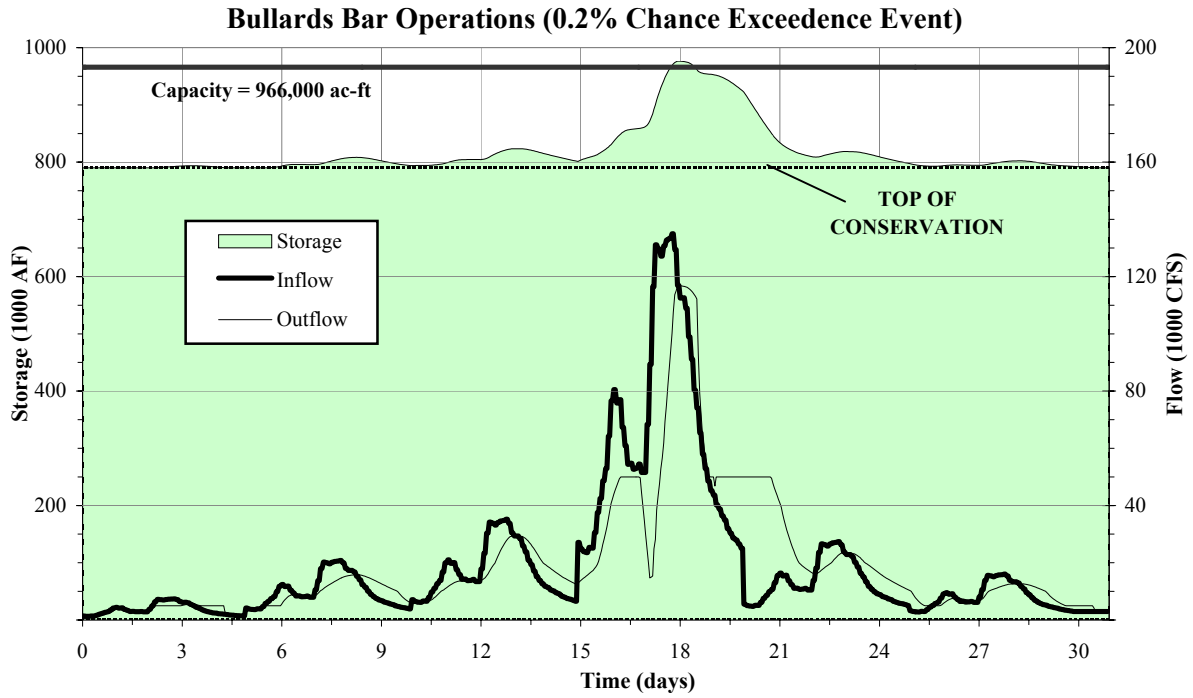
Bullards Bar Operations (1% Chance Exceedence Event)



Bullards Bar Operations (0.5% Chance Exceedence Event)



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Figure C.4-3g Reservoir Simulation Hydrographs Alternative Scenario SAC-B03A
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Figure C.4-3h
Reservoir Simulation Hydrographs
Alternative Scenario SAC-B03A

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TABLE C.4-4a
PEAK FLOW COMPARISONS FOR FOLSOM DAM

Percent Chance Exceedence Event	Peak Inflows (cfs)			Percent Differences	
	ARWI Base Case	ARWI Min Case	Comp Study	Base vs. Comp Study	Min vs. Comp Study
4%	207,410	178,370	196,408	5.6%	-9.2%
2%	274,860	236,380	258,555	6.3%	-8.6%
1%	353,540	304,040	329,258	7.4%	-7.7%
0.5%	444,570	408,320	409,934	8.4%	-0.4%
0.2%	585,930	585,930	536,703	9.2%	9.2%

Percent Chance Exceedence Event	Peak Inflows (cfs)			Percent Differences	
	ARWI Base Case	ARWI Min Case	Comp Study	Base vs. Comp Study	Min vs. Comp Study
4%	115,000	115,000	115,000	0.0%	0.0%
2%	115,000	115,000	115,000	0.0%	0.0%
1%	115,000	115,000	116,814	-1.6%	-1.6%
0.5%	122,570	115,000	119,689	2.4%	-3.9%
0.2%	528,380	498,860	485,040	8.9%	2.8%

Note:

$$\text{Percent Difference} = (\text{ARWI Case} - \text{Comp Study}) / \text{Comp Study} * 100$$

TABLE C.4-4b
EFFECTS OF ALTERNATIVE SCENARIO SAC-B04A

Ord Ferry Storm Runoff Centering							
Percent Chance Exceedence	Mainstem gage location →	Bend Bridge ¹	Vina Bridge ¹	Ord Ferry ¹	Oroville ¹	Verona	Sacramento ¹
50%	% Peak Reduced	0	0	0	9.0	2.5	0.2
	Peak Attenuation (AF)	0.0	0.0	0.0	8,486	-707,260	5,002
10%	% Peak Reduced	0	0	0	0	0	5.3
	Peak Attenuation (AF)	0.0	0.0	0.0	-133,399	39,004	95,580
4%	% Peak Reduced	0	0	0	10.0	2.9	7.9
	Peak Attenuation (AF)	0.0	0.0	0.0	76,866	104,917	129,243
2%	% Peak Reduced	0	0	0	10.0	2.9	8.5
	Peak Attenuation (AF)	0.0	0.0	0.0	99,097	111,999	134,441
1%	% Peak Reduced	0	0	0	40.0	12.7	10.4
	Peak Attenuation (AF)	0.0	0.0	0.0	243,548	251,570	241,050
0.5%	% Peak Reduced	0	0	0	39.9	9.4	6.9
	Peak Attenuation (AF)	0.0	0.0	0.0	302,368	299,814	336,116
0.2%	% Peak Reduced	0	0	0	37.8	9.3	4.6
	Peak Attenuation (AF)	0.0	0.0	0.0	542,654	541,051	571,784

Oroville Storm Runoff Centering							
Percent Chance Exceedence	Mainstem gage location →	Bend Bridge ¹	Vina Bridge ¹	Ord Ferry ¹	Oroville ¹	Verona	Sacramento ¹
50%	% Peak Reduced	0	0	0	0	-7.2	-2.7
	Peak Attenuation (AF)	0.0	0.0	0.0	2,579	-135,790	-123,289
10%	% Peak Reduced	0	0	0	10.0	3.5	7.7
	Peak Attenuation (AF)	0.0	0.0	0.0	30,924	120,985	128,441
4%	% Peak Reduced	0	0	0	40.0	13.9	10.7
	Peak Attenuation (AF)	0.0	0.0	0.0	101,849	291,095	265,159
2%	% Peak Reduced	0	0	0	38.3	10.8	9.1
	Peak Attenuation (AF)	0.0	0.0	0.0	501,067	505,980	248,210
1%	% Peak Reduced	0	0	0	37.8	11.1	9.0
	Peak Attenuation (AF)	0.0	0.0	0.0	611,905	610,165	593,692
0.5%	% Peak Reduced	0	0	0	5.1	2.0	2.9
	Peak Attenuation (AF)	0.0	0.0	0.0	221,808	453,006	613,470
0.2%	% Peak Reduced	0	0	0	9.2	3.4	17.1
	Peak Attenuation (AF)	0.0	0.0	0.0	219,144	216,278	654,095

	Maximum peak flow reduction %
	Maximum peak volume attenuation

Notes:

- Flow at mainstem points are estimated by HEC-5, which assumes all flows remain in channel (bypasses were treated as channels).
Flows at mainstem points are taken "at latitude" (See Chapter III of Appendix B).
- % Peak Reduced = ((Maximum Regulated Baseline Inflow)-(Maximum Regulated Alternative Inflow))/(Maximum Regulated Baseline Inflow) X 100%
- Peak Attenuation = (Σ attenuated peak volume)*(0.08265 ac-ft/cfs)

TABLE C.4-4b (CONT.)
EFFECTS OF ALTERNATIVE SCENARIO SAC-B04A

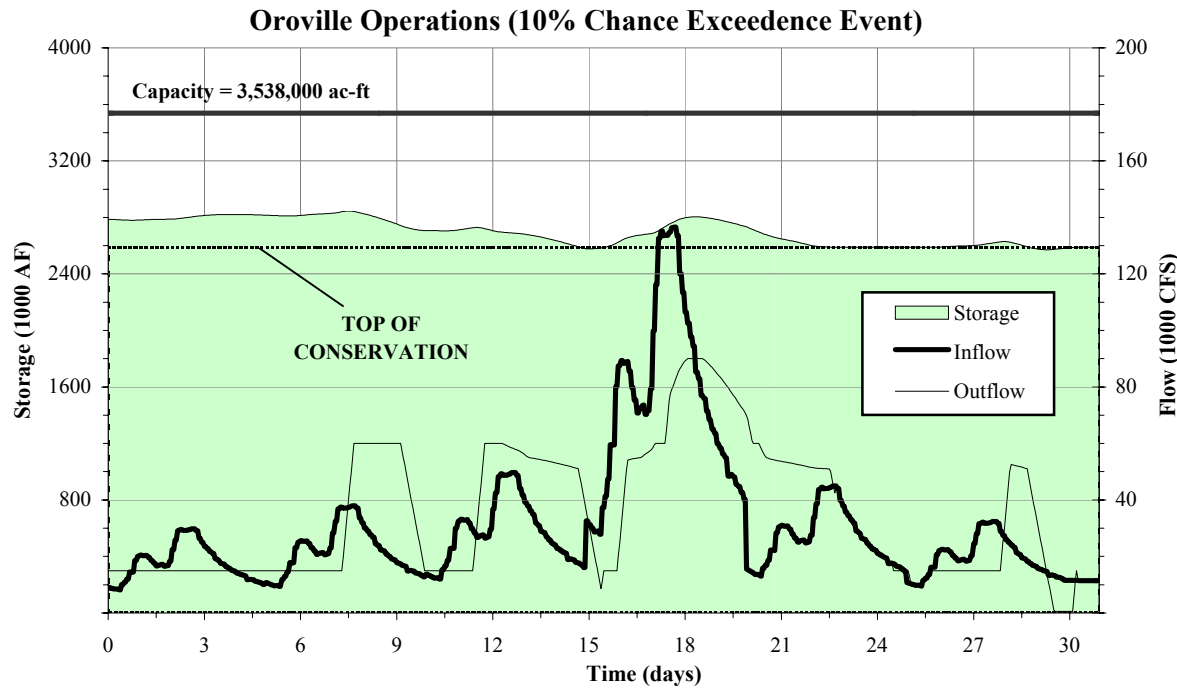
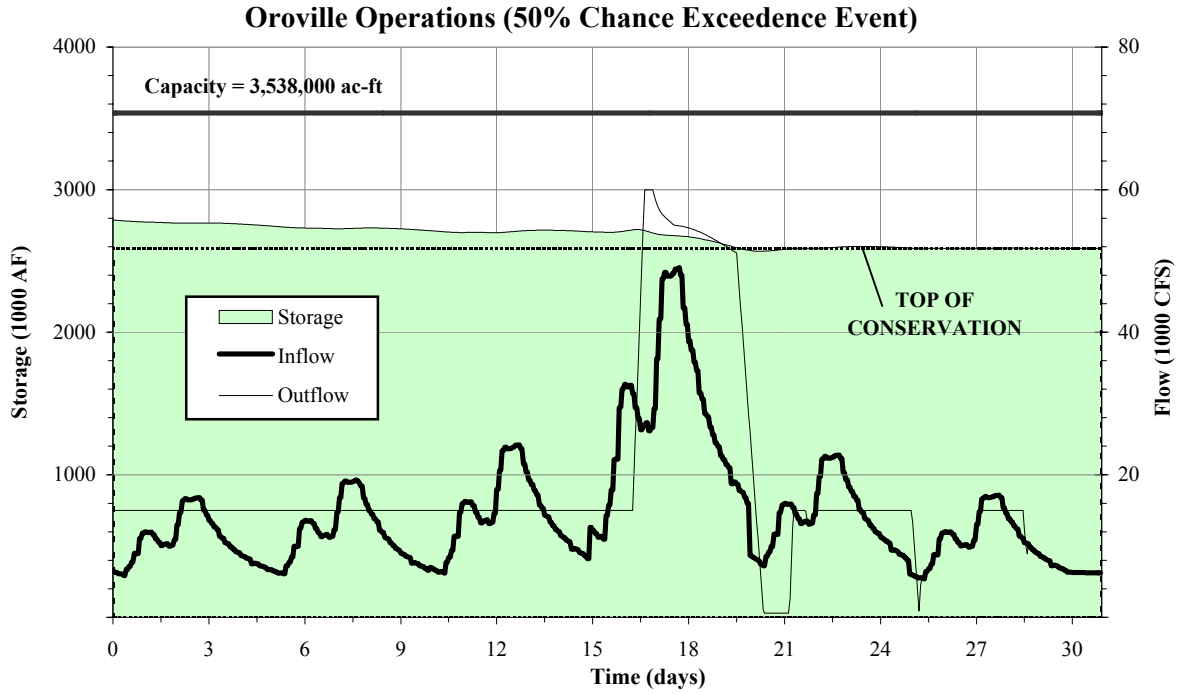
American Storm Runoff Centering							
Percent Chance Exceedence	Mainstem gage location →	Bend Bridge ¹	Vina Bridge ¹	Ord Ferry ¹	Oroville ¹	Verona	Sacramento ¹
50%	% Peak Reduced	0	0	0	9.5	0.4	9.3
	Peak Attenuation (AF)	0.0	0.0	0.0	5,081	3,942	31,044
10%	% Peak Reduced	0	0	0	0	0	9.5
	Peak Attenuation (AF)	0.0	0.0	0.0	-131,504	24,221	155,305
4%	% Peak Reduced	0	0	0	10.0	2.8	2.1
	Peak Attenuation (AF)	0.0	0.0	0.0	99,210	95,950	76,411
2%	% Peak Reduced	0	0	0	40.0	11.5	9.5
	Peak Attenuation (AF)	0.0	0.0	0.0	282,629	284,676	356,820
1%	% Peak Reduced	0	0	0	38.3	8.7	7.6
	Peak Attenuation (AF)	0.0	0.0	0.0	501,664	501,212	628,723
0.5%	% Peak Reduced	0	0	0	40.0	9.4	25.1
	Peak Attenuation (AF)	0.0	0.0	0.0	634,702	633,213	809,957
0.2%	% Peak Reduced	0	0	0	8.1	3.0	5.8
	Peak Attenuation (AF)	0.0	0.0	0.0	229,349	219,903	328,214

Sacramento Storm Runoff Centering							
Percent Chance Exceedence	Mainstem gage location →	Bend Bridge ¹	Vina Bridge ¹	Ord Ferry ¹	Oroville ¹	Verona	Sacramento ¹
50%	% Peak Reduced	0	0	0	0	-8.3	1.7
	Peak Attenuation (AF)	0.0	0.0	0.0	658	-126,208	5,524
10%	% Peak Reduced	0	0	0	15.9	4.9	8.6
	Peak Attenuation (AF)	0.0	0.0	0.0	48,563	137,343	177,565
4%	% Peak Reduced	0	0	0	40.0	13.3	10.5
	Peak Attenuation (AF)	0.0	0.0	0.0	83,817	250,194	251,899
2%	% Peak Reduced	0	0	0	40.0	8.4	7.2
	Peak Attenuation (AF)	0.0	0.0	0.0	118,741	341,394	355,475
1%	% Peak Reduced	0	0	0	38.1	9.6	7.5
	Peak Attenuation (AF)	0.0	0.0	0.0	217,055	624,547	698,176
0.5%	% Peak Reduced	0	0	0	12.0	2.8	12.3
	Peak Attenuation (AF)	0.0	0.0	0.0	151,824	434,261	623,192
0.2%	% Peak Reduced	0	0	0	9.0	2.9	8.7
	Peak Attenuation (AF)	0.0	0.0	0.0	77,438	218,005	360,229

	Maximum peak flow reduction %
	Maximum peak volume attenuation

Notes:

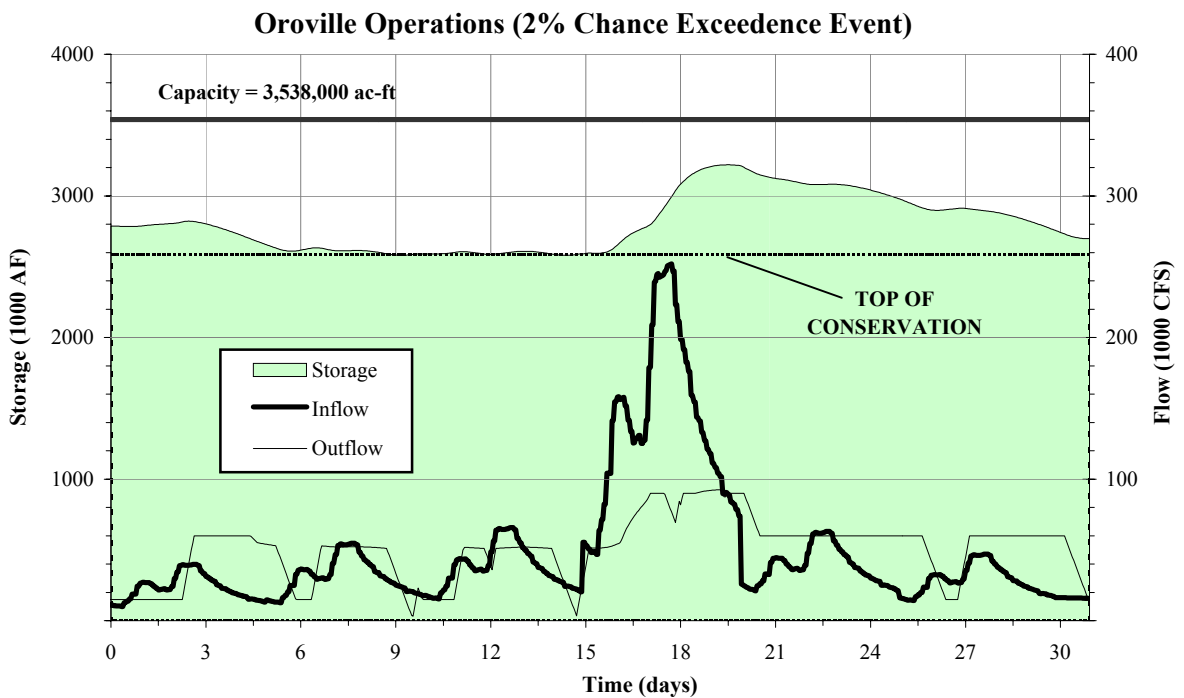
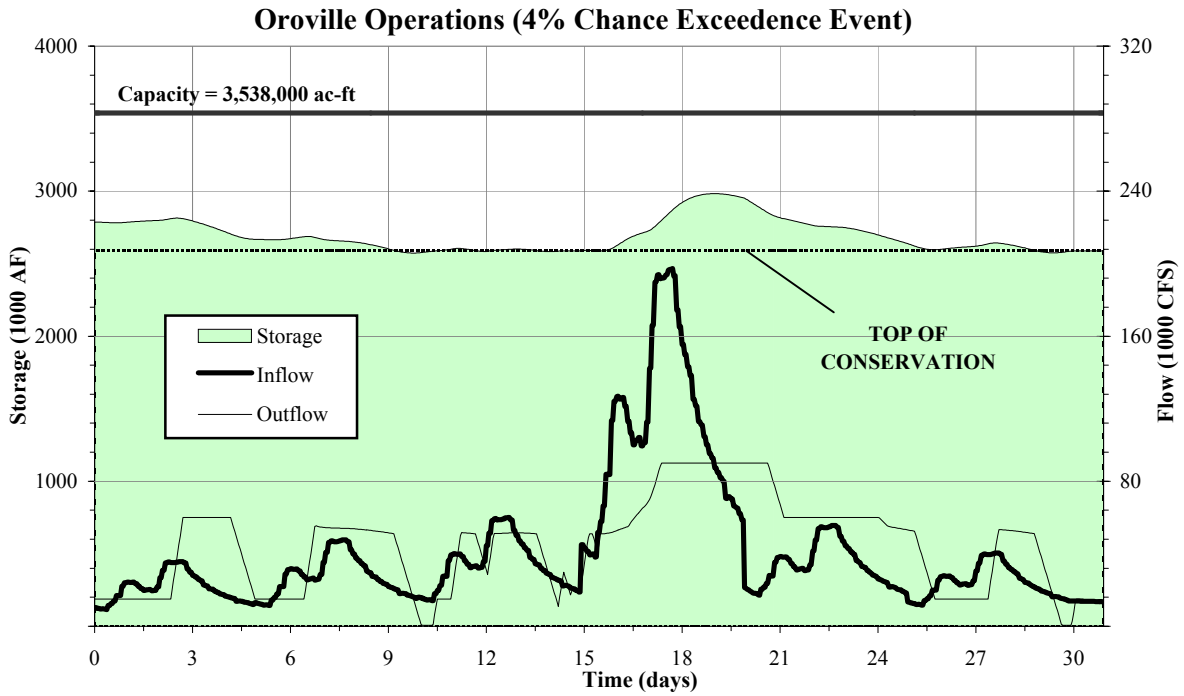
- 1) Flow at mainstem points are estimated by HEC-5, which assumes all flows remain in channel (bypasses were treated as channels).
Flows at mainstem points are taken "at latitude" (See Chapter III of Appendix B).
- 2) % Peak Reduced = ((Maximum Regulated Baseline Inflow)-(Maximum Regulated Alternative Inflow))/(Maximum Regulated Baseline Inflow) X 100%
- 3) Peak Attenuation = (Σ attenuated peak volume)*(0.08265 ac-ft/cfs)



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Figure C.4-4a
Reservoir Simulation Hydrographs
Alternative Scenario SAC-B04A

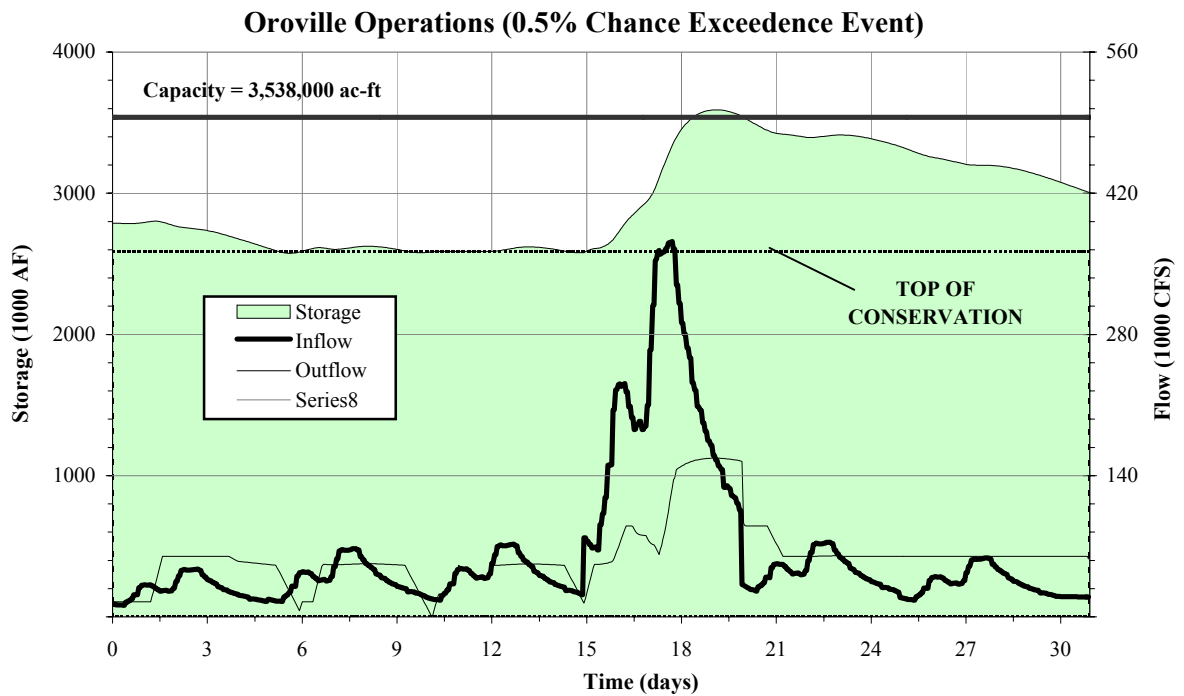
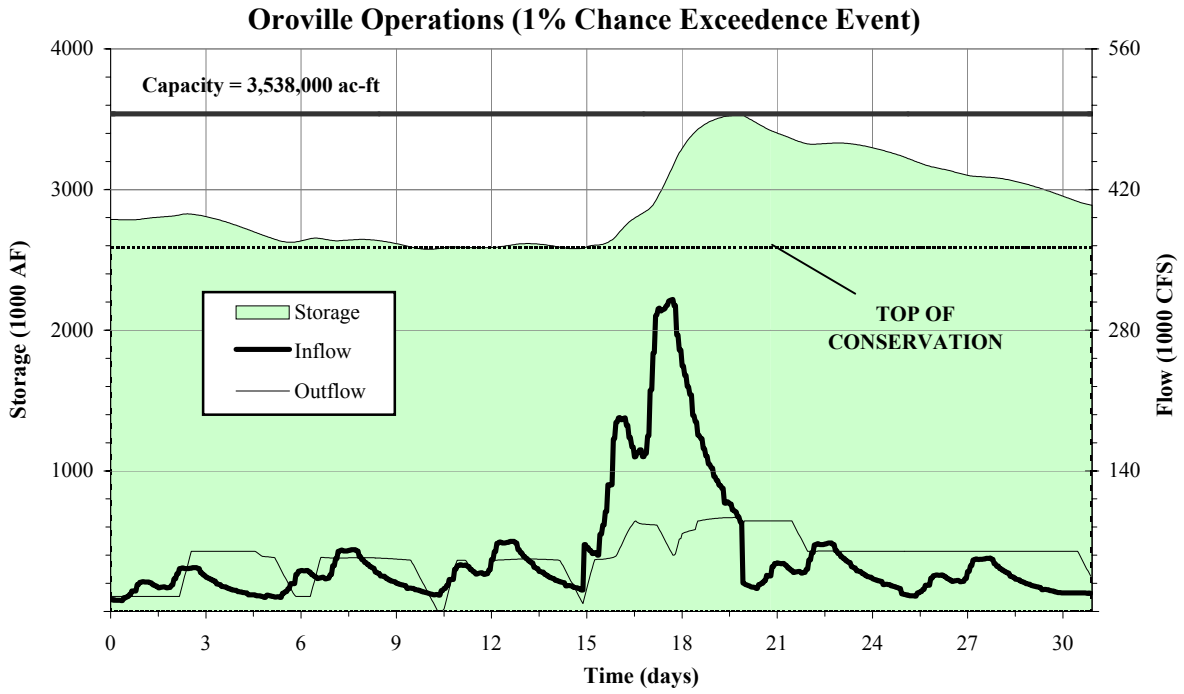
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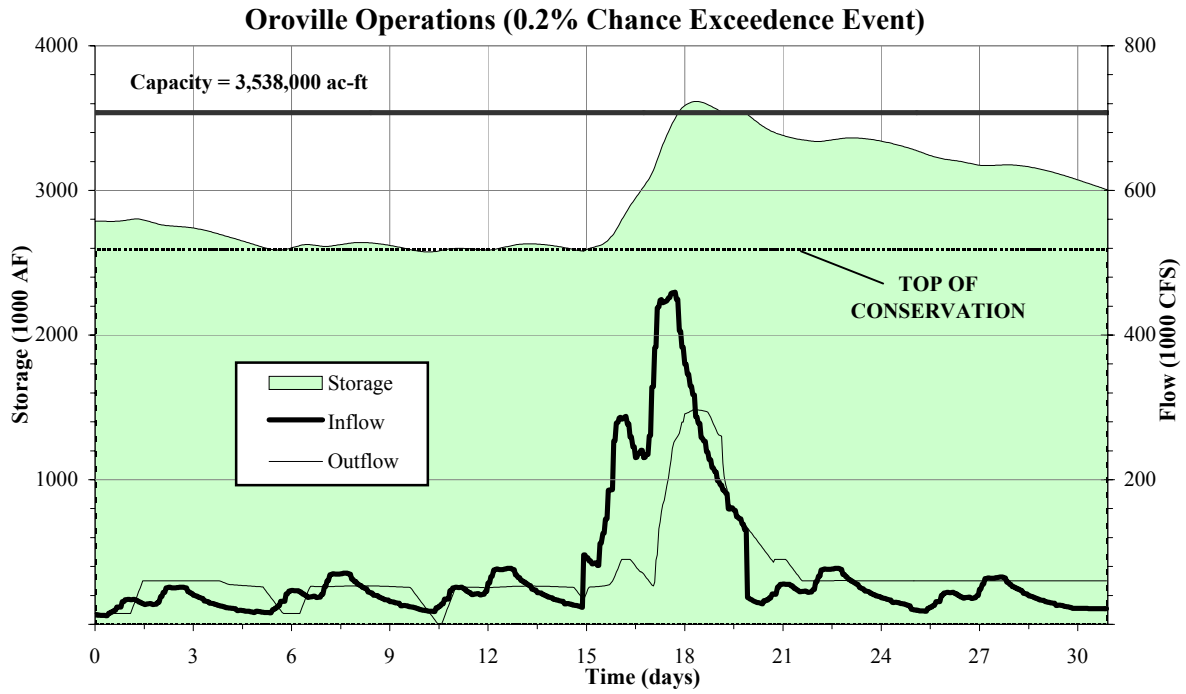
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Figure C.4-4b
Reservoir Simulation Hydrographs
Alternative Scenario SAC-B04A

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Figure C.4-4c Reservoir Simulation Hydrographs Alternative Scenario SAC-B04A
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Figure C.4-4d
Reservoir Simulation Hydrographs
Alternative Scenario SAC-B04A

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TABLE C.4-5a

COMPARISON OF MAXIMUM RELEASE OF BASELINE AND ALTERNATIVE SCENARIO (SJQ-B01A)
SIMULATIONS FOR SPECIFIC ANNUAL PERCENT CHANCE EXCEEDENCE EVENTS

	50% Chance Exceedence Event		10% Chance Exceedence Event		4% Chance Exceedence Event		2% Chance Exceedence Event		1% Chance Exceedence Event		0.5% Chance Exceedence Event		0.2% Chance Exceedence Event		
	Baseline	Alternative	Baseline	Alternative	Baseline	Alternative	Baseline	Alternative	Baseline	Alternative	Baseline	Alternative	Baseline	Alternative	
Friant Centering															
Friant															
Objective Flow:	8,000 cfs														
Flood Storage:	+170 TAF	3,032	2,445	7,971	8,000	9,001	8,000	25,481	8,000	71,093	10,627	108,585	53,938	139,402	124,309
New Exchequer															
Objective Flow:	6,000 cfs	1,976	1,976	1,976	1,976	3,080	3,080	5,478	5,478	5,766	5,766	5,768	5,768	21,381	21,381
Don Pedro															
Objective Flow:	9,000 to 11,000 cfs	3,903	3,052	3,903	3,052	5,894	4,328	9,000	7,633	9,000	9,000	9,000	9,000	42,291	9,000
Flood Storage:	+100 TAF														
New Exchequer Centering															
Friant															
Objective Flow:	8,000 cfs	2,163	2,069	6,785	4,996	7,985	7,987	8,366	8,000	15,006	8,000	51,568	9,982	110,315	57,578
Flood Storage:	+100 TAF														
New Exchequer															
Objective Flow:	6,000 cfs	3,080	3,080	5,766	5,766	5,769	5,769	21,381	21,381	45,533	45,533	81,574	81,574	141,306	141,306
Don Pedro															
Objective Flow:	9,000 to 11,000 cfs	3,903	3,052	8,604	7,416	8,738	8,738	9,000	9,000	38,874	9,000	80,647	9,000	139,910	49,581
Flood Storage:	+100 TAF														
Don Pedro Centering															
Friant															
Objective Flow:	8,000 cfs	2,163	2,069	5,346	3,253	8,000	7,237	8,000	8,000	8,630	8,000	30,749	8,000	92,384	24,321
Flood Storage:	+100 TAF														
New Exchequer															
Objective Flow:	6,000 cfs	1,976	1,976	5,077	5,077	5,766	5,766	5,769	5,769	6,617	6,617	35,028	35,028	83,919	83,919
Don Pedro															
Objective Flow:	9,000 to 11,000 cfs	5,894	4,328	8,737	8,737	9,000	8,738	39,630	9,000	80,821	9,000	126,377	37,443	185,449	105,141
Flood Storage:	+100 TAF														

	Maximum Baseline
	Maximum Alternative

TABLE C.4-5b
EFFECTS OF ALTERNATIVE SCENARIO SJQ-B01A

Friant Dam Storm Runoff Centering									
Percent Chance Exceedence	Index Gage Location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	19.4	8.8	0.0	7.1	21.8	11.3	7.3	6.1
	Peak Attenuation (AF)	2,563	2,970	0	2,946	24,437	24,427	27,584	27,578
10%	% Peak Reduced	-0.4	1.6	0.0	1.2	21.8	11.3	2.8	2.5
	Peak Attenuation (AF)	73	16,224	0	15,365	24,437	24,427	36,028	36,027
4%	% Peak Reduced	11.1	6.0	0.0	6.2	26.6	14.0	6.5	6.1
	Peak Attenuation (AF)	5,726	19,193	0	19,093	33,641	33,627	52,588	52,573
2%	% Peak Reduced	68.6	34.9	0.0	25.6	15.2	3.2	22.8	20.3
	Peak Attenuation (AF)	158,066	144,484	0	119,812	5,872	13,428	159,236	156,538
1%	% Peak Reduced	85.1	57.7	0.0	46.4	0.0	3.3	40.2	36.8
	Peak Attenuation (AF)	162,961	175,810	0	175,438	0	36,389	211,717	211,661
0.5%	% Peak Reduced	50.3	41.2	0.0	37.0	0.0	-2.0	33.5	30.9
	Peak Attenuation (AF)	171,767	212,405	0	212,217	638	-707	253,039	213,817
0.2%	% Peak Reduced	10.8	11.8	0.0	15.0	78.7	63.4	14.6	13.9
	Peak Attenuation (AF)	168,681	182,282	0	182,270	161,437	169,661	381,927	351,720

El Nido Storm Runoff Centering									
Percent Chance Exceedence	Index Gage Location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	9.9	2.3	0.0	1.9	23.1	11.6	3.8	3.2
	Peak Attenuation (AF)	874	461	0	5,072	25,585	25,575	25,980	25,971
10%	% Peak Reduced	0.0	2.1	0.0	1.1	16.4	0.0	3.8	3.3
	Peak Attenuation (AF)	8,386	16,863	0	16,745	21,061	28,933	36,466	36,376
4%	% Peak Reduced	0.9	5.7	0.0	3.2	1.9	4.7	2.4	1.8
	Peak Attenuation (AF)	2,240	23,007	0	22,769	83	35,678	61,102	60,110
2%	% Peak Reduced	44.0	21.8	0.0	16.3	0.0	3.7	12.7	10.8
	Peak Attenuation (AF)	75,157	128,642	0	104,316	786	61,067	33,546	81,006
1%	% Peak Reduced	79.5	51.0	0.0	36.3	71.5	52.5	32.4	29.4
	Peak Attenuation (AF)	14,115	173,143	0	172,796	120,696	120,095	290,203	290,082
0.5%	% Peak Reduced	68.0	47.2	0.0	25.3	86.9	78.5	24.9	23.8
	Peak Attenuation (AF)	182,081	199,020	0	198,914	256,665	295,476	492,239	492,190
0.2%	% Peak Reduced	34.7	18.4	0.0	8.8	73.1	73.5	7.9	7.8
	Peak Attenuation (AF)	172,598	198,523	0	198,522	305,610	314,776	513,242	513,201

	Maximum peak flow reduction %
	Maximum peak volume attenuation

Notes:

- 1) Flow at mainstem points are estimated by HEC-5, which assumes all flows remain in channel (bypasses were treated as channels).
Flows at mainstem points are taken "at latitude" (See Chapter III of Appendix B).
- 2) % Peak Reduced = ((Maximum Regulated Baseline Inflow)-(Maximum Regulated Alternative Inflow))/(Maximum Regulated Baseline Inflow) X 100%.
- 3) Peak Attenuation = (Σ attenuated peak volume)*(0.08265 ac-ft/cfs)

TABLE C.4-5b (CONT.)
EFFECTS OF ALTERNATIVE SCENARIO SJQ-B01A

Exchequer Storm Runoff Centering									
Percent Chance Exceedence	Index Gage Location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	4.4	0.7	0.0	0.0	21.8	11.3	7.2	6.1
	Peak Attenuation (AF)	262	163	0	60	24,437	24,427	24,424	24,421
10%	% Peak Reduced	26.4	19.6	0.0	11.2	13.8	12.9	10.4	9.0
	Peak Attenuation (AF)	14,092	14,367	0	14,309	51,579	51,559	65,770	65,754
4%	% Peak Reduced	0.0	2.4	0.0	1.0	0.0	0.2	0.8	1.2
	Peak Attenuation (AF)	3	11,602	0	14,592	0	37,902	11,381	11,342
2%	% Peak Reduced	4.4	3.9	0.0	1.7	0.0	2.7	0.2	0.2
	Peak Attenuation (AF)	4,281	25,900	0	25,784	477	40,834	11,313	11,173
1%	% Peak Reduced	46.7	21.1	0.0	1.8	76.8	66.0	13.5	12.7
	Peak Attenuation (AF)	68,893	121,714	0	96,265	134,895	134,440	221,336	218,996
0.5%	% Peak Reduced	80.6	52.0	0.0	1.2	88.8	81.8	18.7	18.2
	Peak Attenuation (AF)	159,920	172,981	0	172,642	281,136	287,199	455,409	455,259
0.2%	% Peak Reduced	47.8	37.2	0.0	0.9	64.6	64.2	6.2	6.3
	Peak Attenuation (AF)	172,260	212,145	0	211,975	304,600	340,016	551,938	551,910

Newman Storm Runoff Centering									
Percent Chance Exceedence	Index Gage Location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	7.1	3.5	0.0	-3.4	25.4	-15.3	-5.9	-5.1
	Peak Attenuation (AF)	505	578	0	-3,536	28,582	-4,556	-16,350	-16,348
10%	% Peak Reduced	13.1	5.7	0.0	-17.4	11.0	-59.0	-12.0	-10.6
	Peak Attenuation (AF)	643	14,845	0	-33,360	3,621	-57,814	-104,349	-104,332
4%	% Peak Reduced	0.0	0.0	0.0	-19.3	0.0	-27.9	-30.7	-24.0
	Peak Attenuation (AF)	1,228	3,383	0	-68,936	1.60	-154,446	-249,330	-246,833
2%	% Peak Reduced	27.1	16.2	0.0	15.8	58.7	27.6	2.7	1.8
	Peak Attenuation (AF)	61,659	114,310	0	45,544	65,547	8,543	2,411	3,523
1%	% Peak Reduced	79.0	44.2	0.0	5.6	85.3	22.8	5.7	5.2
	Peak Attenuation (AF)	142,437	187,258	0	13,058	232,247	40,543	52,559	52,073
0.5%	% Peak Reduced	76.7	51.0	0.0	2.1	74.4	15.3	2.8	2.7
	Peak Attenuation (AF)	175,295	184,246	0	10,188	304,183	44,580	51,453	50,870
0.2%	% Peak Reduced	44.1	21.1	0.0	1.9	58.7	8.9	2.4	2.2
	Peak Attenuation (AF)	177,341	180,318	0	108,510	308,237	44,876	137,306	136,646

	Maximum peak flow reduction %
	Maximum peak volume attenuation

Notes:

- 1) Flow at mainstem points are estimated by HEC-5, which assumes all flows remain in channel (bypasses were treated as channels).
Flows at mainstem points are taken "at latitude" (See Chapter III of Appendix B).
- 2) % Peak Reduced = ((Maximum Regulated Baseline Inflow)-(Maximum Regulated Alternative Inflow))/(Maximum Regulated Baseline Inflow) X 100%.
- 3) Peak Attenuation = (Σ attenuated peak volume)*(0.08265 ac-ft/cfs)

TABLE C.4-5b (CONT.)
EFFECTS OF ALTERNATIVE SCENARIO SJQ-B01A

Don Pedro Storm Runoff Centering									
Percent Chance Exceedence	Index Gage Location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	4.4	0.7	0.0	0.0	26.6	22.2	11.8	10.1
	Peak Attenuation (AF)	262	163	0	0	33,641	33,627	33,623	33,618
10%	% Peak Reduced	39.1	26.7	0.0	14.4	0.0	0.7	8.5	6.8
	Peak Attenuation (AF)	8,710	8,468	0	8,434	0	38,199	13,065	12,690
4%	% Peak Reduced	6.5	8.0	0.0	4.8	2.9	1.1	3.8	3.7
	Peak Attenuation (AF)	5,183	16,212	0	16,117	1,192	1,481	12,190	52,966
2%	% Peak Reduced	0.0	0.0	0.0	0.2	77.3	71.8	42.8	36.7
	Peak Attenuation (AF)	0	0	0	12,029	131,820	172,536	184,432	184,255
1%	% Peak Reduced	7.3	8.8	0.0	4.3	88.9	83.6	60.9	55.7
	Peak Attenuation (AF)	3,564	37,853	0	37,669	280,147	286,454	323,125	323,078
0.5%	% Peak Reduced	74.0	37.1	0.0	2.0	70.4	70.6	38.9	36.2
	Peak Attenuation (AF)	109,503	162,329	0	138,019	306,851	306,664	435,224	432,681
0.2%	% Peak Reduced	73.7	52.5	0.0	1.2	43.3	46.0	18.0	14.5
	Peak Attenuation (AF)	182,260	195,327	0	195,185	311,535	311,350	505,738	505,677

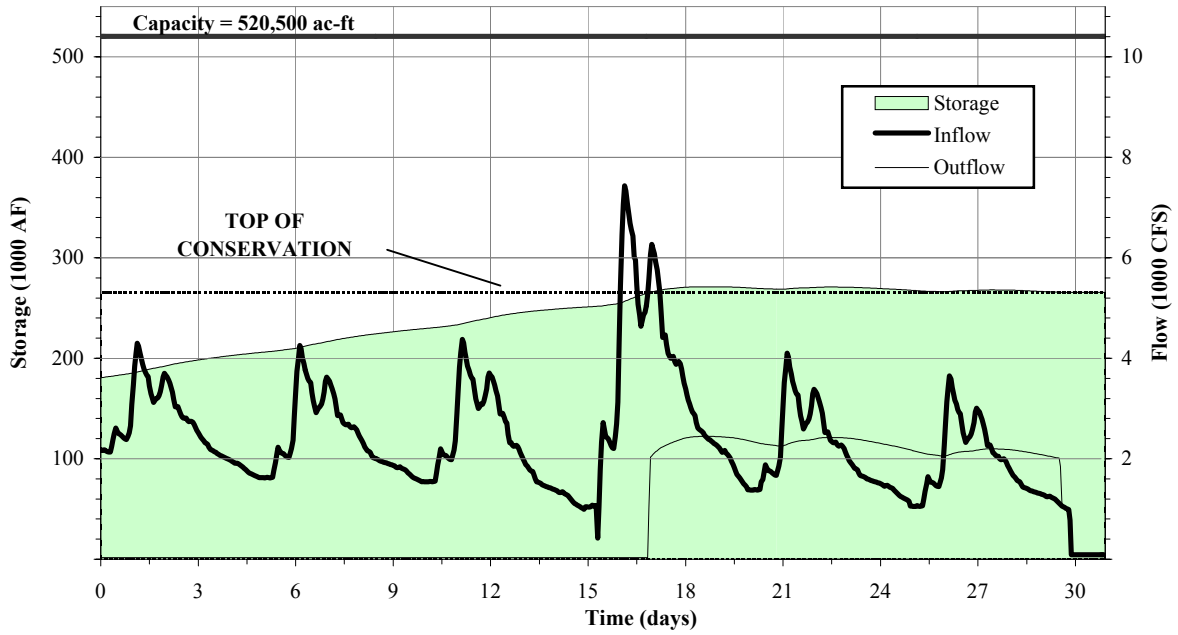
Vernalis Storm Runoff Centering									
Percent Chance Exceedence	Index Gage Location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	6.6	3.5	0.0	0.0	26.2	13.2	9.5	8.3
	Peak Attenuation (AF)	453	332	0	0	30,752	30,745	30,741	30,737
10%	% Peak Reduced	18.4	10.9	0.0	5.7	4.2	2.2	4.8	4.0
	Peak Attenuation (AF)	596	14,927	0	14,903	484	35,164	54,655	54,241
4%	% Peak Reduced	0.0	0.0	0.0	1.8	0.0	3.9	2.9	2.3
	Peak Attenuation (AF)	0	0	0	11,508	726	40,001	52,853	52,810
2%	% Peak Reduced	7.7	9.6	0.0	6.2	71.6	52.6	28.6	24.5
	Peak Attenuation (AF)	29,350	88,963	0	63,879	120,897	120,296	174,615	172,180
1%	% Peak Reduced	74.8	35.2	0.0	9.7	87.3	79.0	30.5	28.1
	Peak Attenuation (AF)	114,312	170,616	0	146,555	239,380	302,465	439,269	436,385
0.5%	% Peak Reduced	85.2	55.3	0.0	1.3	76.5	74.2	14.3	12.3
	Peak Attenuation (AF)	167,066	180,077	0	179,976	305,120	314,120	439,984	439,912
0.2%	% Peak Reduced	46.0	24.8	0.0	0.7	49.6	52.0	3.2	3.5
	Peak Attenuation (AF)	172,680	178,496	0	177,710	310,713	321,746	499,276	517,540

	Maximum peak flow reduction %
	Maximum peak volume attenuation

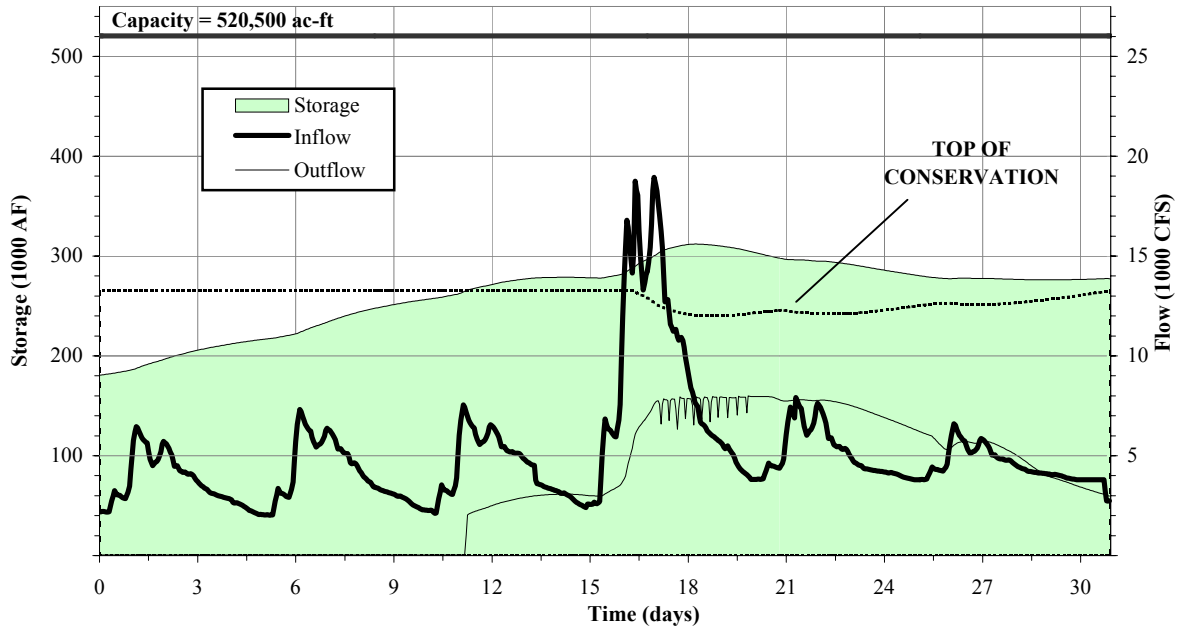
Notes:

- 1) Flow at mainstem points are estimated by HEC-5, which assumes all flows remain in channel (bypasses were treated as channels).
Flows at mainstem points are taken "at latitude" (See Chapter III of Appendix B).
- 2) % Peak Reduced = ((Maximum Regulated Baseline Inflow)-(Maximum Regulated Alternative Inflow))/(Maximum Regulated Baseline Inflow) X 100%.
- 3) Peak Attenuation = (Σ attenuated peak volume)*(0.08265 ac-ft/cfs)

Friant Operations (50% Chance Exceedence Event)



Friant Operations (10% Chance Exceedence Event)

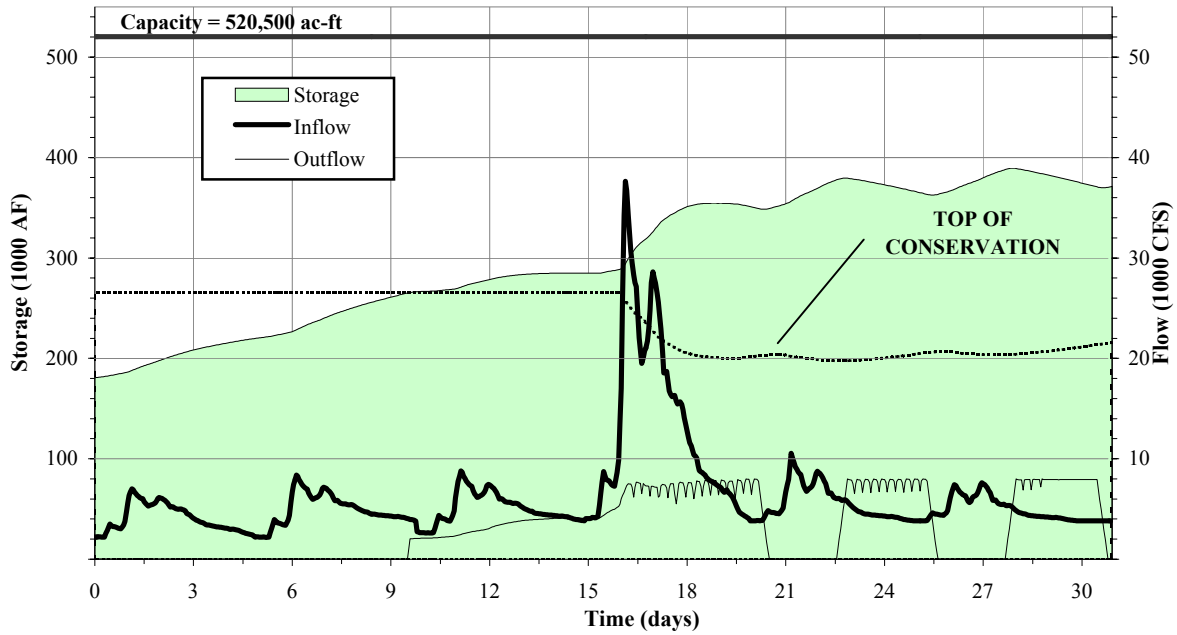


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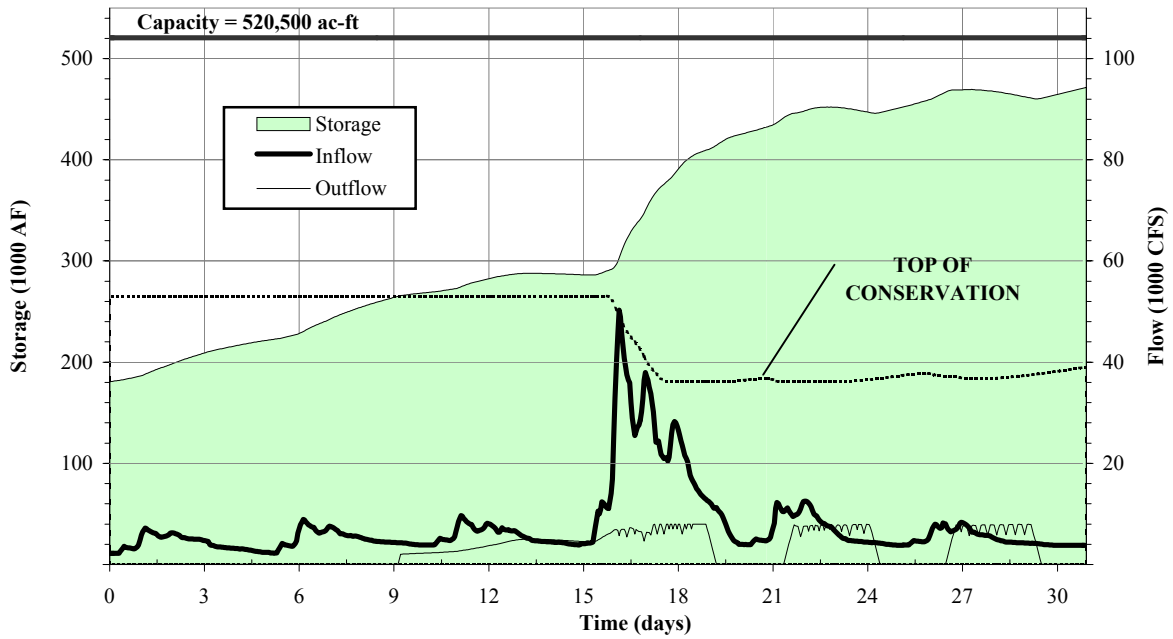
Figure C.4-5a
Reservoir Simulation Hydrographs
Alternative Scenario SJQ-B01A

US Army Corps of Engineers
The Reclamation Board, State of California December 2002

Friant Operations (4% Chance Exceedence Event)



Friant Operations (2% Chance Exceedence Event)

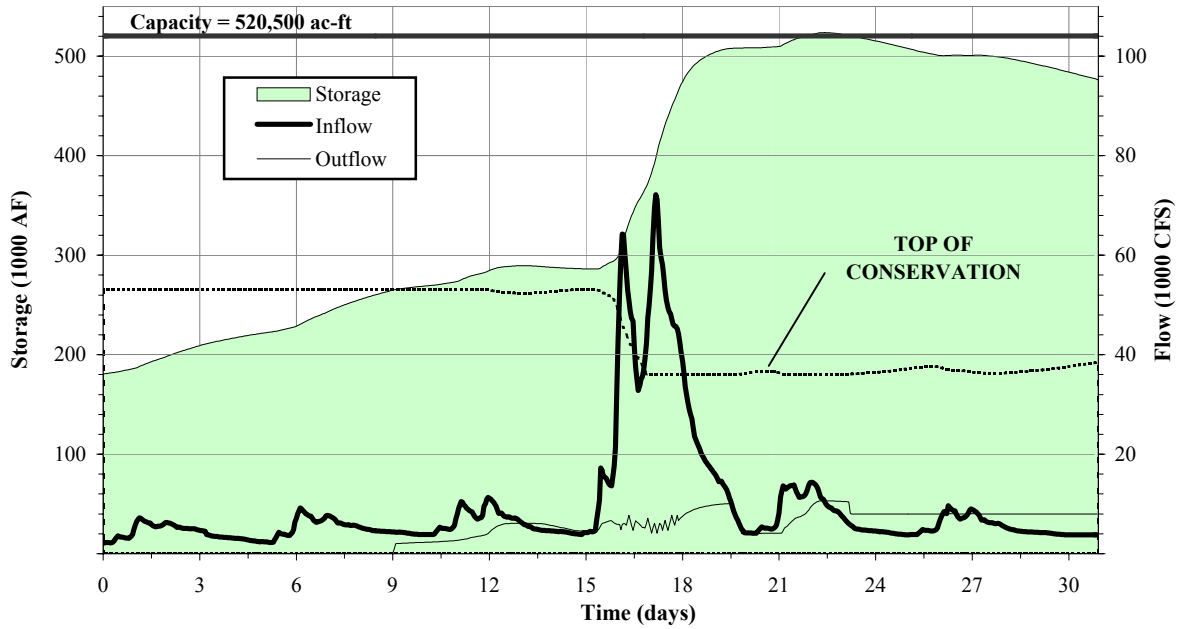


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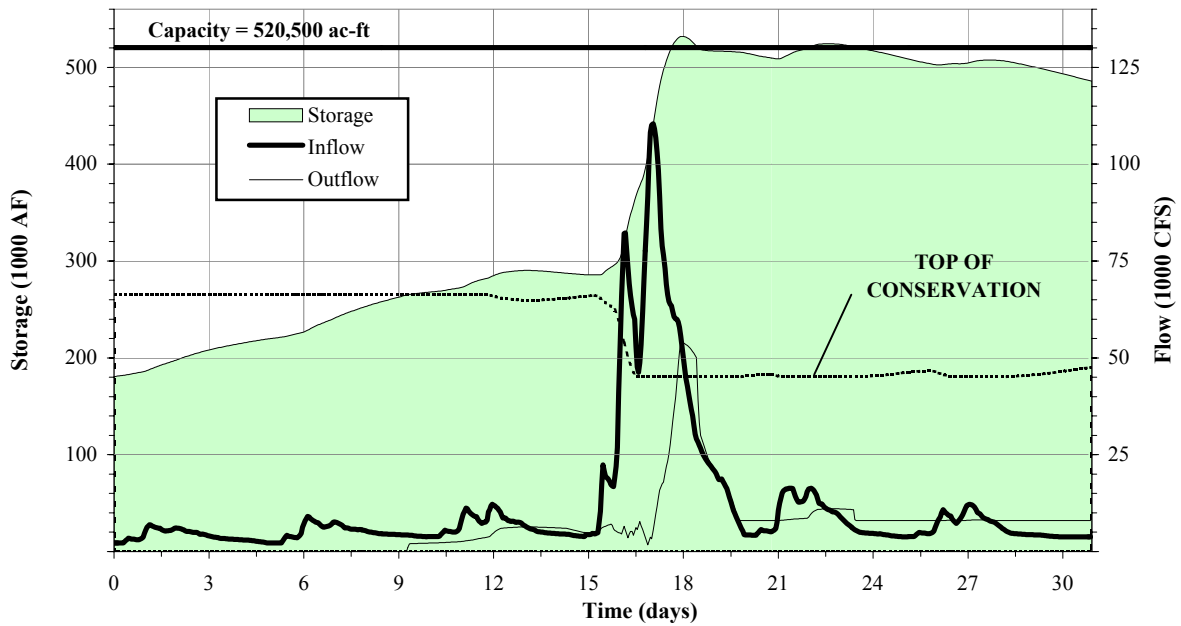
Figure C.4-5b
Reservoir Simulation Hydrographs
Alternative Scenario SJQ-B01A

US Army Corps of Engineers
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Friant Operations (1% Chance Exceedence Event)



Friant Operations (0.5% Chance Exceedence Event)

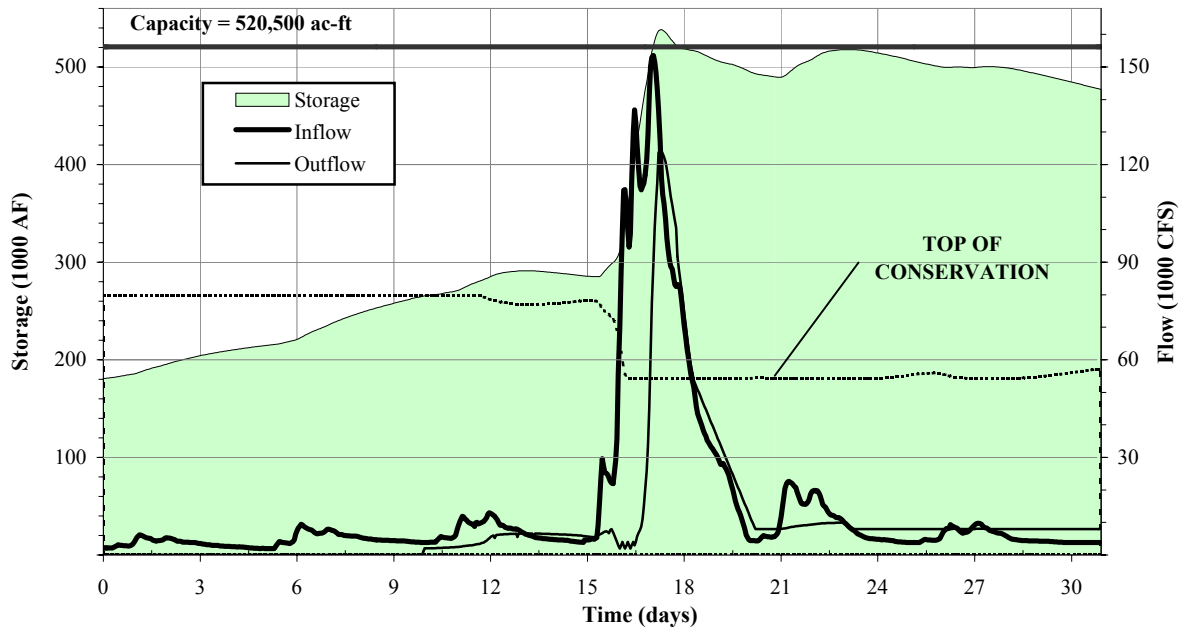


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Figure C.4-5c
Reservoir Simulation Hydrographs
Alternative Scenario SJQ-B01A

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Friant Operations (0.2% Chance Exceedence Event)

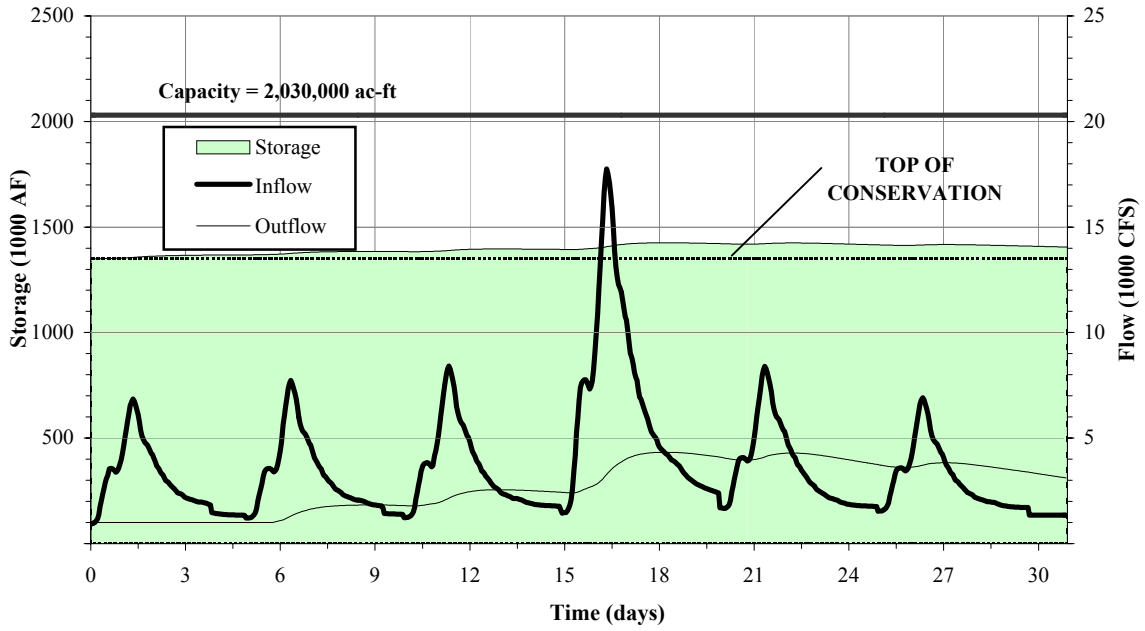


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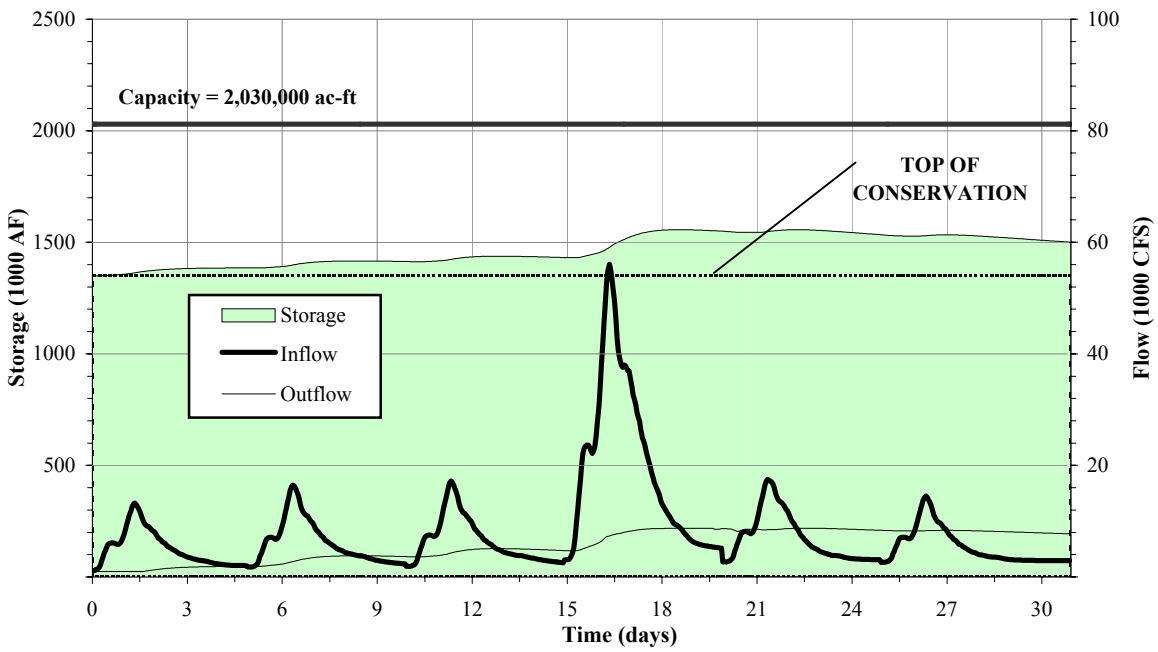
Figure C.4-5d
Reservoir Simulation Hydrographs
Alternative Scenario SJQ-B01A

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Don Pedro Operations (50% Chance Exceedence Event)



Don Pedro Operations (10% Chance Exceedence Event)

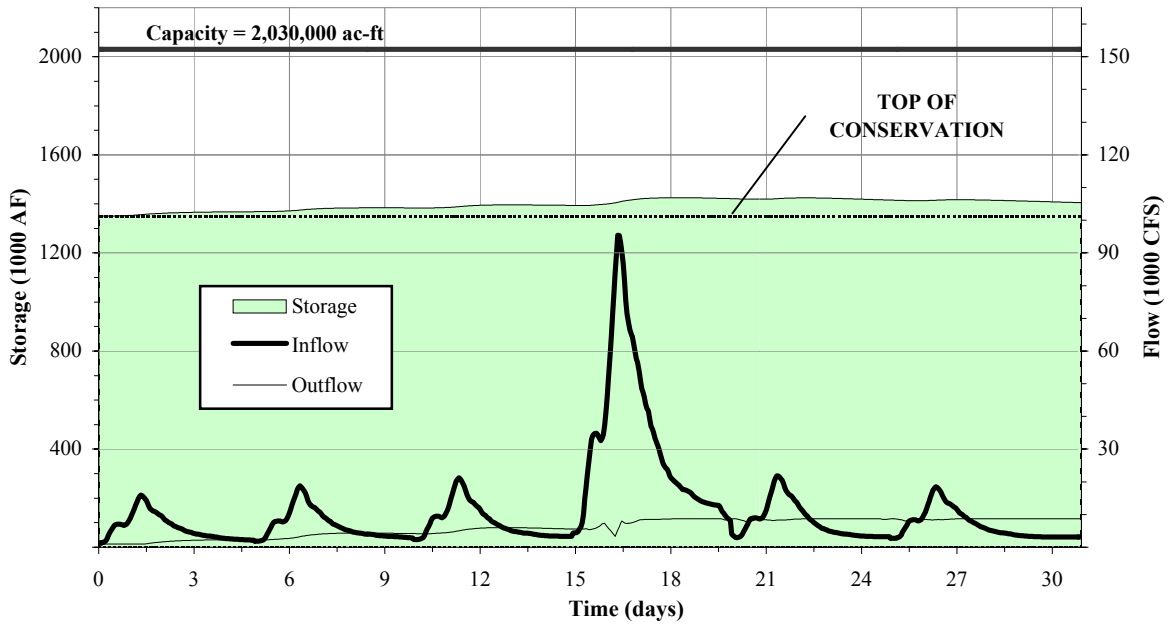


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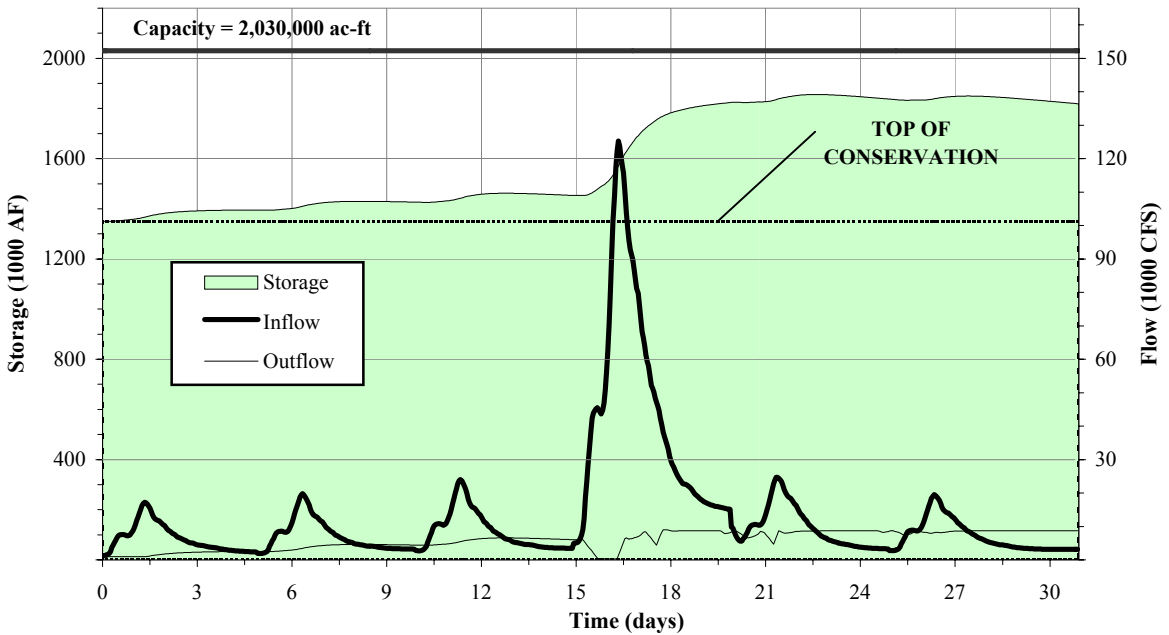
Figure C.4-5e
Reservoir Simulation Hydrographs
Alternative Scenario SJQ-B01A

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Don Pedro Operations (4% Chance Exceedence Event)



Don Pedro Operations (2% Chance Exceedence Event)

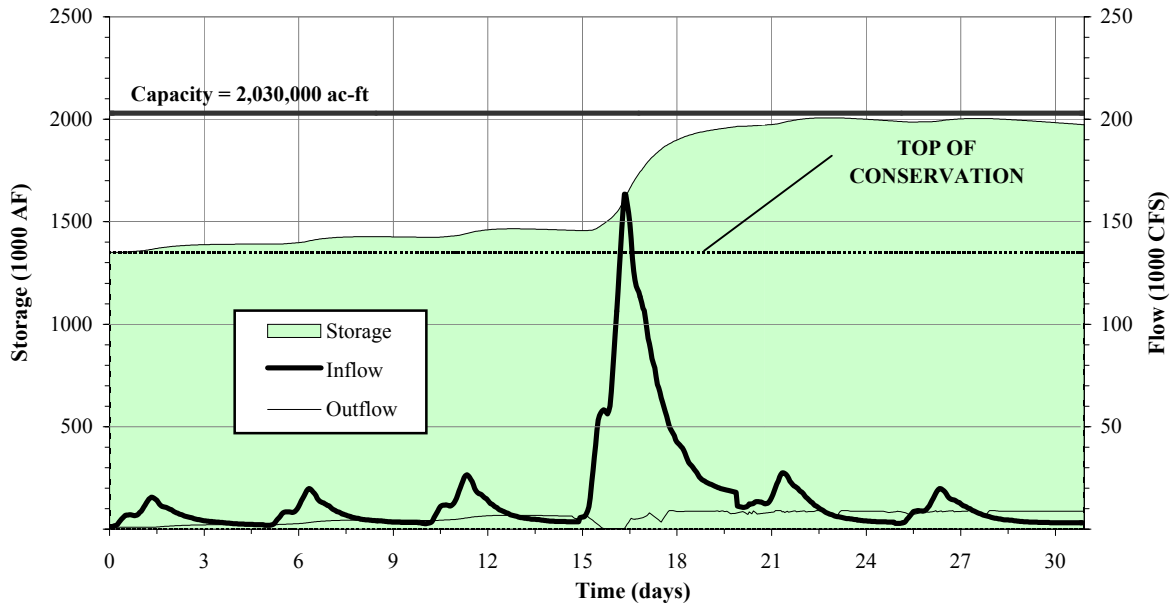


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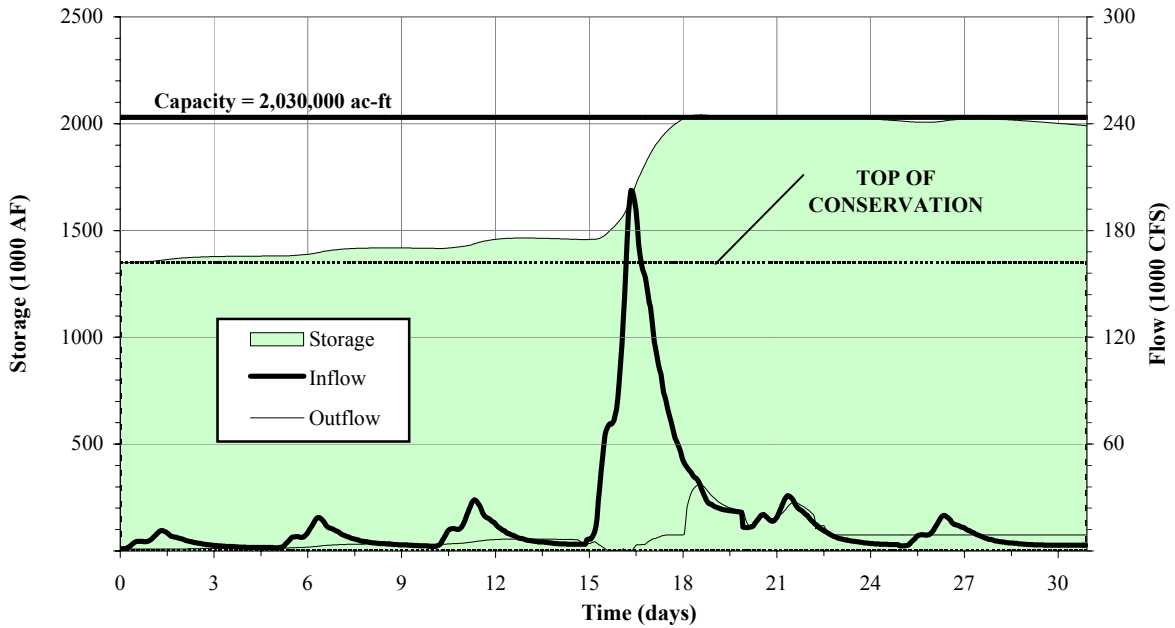
Figure C.4-5f
Reservoir Simulation Hydrographs
Alternative Scenario SJQ-B01A

US Army Corps of Engineers
The Reclamation Board, State of California December 2002

Don Pedro Operations (1% Chance Exceedence Event)



Don Pedro Operations (0.5% Chance Exceedence Event)

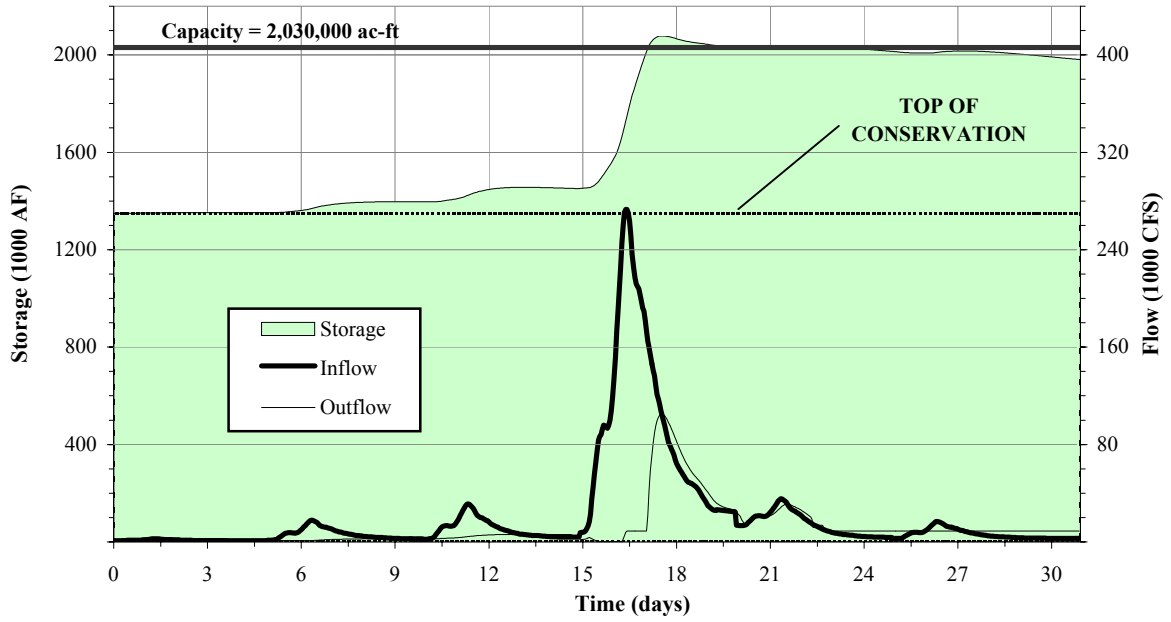


Sacramento & San Joaquin River Basins
Comprehensive Study

Figure C.4-5g
Reservoir Simulation Hydrographs
Alternative Scenario SJQ-B01A

US Army Corps of Engineers
The Reclamation Board, State of California December 2002

Don Pedro Operations (0.2% Chance Exceedence Event)



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Comprehensive Study

Figure C.4-5h
Reservoir Simulation Hydrographs
Alternative Scenario SJQ-B01A

US Army Corps of Engineers
The Reclamation Board, State of California December 2002

TABLE C.4-6a

COMPARISON OF MAXIMUM RELEASE OF BASELINE AND ALTERNATIVE SCENARIO (SJQ-B02A)
SIMULATIONS FOR SPECIFIC ANNUAL PERCENT CHANCE EXCEEDENCE EVENTS

	50% Chance Exceedence Event		10% Chance Exceedence Event		4% Chance Exceedence Event		2% Chance Exceedence Event		1% Chance Exceedence Event		0.5% Chance Exceedence Event		0.2% Chance Exceedence Event	
	Baseline	Alternative	Baseline	Alternative	Baseline	Alternative	Baseline	Alternative	Baseline	Alternative	Baseline	Alternative	Baseline	Alternative
Friant Centering														
Friant														
Objective Flow: 8,000 cfs														
Flood Storage: +100 TAF	3,032	2,577	7,971	7,991	9,001	8,000	25,481	8,216	71,093	29,012	108,585	66,039	139,402	137,960
New Exchequer														
Objective Flow: 6,000 cfs														
Flood Storage: +50 TAF	1,976	1,870	1,976	1,870	3,080	2,899	5,478	5,263	5,766	5,766	5,768	5,768	21,381	5,764
Don Pedro														
Objective Flow: 9,000 to 11,000 cfs														
Flood Storage: +100 TAF	3,903	3,813	3,903	3,813	5,894	5,758	9,000	9,757	9,000	11,000	9,000	11,000	42,291	18,426
New Exchequer Centering														
Friant														
Objective Flow: 8,000 cfs														
Flood Storage: +100 TAF	2,163	2,090	6,785	6,003	7,985	8,000	8,366	8,000	15,006	8,000	51,568	18,107	110,315	70,868
New Exchequer														
Objective Flow: 6,000 cfs														
Flood Storage: +50 TAF	3,080	2,899	5,766	5,766	5,769	5,769	21,381	5,764	45,533	27,047	81,574	69,099	141,306	125,306
Don Pedro														
Objective Flow: 9,000 to 11,000 cfs														
Flood Storage: +100 TAF	3,903	3,813	8,604	9,486	8,738	10,717	9,000	10,826	38,874	11,000	80,647	46,480	139,910	109,064
Don Pedro Centering														
Friant														
Objective Flow: 8,000 cfs														
Flood Storage: +100 TAF	2,163	2,090	5,346	3,802	8,000	7,930	8,000	8,000	8,630	8,000	30,749	8,790	92,384	51,041
New Exchequer														
Objective Flow: 6,000 cfs														
Flood Storage: +50 TAF	1,976	1,870	5,077	4,809	5,766	5,766	5,769	5,769	6,617	5,763	35,028	26,058	83,919	71,911
Don Pedro														
Objective Flow: 9,000 to 11,000 cfs														
Flood Storage: +100 TAF	5,894	5,758	8,737	10,717	9,000	10,717	39,630	11,000	80,821	47,498	126,377	93,048	185,449	162,416

	Maximum Baseline
	Maximum Alternative

TABLE C.4-6b
EFFECTS OF ALTERNATIVE SCENARIO SJQ-B02A

Friant Dam Storm Runoff Centering									
Percent Chance Exceedence	Index Gage Location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	15	6.2	5.4	6.0	2.3	1.8	4.0	3.4
	Peak Attenuation (AF)	1,894	2,020	1,857	3,791	3,161	3,150	6,837	6,832
10%	% Peak Reduced	-0.2	0.6	5.4	0.8	2.3	1.8	0.8	0.7
	Peak Attenuation (AF)	-3	7,379	1,857	9,275	3,161	3,150	12,359	12,356
4%	% Peak Reduced	11.1	6.0	5.9	6.5	2.3	1.8	5.4	5.0
	Peak Attenuation (AF)	5,726	13,738	3,219	31,188	3,495	3,462	34,235	34,109
2%	% Peak Reduced	67.8	34.9	3.9	26.1	-8.4	-18.3	19.5	17.2
	Peak Attenuation (AF)	87,100	118,687	6,658	111,286	-21,610	-21,567	102,454	100,064
1%	% Peak Reduced	59.2	39.5	0.0	31.2	-22.2	-3.2	24.1	22.0
	Peak Attenuation (AF)	102,790	107,203	0	108,982	-52,092	-51,761	80,987	80,684
0.5%	% Peak Reduced	39.2	25.9	0.0	21.7	-22.2	-8.8	17.6	16.1
	Peak Attenuation (AF)	105,836	133,156	0	137,457	-21,400	-57,542	99,556	99,358
0.2%	% Peak Reduced	1.0	6.1	73.0	11.7	56.4	55.6	10.1	9.8
	Peak Attenuation (AF)	109,515	117,816	31,925	153,001	96,401	107,785	239,850	239,685

El Nido Storm Runoff Centering									
Percent Chance Exceedence	Index Gage Location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	7.6	1.6	5.8	2.3	2.2	1.8	1.5	1.2
	Peak Attenuation (AF)	658	349	2,153	2,440	3,168	3,156	5,549	5,540
10%	% Peak Reduced	0.0	1.2	3.3	1.4	-6.2	-22.1	2.0	1.2
	Peak Attenuation (AF)	3,687	10,339	4,436	16,905	-15,072	-16,003	19,349	18,984
4%	% Peak Reduced	0.9	5.6	0.0	3.2	-22.2	-10.3	-2.7	-3.7
	Peak Attenuation (AF)	1,937	9,588	0	21,095	-50,297	-50,243	-31,948	-31,894
2%	% Peak Reduced	43.2	21.4	0.0	16.1	-22.2	-4.2	8.4	7.1
	Peak Attenuation (AF)	73,729	118,463	0	103,236	-18,564	-1,459	48,227	48,072
1%	% Peak Reduced	61.2	35.5	53.9	33.0	65.2	48.6	26.4	23.7
	Peak Attenuation (AF)	100,106	103,101	14,119	120,161	65,817	82,733	191,058	190,860
0.5%	% Peak Reduced	44.6	29.3	24.9	20.7	46.4	46.6	17.5	16.4
	Peak Attenuation (AF)	107,494	125,080	49,381	114,744	108,764	108,414	263,071	262,893
0.2%	% Peak Reduced	1.9	9.1	15.2	10.0	27.0	27.1	9.8	9.0
	Peak Attenuation (AF)	109,943	119,410	53,316	170,375	104,111	105,833	253,509	253,457

	Maximum peak flow reduction %
	Maximum peak volume attenuation

Notes:

- 1) Flow at mainstem points are estimated by HEC-5, which assumes all flows remain in channel (bypasses were treated as channels).
Flows at mainstem points are taken "at latitude" (See Chapter III of Appendix B).
- 2) % Peak Reduced = ((Maximum Regulated Baseline Inflow)-(Maximum Regulated Alternative Inflow))/(Maximum Regulated Baseline Inflow) X 100%.
- 3) Peak Attenuation = (Σ attenuated peak volume)*(0.08265 ac-ft/cfs)

TABLE C.4-6b (CONT.)
EFFECTS OF ALTERNATIVE SCENARIO SJQ-B02A

Exchequer Storm Runoff Centering									
Percent Chance Exceedence	Index Gage Location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	3.4	0.5	5.9	3.1	2.3	1.8	2.5	2.1
	Peak Attenuation (AF)	201	126	3,219	3,218	3,161	3,150	6,278	6,273
10%	% Peak Reduced	11.5	10.9	0.0	6.2	-10.3	-10.8	4.0	3.1
	Peak Attenuation (AF)	8,681	8,260	0	8,499	-9,716	-9,627	13,044	13,018
4%	% Peak Reduced	-0.2	1.3	0.0	0.6	-22.7	-22.0	-5.5	-4.2
	Peak Attenuation (AF)	-91	7,627	0	12,203	-54,765	-53,844	-44,648	-44,214
2%	% Peak Reduced	4.4	3.8	73.0	31.5	-20.3	-9.1	20.0	16.7
	Peak Attenuation (AF)	12,344	20,725	31,925	49,989	-18,941	-54,662	22,629	22,422
1%	% Peak Reduced	46.7	21.1	40.6	21.2	71.7	62.9	26.1	24.0
	Peak Attenuation (AF)	68,925	113,682	52,002	140,123	77,961	98,975	207,807	207,652
0.5%	% Peak Reduced	64.9	36.4	15.3	9.7	42.4	41.4	11.0	10.7
	Peak Attenuation (AF)	100,457	104,185	53,418	153,397	105,732	108,927	245,976	245,644
0.2%	% Peak Reduced	35.8	23.8	11.3	6.4	22.0	22.6	8.1	7.5
	Peak Attenuation (AF)	105,457	137,705	57,079	57,897	105,734	107,548	163,570	163,092

Newman Storm Runoff Centering									
Percent Chance Exceedence	Index Gage Location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	5.5	2.6	6.2	2.6	2.2	1.7	2.1	1.8
	Peak Attenuation (AF)	384	288	2,816	3,013	3,256	3,235	5,951	5,944
10%	% Peak Reduced	3.9	2.9	0.0	1.3	-14.9	-16.7	-0.7	-0.8
	Peak Attenuation (AF)	459	5,318	0	11,989	-28,719	-28,695	-22,773	-22,738
4%	% Peak Reduced	0.0	0.0	0.0	-0.2	-22.2	-5.8	-5.4	-4.3
	Peak Attenuation (AF)	1,506	0	0	-163	-57,498	-55,273	-41,952	-40,869
2%	% Peak Reduced	27.1	16.2	61.3	28.1	49.6	30.6	18.7	15.8
	Peak Attenuation (AF)	61,625	108,675	20,582	109,913	17,545	35,630	111,525	111,397
1%	% Peak Reduced	75.6	40.1	38.0	21.4	51.5	52.2	21.5	19.6
	Peak Attenuation (AF)	95,428	103,273	50,543	60,559	108,742	108,365	163,601	163,239
0.5%	% Peak Reduced	44.7	29.9	15.5	10.1	34.6	34.5	11.4	11.0
	Peak Attenuation (AF)	104,433	109,191	52,458	159,495	106,922	108,653	253,113	252,835
0.2%	% Peak Reduced	16.7	13.3	11.8	7.4	18.1	20.0	8.9	8.3
	Peak Attenuation (AF)	99,501	103,783	57,140	214,288	104,988	106,804	302,766	302,680

	Maximum peak flow reduction %
	Maximum peak volume attenuation

Notes:

- 1) Flow at mainstem points are estimated by HEC-5, which assumes all flows remain in channel (bypasses were treated as channels).
Flows at mainstem points are taken "at latitude" (See Chapter III of Appendix B).
- 2) % Peak Reduced = ((Maximum Regulated Baseline Inflow)-(Maximum Regulated Alternative Inflow))/(Maximum Regulated Baseline Inflow) X 100%.
- 3) Peak Attenuation = (Σ attenuated peak volume)*(0.08265 ac-ft/cfs)

TABLE C.4-6b (CONT.)
EFFECTS OF ALTERNATIVE SCENARIO SJQ-B02A

Don Pedro Storm Runoff Centering									
Percent Chance Exceedence	Index Gage Location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	3.4	0.5	5.4	2.1	2.3	2.0	1.9	1.6
	Peak Attenuation (AF)	201	126	1,857	1,856	3,495	3,462	5,228	5,218
10%	% Peak Reduced	28.9	20.4	5.3	12.2	-22.7	-22.1	-2.9	-2.3
	Peak Attenuation (AF)	6,302	6,022	6,156	11,896	-42,362	-42,280	-33,175	-32,945
4%	% Peak Reduced	0.9	2.5	0.0	1.5	-19.1	-20.6	-5.8	-4.0
	Peak Attenuation (AF)	3,888	9,701	0	9,277	-62,582	-59,213	-49,008	-47,364
2%	% Peak Reduced	0.0	0.0	0.0	0.1	72.2	67.5	39.2	33.6
	Peak Attenuation (AF)	0	0	0	12,288	77,843	76,816	104,602	104,503
1%	% Peak Reduced	7.3	8.9	12.9	4.3	41.2	40.2	27.4	25.1
	Peak Attenuation (AF)	3,564	32,339	2,165	37,078	102,517	105,524	113,110	114,360
0.5%	% Peak Reduced	71.4	37.1	25.6	17.7	26.4	26.6	21.5	20.2
	Peak Attenuation (AF)	98,249	106,370	49,410	60,524	108,236	109,593	164,778	164,524
0.2%	% Peak Reduced	44.8	32.7	14.3	9.3	12.4	14.2	12.9	11.0
	Peak Attenuation (AF)	105,158	123,626	53,536	174,036	105,800	107,725	263,202	262,982

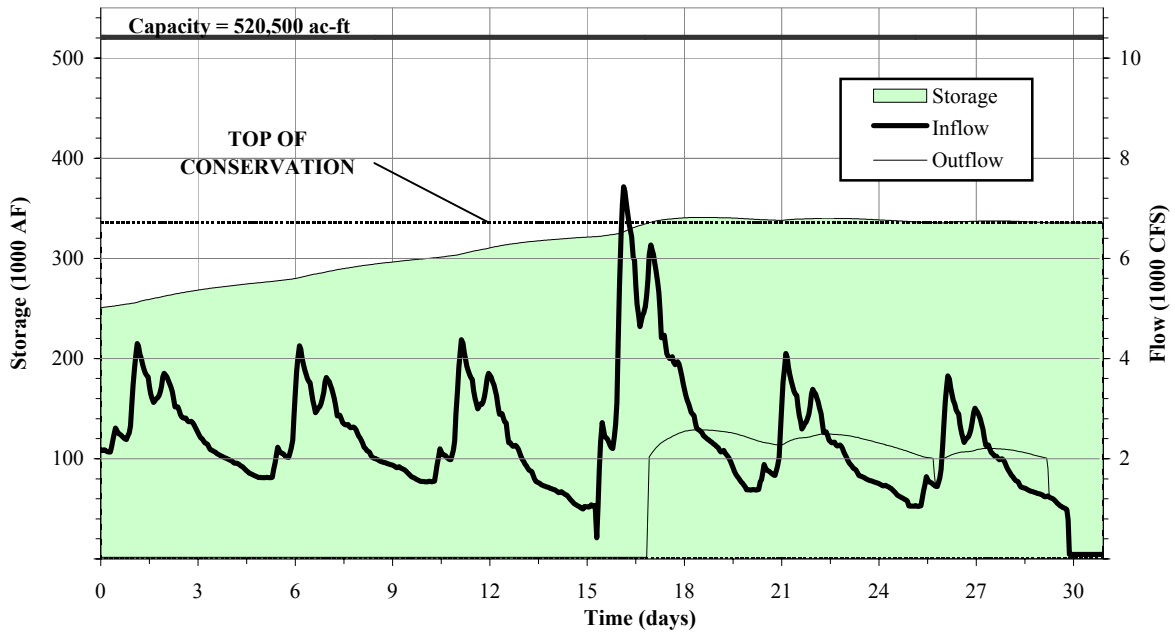
Vernalis Storm Runoff Centering									
Percent Chance Exceedence	Mainstem gage location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	5.1	2.7	6.1	2.5	2.3	1.7	2.0	1.8
	Peak Attenuation (AF)	345	253	2,544	2,709	3,346	3,320	5,759	5,750
10%	% Peak Reduced	11.8	5.8	0.0	3.0	-22.2	-4.9	-4.1	-3.5
	Peak Attenuation (AF)	387	8,945	0	12,565	-41,508	-42,109	-32,180	-32,152
4%	% Peak Reduced	0.0	0.0	0.0	0.5	-22.2	-4.2	-3.1	-2.6
	Peak Attenuation (AF)	0	0	0	11,709	-20,093	-1,388	-45,862	-44,525
2%	% Peak Reduced	7.7	9.6	0.0	6.2	65.3	48.7	21.9	18.9
	Peak Attenuation (AF)	29,350	83,691	0	62,845	65,793	82,912	114,835	114,658
1%	% Peak Reduced	71.3	35.2	18.3	17.4	45.4	45.3	28.4	26.1
	Peak Attenuation (AF)	95,384	104,372	49,282	93,481	108,905	108,511	164,093	237,446
0.5%	% Peak Reduced	51.7	34.1	18.9	12.3	29.6	29.5	14.6	11.9
	Peak Attenuation (AF)	104,171	108,234	52,712	157,046	104,140	105,980	248,923	248,718
0.2%	% Peak Reduced	25.5	14.7	12.3	7.8	13.3	16.2	9.7	9.0
	Peak Attenuation (AF)	102,269	113,707	57,027	169,690	105,295	107,184	265,465	265,312

	Maximum peak flow reduction %
	Maximum peak volume attenuation

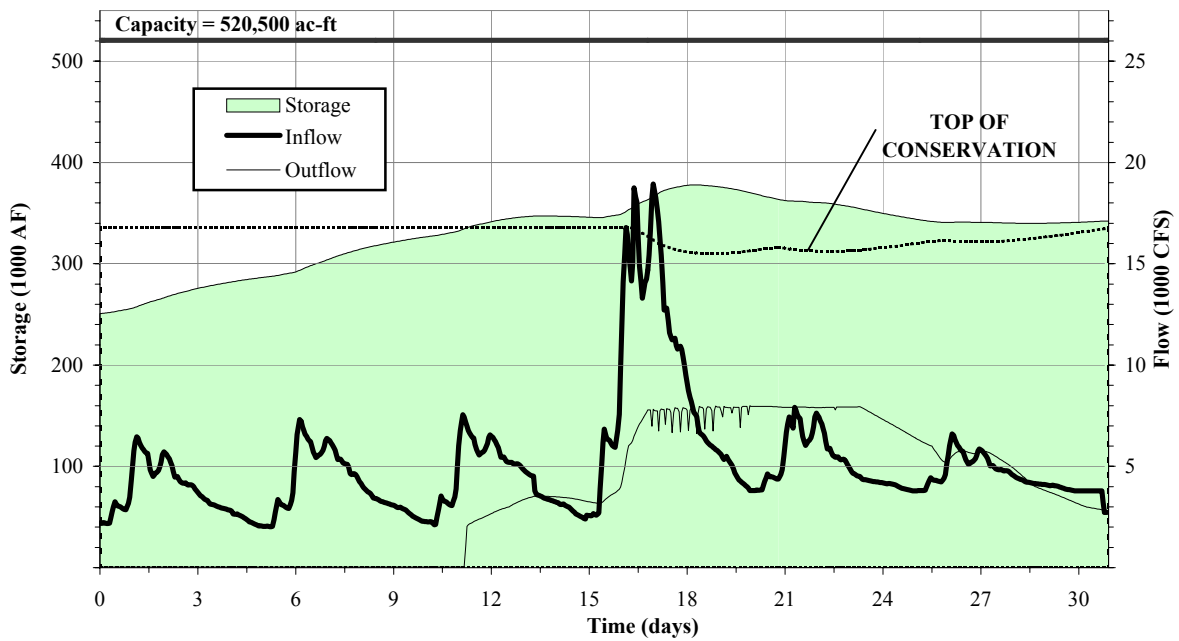
Notes:

- 1) Flow at mainstem points are estimated by HEC-5, which assumes all flows remain in channel (bypasses were treated as channels).
Flows at mainstem points are taken "at latitude" (See Chapter III of Appendix B).
- 2) % Peak Reduced = ((Maximum Regulated Baseline Inflow)-(Maximum Regulated Alternative Inflow))/(Maximum Regulated Baseline Inflow) X 100%.
- 3) Peak Attenuation = (Σ attenuated peak volume)*(0.08265 ac-ft/cfs)

Friant Operations (50% Chance Exceedence Event)



Friant Operations (10% Chance Exceedence Event)

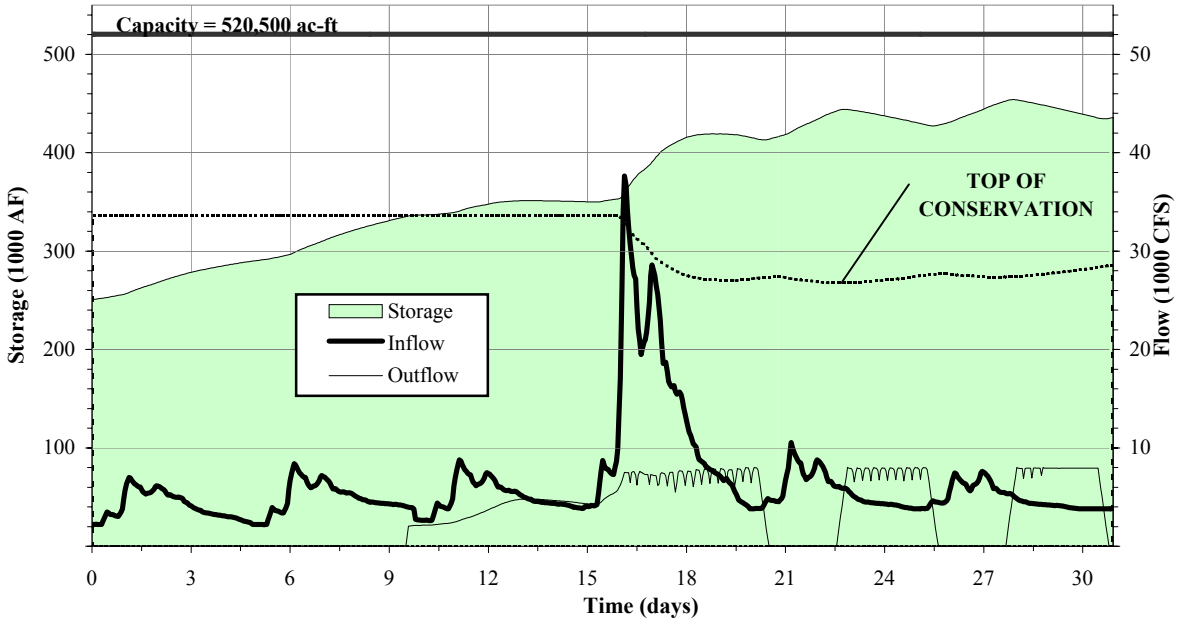


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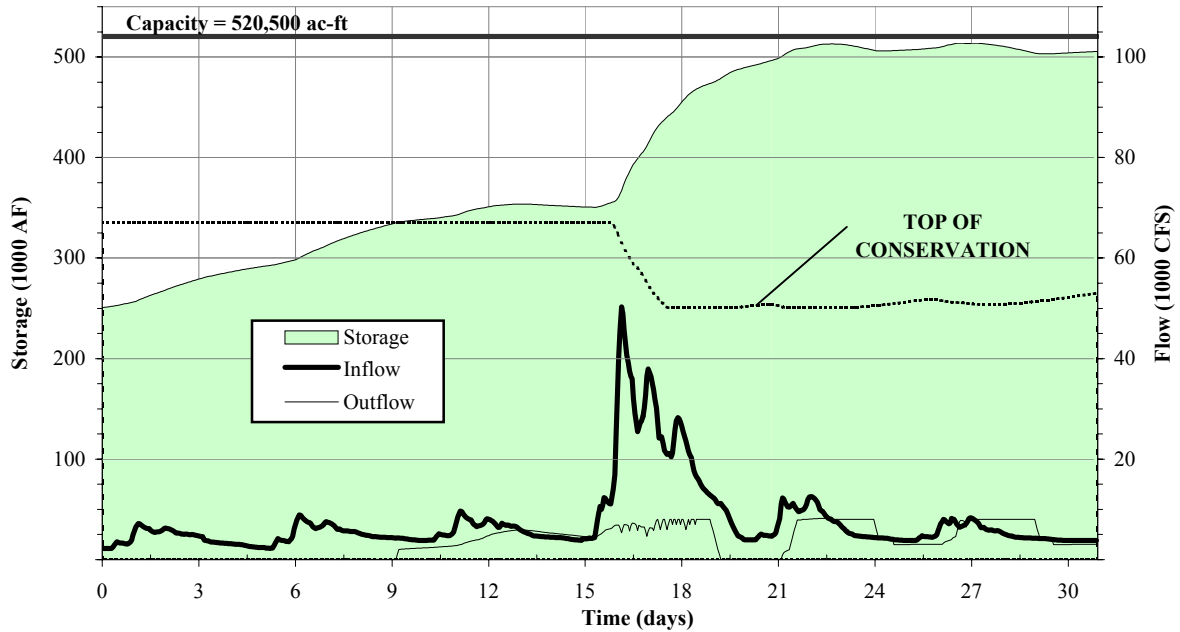
Figure C.4-6a
Reservoir Simulation Hydrographs
Alternative Scenario SJQ-B02A

US Army Corps of Engineers
The Reclamation Board, State of California December 2002

Friant Operations (4% Chance Exceedence Event)



Friant Operations (2% Chance Exceedence Event)

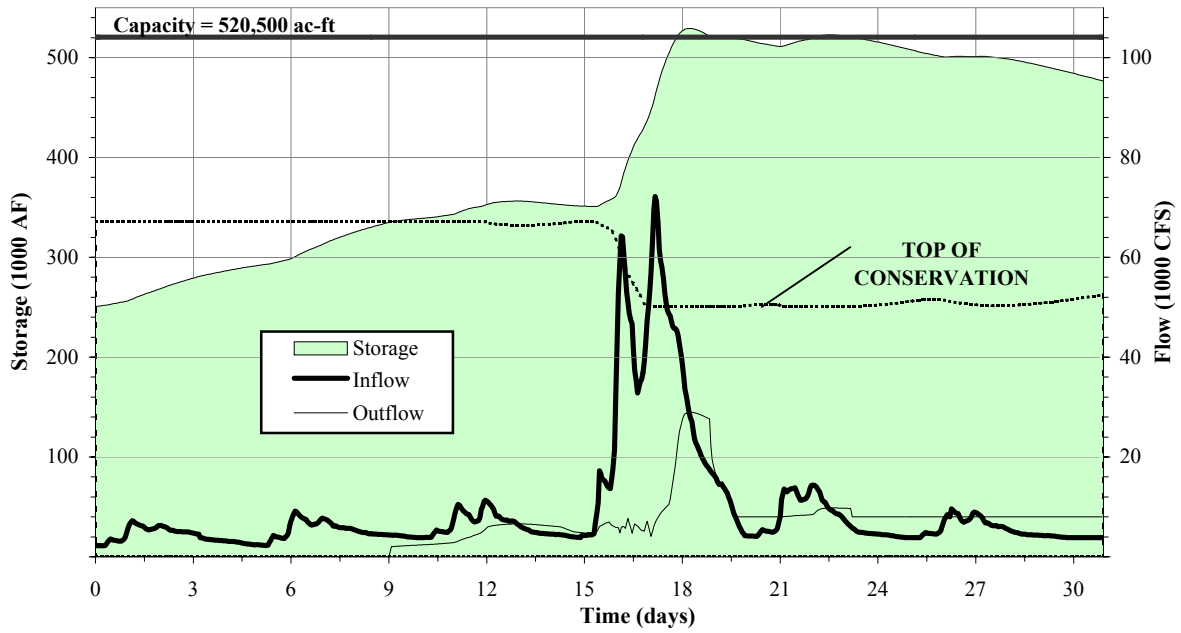


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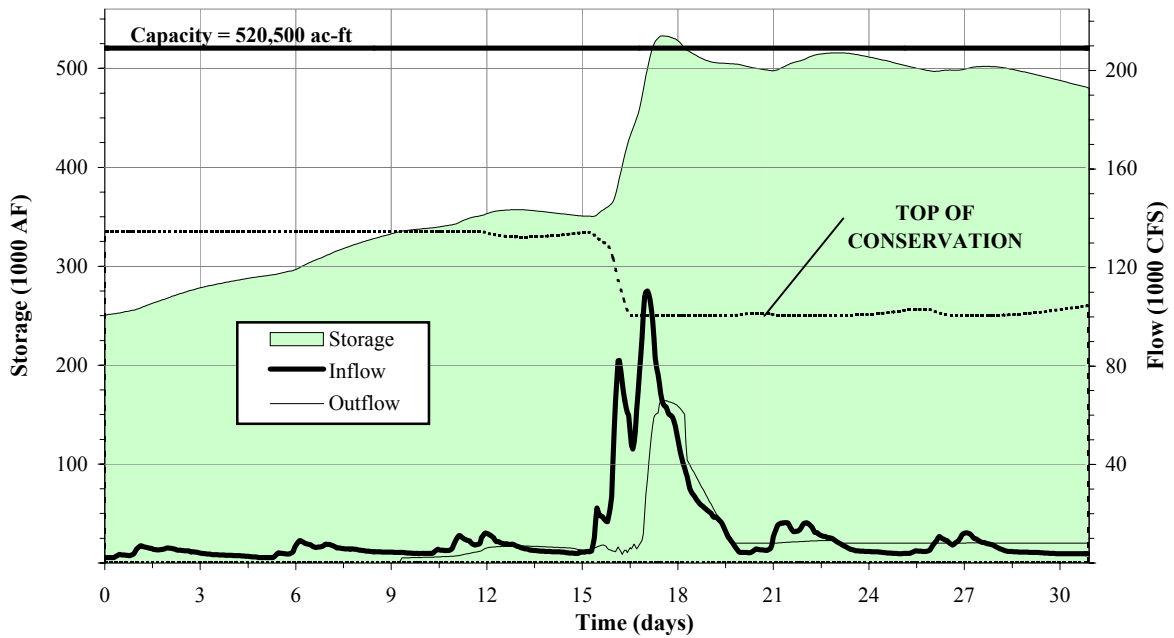
Figure C.4-6b
Reservoir Simulation Hydrographs
Alternative Scenario SJQ-B02A

US Army Corps of Engineers
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Friant Operations (1% Chance Exceedence Event)



Friant Operations (0.5% Chance Exceedence Event)

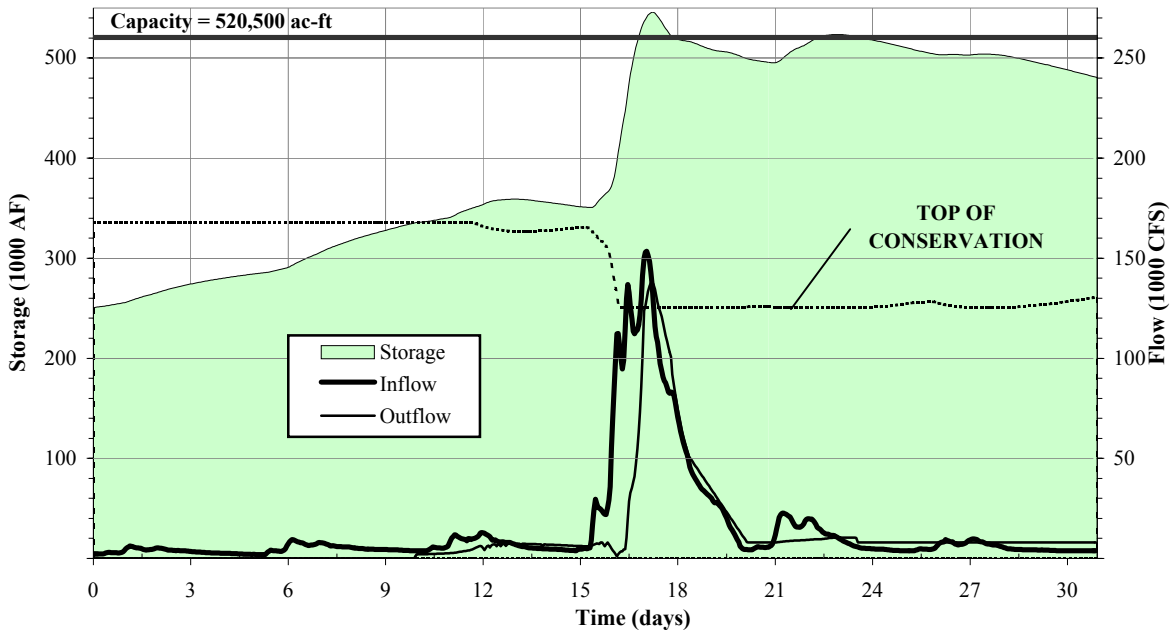


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Figure C.4-6c
Reservoir Simulation Hydrographs
Alternative Scenario SJQ-B02A

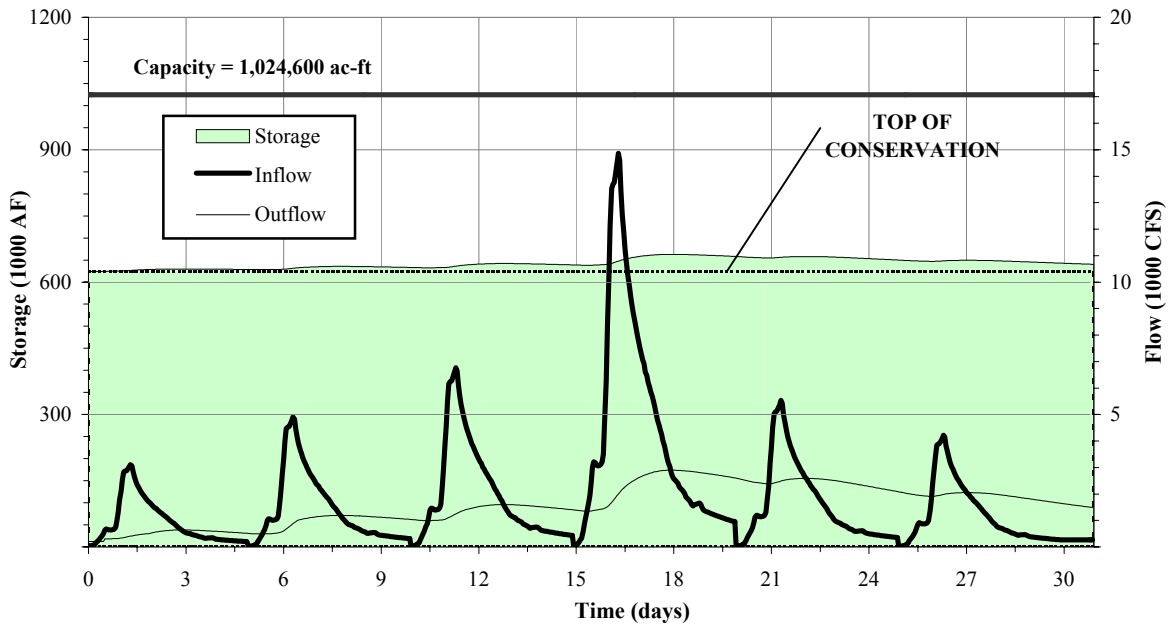
US Army Corps of Engineers
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Friant Operations (0.2% Chance Exceedence Event)

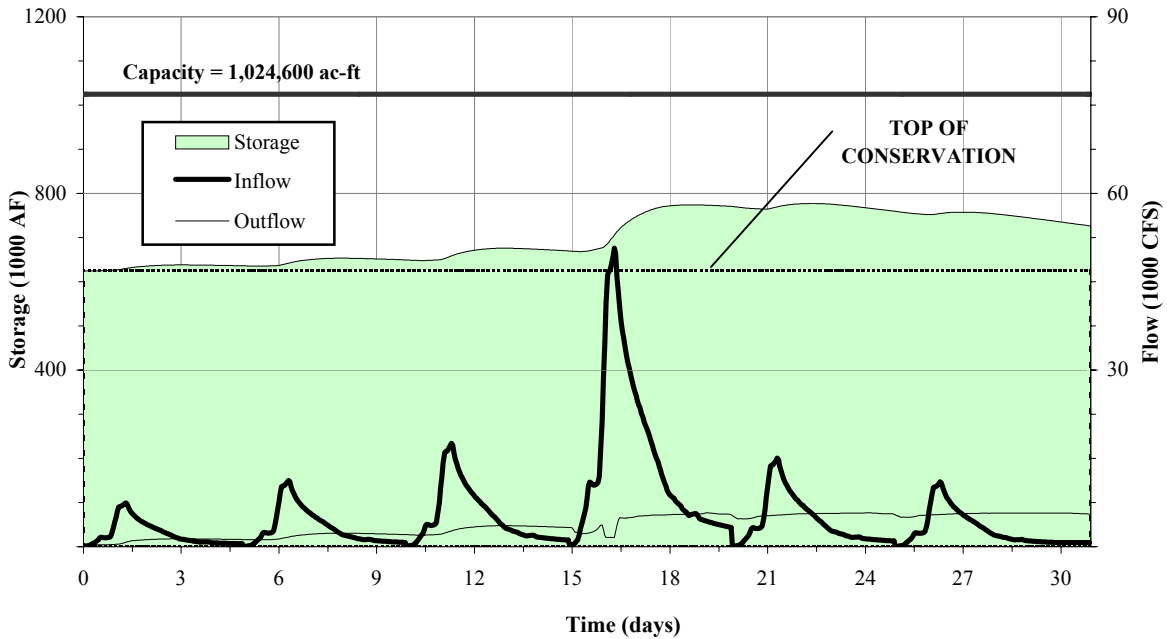


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Figure C.4-6d Reservoir Simulation Hydrographs Alternative Scenario SJQ-B02A	
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New Exchequer Operations (50% Chance Exceedence Event)

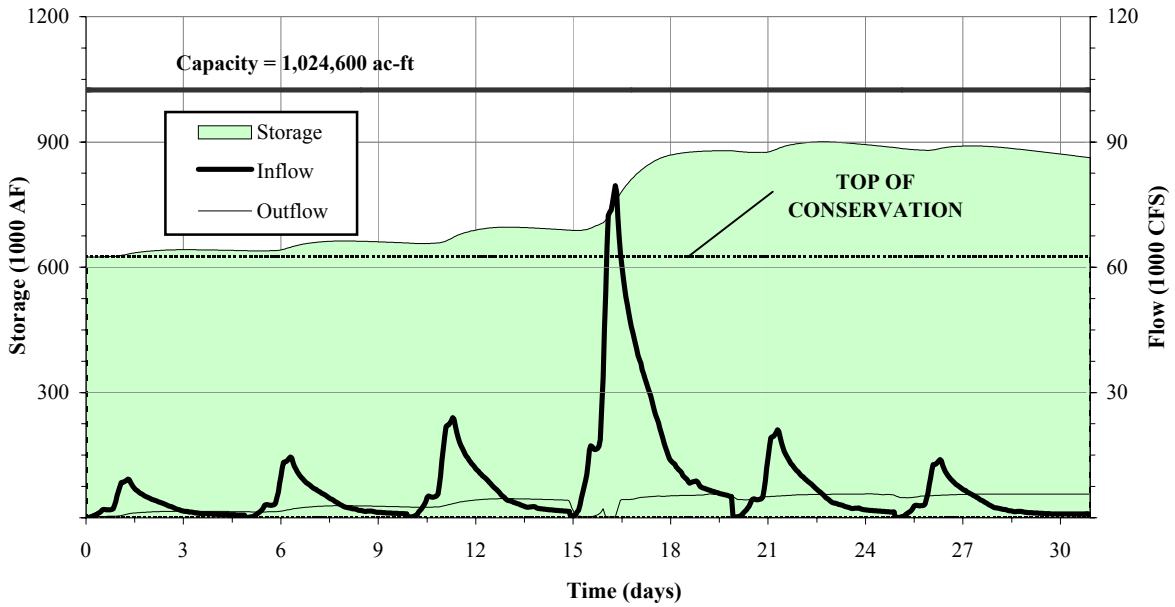


New Exchequer Operations (10% Chance Exceedence Event)

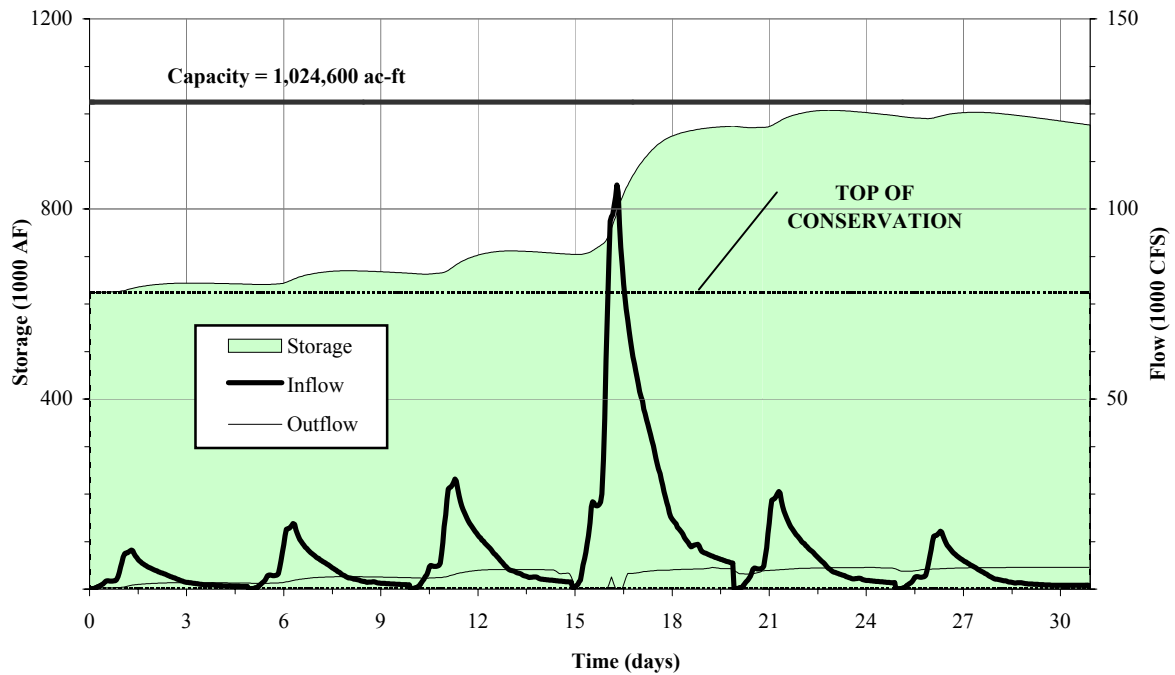


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Figure C.4-6e Reservoir Simulation Hydrographs Alternative Scenario SJQ-B02A	
US Army Corps of Engineers The Reclamation Board, State of California	December 2002

New Exchequer Operations (4% Chance Exceedence Event)



New Exchequer Operations (2% Chance Exceedence Event)

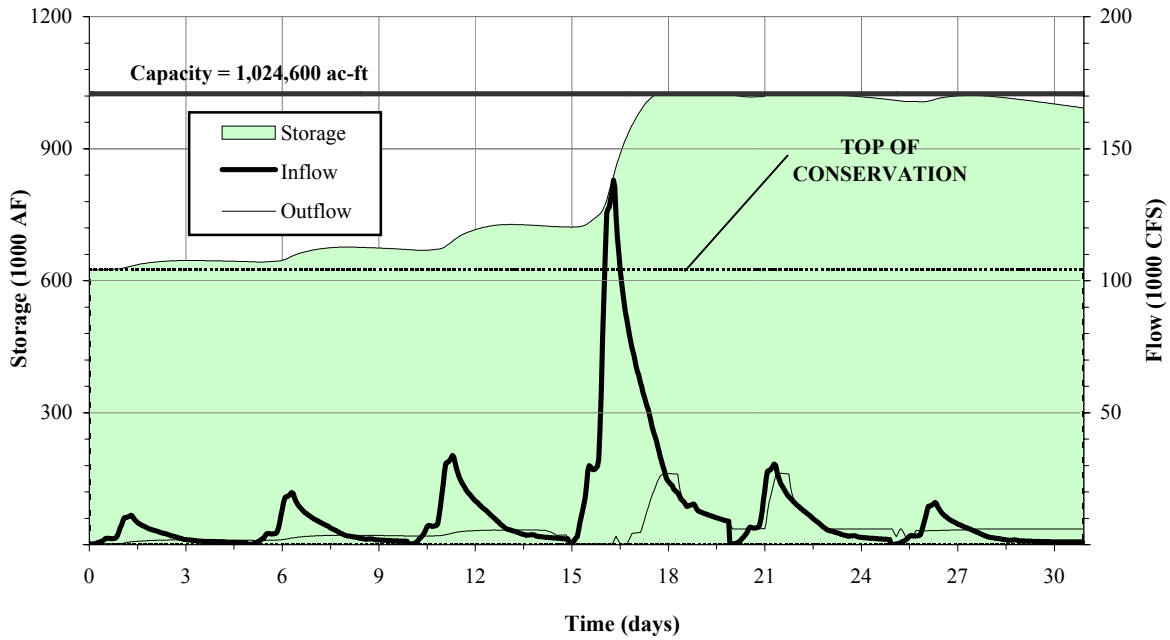


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Comprehensive Study

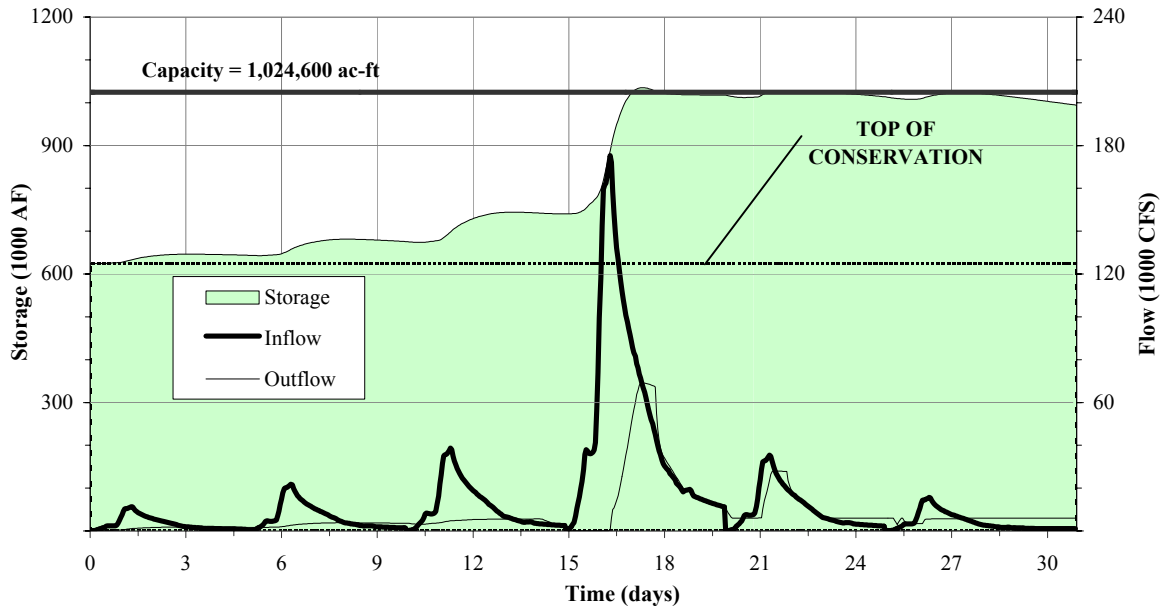
Figure C.4-6f
Reservoir Simulation Hydrographs
Alternative Scenario SJQ-B02A

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New Exchequer Operations (1% Chance Exceedence Event)

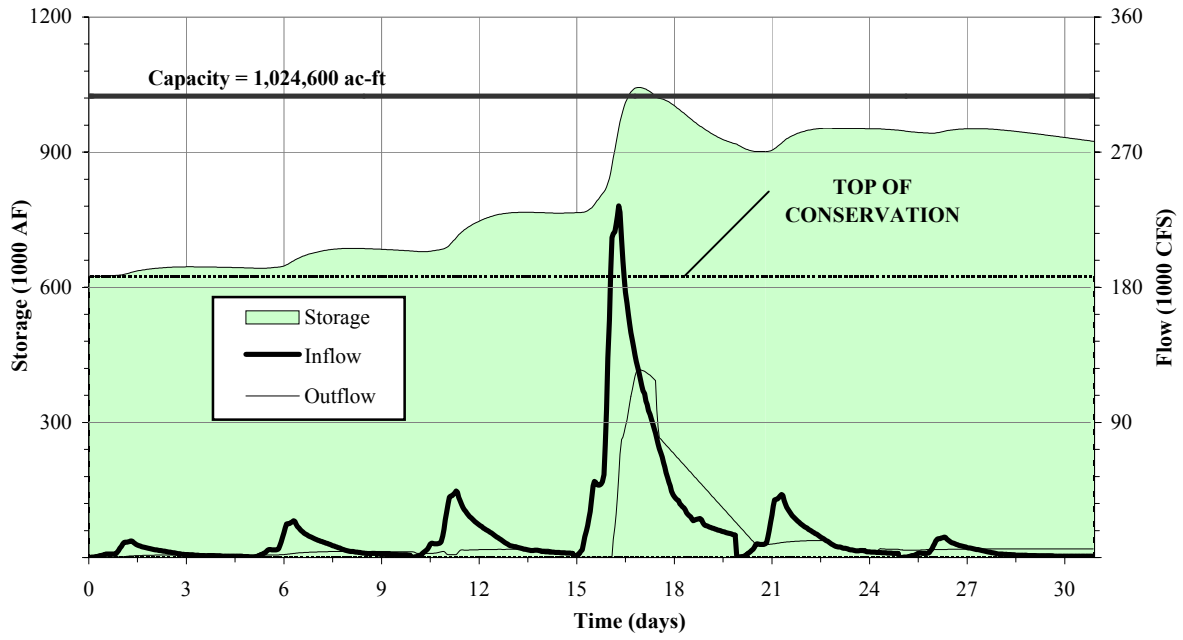


New Exchequer Operations (0.5% Chance Exceedence Event)

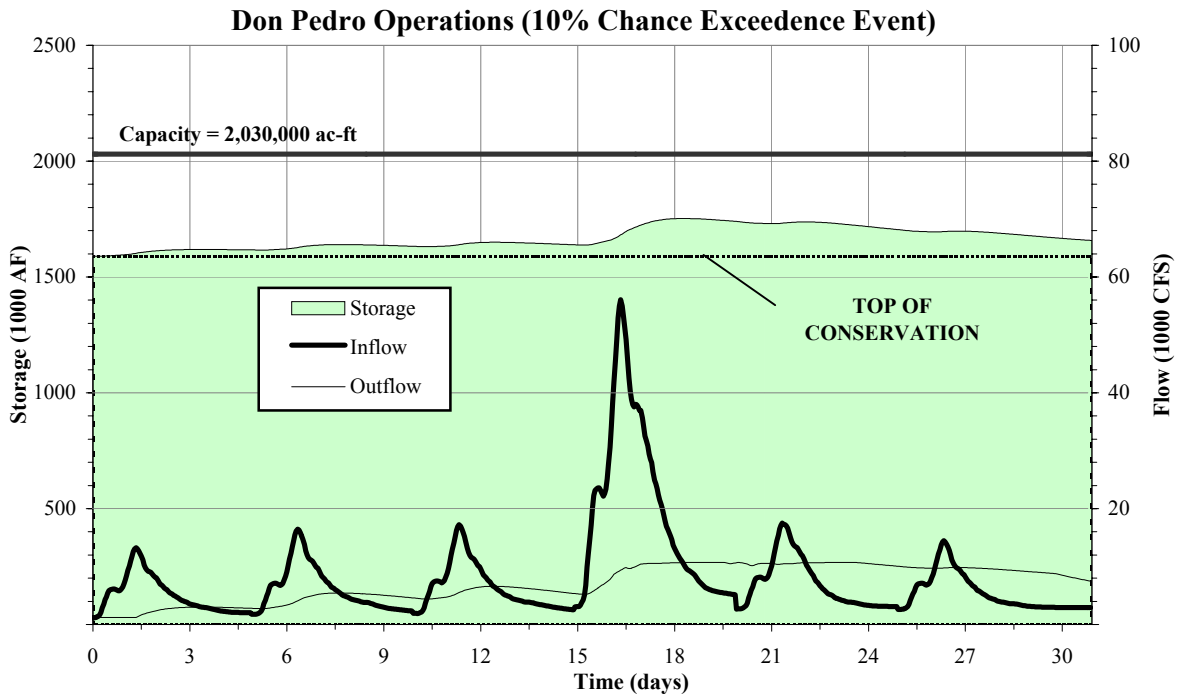
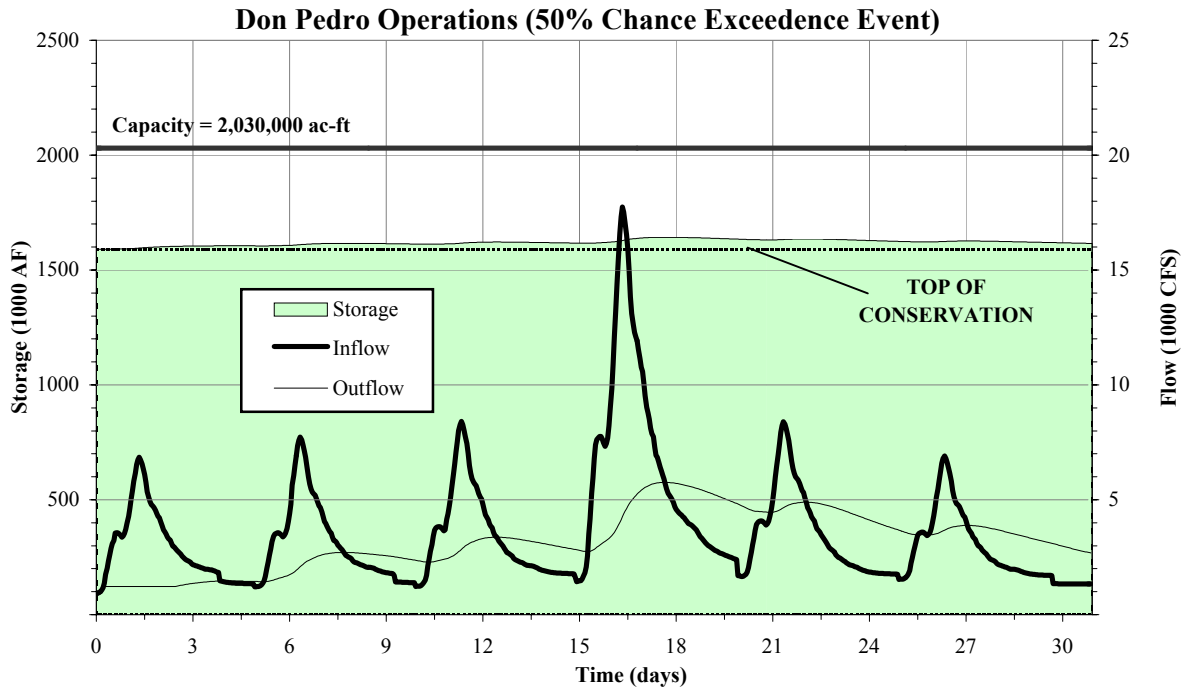


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Figure C.4-6g Reservoir Simulation Hydrographs Alternative Scenario SJQ-B02A	
US Army Corps of Engineers The Reclamation Board, State of California	December 2002

New Exchequer Operations (0.2% Chance Exceedence Event)

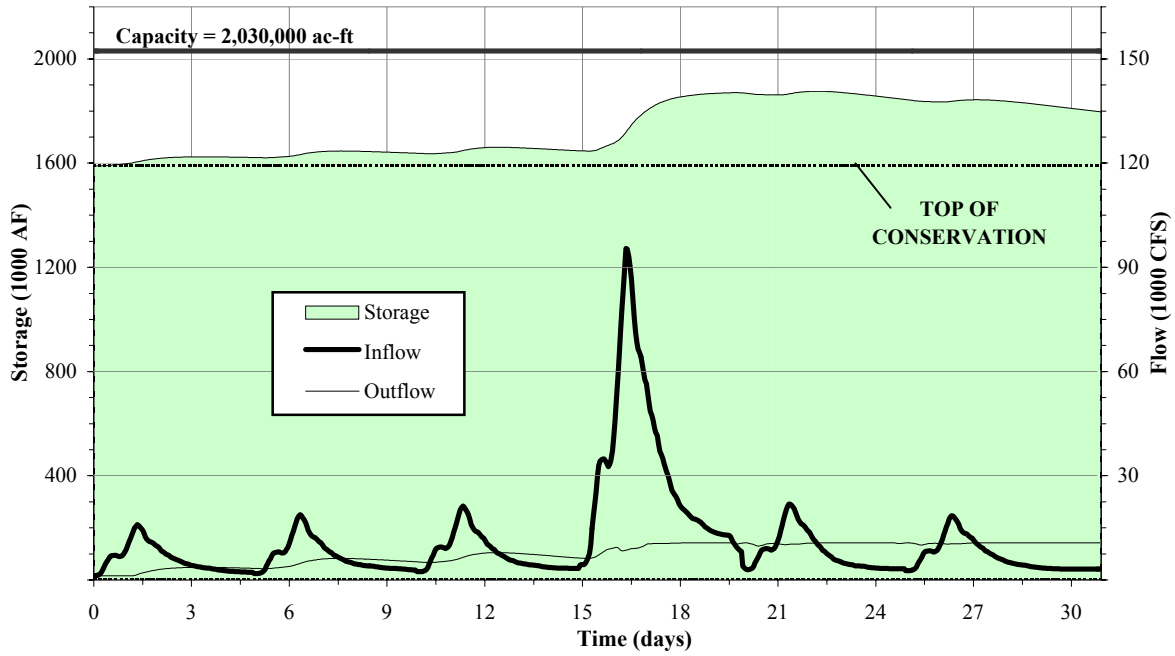


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Figure C.4-6h Reservoir Simulation Hydrographs Alternative Scenario SJQ-B02A
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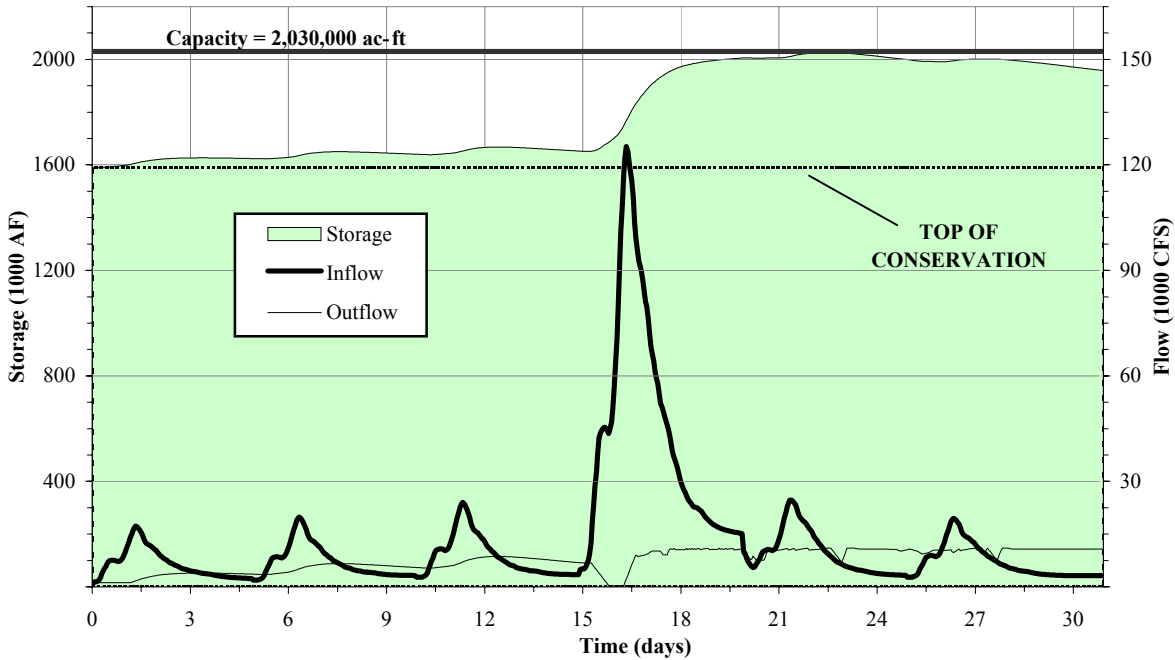


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Figure C.4-6i Reservoir Simulation Hydrographs Alternative Scenario SJQ-B02A	
US Army Corps of Engineers The Reclamation Board, State of California	December 2002

Don Pedro Operations (4% Chance Exceedence Event)



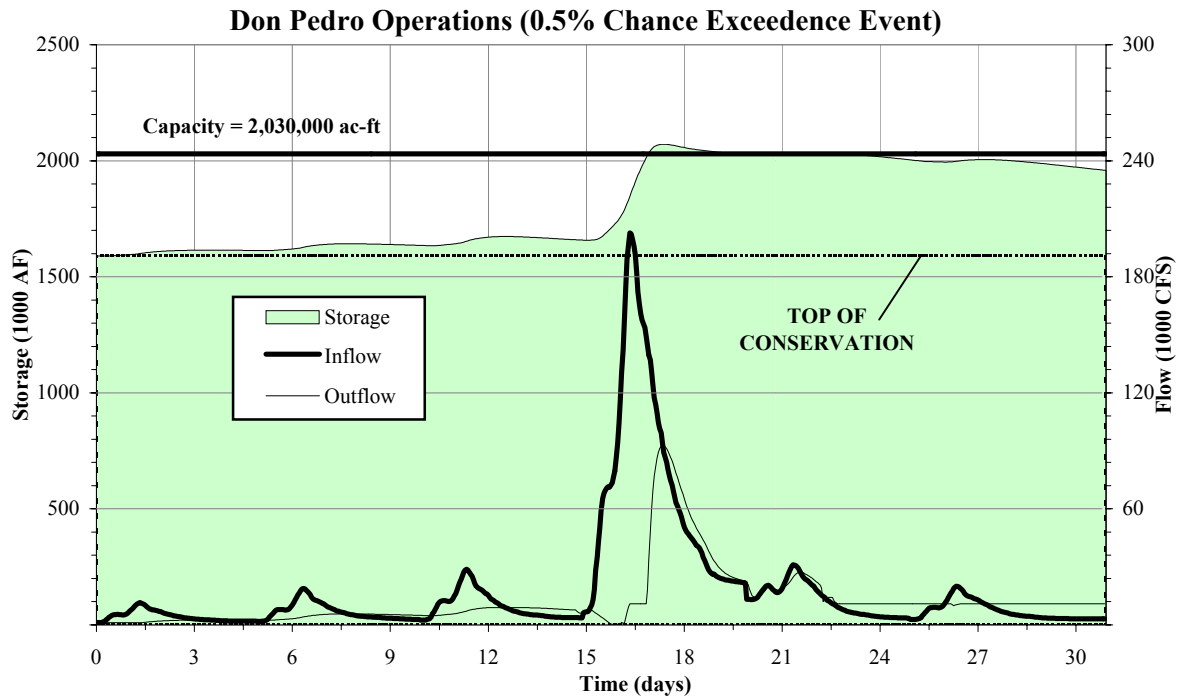
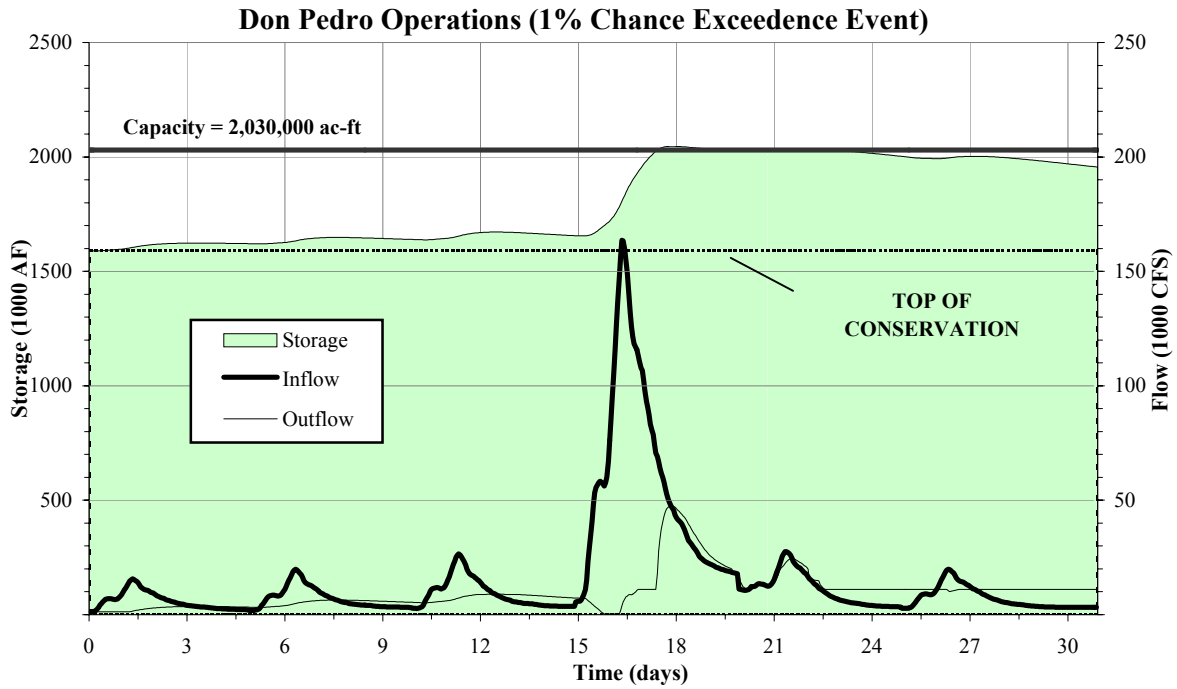
Don Pedro Operations (2% Chance Exceedence Event)



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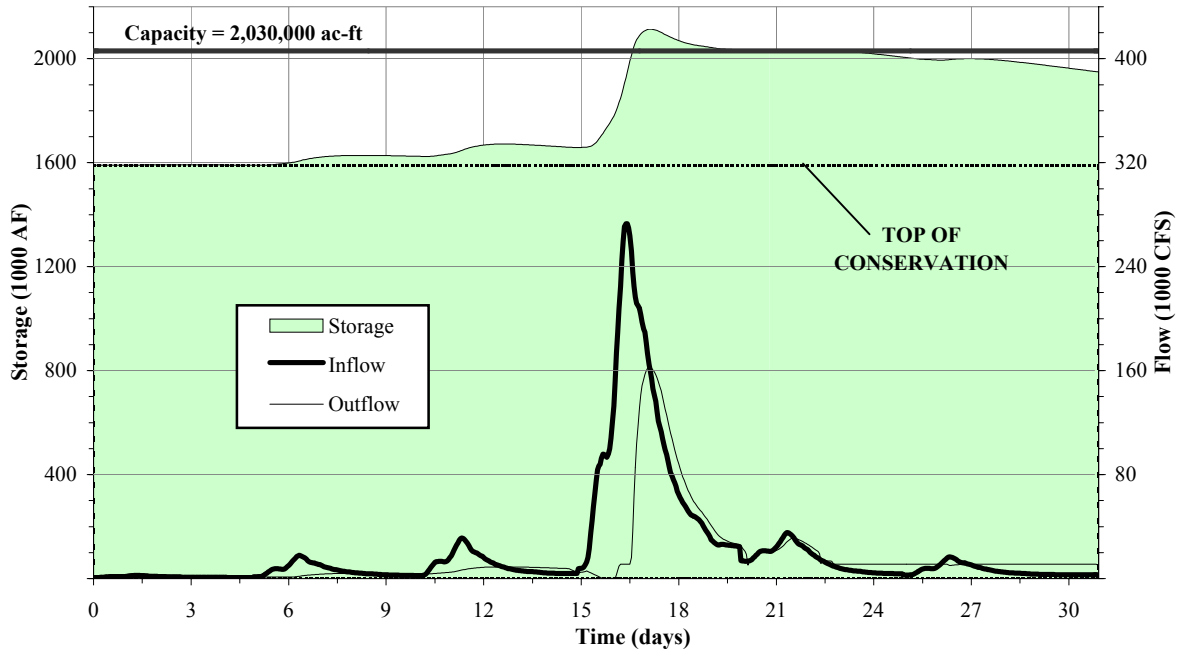
Figure C.4-6j
Reservoir Simulation Hydrographs
Alternative Scenario SJQ-B02A

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Figure C.4-6k Reservoir Simulation Hydrographs Alternative Scenario SJQ-B02A	
US Army Corps of Engineers The Reclamation Board, State of California	December 2002

Don Pedro Operations (0.2% Chance Exceedence Event)



Sacramento & San Joaquin River Basins
Comprehensive Study

Figure C.4-6I
Reservoir Simulation Hydrographs
Alternative Scenario SJQ-B02A

US Army Corps of Engineers
The Reclamation Board, State of California December 2002

TABLE C.4-7a
COMPARISON OF MAXIMUM RELEASE OF BASELINE AND ALTERNATIVE SCENARIO (SJQ-B03A)
SIMULATIONS FOR SPECIFIC ANNUAL PERCENT CHANCE EXCEEDENCE EVENTS

	50% Chance Exceedence Event		10% Chance Exceedence Event		4% Chance Exceedence Event		2% Chance Exceedence Event		1% Chance Exceedence Event		0.5% Chance Exceedence Event		0.2% Chance Exceedence Event	
	Baseline	Alternative	Baseline	Alternative	Baseline	Alternative	Baseline	Alternative	Baseline	Alternative	Baseline	Alternative	Baseline	Alternative
Friant Centering														
Friant														
Objective Flow: 8,000 cfs	3,032	3,032	7,971	7,971	9,001	9,001	25,481	25,481	71,093	71,093	108,585	108,585	139,402	139,402
New Exchequer														
Objective Flow: 6,000 cfs	1,976	1,976	1,976	1,976	3,080	3,080	5,478	5,478	5,766	5,766	5,768	5,768	21,381	21,381
Don Pedro														
Objective Flow: 9,000 to 15,000 cfs	3,903	4,598	3,903	4,598	5,894	7,179	9,000	12,773	9,000	15,000	9,000	15,000	42,291	25,292
New Exchequer Centering														
Friant														
Objective Flow: 8,000 cfs	2,163	2,163	6,785	6,785	7,985	7,985	8,366	8,366	15,006	15,006	51,568	51,568	110,315	110,315
New Exchequer														
Objective Flow: 6,000 cfs	3,080	3,080	5,766	5,766	5,769	5,769	21,381	21,381	45,533	45,533	81,574	81,574	141,306	141,306
Don Pedro														
Objective Flow: 9,000 to 15,000 cfs	3,903	4,598	8,604	12,670	8,738	14,676	9,000	15,000	38,874	20,387	80,647	65,781	139,910	126,927
Don Pedro Centering														
Friant														
Objective Flow: 8,000 cfs	2,163	2,163	5,346	5,346	8,000	8,000	8,000	8,000	8,630	8,630	30,749	30,749	92,384	92,384
New Exchequer														
Objective Flow: 6,000 cfs	1,976	1,976	5,077	5,077	5,766	5,766	5,769	5,769	6,617	6,617	35,028	35,028	83,919	83,919
Don Pedro														
Objective Flow: 9,000 to 15,000 cfs	5,894	7,179	8,737	14,676	9,000	14,676	39,630	16,611	80,821	66,043	126,377	112,617	185,449	176,235

	Maximum Baseline
	Maximum Alternative

TABLE C.4-7b
EFFECTS OF ALTERNATIVE SCENARIO SJQ-B03A

Friant Dam Storm Runoff Centering									
Percent Chance Exceedence	Index Gage Location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	0.0	0.0	0.0	0.0	-17.81	-13.33	0.78	0.64
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	-3,138	-3,108	1,331	1,324
10%	% Peak Reduced	0.0	0.0	0.0	0.0	-17.81	-13.33	0.28	0.25
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	-3,138	-3,108	1,331	1,324
4%	% Peak Reduced	0.0	0.0	0.0	0.0	-21.80	-17.11	0.59	0.46
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	-6,334	-6,281	3,880	3,636
2%	% Peak Reduced	0.0	0.0	0.0	0.0	-41.93	-60.85	2.85	2.54
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	-40,378	-42,081	26,126	24,727
1%	% Peak Reduced	0.0	0.0	0.0	0.0	-66.67	-28.09	-5.37	-5.03
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	-104,892	-106,458	-106,398	-106,344
0.5%	% Peak Reduced	0.0	0.0	0.0	0.0	-66.67	-13.65	-5.86	-5.49
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	-167,954	-164,985	-161,904	-158,545
0.2%	% Peak Reduced	0.0	0.0	0.0	0.0	40.20	38.65	-3.95	-3.78
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	40,071	38,038	-83,222	-79,816

El Nido Storm Runoff Centering									
Percent Chance Exceedence	Index Gage Location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	0.0	0.0	0.0	0.0	-18.46	-13.94	-1.4	-1.39
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	-3,536	-3,503	-3,491	-3,480
10%	% Peak Reduced	0.0	0.0	0.0	0.0	-41.09	-60.22	-0.28	-0.57
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	-32,093	-32,128	-32,069	-32,021
4%	% Peak Reduced	0.0	0.0	0.0	0.0	-66.67	-50.52	-13.14	-12.89
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	-95,505	-95,218	-95,143	-95,077
2%	% Peak Reduced	0.0	0.0	0.0	0.0	-66.67	-18.33	-13.18	-11.41
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	-178,420	-170,272	-166,367	-162,431
1%	% Peak Reduced	0.0	0.0	0.0	0.0	52.56	44.59	-7.64	-6.91
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	35,323	33,048	-75,773	-71,813
0.5%	% Peak Reduced	0.0	0.0	0.0	0.0	21.72	21.39	-5.79	-5.38
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	44,698	41,793	-83,041	-79,705
0.2%	% Peak Reduced	0.0	0.0	0.0	0.0	11.83	12.09	0.08	0.08
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	46,200	43,614	43,395	43,226

	Maximum peak flow reduction %
	Maximum peak volume attenuation

Notes:

- 1) Flow at mainstem points are estimated by HEC-5, which assumes all flows remain in channel (bypasses were treated as channels).
Flows at mainstem points are taken "at latitude" (See Chapter III of Appendix B).
- 2) % Peak Reduced = ((Maximum Regulated Baseline Inflow)-(Maximum Regulated Alternative Inflow))/(Maximum Regulated Baseline Inflow) X 100%.
- 3) Peak Attenuation = (Σ attenuated peak volume)*(0.08265 ac-ft/cfs)

TABLE C.4-7b (CONT.)
EFFECTS OF ALTERNATIVE SCENARIO SJQ-B03A

Exchequer Dam Storm Runoff Centering									
Percent Chance Exceedence	Index Gage Location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	0.0	0.0	0.0	0.0	-17.81	-13.32	-2.83	-2.41
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	-3,138	-3,108	-3,098	-3,087
10%	% Peak Reduced	0.0	0.0	0.0	0.0	-47.25	-44.86	0.61	-1.72
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	-24,821	-24,704	17,239	-24,635
4%	% Peak Reduced	0.0	0.0	0.0	0.0	-67.96	-66.15	-17.35	-14.98
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	-106,559	-106,338	-106,274	-106,214
2%	% Peak Reduced	0.0	0.0	0.0	0.0	-66.67	-46.87	-12.79	-11.16
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	-184,065	-176,282	-172,667	-168,448
1%	% Peak Reduced	0.0	0.0	0.0	0.0	47.56	46.88	1.74	1.84
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	45,091	42,459	41,968	41,542
0.5%	% Peak Reduced	0.0	0.0	0.0	0.0	18.43	18.23	0.24	0.27
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	44,628	41,825	41,381	41,084
0.2%	% Peak Reduced	0.0	0.0	0.0	0.0	9.28	9.70	0.14	0.15
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	44,860	42,562	42,343	40,885

Newman Storm Runoff Centering									
Percent Chance Exceedence	Index Gage Location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	0.0	0.0	0.0	0.0	-19.94	-15.34	-3.93	-3.4
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	-4,597	-4,556	-4,541	-4,528
10%	% Peak Reduced	0.0	0.0	0.0	0.0	-51.80	-59.03	-6.47	-6.18
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	-58,071	-57,814	-57,742	-57,678
4%	% Peak Reduced	0.0	0.0	0.0	0.0	-66.67	-27.92	-16.09	-13.49
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	-154,687	-154,446	-154,363	-153,849
2%	% Peak Reduced	0.0	0.0	0.0	0.0	31.21	27.60	-9.77	-8.75
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	10,335	8,543	-72,543	-68,662
1%	% Peak Reduced	0.0	0.0	0.0	0.0	23.52	22.82	0.22	0.26
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	43,266	40,543	40,067	39,732
0.5%	% Peak Reduced	0.0	0.0	0.0	0.0	15.08	15.25	0.15	0.16
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	46,467	44,480	44,139	43,900
0.2%	% Peak Reduced	0.0	0.0	0.0	0.0	7.18	8.93	0.13	0.16
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	46,650	44,876	44,665	44,443

	Maximum peak flow reduction %
	Maximum peak volume attenuation

Notes:

- 1) Flow at mainstem points are estimated by HEC-5, which assumes all flows remain in channel (bypasses were treated as channels).
Flows at mainstem points are taken "at latitude" (See Chapter III of Appendix B).
- 2) % Peak Reduced = ((Maximum Regulated Baseline Inflow)-(Maximum Regulated Alternative Inflow))/(Maximum Regulated Baseline Inflow) X 100%.
- 3) Peak Attenuation = (Σ attenuated peak volume)*(0.08265 ac-ft/cfs)

TABLE C.4-7b (CONT.)
EFFECTS OF ALTERNATIVE SCENARIO SJQ-B03A

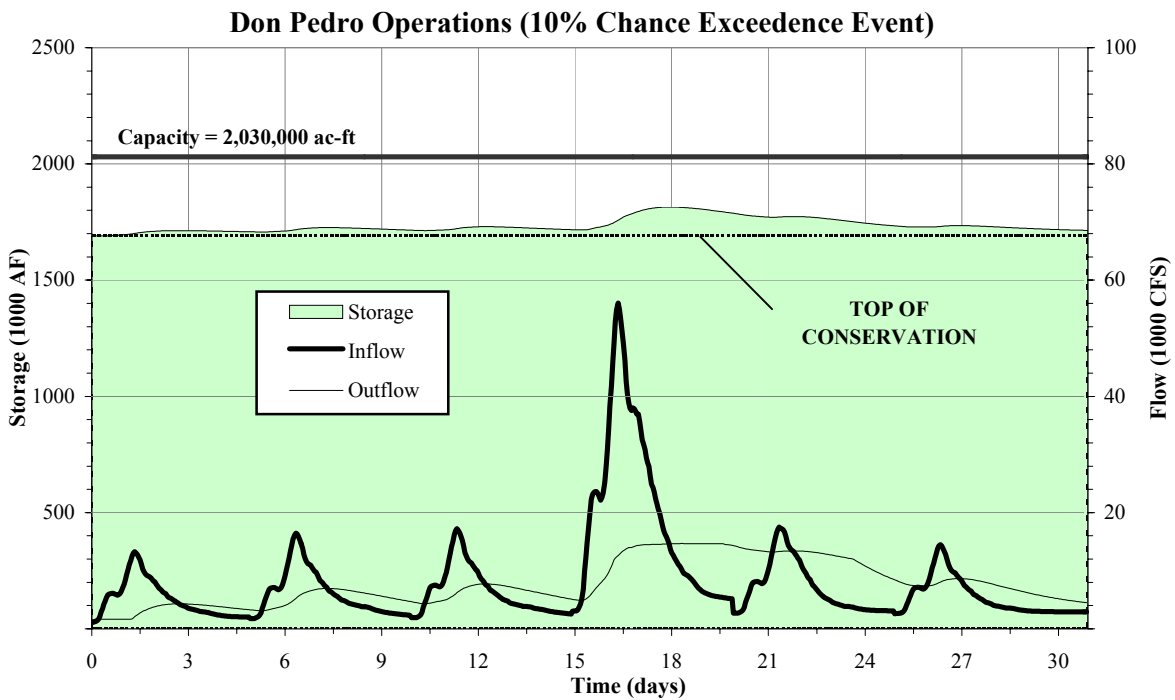
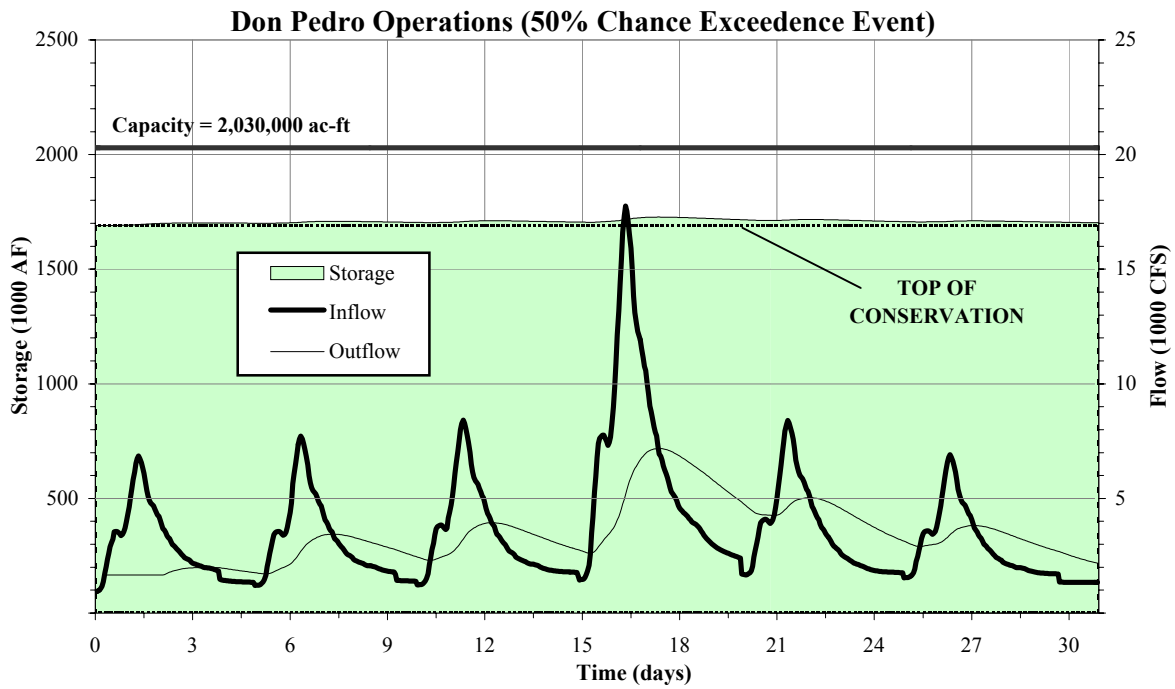
Don Pedro Storm Runoff Centering									
Percent Chance Exceedence	Index Gage Location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	0.0	0.0	0.0	0.0	-21.80	-19.61	-6.95	-5.99
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	-6,334	-6,281	-6,264	-6,248
10%	% Peak Reduced	0.0	0.0	0.0	0.0	-67.97	-65.70	-18.10	-14.51
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	-82,779	-82,566	-82,498	-82,433
4%	% Peak Reduced	0.0	0.0	0.0	0.0	-63.07	-64.37	-21.66	-17.04
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	-176,824	-170,001	-166,704	-163,133
2%	% Peak Reduced	0.0	0.0	0.0	0.0	58.08	53.59	31.04	26.31
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	52,851	50,291	49,716	49,183
1%	% Peak Reduced	0.0	0.0	0.0	0.0	18.29	17.99	12.12	10.97
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	43,831	40,768	40,244	39,831
0.5%	% Peak Reduced	0.0	0.0	0.0	0.0	10.89	11.03	8.88	8.23
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	44,722	42,803	42,507	42,253
0.2%	% Peak Reduced	0.0	0.0	0.0	0.0	4.97	5.82	4.87	3.83
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	43,266	41,457	41,159	40,842

Vernalis Storm Runoff Centering									
Percent Chance Exceedence	Index Gage Location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	0.0	0.0	0.0	0.0	-20.79	-16.19	-4.99	-4.59
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	-2,362	-5,316	-5,300	-5,285
10%	% Peak Reduced	0.0	0.0	0.0	0.0	-66.67	-41.88	-11.29	-12.98
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	-86,741	-86,469	-86,393	-86,324
4%	% Peak Reduced	0.0	0.0	0.0	0.0	-66.67	-17.70	-13.86	-11.56
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	-175,087	-168,314	-166,306	-163,019
2%	% Peak Reduced	0.0	0.0	0.0	0.0	52.68	44.82	14.93	12.44
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	35,178	32,912	32,385	31,933
1%	% Peak Reduced	0.0	0.0	0.0	0.0	21.05	20.81	12.08	10.99
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	44,805	42,052	41,592	41,254
0.5%	% Peak Reduced	0.0	0.0	0.0	0.0	12.97	13.26	1.74	0.10
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	46,602	43,975	43,730	43,550
0.2%	% Peak Reduced	0.0	0.0	0.0	0.0	5.86	7.06	0.22	0.27
	Peak Attenuation (AF)	0.0	0.0	0.0	0.0	46,283	44,622	44,439	44,214

	Maximum peak flow reduction %
	Maximum peak volume attenuation

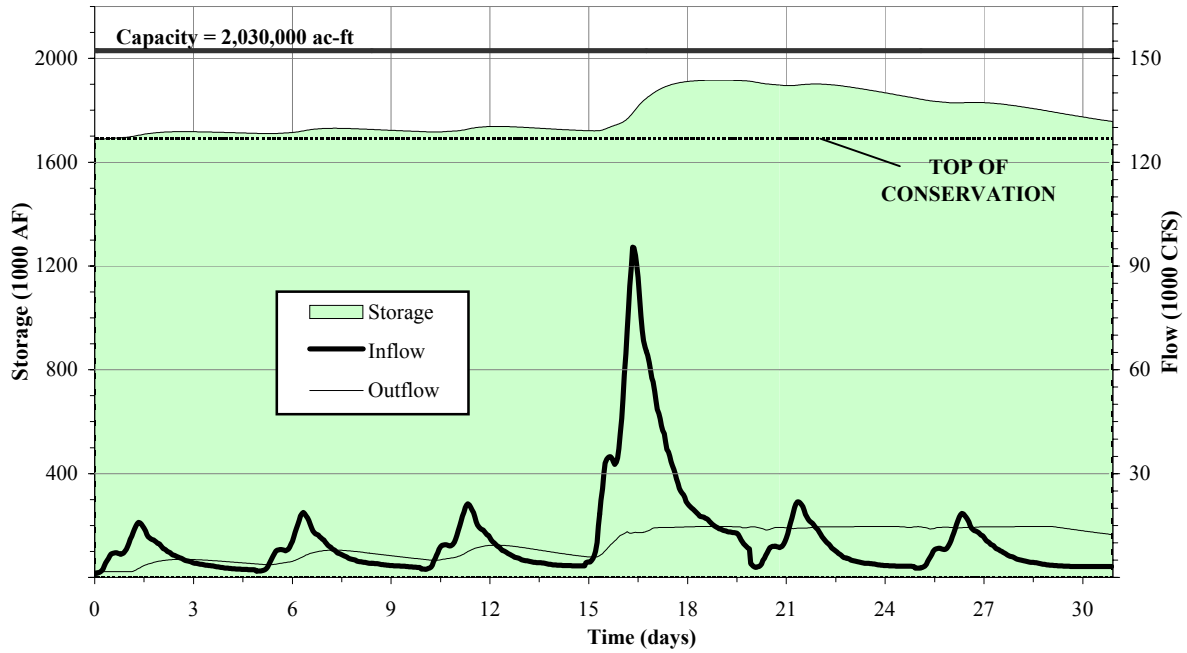
Notes:

- 1) Flow at mainstem points are estimated by HEC-5, which assumes all flows remain in channel (bypasses were treated as channels).
Flows at mainstem points are taken "at latitude" (See Chapter III of Appendix B).
- 2) % Peak Reduced = ((Maximum Regulated Baseline Inflow)-(Maximum Regulated Alternative Inflow))/(Maximum Regulated Baseline Inflow) X 100%.
- 3) Peak Attenuation = (Σ attenuated peak volume)*(0.08265 ac-ft/cfs)

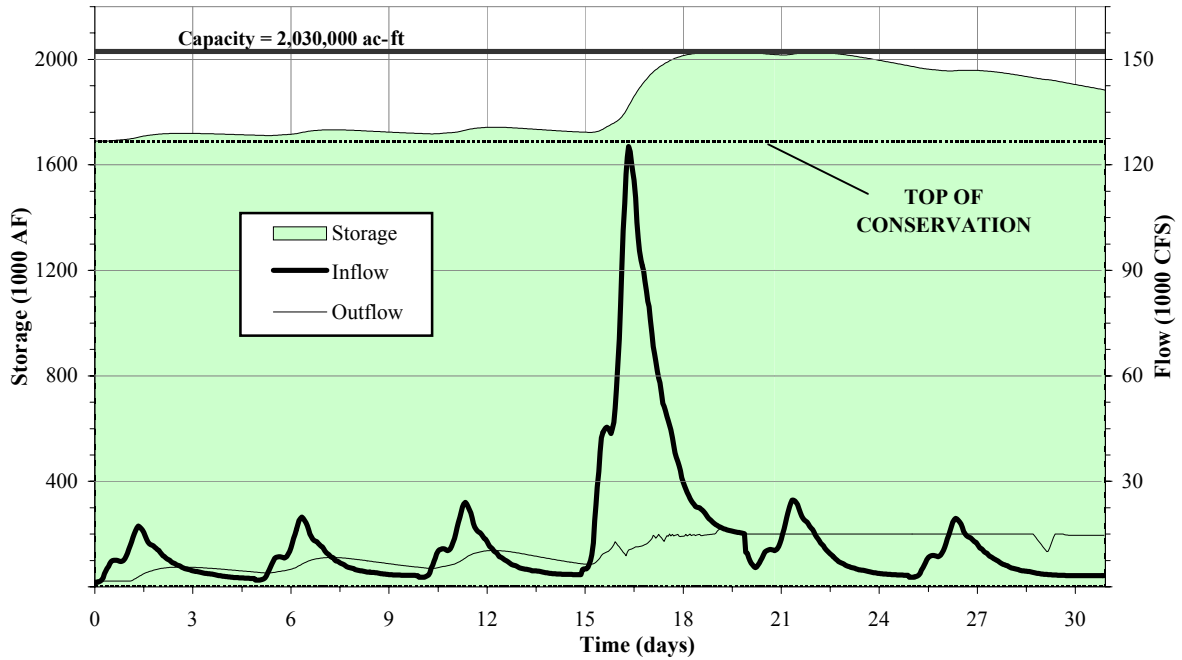


Sacramento & San Joaquin River Basins Comprehensive Study	
Figure C.4-7a Reservoir Simulation Hydrographs Alternative Scenario SJQ-B03A	
US Army Corps of Engineers The Reclamation Board, State of California	December 2002

Don Pedro Operations (4% Chance Exceedence Event)



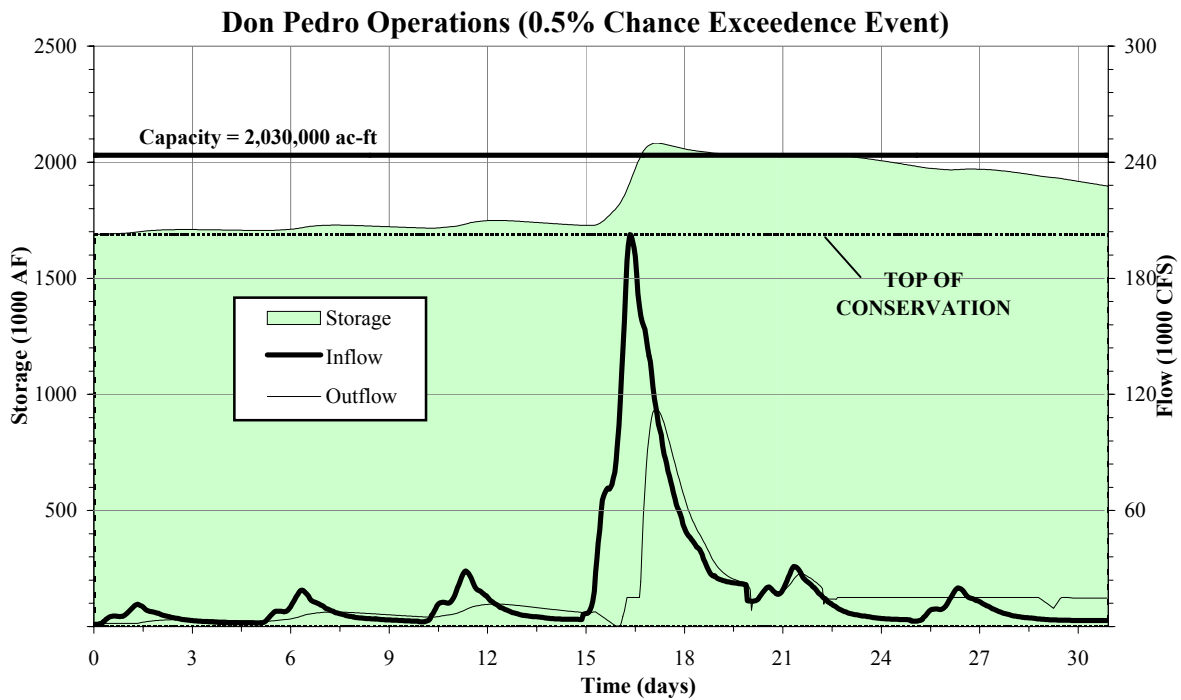
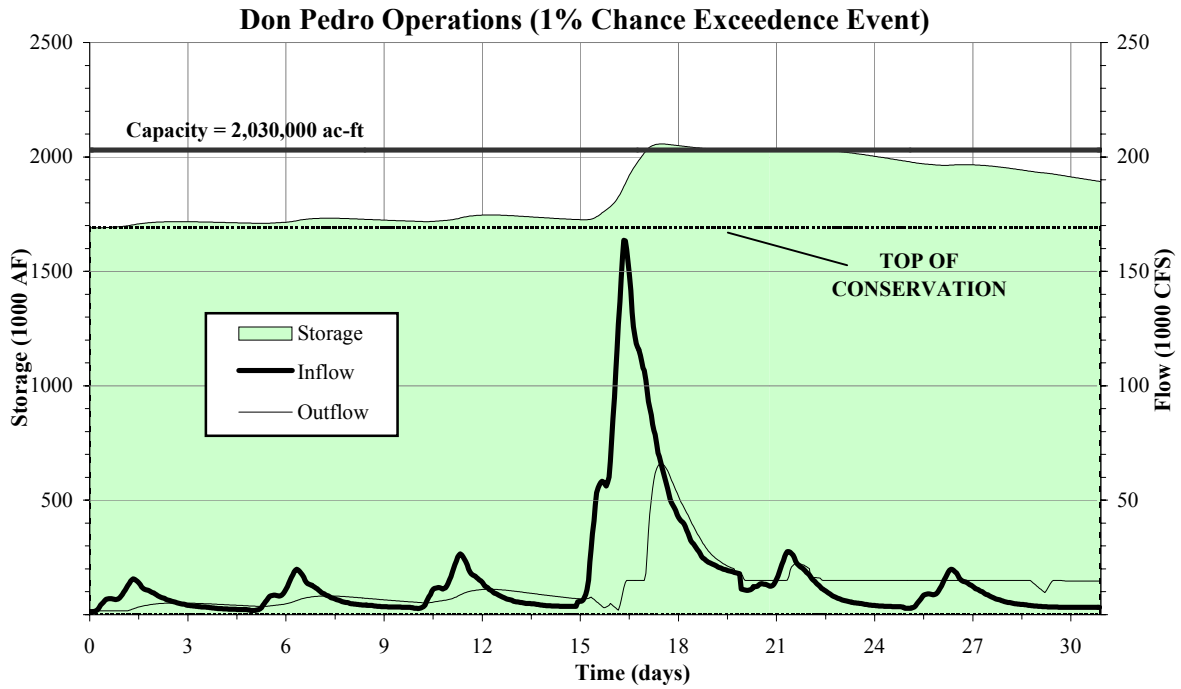
Don Pedro Operations (2% Chance Exceedence Event)



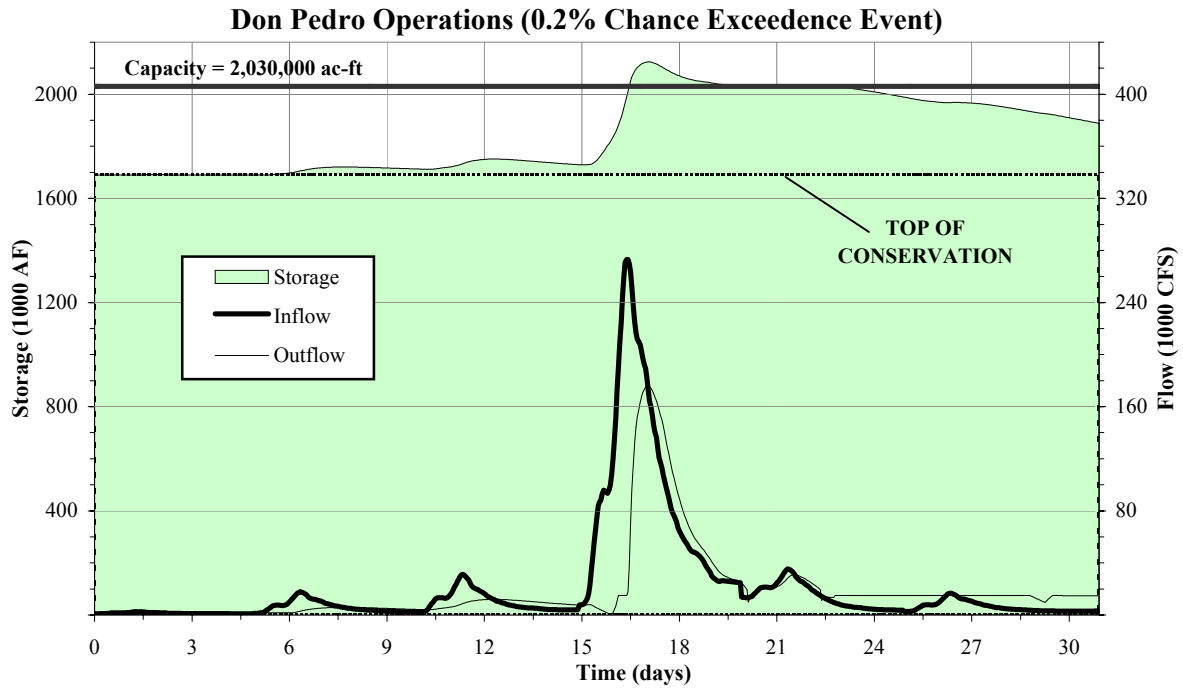
Sacramento & San Joaquin River Basins
Comprehensive Study

Figure C.4-7b
Reservoir Simulation Hydrographs
Alternative Scenario SJQ-B03A

US Army Corps of Engineers
The Reclamation Board, State of California December 2002



Sacramento & San Joaquin River Basins Comprehensive Study	
Figure C.4-7c Reservoir Simulation Hydrographs Alternative Scenario SJQ-B03A	
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Comprehensive Study

Figure C.4-7d
Reservoir Simulation Hydrographs
Alternative Scenario SJQ-B03A

US Army Corps of Engineers
The Reclamation Board, State of California December 2002

TABLE C.4-8a

**COMPARISON OF MAXIMUM RELEASE OF BASELINE AND ALTERNATIVE SCENARIO (SJQ-B04A)
SIMULATIONS FOR SPECIFIC ANNUAL PERCENT CHANCE EXCEEDENCE EVENTS**

	50% Chance Exceedence Event		10% Chance Exceedence Event		4% Chance Exceedence Event		2% Chance Exceedence Event		1% Chance Exceedence Event		0.5% Chance Exceedence Event		0.2% Chance Exceedence Event		
	Baseline	Alternative	Baseline	Alternative	Baseline	Alternative	Baseline	Alternative	Baseline	Alternative	Baseline	Alternative	Baseline	Alternative	
Friant Centering															
Friant															
Max. Release:	8,000 to 11,000	3,032	3,598	7,971	11,970	9,001	12,000	25,481	12,288	71,093	44,079	108,585	76,964	139,402	140,024
New Exchequer															
Max. Release:	6,000 to 7,000	1,976	2,140	1,976	2,140	3,080	3,359	5,478	6,177	5,766	6,753	5,768	6,756	21,381	11,438
Don Pedro															
Max. Release:	9,000 to 15,000	3,903	4,598	3,903	4,598	5,894	7,179	9,000	12,773	9,000	15,000	9,000	15,000	42,291	25,292
New Exchequer Centering															
Friant															
Max. Release:	8,000 to 11,000	2,163	3,012	6,785	7,144	7,985	11,978	8,366	12,000	15,006	12,000	51,568	30,832	110,315	73,587
New Exchequer															
Max. Release:	6,000 to 7,000	3,080	3,359	5,766	6,753	5,769	6,757	21,381	11,438	45,533	40,981	81,574	77,975	141,306	134,633
Don Pedro															
Max. Release:	9,000 to 15,000	3,903	4,598	8,604	12,670	8,738	14,676	9,000	15,000	38,874	20,387	80,647	65,781	139,910	126,542
Don Pedro Centering															
Friant															
Max. Release:	8,000 to 11,000	2,163	3,012	5,346	4,901	8,000	10,987	8,000	12,000	8,630	12,000	30,749	13,883	92,384	54,945
New Exchequer															
Max. Release:	6,000 to 7,000	1,976	2,140	5,077	5,655	5,766	6,754	5,769	6,756	6,617	6,751	35,028	29,897	83,919	80,000
Don Pedro															
Max. Release:	9,000 to 15,000	5,894	7,179	8,737	14,676	9,000	14,676	39,630	16,611	80,821	66,043	126,377	112,617	185,449	176,235

	Maximum Baseline
	Maximum Alternative

TABLE C.4-8b
EFFECTS OF ALTERNATIVE SCENARIO SJQ-B04A

Friant Dam Storm Runoff Centering									
Percent Chance Exceedence	Index Gage Location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	-18.7	-8.3	-8.3	-8.6	-17.8	-13.3	-5.1	-4.2
	Peak Attenuation (AF)	-2,886	-2,346	-1,416	-3,595	-3,139	-3,109	-2,596	-2,578
10%	% Peak Reduced	-50.2	-34.0	-8.3	-28.6	-17.8	-13.3	-23.0	-20.8
	Peak Attenuation (AF)	-27,954	-28,061	-1,416	-30,572	-3,139	-3,109	-32,034	-33,872
4%	% Peak Reduced	-33.3	-16.4	-9.0	-14.5	-21.8	-17.1	-11.3	-10.5
	Peak Attenuation (AF)	-54,024	-27,211	-3,198	-28,217	-6,334	-6,281	-44,261	-44,201
2%	% Peak Reduced	51.8	21.6	-12.8	14.3	-41.9	-60.9	13.4	11.0
	Peak Attenuation (AF)	56,420	166,203	-11,518	48,756	-40,379	-42,082	62,902	65,382
1%	% Peak Reduced	38.0	25.7	-17.1	20.1	-66.7	-28.1	12.3	11.0
	Peak Attenuation (AF)	68,961	59,552	-35,635	50,515	-104,892	-106,459	25,507	24,989
0.5%	% Peak Reduced	29.1	20.5	-17.1	15.7	-66.7	-13.7	8.2	7.4
	Peak Attenuation (AF)	67,895	78,263	-28,303	68,202	-167,955	-164,985	24,836	24,486
0.2%	% Peak Reduced	-0.4	2.8	46.5	5.4	40.2	38.7	1.6	1.7
	Peak Attenuation (AF)	-52,319	61,353	20,779	73,799	39,867	38,039	60,158	59,349

El Nido Storm Runoff Centering									
Percent Chance Exceedence	Index Gage Location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	-28.3	-8.7	-8.1	-5.3	-18.5	-13.9	-3.2	-2.9
	Peak Attenuation (AF)	-1,359	-909	-2,376	-3,157	-3,537	-3,503	-4,507	-6,488
10%	% Peak Reduced	-46.8	-22.3	-13.6	-16.3	-41.1	-60.2	-9.6	-8.4
	Peak Attenuation (AF)	-20,209	-18,939	-13,477	-34,372	-32,094	-32,128	-74,774	-74,745
4%	% Peak Reduced	-48.6	-14.8	-17.1	-13.7	-6.637	-50.5	-20.8	-19.8
	Peak Attenuation (AF)	-23,104	-26,758	-38,098	-53,262	-95,843	-95,219	-165,429	-165,485
2%	% Peak Reduced	16.0	7.3	-17.2	3.0	-66.7	-18.3	-10.8	-9.3
	Peak Attenuation (AF)	51,402	46,352	-28,324	36,027	-178,420	-170,272	-142,073	-142,181
1%	% Peak Reduced	41.3	26.0	46.0	25.1	52.6	44.6	13.8	12.2
	Peak Attenuation (AF)	65,410	55,471	9,741	59,443	35,323	33,048	39,889	39,266
0.5%	% Peak Reduced	37.8	22.4	16.7	16.1	21.7	21.4	9.0	8.4
	Peak Attenuation (AF)	70,353	72,829	14,758	84,357	44,698	41,794	48,410	47,874
0.2%	% Peak Reduced	0.8	4.6	4.2	5.5	11.8	12.1	1.8	1.7
	Peak Attenuation (AF)	60,622	58,967	18,742	66,888	46,201	43,614	88,239	87,714

	Maximum peak flow reduction %
	Maximum peak volume attenuation

Notes:

- 1) Flow at mainstem points are estimated by HEC-5, which assumes all flows remain in channel (bypasses were treated as channels).
Flows at mainstem points are taken "at latitude" (See Chapter III of Appendix B).
- 2) % Peak Reduced = ((Maximum Regulated Baseline Inflow)-(Maximum Regulated Alternative Inflow))/(Maximum Regulated Baseline Inflow) X 100%.
- 3) Peak Attenuation = (Σ attenuated peak volume)*(0.08265 ac-ft/cfs)

TABLE C.4-8b (CONT.)
EFFECTS OF ALTERNATIVE SCENARIO SJQ-B04A

Exchequer Dam Storm Runoff Centering									
Percent Chance Exceedence	Index Gage Location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	-39.2	4.4	-9.0	-4.5	-17.8	-13.3	-5.5	-4.6
	Peak Attenuation (AF)	-508	117	-3,198	-3,306	-3,138	-3,109	-15,278	-15,274
10%	% Peak Reduced	-5.3	0.8	-17.1	-4.9	-47.3	-44.9	-3.7	-5.4
	Peak Attenuation (AF)	-477	657	-35,635	-36,414	-24,822	-24,705	-62,353	-62,374
4%	% Peak Reduced	-50.0	-26.1	-17.1	-20.2	-68.0	-66.1	-30.2	-25.2
	Peak Attenuation (AF)	-29,599	-29,807	-28,323	-58,022	-106,559	-106,339	-184,227	-184,284
2%	% Peak Reduced	-43.4	-15.8	46.5	13.4	-66.7	-46.9	-2.7	-2.9
	Peak Attenuation (AF)	-33,491	-32,347	20,779	10,518	-184,065	-176,283	-23,587	-229,622
1%	% Peak Reduced	20.0	8.3	10.0	5.1	47.6	46.9	6.0	5.7
	Peak Attenuation (AF)	50,519	44,833	15,058	14,919	45,092	42,460	56,388	55,896
0.5%	% Peak Reduced	40.2	24.2	4.4	2.9	18.4	18.2	3.3	3.1
	Peak Attenuation (AF)	63,111	54,405	16,007	20,926	44,629	41,825	59,199	58,686
0.2%	% Peak Reduced	33.3	22.3	4.7	2.3	9.3	9.7	2.7	2.5
	Peak Attenuation (AF)	68,088	85,542	21,912	159,693	263,606	42,563	171,246	168,849

Newman Storm Runoff Centering									
Percent Chance Exceedence	Index Gage Location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	-32.5	1.1	-8.3	-3.4	-19.9	-15.3	-5.9	-5.1
	Peak Attenuation (AF)	-1,184	-835	-2,883	-3,536	-4,598	-4,556	-16,350	-16,348
10%	% Peak Reduced	-31.5	-24.9	-17.2	-17.4	-51.8	-59.0	-12.0	-10.6
	Peak Attenuation (AF)	-12,828	-11,186	-27,834	-33,360	-58,071	-57,814	-104,350	-104,333
4%	% Peak Reduced	-50.0	-22.6	-17.1	-19.3	-66.7	-27.9	-30.7	-24.0
	Peak Attenuation (AF)	-41,335	-41,094	-28,310	-68,937	-154,688	-154,446	-249,331	-246,838
2%	% Peak Reduced	-9.4	-1.2	54.7	15.8	31.2	27.6	2.7	1.8
	Peak Attenuation (AF)	-18,942	-6,202	15,930	45,549	103,361	8,544	2,412	3,523
1%	% Peak Reduced	54.3	27.2	10.3	5.6	23.5	22.8	5.7	5.2
	Peak Attenuation (AF)	64,102	53,189	13,873	13,058	43,266	40,543	52,560	52,073
0.5%	% Peak Reduced	40.1	21.6	4.6	2.1	15.1	15.3	2.8	2.7
	Peak Attenuation (AF)	69,182	61,957	15,569	10,188	46,468	44,481	51,453	50,870
0.2%	% Peak Reduced	6.3	6.1	4.9	1.9	7.2	8.9	2.4	2.2
	Peak Attenuation (AF)	61,601	136,650	20,943	108,511	46,647	44,877	137,305	136,647

	Maximum peak flow reduction %
	Maximum peak volume attenuation

Notes:

- 1) Flow at mainstem points are estimated by HEC-5, which assumes all flows remain in channel (bypasses were treated as channels).
Flows at mainstem points are taken "at latitude" (See Chapter III of Appendix B).
- 2) % Peak Reduced = ((Maximum Regulated Baseline Inflow)-(Maximum Regulated Alternative Inflow))/(Maximum Regulated Baseline Inflow) X 100%.
- 3) Peak Attenuation = (Σ attenuated peak volume)*(0.08265 ac-ft/cfs)

TABLE C.4-8b (CONT.)
EFFECTS OF ALTERNATIVE SCENARIO SJQ-B04A

Don Pedro Storm Runoff Centering									
Percent Chance Exceedence	Index Gage Location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	-39.2	4.4	-8.3	-3.3	-21.8	-19.6	-8.4	-7.2
	Peak Attenuation (AF)	508	117	-1,416	-1,577	-6,334	-6,282	-7,137	-18,226
10%	% Peak Reduced	8.3	2.3	-11.4	-1.1	-68.0	-65.7	-18.6	-14.9
	Peak Attenuation (AF)	1,147	396	-8,034	-12,095	-82,779	-82,567	-88,722	-88,685
4%	% Peak Reduced	-37.3	-27.0	-17.1	-20.5	-63.1	-64.4	-35.1	-28.3
	Peak Attenuation (AF)	-12,188	-10,751	-36,864	-37,303	-177,126	-170,002	-1,972	-192,953
2%	% Peak Reduced	-50.0	-28.0	-17.1	-22.3	58.1	53.6	21.8	18.2
	Peak Attenuation (AF)	-51,422	22,782	-28,307	-81,502	52,851	50,291	46,377	45,746
1%	% Peak Reduced	-39.0	-13.3	-2.0	-13.2	18.3	18.0	12.2	11.1
	Peak Attenuation (AF)	-19,762	-18,412	-25,423	-29,300	43,831	40,768	39,855	39,309
0.5%	% Peak Reduced	54.9	18.8	14.6	7.0	10.9	11.0	9.0	8.4
	Peak Attenuation (AF)	56,232	53,124	14,190	12,604	44,722	42,803	55,055	54,666
0.2%	% Peak Reduced	40.5	24.5	4.7	3.0	5.0	5.8	4.6	3.7
	Peak Attenuation (AF)	70,077	65,814	16,467	23,613	43,267	41,457	95,812	95,804

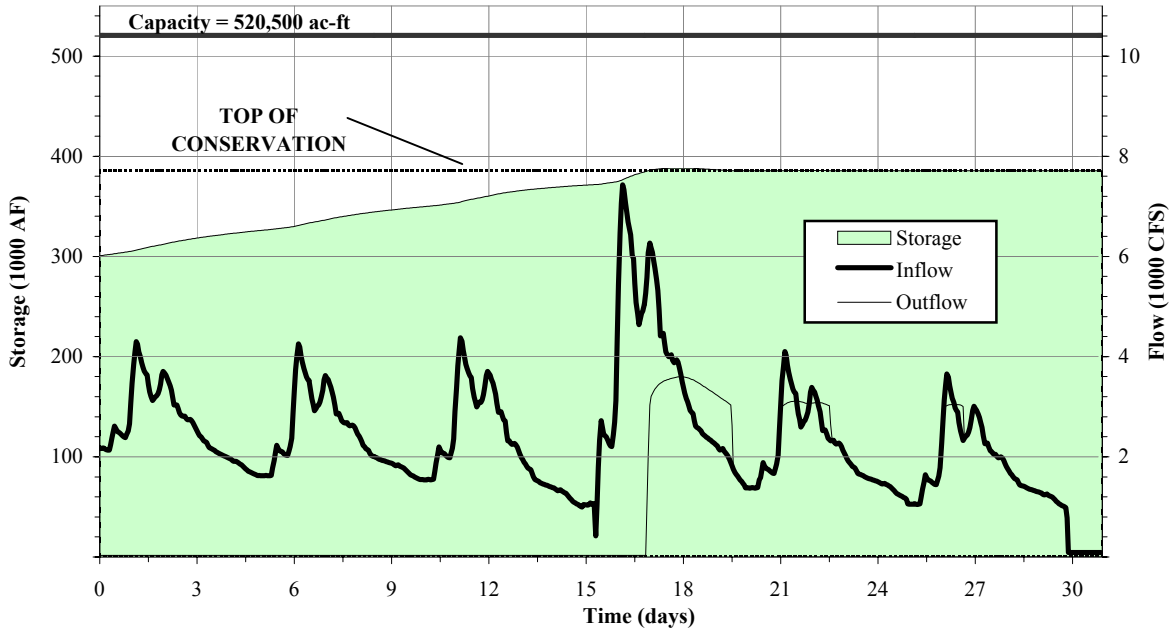
Vernalis Storm Runoff Centering									
Percent Chance Exceedence	Index Gage Location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	-33.6	1.1	-8.2	-3.4	-20.8	-16.2	-6.8	-6.1
	Peak Attenuation (AF)	-820	751	-2,677	-3,272	-5,363	-5,316	-6,840	-17,319
10%	% Peak Reduced	-21.7	-15.9	-17.1	-11.8	-66.7	-41.9	-16.8	-17.0
	Peak Attenuation (AF)	-6,856	-5,355	-23,936	-25,235	-86,741	-86,470	-129,597	-12,969
4%	% Peak Reduced	-50.0	-26.5	-17.1	-17.7	-66.7	-17.7	-27.1	-22.5
	Peak Attenuation (AF)	-47,943	-48,052	-28,305	-77,543	-175,087	-169,314	-266,793	-263,762
2%	% Peak Reduced	-38.4	-9.9	-17.1	-10.2	52.7	44.8	8.7	7.0
	Peak Attenuation (AF)	-34,387	-15,392	-29,149	-26,497	35,178	32,913	29,939	29,515
1%	% Peak Reduced	57.1	18.8	19.6	11.2	21.1	20.8	11.7	10.7
	Peak Attenuation (AF)	53,655	55,879	15,295	49,564	44,805	42,052	54,609	54,001
0.5%	% Peak Reduced	37.8	22.9	5.6	4.0	13.0	13.3	5.4	3.4
	Peak Attenuation (AF)	69,180	60,924	15,472	19,819	46,602	43,976	61,988	61,581
0.2%	% Peak Reduced	10.9	6.5	4.7	2.0	5.9	7.1	2.7	2.4
	Peak Attenuation (AF)	69,158	52,453	19,965	80,837	46,748	44,622	112,613	112,000

	Maximum peak flow reduction %
	Maximum peak volume attenuation

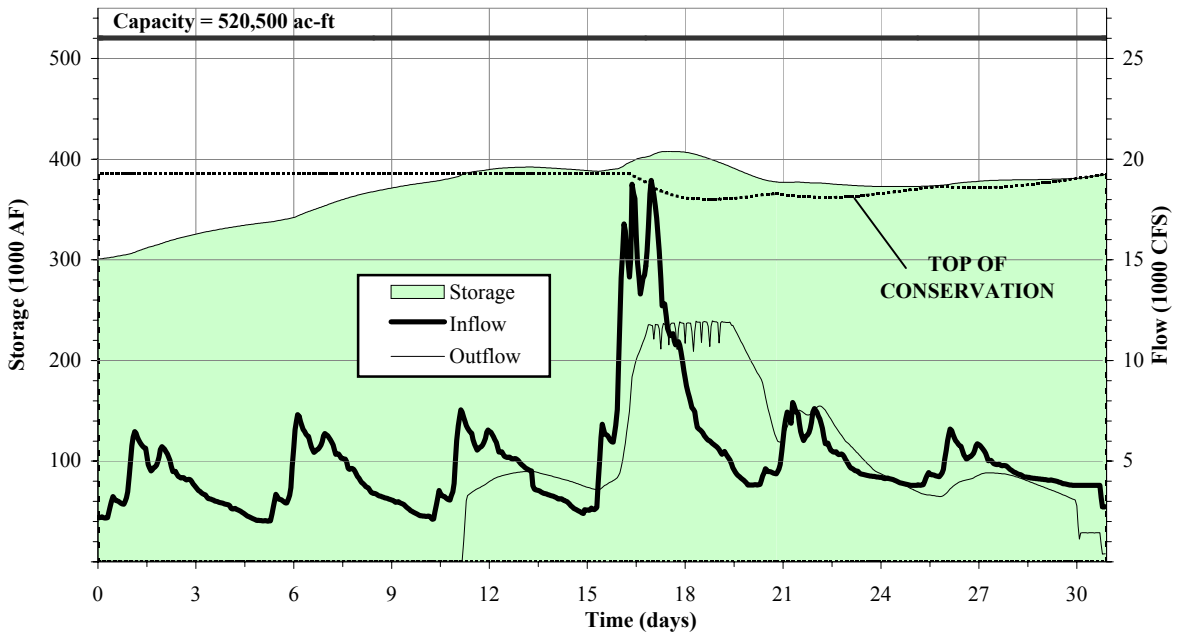
Notes:

- 1) Flow at mainstem points are estimated by HEC-5, which assumes all flows remain in channel (bypasses were treated as channels).
Flows at mainstem points are taken "at latitude" (See Chapter III of Appendix B).
- 2) % Peak Reduced = ((Maximum Regulated Baseline Inflow)-(Maximum Regulated Alternative Inflow))/(Maximum Regulated Baseline Inflow) X 100%.
- 3) Peak Attenuation = (Σ attenuated peak volume)*(0.08265 ac-ft/cfs)

Friant Operations (50% Chance Exceedence Event)



Friant Operations (10% Chance Exceedence Event)

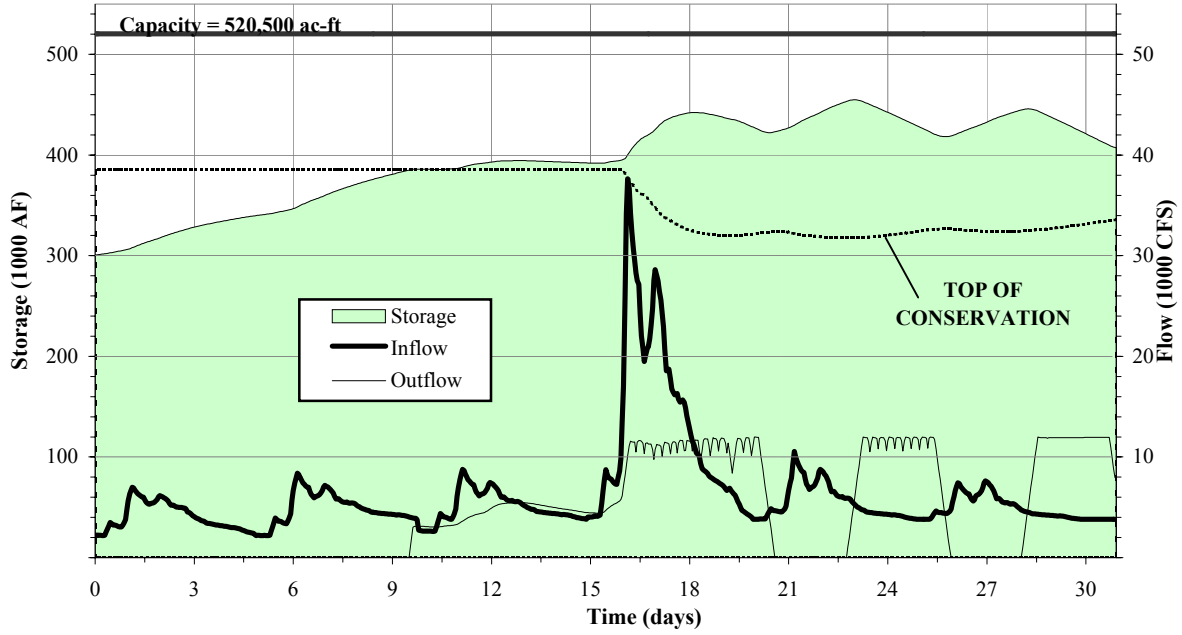


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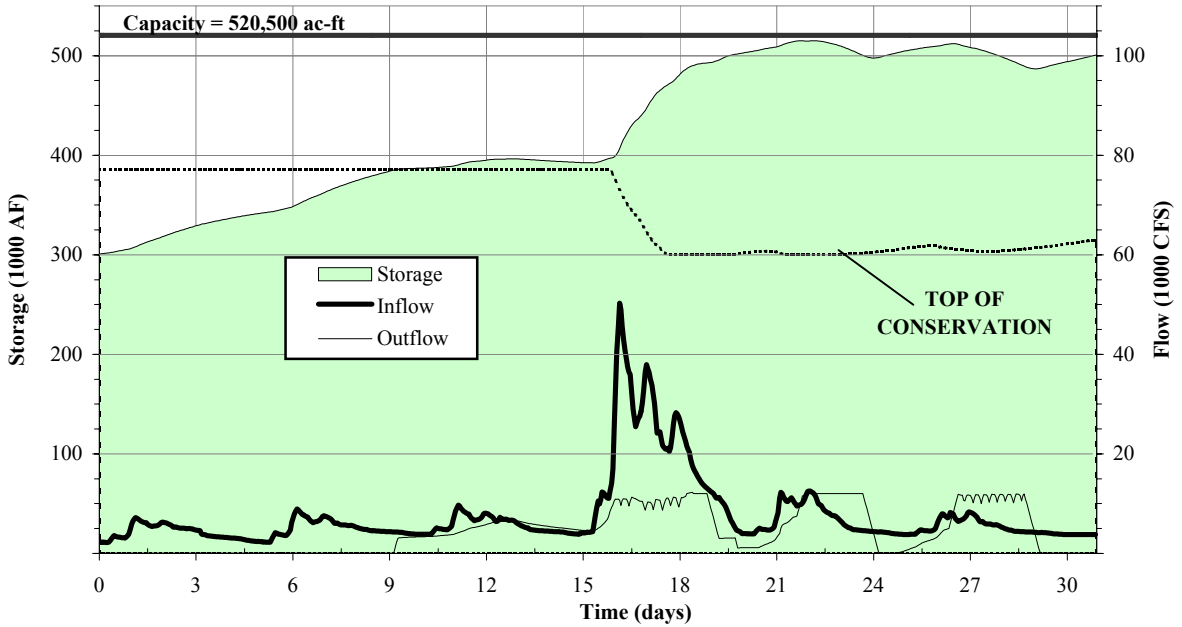
Figure C.4-8a
Reservoir Simulation Hydrographs
Alternative Scenario SJQ-B04A

US Army Corps of Engineers
The Reclamation Board, State of California December 2002

Friant Operations (4% Chance Exceedence Event)



Friant Operations (2% Chance Exceedence Event)

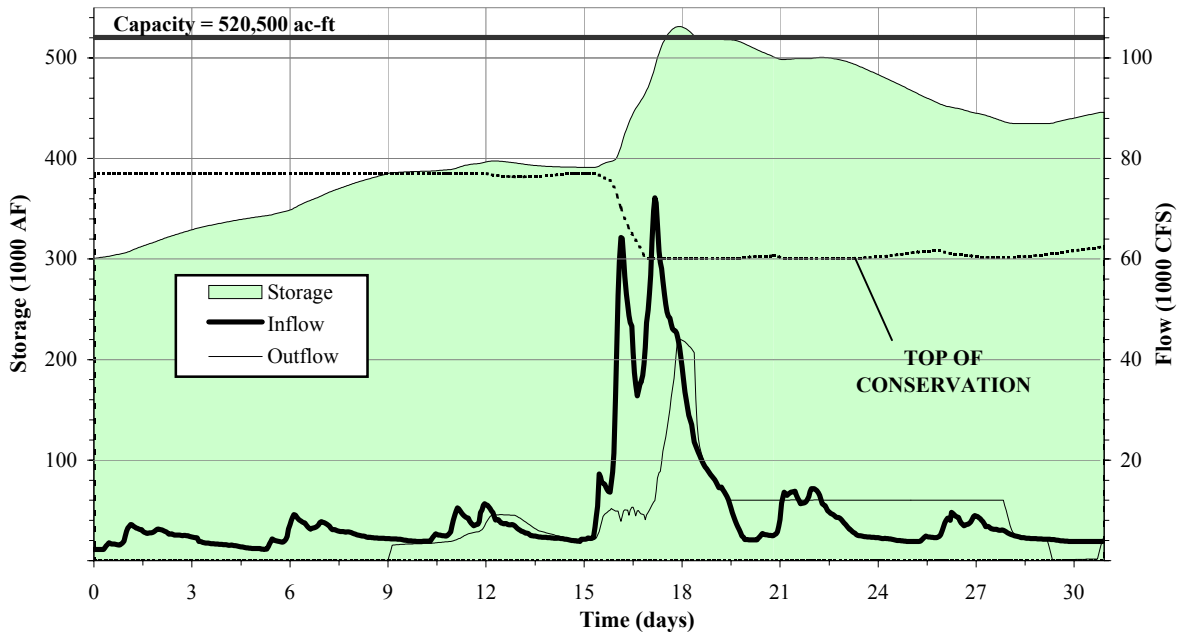


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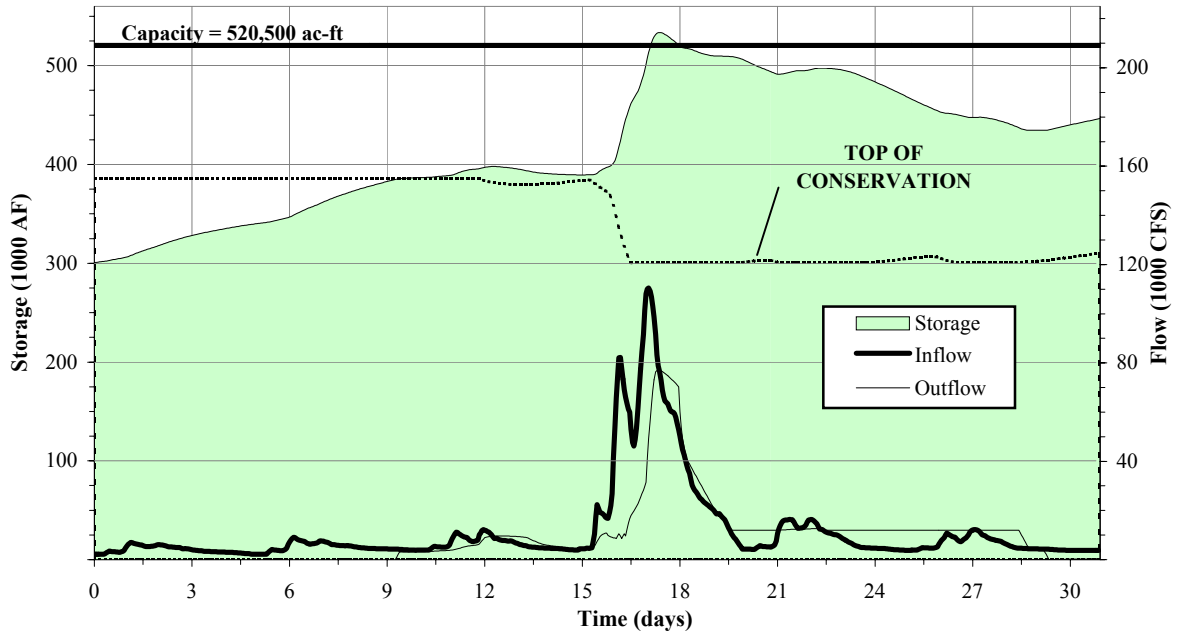
Figure C.4-8b
Reservoir Simulation Hydrographs
Alternative Scenario SJQ-B04A

US Army Corps of Engineers
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Friant Operations (1% Chance Exceedence Event)



Friant Operations (0.5% Chance Exceedence Event)

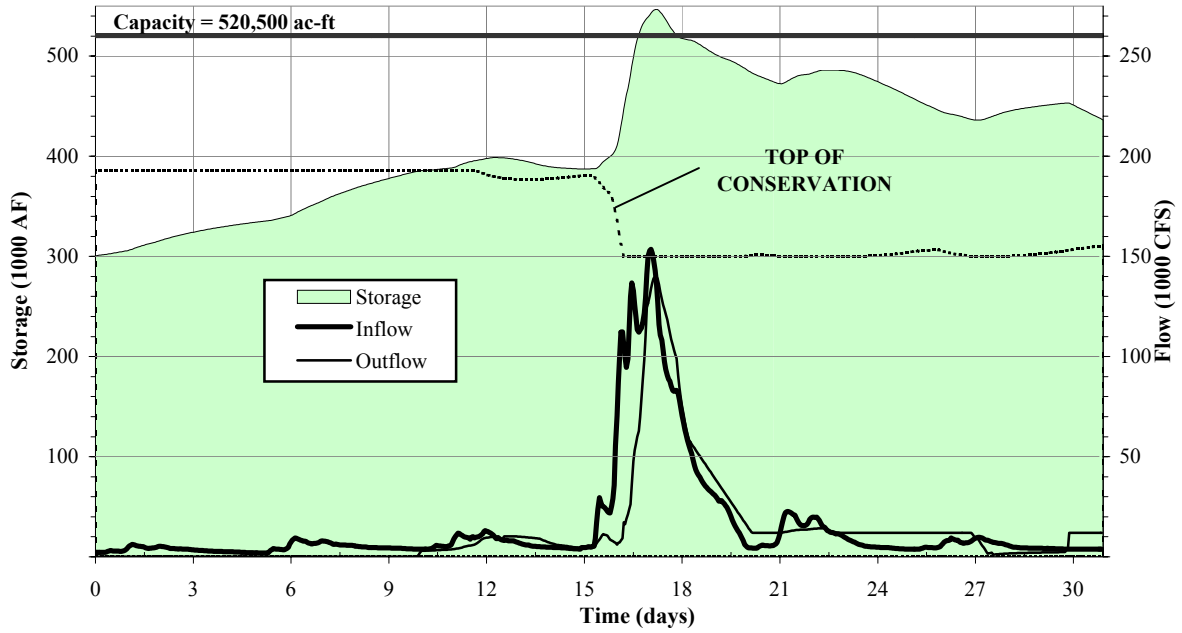


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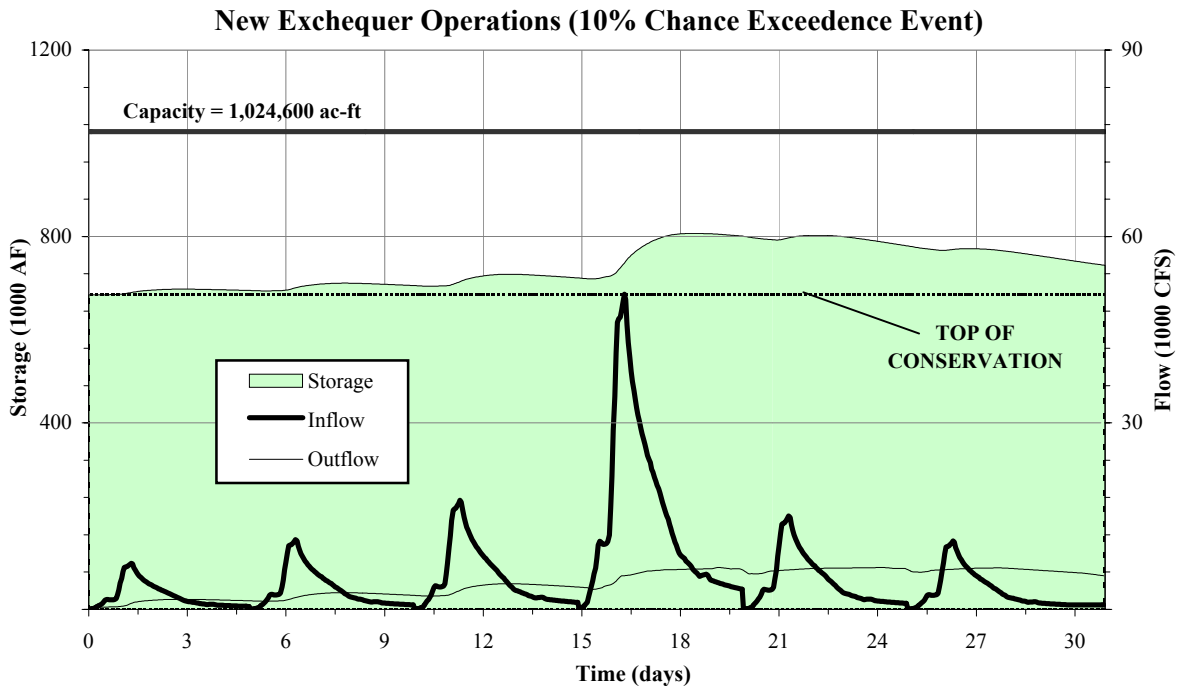
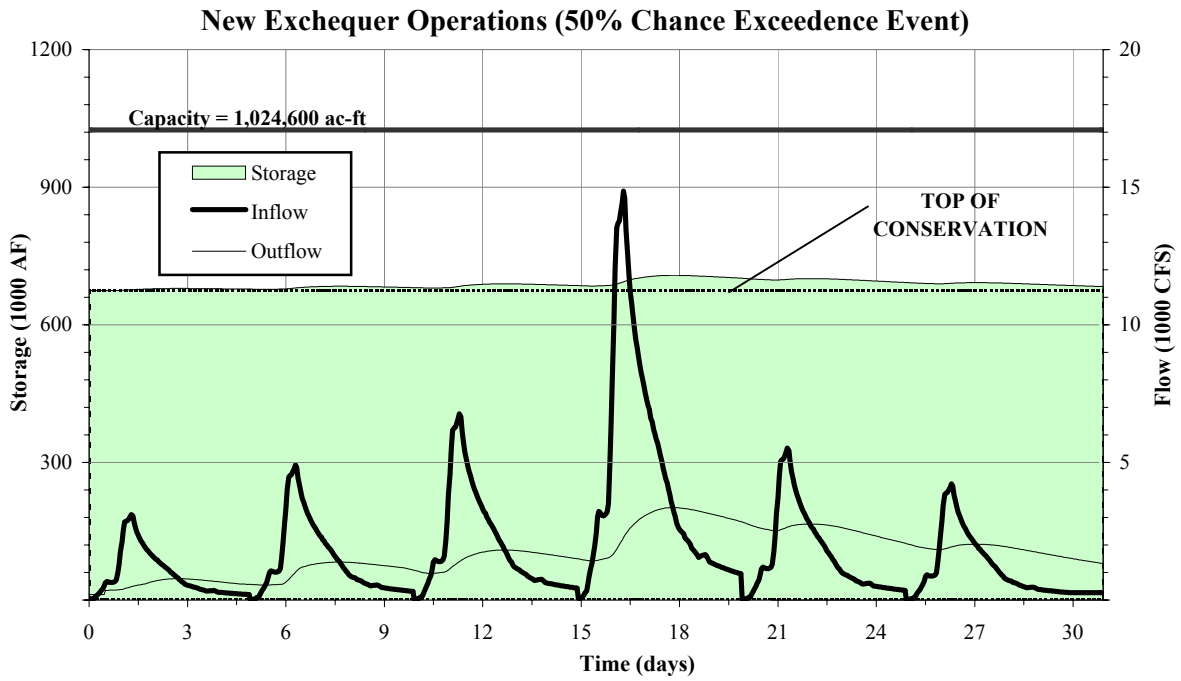
Figure C.4-8c
Reservoir Simulation Hydrographs
Alternative Scenario SJQ-B04A

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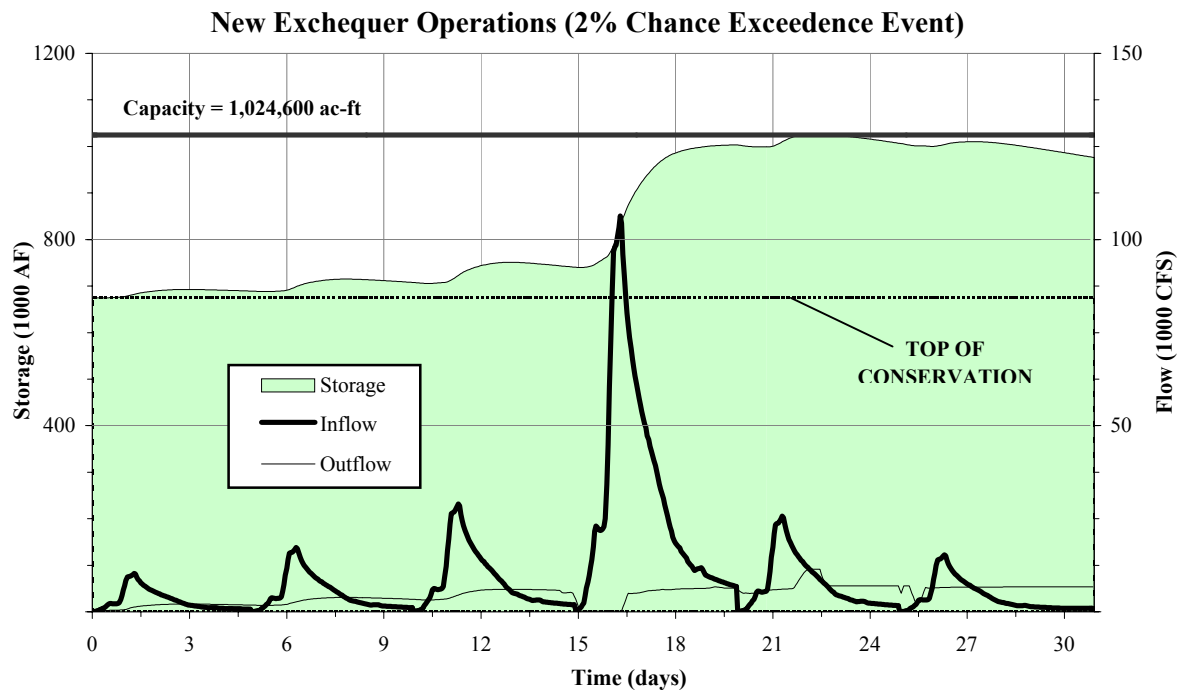
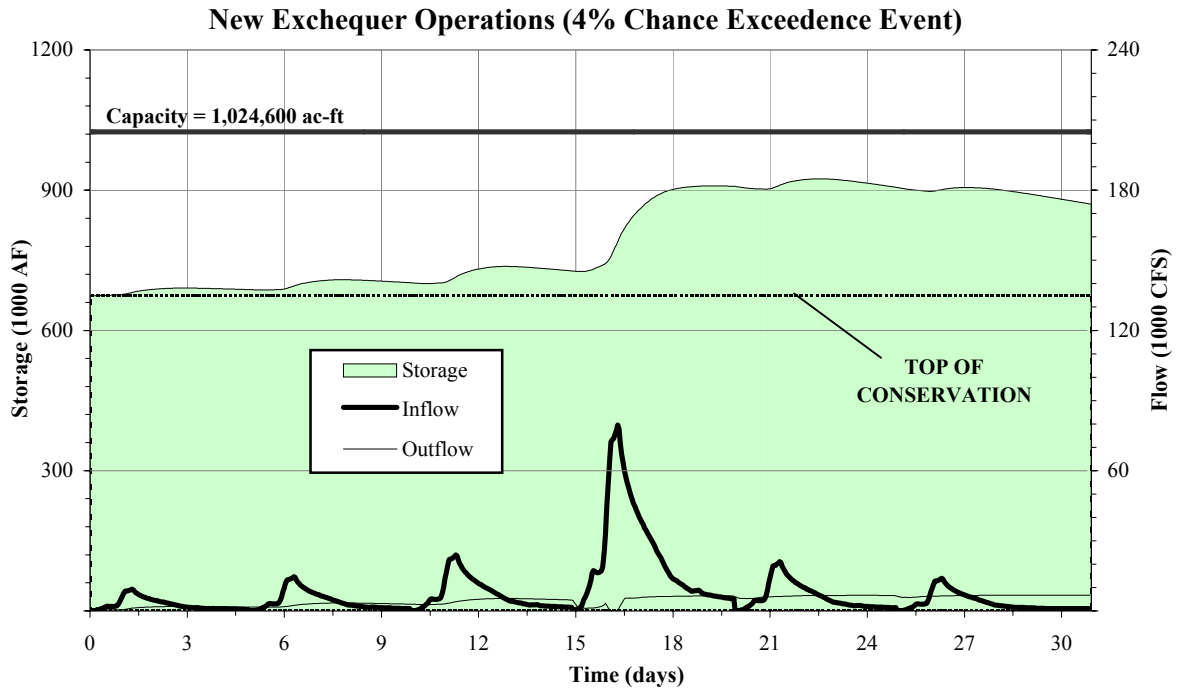
Friant Operations (0.2% Chance Exceedence Event)



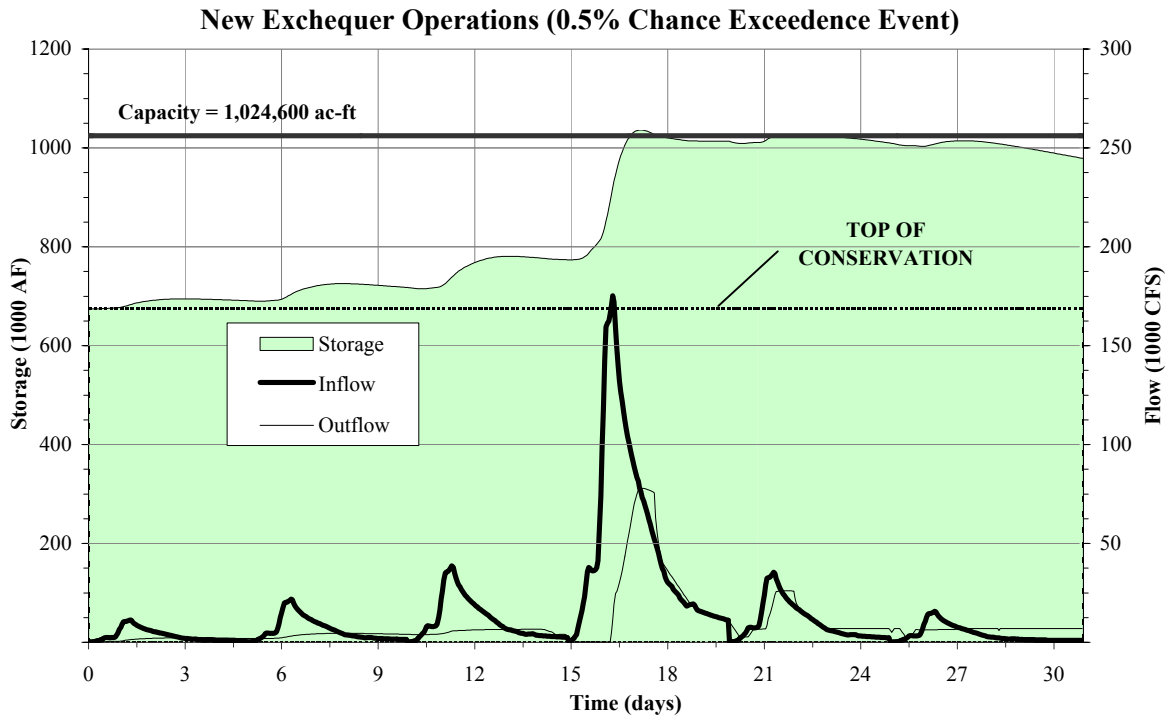
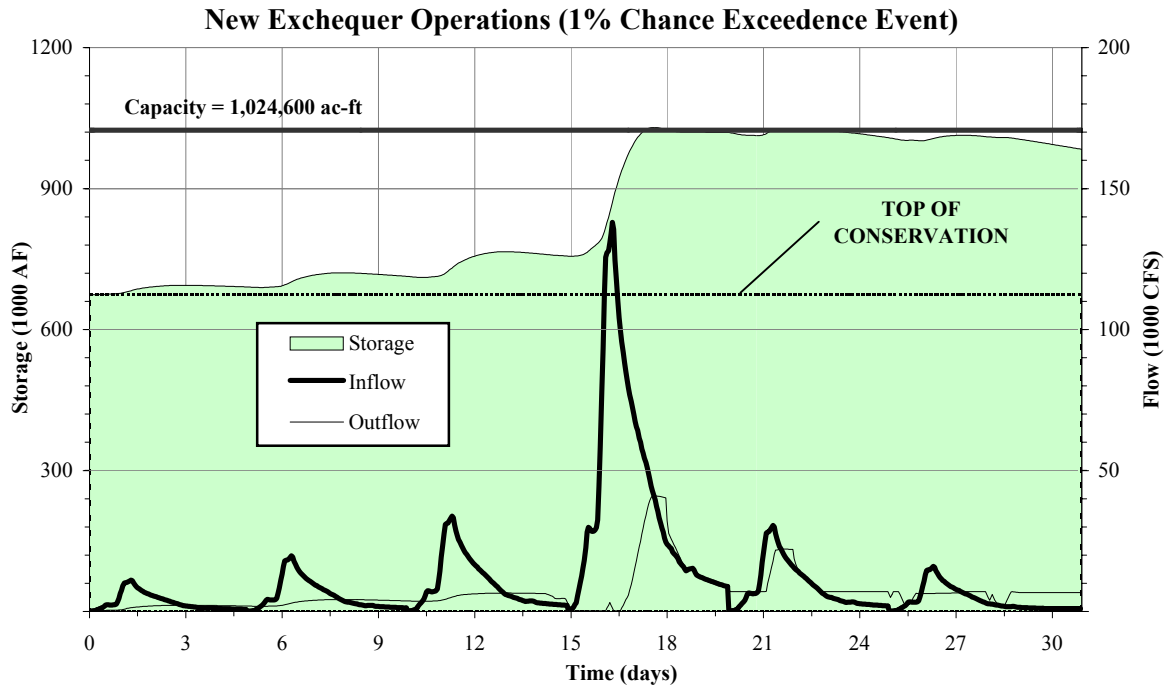
Sacramento & San Joaquin River Basins Comprehensive Study	
Figure C.4-8d Reservoir Simulation Hydrographs Alternative Scenario SJQ-B04A	
US Army Corps of Engineers The Reclamation Board, State of California	December 2002



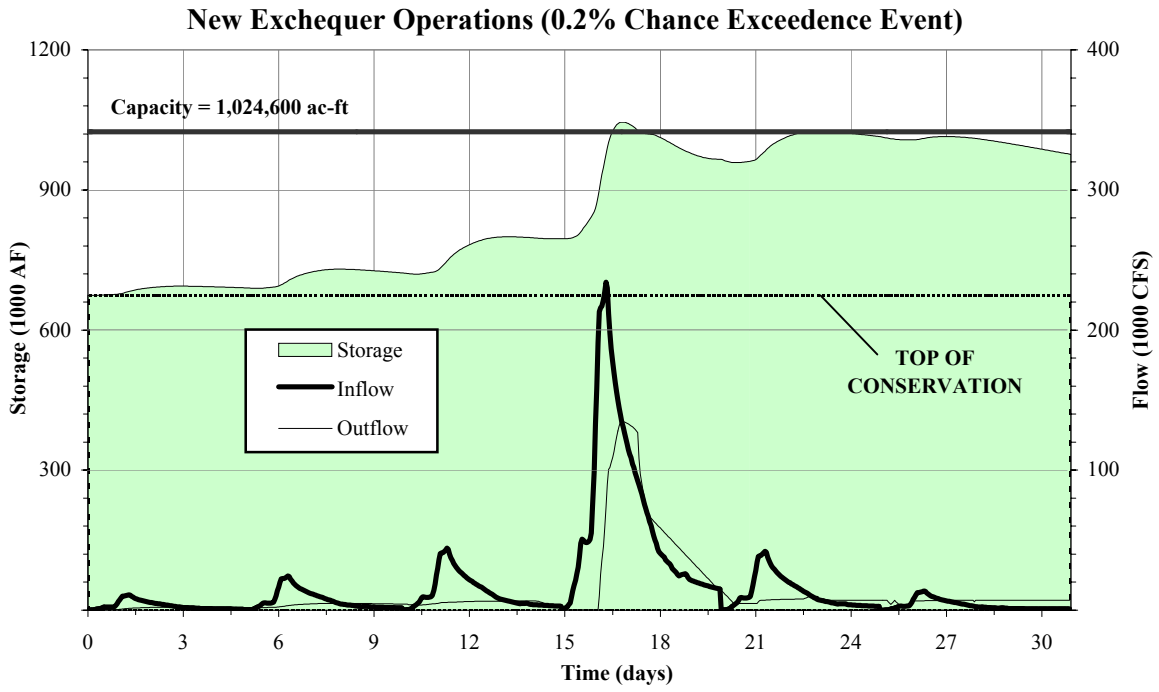
Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.4-8e Reservoir Simulation Hydrographs Alternative Scenario SJQ-B04A
US Army Corps of Engineers The Reclamation Board, State of California December 2002



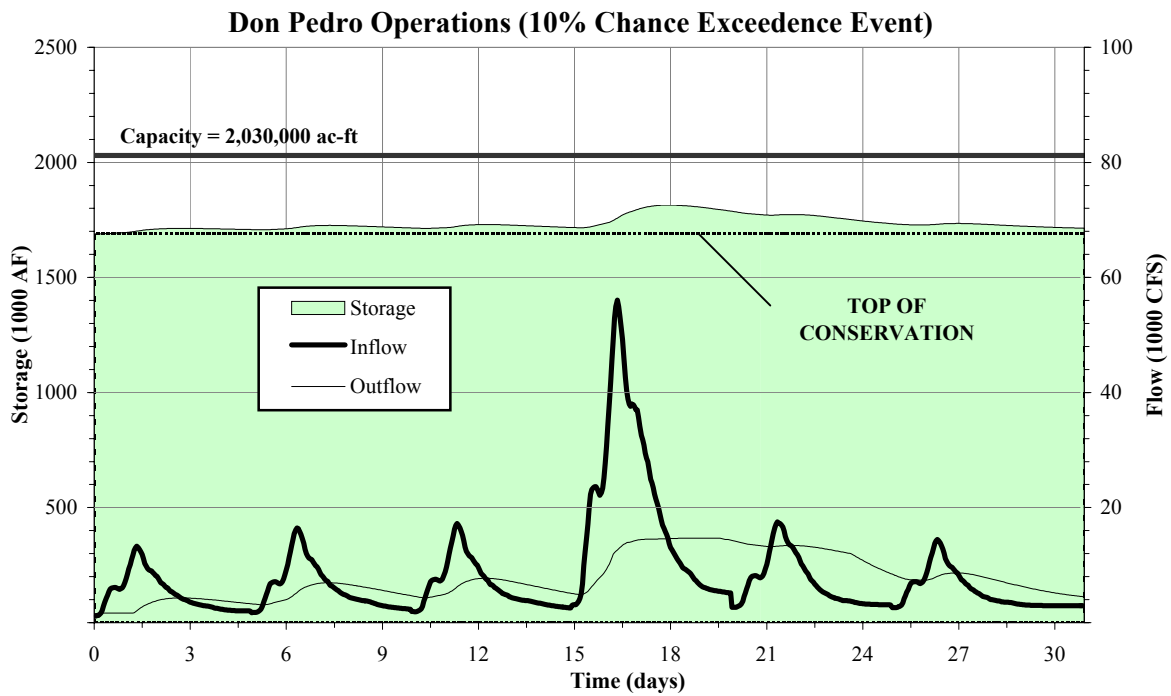
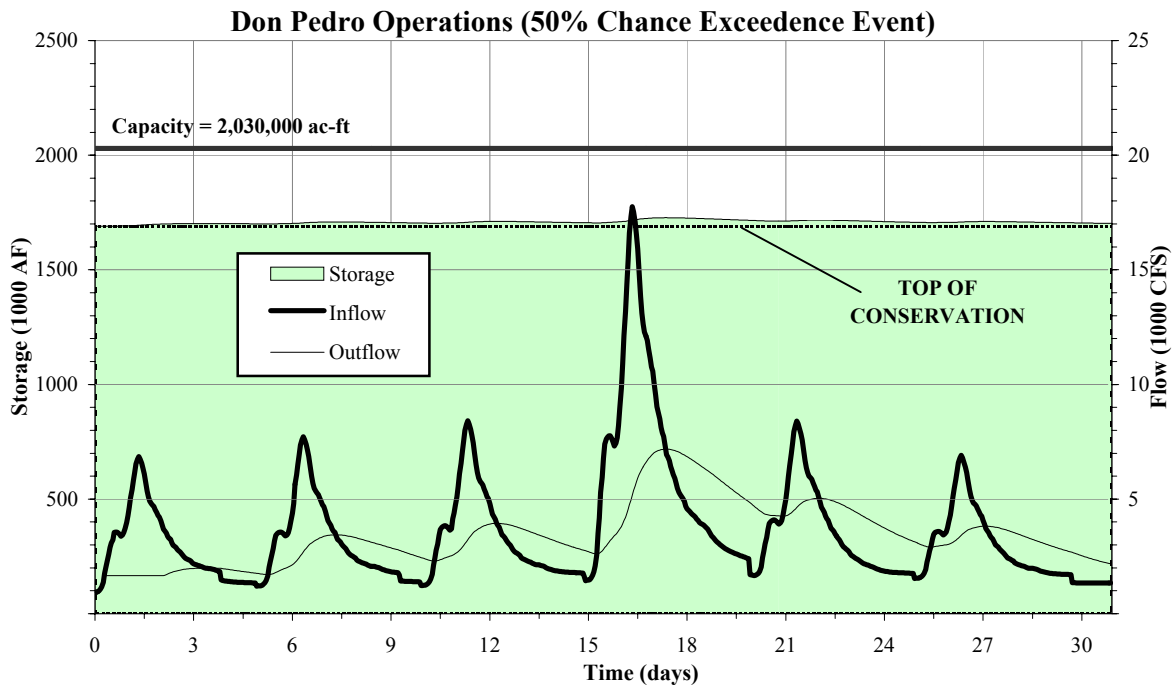
Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.4-8f Reservoir Simulation Hydrographs Alternative Scenario SJQ-B04A
US Army Corps of Engineers The Reclamation Board, State of California December 2002



Sacramento & San Joaquin River Basins Comprehensive Study	
Figure C.4-8g Reservoir Simulation Hydrographs Alternative Scenario SJQ-B04A	
US Army Corps of Engineers The Reclamation Board, State of California December 2002	

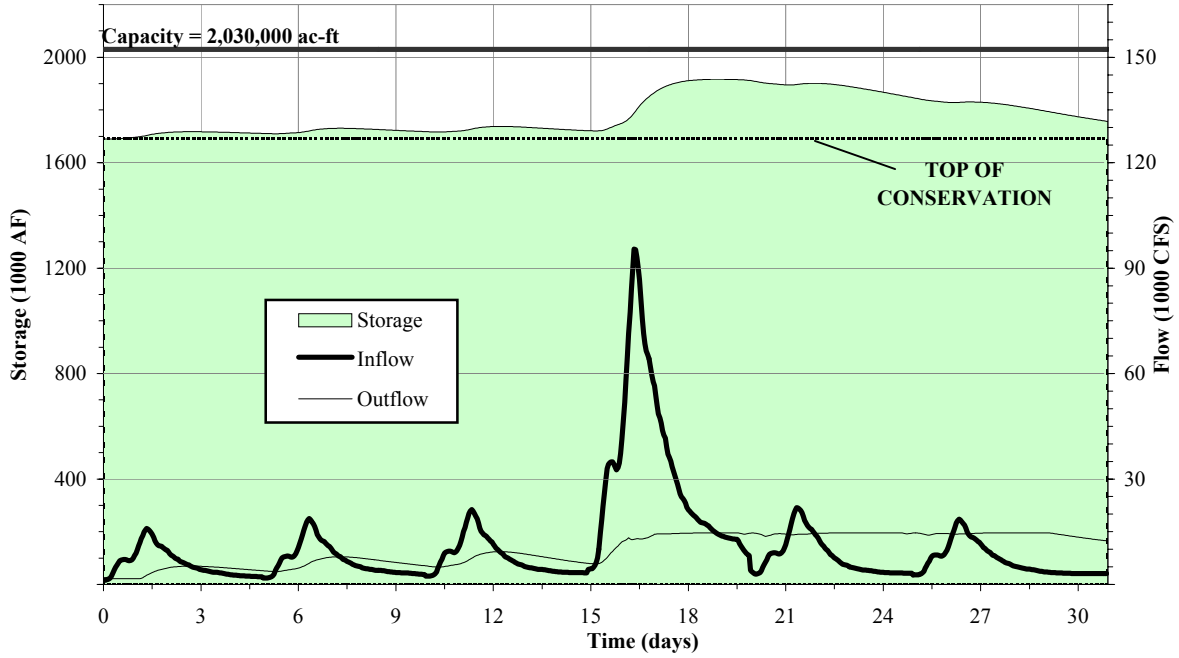


Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.4-8h Reservoir Simulation Hydrographs Alternative Scenario SJQ-B04A
US Army Corps of Engineers The Reclamation Board, State of California December 2002

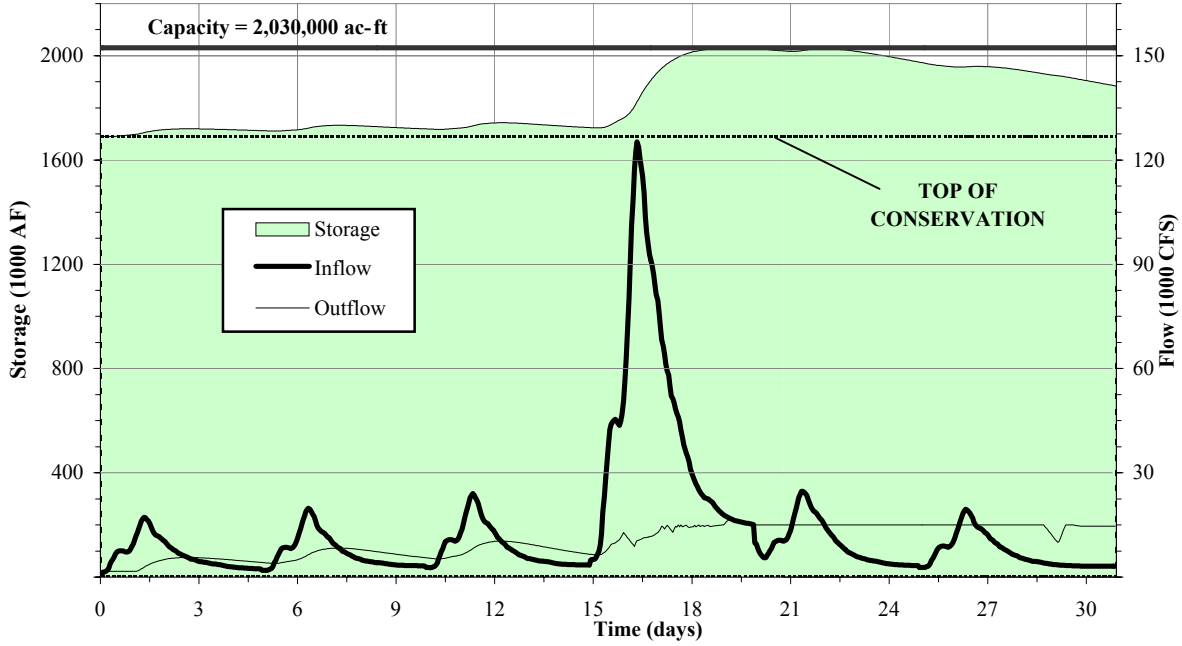


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Figure C.4-8i Reservoir Simulation Hydrographs Alternative Scenario SJQ-B04A	
US Army Corps of Engineers The Reclamation Board, State of California	December 2002

Don Pedro Operations (4% Chance Exceedence Event)



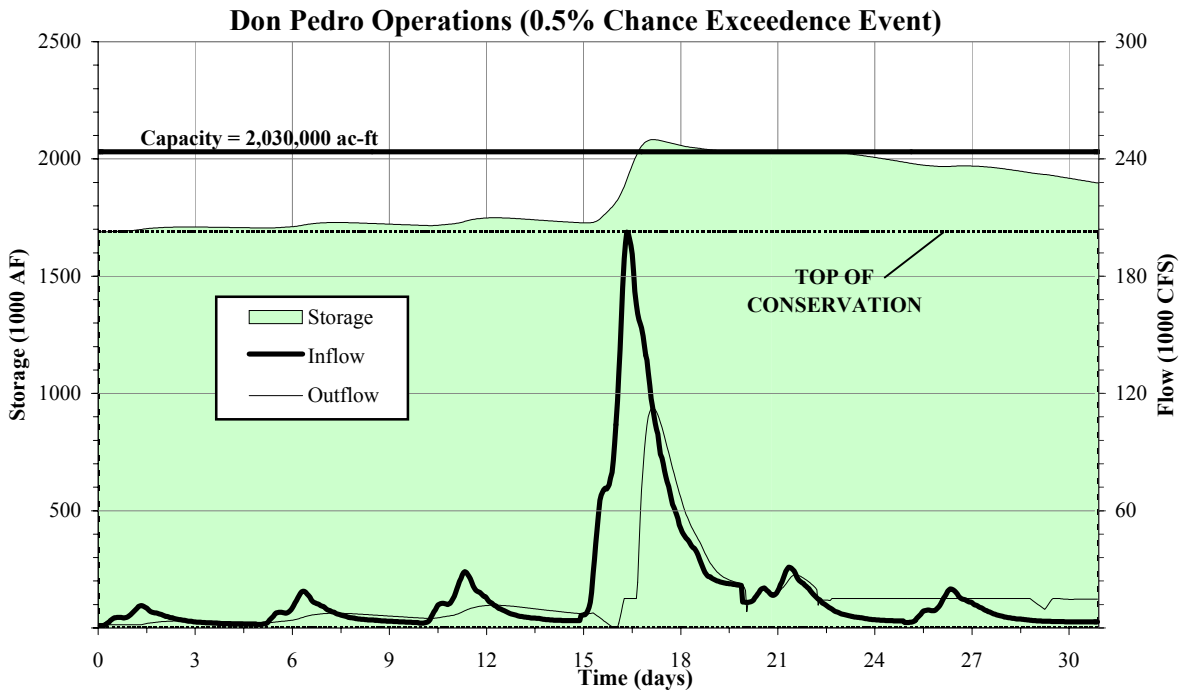
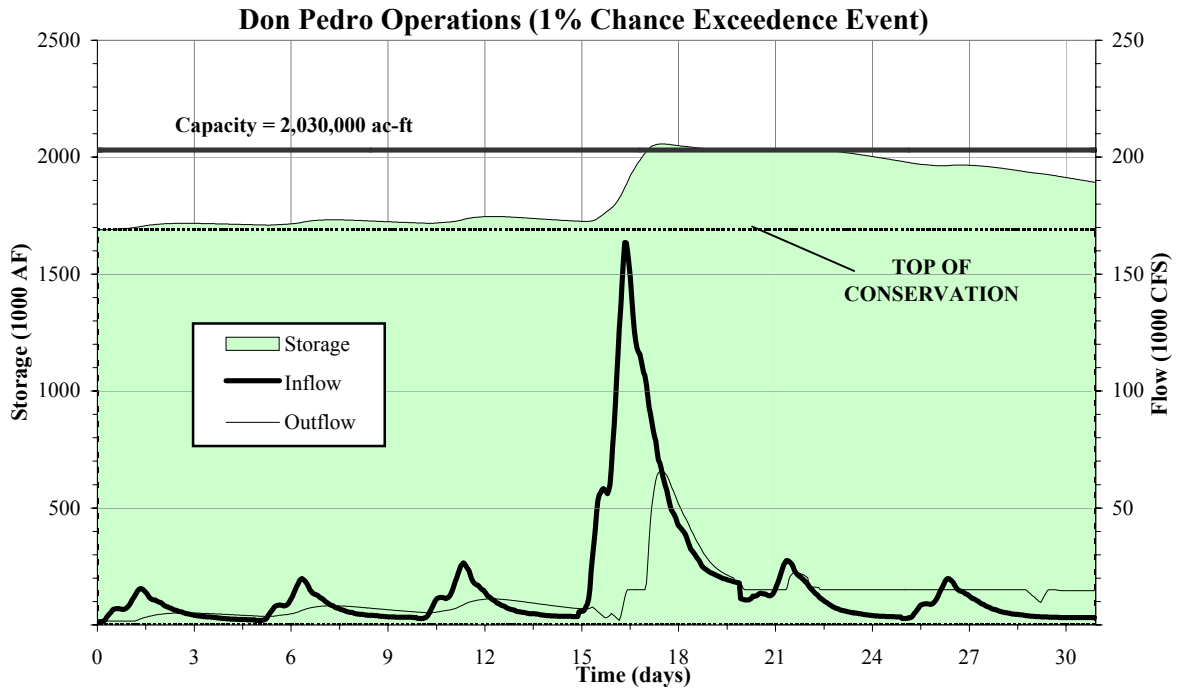
Don Pedro Operations (2% Chance Exceedence Event)



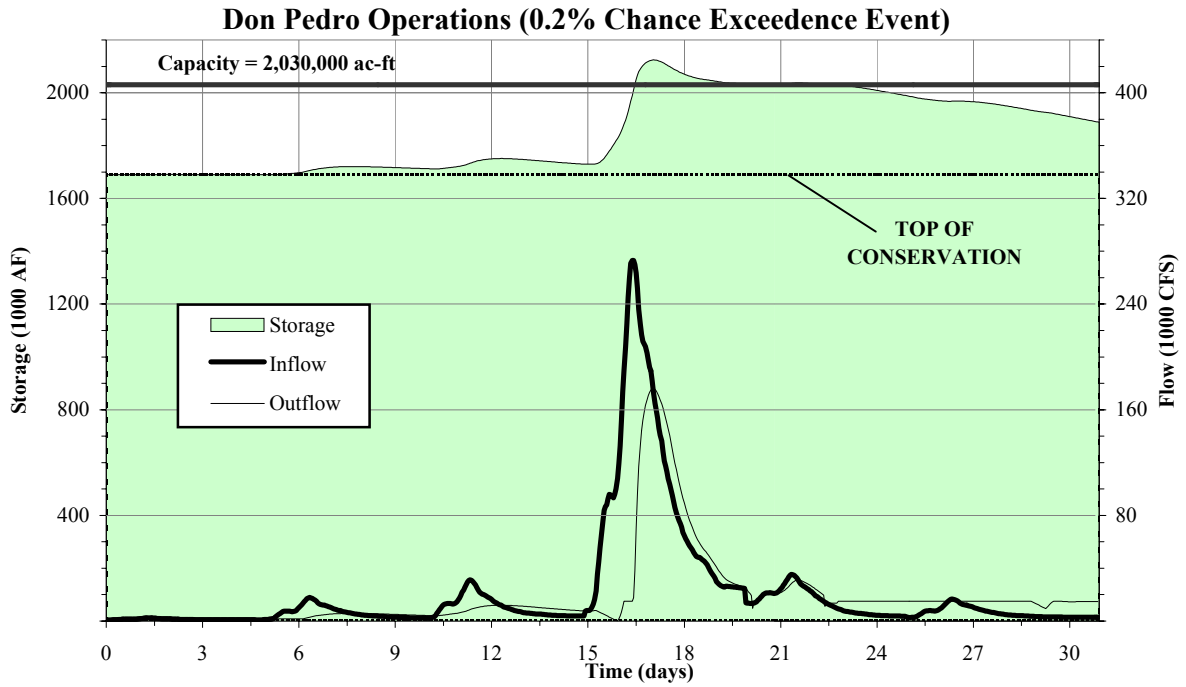
Sacramento & San Joaquin River Basins
Comprehensive Study

Figure C.4-8j
Reservoir Simulation Hydrographs
Alternative Scenario SJQ-B04A

US Army Corps of Engineers
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Figure C.4-8k Reservoir Simulation Hydrographs Alternative Scenario SJQ-B04A	
US Army Corps of Engineers The Reclamation Board, State of California	December 2002



Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.4-8I Reservoir Simulation Hydrographs Alternative Scenario SJQ-B04A
US Army Corps of Engineers The Reclamation Board, State of California December 2002

TABLE C.4-9a

COMPARISON OF MAXIMUM RELEASE OF BASELINE AND ALTERNATIVE SCENARIO (SJQ-B05A)
SIMULATIONS FOR SPECIFIC ANNUAL PERCENT CHANCE EXCEEDENCE EVENTS

	50% Chance Exceedence Event		10% Chance Exceedence Event		4% Chance Exceedence Event		2% Chance Exceedence Event		1% Chance Exceedence Event		0.5% Chance Exceedence Event		0.2% Chance Exceedence Event		
	Baseline	Alternative	Baseline	Alternative	Baseline	Alternative	Baseline	Alternative	Baseline	Alternative	Baseline	Alternative	Baseline	Alternative	
Friant Centering															
Friant															
Objective Flow:	8,000 cfs														
Flood Conserv. Increase:	170 to 270 TAF	2,577	3,032	7,991	7,971	8,000	9,001	8,216	25,481	29,012	71,093	66,039	108,585	137,960	139,402
New Exchequer															
Objective Flow:	6,000 cfs														
Flood Conserv. Increase:	350 to 400 TAF	1,976	1,870	1,976	1,870	3,080	2,899	5,478	5,263	5,766	5,766	5,768	5,768	21,381	5,764
Don Pedro															
Objective Flow:	9,000 cfs														
Flood Conserv. Increase:	340 to 540 TAF	3,903	3,274	3,903	3,274	5,894	4,850	9,000	8,105	9,000	9,000	9,000	9,000	42,291	9,000
New Exchequer Centering															
Friant															
Objective Flow:	8,000 cfs														
Flood Conserv. Increase:	170 to 270 TAF	2,163	2,090	6,785	6,003	7,985	8,000	8,366	8,000	15,006	8,000	51,568	18,107	110,315	70,868
New Exchequer															
Objective Flow:	6,000 cfs														
Flood Conserv. Increase:	350 to 400 TAF	3,080	2,899	5,766	5,766	5,769	5,769	21,381	5,764	45,533	27,047	81,574	69,099	141,306	125,306
Don Pedro															
Objective Flow:	9,000 cfs														
Flood Conserv. Increase:	340 to 540 TAF	3,903	3,274	8,604	7,771	8,738	8,738	9,000	9,000	38,874	9,000	80,647	30,213	139,910	88,213
Don Pedro Centering															
Friant															
Objective Flow:	8,000 cfs														
Flood Conserv. Increase:	170 to 270 TAF	2,163	2,090	5,346	3,802	8,000	7,930	8,000	8,000	8,630	8,000	30,749	8,790	92,384	51,041
New Exchequer															
Objective Flow:	6,000 cfs														
Flood Conserv. Increase:	350 to 400 TAF	1,976	1,870	5,077	4,809	5,766	5,766	5,769	5,769	6,617	5,763	35,028	26,058	83,919	71,911
Don Pedro															
Objective Flow:	9,000 cfs														
Flood Conserv. Increase:	340 to 540 TAF	5,894	4,850	8,737	8,737	9,000	8,738	39,630	9,000	80,821	29,731	126,377	73,128	185,449	146,052



 Maximum Baseline
 Maximum Alternative

TABLE C.4-9b
EFFECTS OF ALTERNATIVE SCENARIO SJQ-B05A

Friant Dam Storm Runoff Centering									
Percent Chance Exceedence	Index Gage Location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	15	6.2	5.4	6.0	16.1	7.2	5.1	4.3
	Peak Attenuation (AF)	1,894	2,020	1,858	3,791	15,647	15,340	18,785	18,781
10%	% Peak Reduced	-0.2	0.6	5.4	0.8	16.1	7.2	1.5	1.3
	Peak Attenuation (AF)	-3.0	7,379	1,858	9,275	15,647	15,340	24,544	24,541
4%	% Peak Reduced	11.1	6.0	5.9	6.5	17.7	10.9	6.0	5.6
	Peak Attenuation (AF)	5,499	13,739	3,220	31,188	21,197	21,187	37,714	37,698
2%	% Peak Reduced	67.8	34.9	3.9	26.1	9.8	1.8	22.4	19.8
	Peak Attenuation (AF)	87,100	118,687	6,659	111,286	3,624	23,232	135,739	134,048
1%	% Peak Reduced	59.2	39.5	0.0	31.2	0.0	1.3	26.9	24.6
	Peak Attenuation (AF)	102,791	107,203	0	108,982	0	23,524	132,344	132,270
0.5%	% Peak Reduced	39.2	25.9	0.0	21.7	0.0	-2.8	19.5	18.0
	Peak Attenuation (AF)	105,836	133,194	0	137,457	33.0	-747	163,101	163,069
0.2%	% Peak Reduced	1.0	6.1	73.0	11.7	78.7	63.2	11.4	11.0
	Peak Attenuation (AF)	109,516	117,817	31,926	153,001	112,456	156,321	305,019	304,939

El Nido Storm Runoff Centering									
Percent Chance Exceedence	Index Gage Location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	7.6	1.6	5.8	2.3	16.3	7.8	2.5	2.1
	Peak Attenuation (AF)	658	350	2,153	2,441	16,070	16,064	5,318	18,457
10%	% Peak Reduced	0.0	1.2	3.3	1.4	12.0	0.0	3.0	2.6
	Peak Attenuation (AF)	4,257	10,340	4,436	16,906	4,385	0.0	37,101	25,389
4%	% Peak Reduced	0.9	5.6	0.0	3.2	0.0	2.1	2.4	1.1
	Peak Attenuation (AF)	1,937	9,588	0	21,096	0	23,089	41,576	44,131
2%	% Peak Reduced	43.2	21.4	0.0	16.1	0.0	1.4	12.5	10.7
	Peak Attenuation (AF)	73,729	118,464	0	103,237	443	230	73,821	80,095
1%	% Peak Reduced	61.2	35.5	53.9	33.0	71.5	53.9	29.0	26.1
	Peak Attenuation (AF)	100,107	103,101	14,120	120,161	77,362	123,368	122,240	236,700
0.5%	% Peak Reduced	44.6	29.3	24.9	20.7	65.3	62.3	19.4	18.2
	Peak Attenuation (AF)	107,494	125,081	49,381	114,744	176,630	180,292	99,802	374,731
0.2%	% Peak Reduced	1.9	9.1	15.2	10.0	45.3	45.3	10.1	9.3
	Peak Attenuation (AF)	109,944	119,411	53,316	170,375	175,094	184,196	315,902	351,376

	Maximum peak flow reduction %
	Maximum peak volume attenuation

Notes:

- 1) Flow at mainstem points are estimated by HEC-5, which assumes all flows remain in channel (bypasses were treated as channels).
Flows at mainstem points are taken "at latitude" (See Chapter III of Appendix B).
- 2) % Peak Reduced = ((Maximum Regulated Baseline Inflow)-(Maximum Regulated Alternative Inflow))/(Maximum Regulated Baseline Inflow) X 100%.
- 3) Peak Attenuation = (Σ attenuated peak volume)*(0.08265 ac-ft/cfs)

TABLE C.4-9b (CONT.)
EFFECTS OF ALTERNATIVE SCENARIO SJQ-B05A

Exchequer Dam Storm Runoff Centering									
Percent Chance Exceedence	Index Gage Location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	3.4	0.5	5.9	3.1	16.1	7.2	6.3	5.3
	Peak Attenuation (AF)	202	123	3,220	3,219	15,347	15,340	18,468	18,465
10%	% Peak Reduced	11.5	10.9	0.0	6.2	9.7	6.9	5.9	5.4
	Peak Attenuation (AF)	8,682	8,260	0	8,500	32,107	32,092	43,135	043,125
4%	% Peak Reduced	-0.2	1.3	0.0	0.6	0.0	0.2	0.4	0.8
	Peak Attenuation (AF)	-92	7,627	0	12,204	0	24,294	7,464	7,429
2%	% Peak Reduced	4.4	3.8	73.0	31.5	0.0	1.3	23.8	20.0
	Peak Attenuation (AF)	4,182	20,725	31,926	49,989	440	26,894	84,473	84,383
1%	% Peak Reduced	46.7	21.1	40.6	21.2	76.8	65.7	28.6	26.3
	Peak Attenuation (AF)	36,873	113,682	52,002	140,124	94,599	133,718	260,840	258,500
0.5%	% Peak Reduced	64.9	36.4	15.3	9.7	62.5	62.4	13.5	13.3
	Peak Attenuation (AF)	100,457	104,185	53,418	153,398	175,699	200,039	353,304	353,255
0.2%	% Peak Reduced	35.8	23.8	11.3	6.4	36.9	37.6	8.5	7.9
	Peak Attenuation (AF)	105,657	137,705	57,079	57,897	174,257	200,008	259,248	258,931

Newman Storm Runoff Centering									
Percent Chance Exceedence	Index Gage Location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	5.5	2.6	6.2	2.6	16.9	9.1	6.6	5.7
	Peak Attenuation (AF)	384	288	2,817	3,013	17,989	17,981	20,687	20,683
10%	% Peak Reduced	3.9	2.9	0.0	1.3	5.3	-0.3	2.6	2.3
	Peak Attenuation (AF)	459	5,318	0	11,989	1,131	-47	41,083	40,936
4%	% Peak Reduced	0.0	0.0	0.0	-0.2	0.0	1.6	0.0	0.2
	Peak Attenuation (AF)	0	0	0	-164	0	25,349	37,810	37,805
2%	% Peak Reduced	27.1	16.2	61.3	28.1	58.7	35.8	23.4	19.8
	Peak Attenuation (AF)	61,625	108,676	20,582	109,914	33,413	71,672	166,880	164,001
1%	% Peak Reduced	75.6	40.1	38.0	21.4	61.7	58.7	31.6	29.1
	Peak Attenuation (AF)	95,429	103,273	50,544	60,560	175,080	200,013	352,962	352,942
0.5%	% Peak Reduced	44.7	29.9	15.5	10.1	55.1	54.0	12.1	11.8
	Peak Attenuation (AF)	104,433	109,192	52,459	159,496	178,441	182,970	339,313	339,266
0.2%	% Peak Reduced	16.7	13.3	11.8	7.4	32.4	34.3	9.2	8.6
	Peak Attenuation (AF)	99,502	130,784	57,140	214,288	177,390	186,308	399,210	399,158

	Maximum peak flow reduction %
	Maximum peak volume attenuation

Notes:

- 1) Flow at mainstem points are estimated by HEC-5, which assumes all flows remain in channel (bypasses were treated as channels).
Flows at mainstem points are taken "at latitude" (See Chapter III of Appendix B).
- 2) % Peak Reduced = ((Maximum Regulated Baseline Inflow)-(Maximum Regulated Alternative Inflow))/(Maximum Regulated Baseline Inflow) X 100%.
- 3) Peak Attenuation = (Σ attenuated peak volume)*(0.08265 ac-ft/cfs)

TABLE C.4-9b (CONT.)
EFFECTS OF ALTERNATIVE SCENARIO SJQ-B05A

Don Pedro Storm Runoff Centering									
Percent Chance Exceedence	Index Gage Location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	3.4	0.5	5.4	2.1	17.7	14.8	8.5	7.2
	Peak Attenuation (AF)	202	126	1,858	1,856	21,197	21,187	7,564	22,965
10%	% Peak Reduced	28.9	20.4	5.3	12.2	0.0	0.0	6.7	5.4
	Peak Attenuation (AF)	6,303	6,023	6,156	11,896	0	-1	10,713	36,241
4%	% Peak Reduced	0.9	2.5	0.0	1.5	2.9	101	1.6	1.9
	Peak Attenuation (AF)	3,796	9,702	0	9,277	1,051	1,482	8,894	37,380
2%	% Peak Reduced	0.0	0.0	0.0	0.1	77.3	71.7	42.7	36.6
	Peak Attenuation (AF)	0	0	0	12,288	88,918	155,472	83,605	167,447
1%	% Peak Reduced	7.3	8.9	12.9	4.3	63.2	62.9	43.6	39.8
	Peak Attenuation (AF)	3,564	32,340	2,166	37,079	176,284	176,253	165,152	208,844
0.5%	% Peak Reduced	71.4	37.1	25.6	17.7	42.1	42.2	32.7	30.8
	Peak Attenuation (AF)	98,250	106,371	49,410	60,524	173,266	200,004	229,906	260,197
0.2%	% Peak Reduced	44.8	32.7	14.3	9.3	21.2	24.7	21.2	17.8
	Peak Attenuation (AF)	105,158	123,626	56,743	174,037	177,967	200,007	334,118	373,900

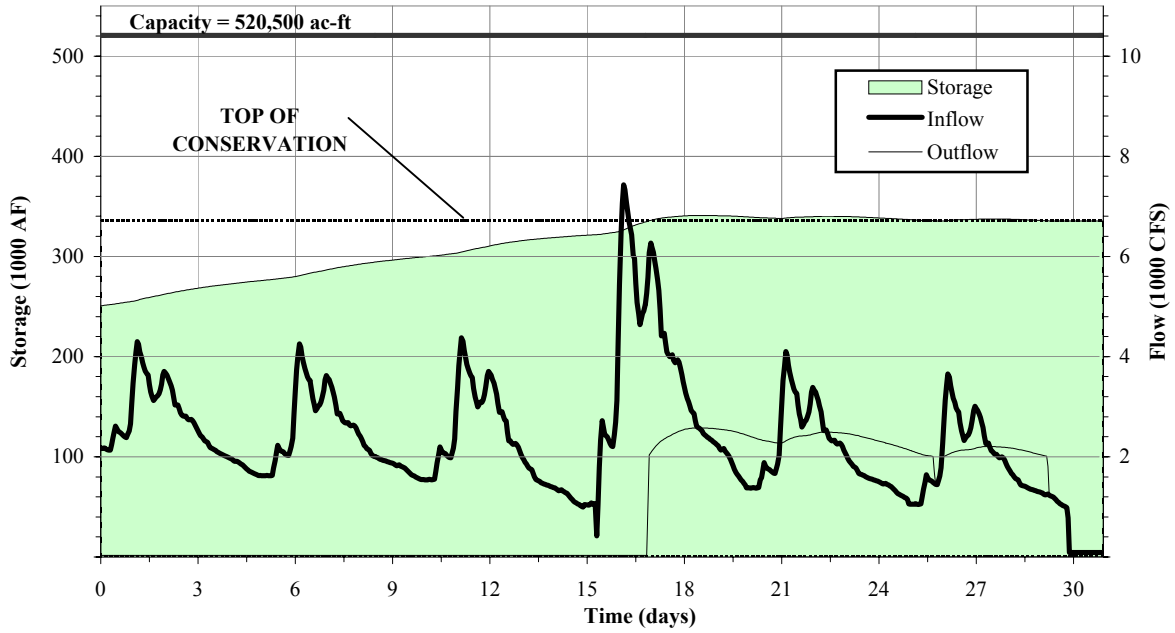
Vernalis Storm Runoff Centering									
Percent Chance Exceedence	Index Gage Location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	5.1	2.7	6.1	2.5	17.3	9.9	7.3	6.4
	Peak Attenuation (AF)	345	253	2,544	2,709	19,373	19,364	21,799	21,795
10%	% Peak Reduced	11.8	5.8	0.0	3.0	0.0	0.0	2.2	1.9
	Peak Attenuation (AF)	387	8,946	0	12,565	0	-20	36,040	35,694
4%	% Peak Reduced	0.0	0.0	0.0	0.5	0.0	1.7	2.2	1.7
	Peak Attenuation (AF)	0	0	0	11,710	0	280	38,827	38,792
2%	% Peak Reduced	7.7	9.6	0.0	6.2	71.6	54.0	28.6	24.5
	Peak Attenuation (AF)	29,351	83,691	0	62,845	111,364	123,357	172,626	170,207
1%	% Peak Reduced	71.3	35.2	18.3	17.4	66.3	63.4	34.9	31.9
	Peak Attenuation (AF)	95,384	104,372	49,282	93,481	176,837	180,376	238,680	261,090
0.5%	% Peak Reduced	51.7	34.1	18.9	12.3	48.7	48.4	14.9	12.3
	Peak Attenuation (AF)	104,171	108,234	52,713	157,046	179,105	183,795	337,643	337,555
0.2%	% Peak Reduced	25.5	14.7	12.3	7.8	25.6	28.9	9.9	9.2
	Peak Attenuation (AF)	102,269	113,708	57,027	169,691	178,930	188,374	358,015	358,392

	Maximum peak flow reduction %
	Maximum peak volume attenuation

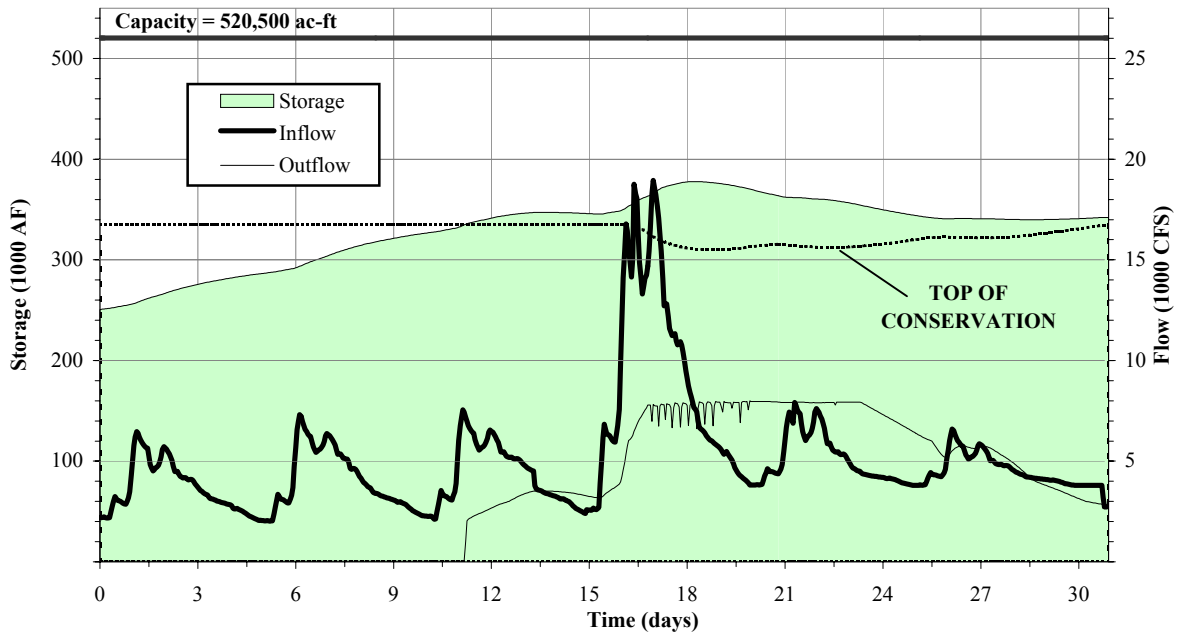
Notes:

- 1) Flow at mainstem points are estimated by HEC-5, which assumes all flows remain in channel (bypasses were treated as channels).
Flows at mainstem points are taken "at latitude" (See Chapter III of Appendix B).
- 2) % Peak Reduced = ((Maximum Regulated Baseline Inflow)-(Maximum Regulated Alternative Inflow))/(Maximum Regulated Baseline Inflow) X 100%.
- 3) Peak Attenuation = (Σ attenuated peak volume)*(0.08265 ac-ft/cfs)

Friant Operations (50% Chance Exceedence Event)



Friant Operations (10% Chance Exceedence Event)

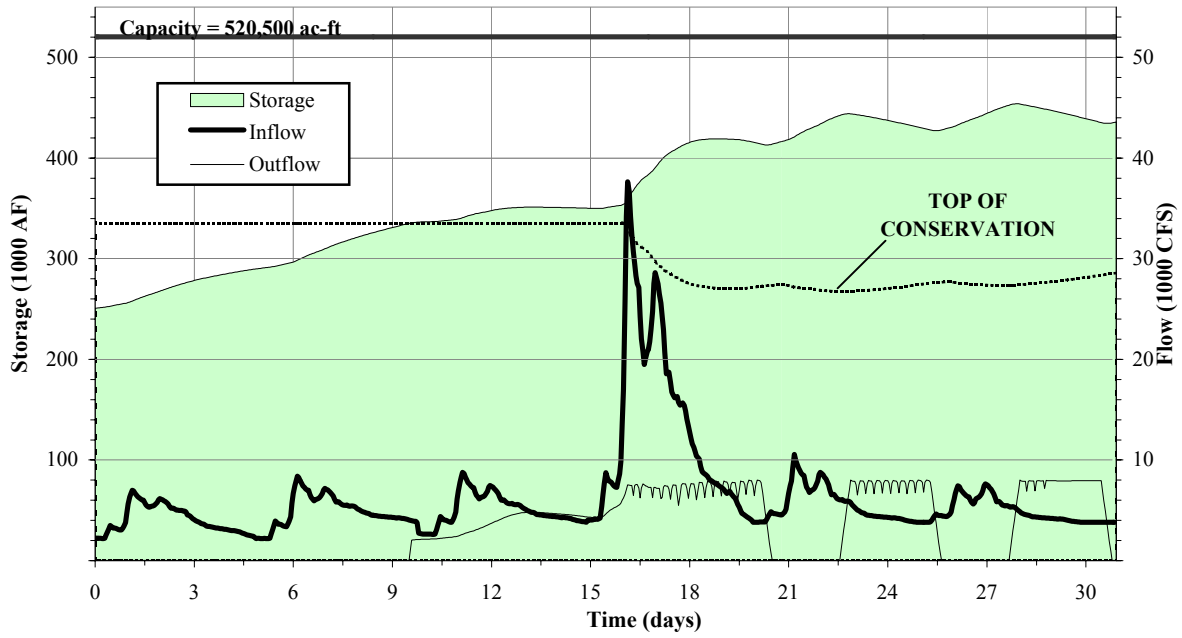


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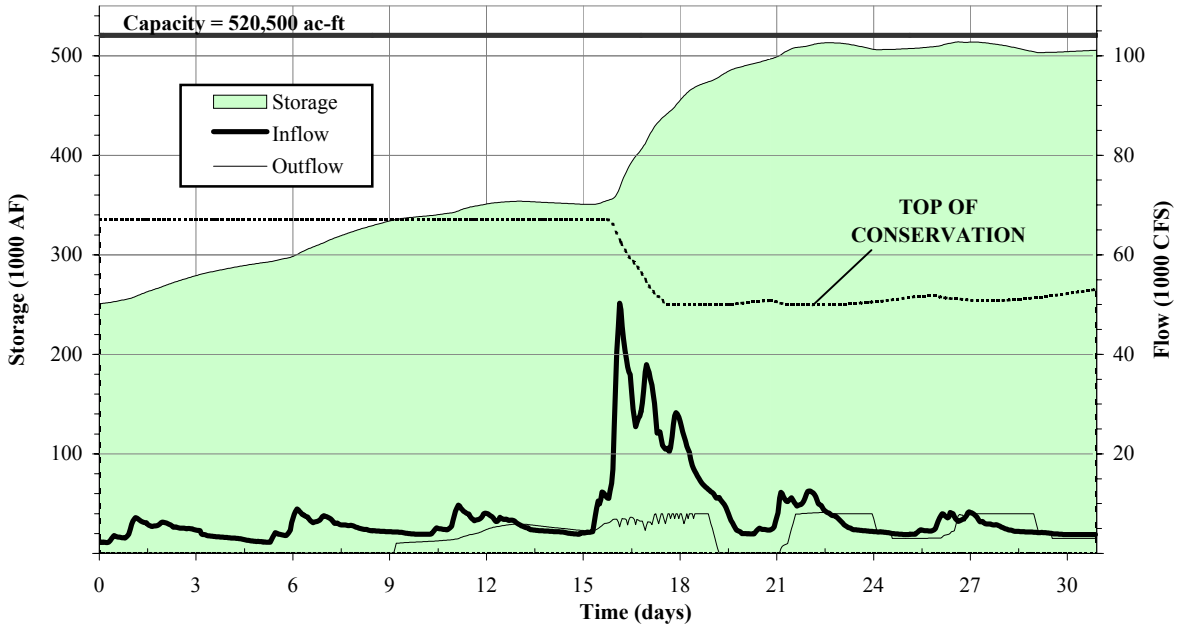
Figure C.4-9a
Reservoir Simulation Hydrographs
Alternative Scenario SJQ-B05A

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Friant Operations (4% Chance Exceedence Event)



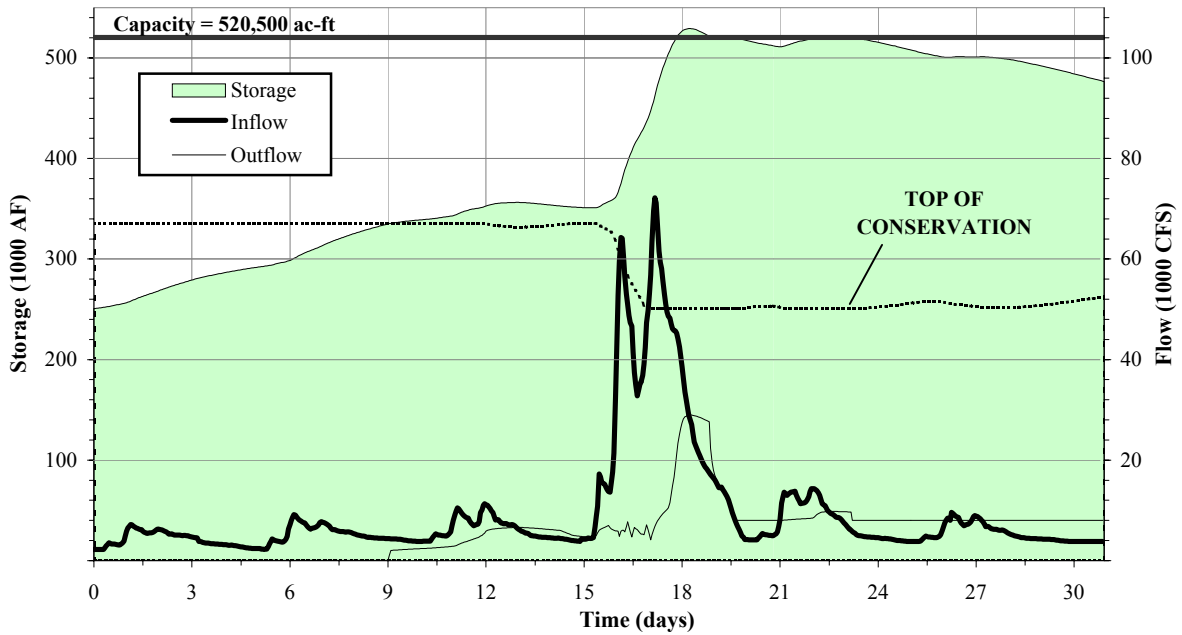
Friant Operations (2% Chance Exceedence Event)



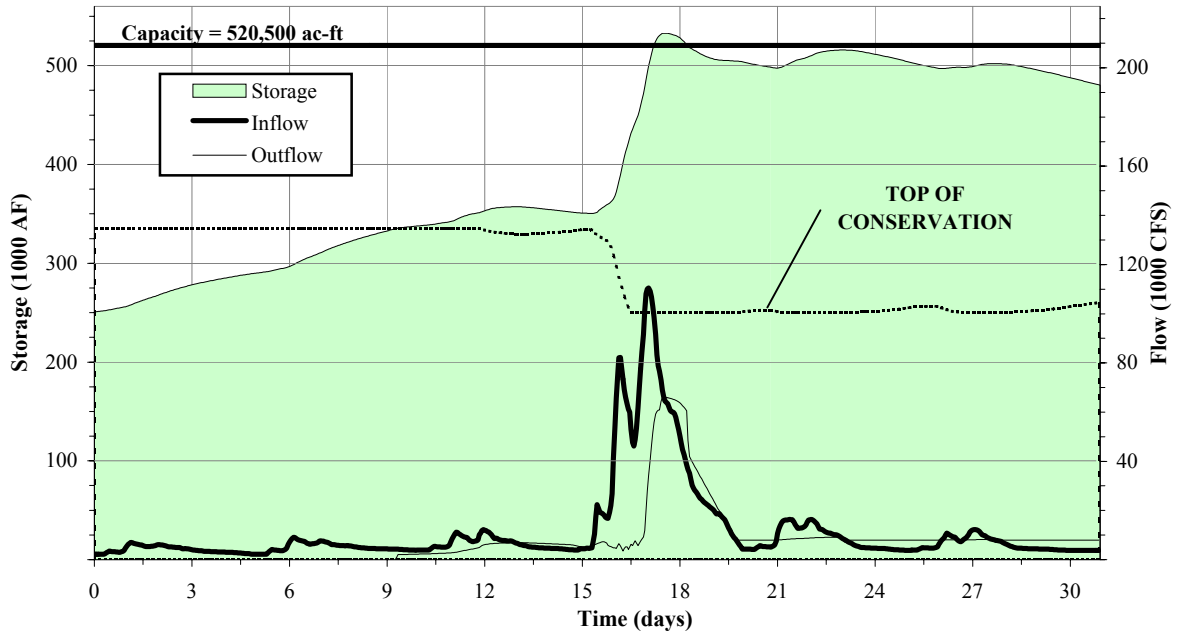
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Figure C.4-9b
Reservoir Simulation Hydrographs
Alternative Scenario SJQ-B05A

Friant Operations (1% Chance Exceedence Event)



Friant Operations (0.5% Chance Exceedence Event)

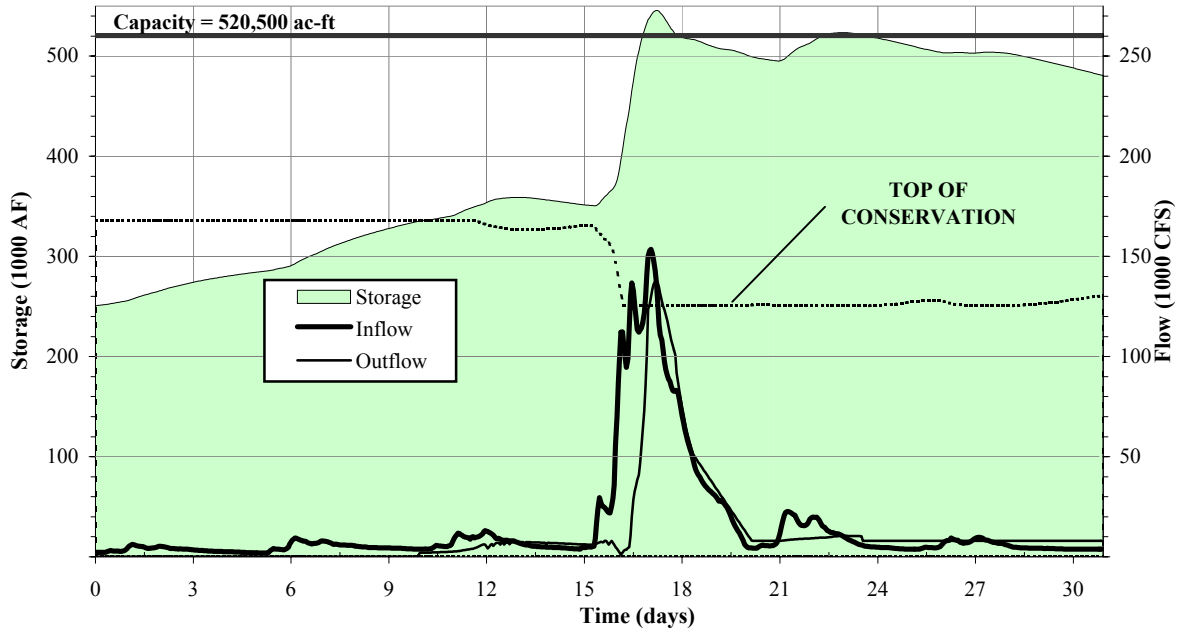


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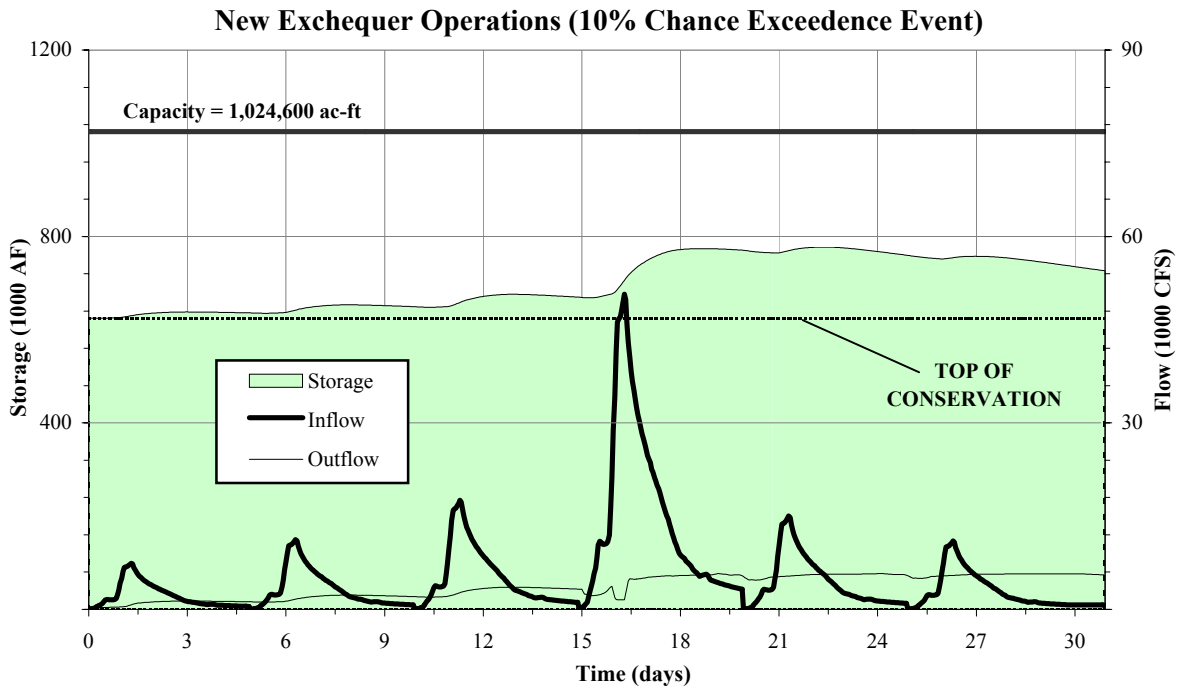
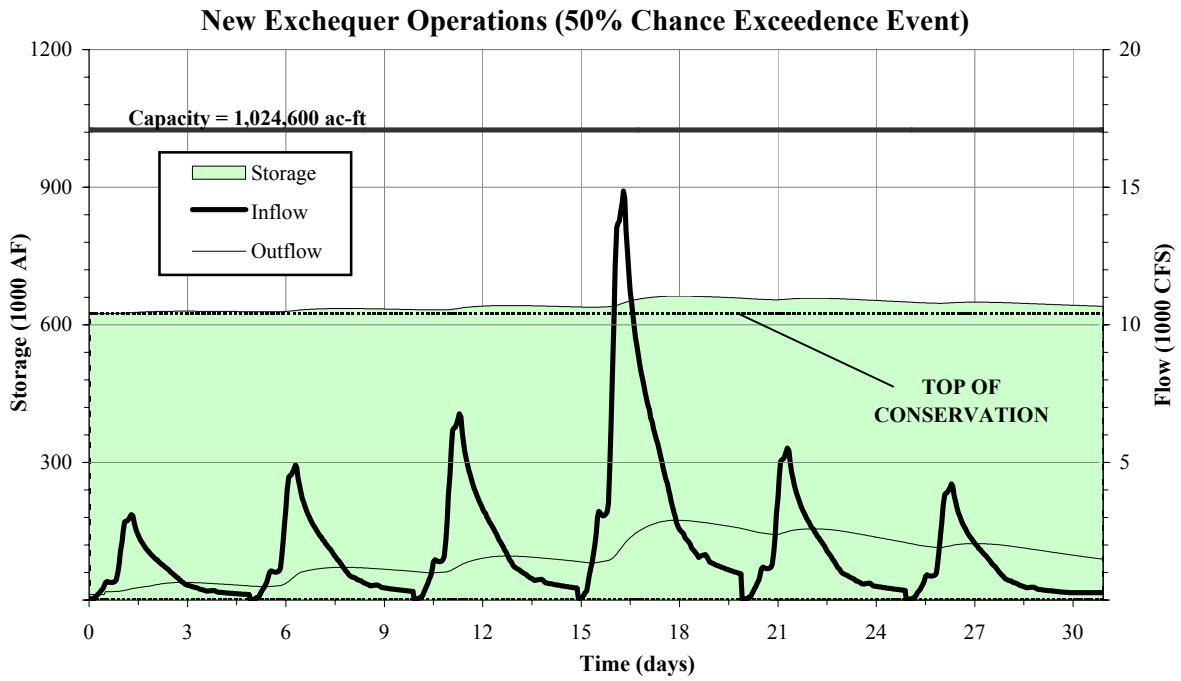
Figure C.4-9c
Reservoir Simulation Hydrographs
Alternative Scenario SJQ-B05A

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Friant Operations (0.2% Chance Exceedence Event)



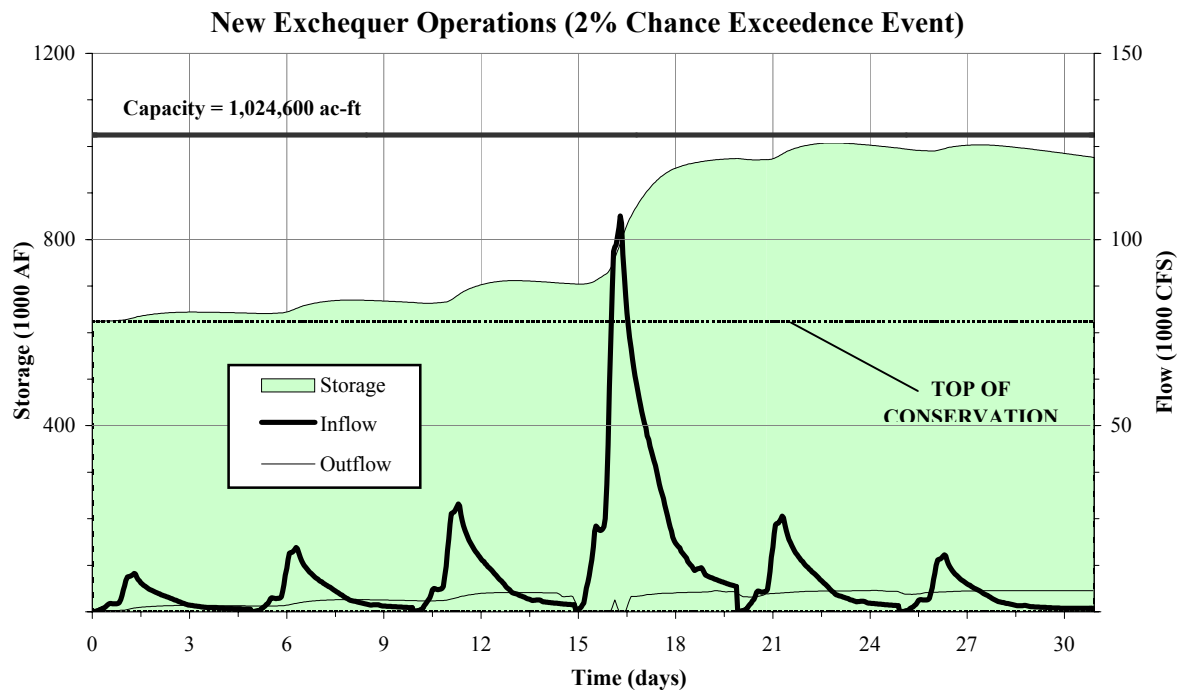
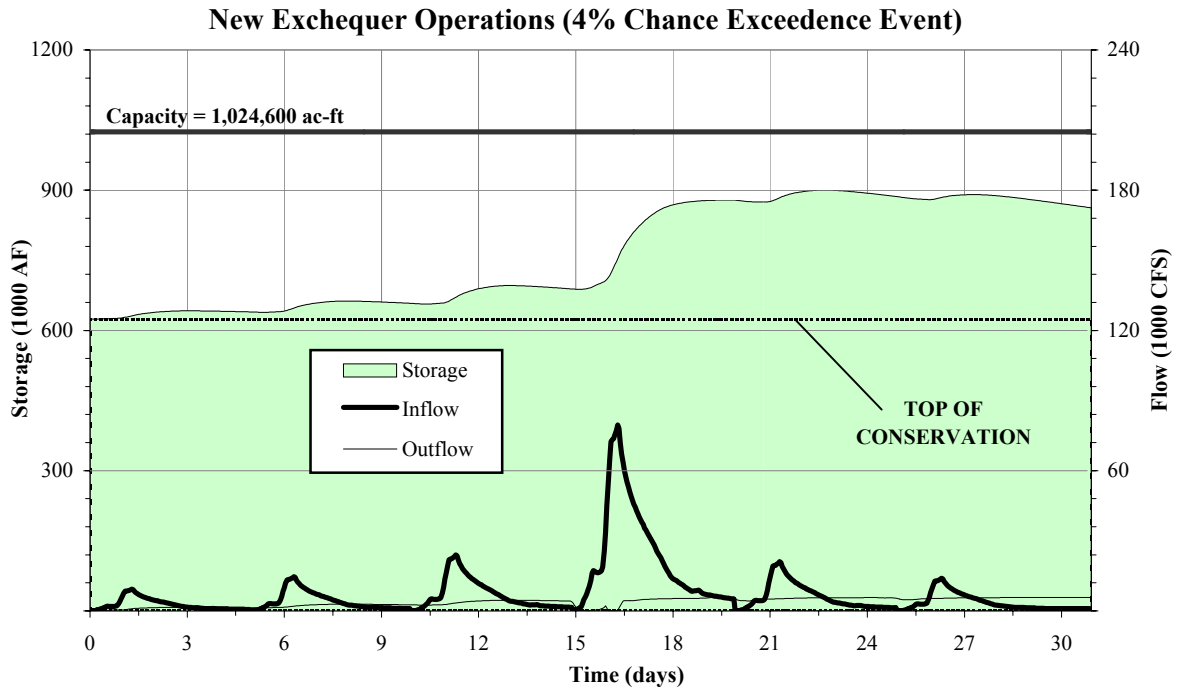
Sacramento & San Joaquin River Basins Comprehensive Study	
Figure C.4-9d Reservoir Simulation Hydrographs Alternative Scenario SJQ-B05A	
US Army Corps of Engineers The Reclamation Board, State of California	December 2002



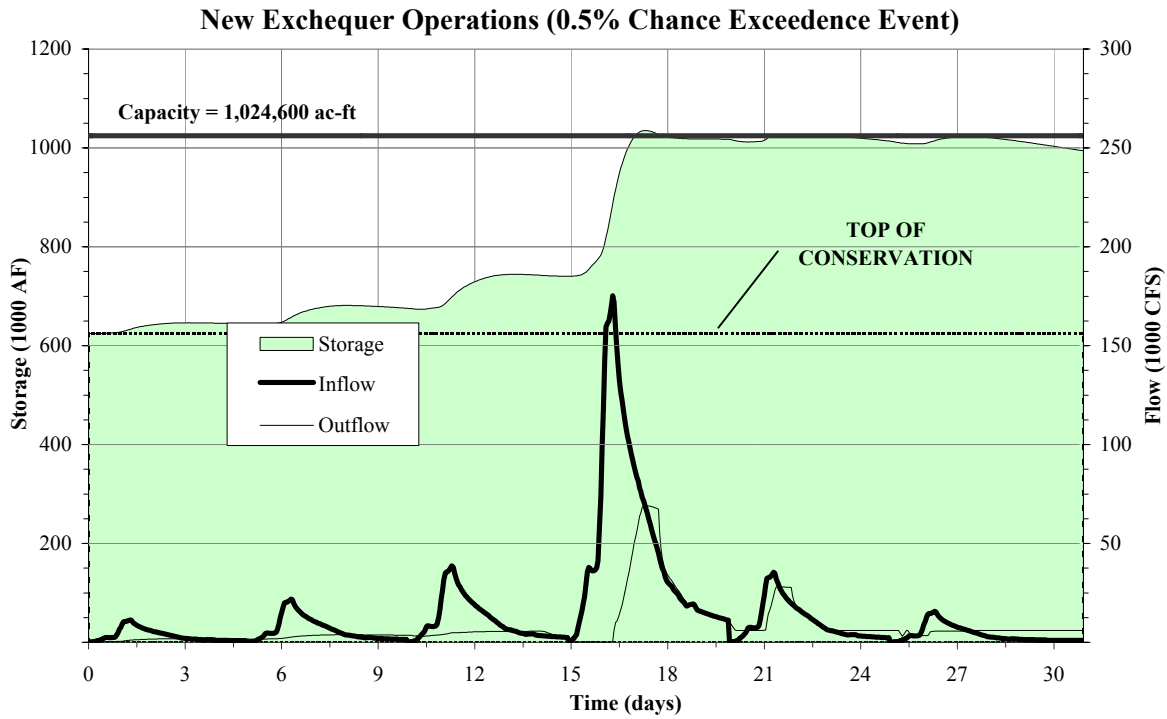
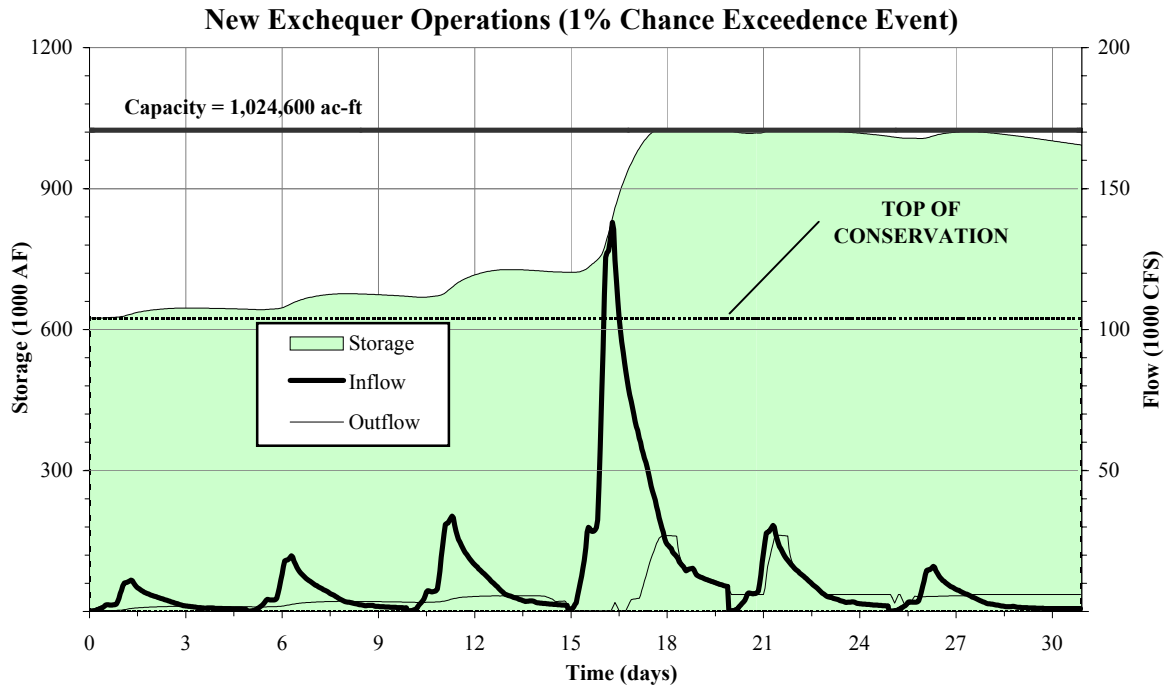
Sacramento & San Joaquin River Basins
Comprehensive Study

Figure C.4-9e
Reservoir Simulation Hydrographs
Alternative Scenario SJQ-B05A

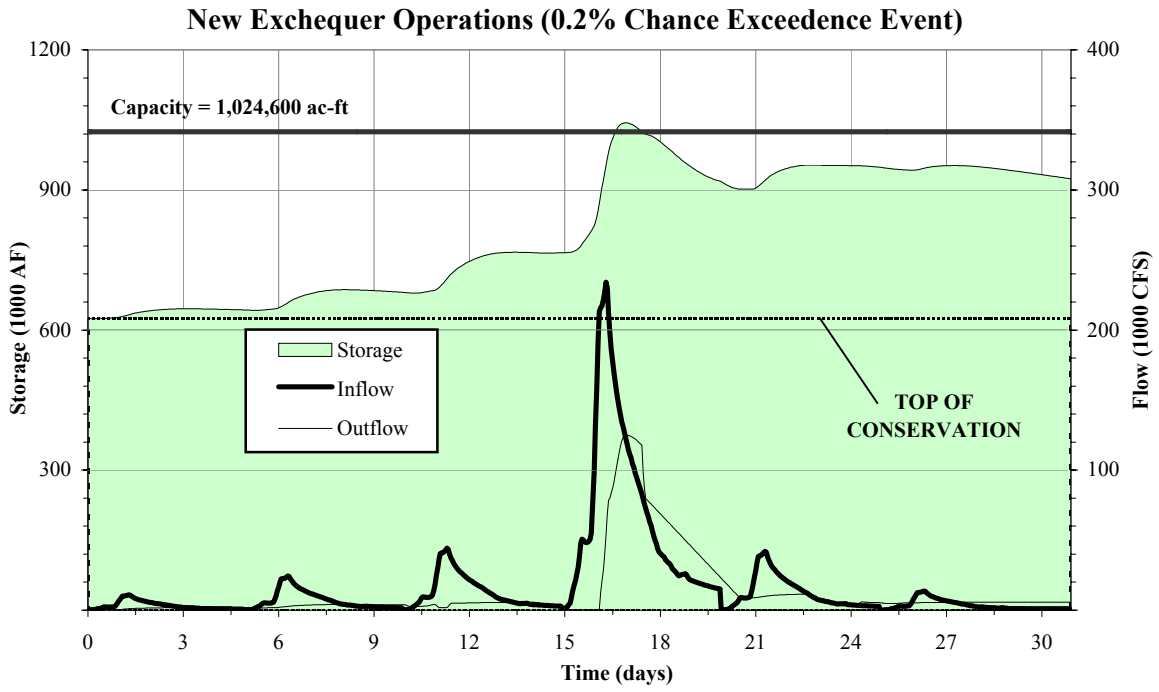
US Army Corps of Engineers
The Reclamation Board, State of California December 2002



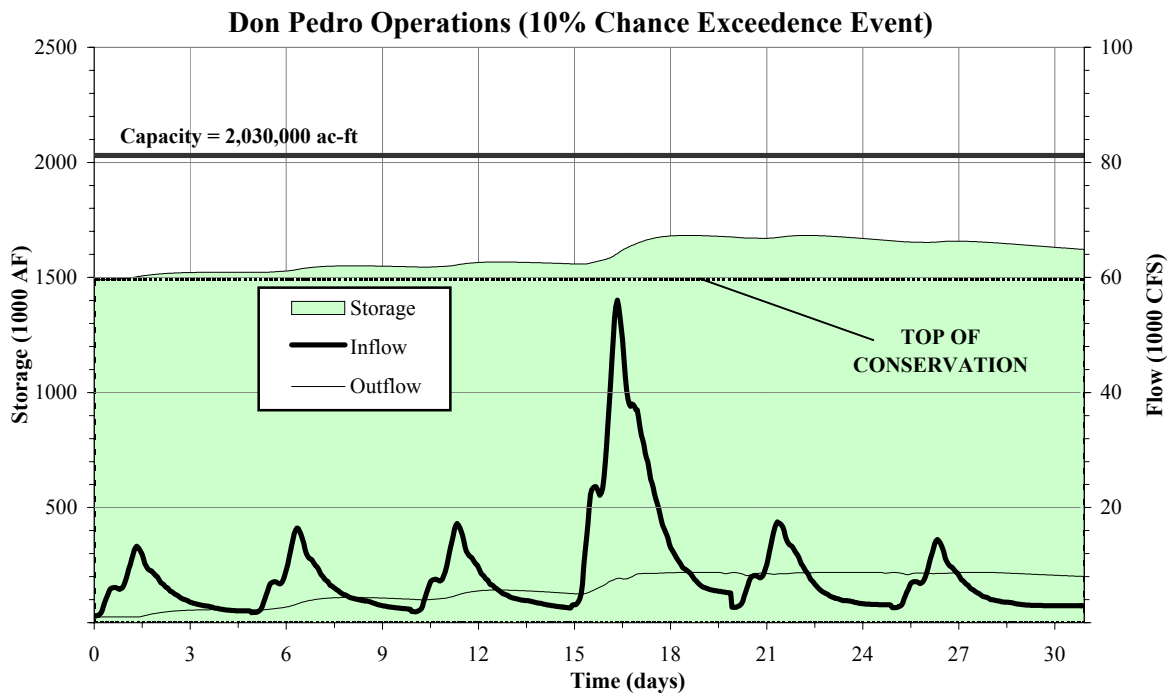
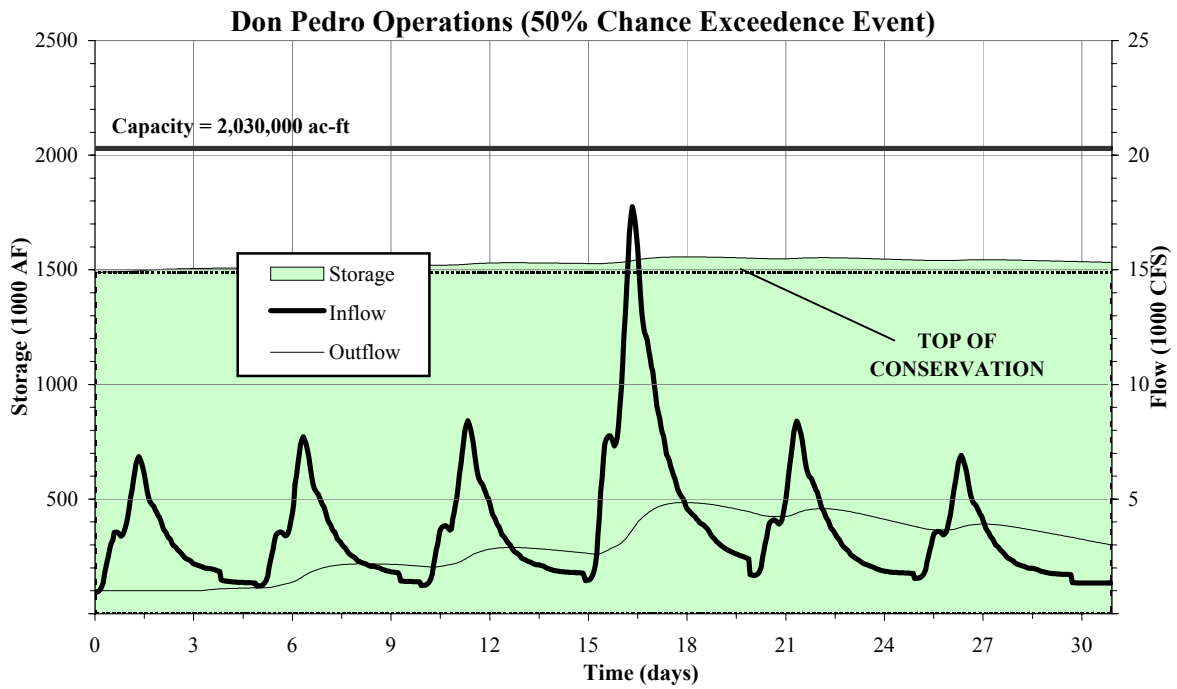
Sacramento & San Joaquin River Basins Comprehensive Study	
Figure C.4-9f Reservoir Simulation Hydrographs Alternative Scenario SJQ-B05A	
US Army Corps of Engineers The Reclamation Board, State of California	December 2002



Sacramento & San Joaquin River Basins Comprehensive Study	
Figure C.4-9g Reservoir Simulation Hydrographs Alternative Scenario SJQ-B05A	
US Army Corps of Engineers The Reclamation Board, State of California	December 2002

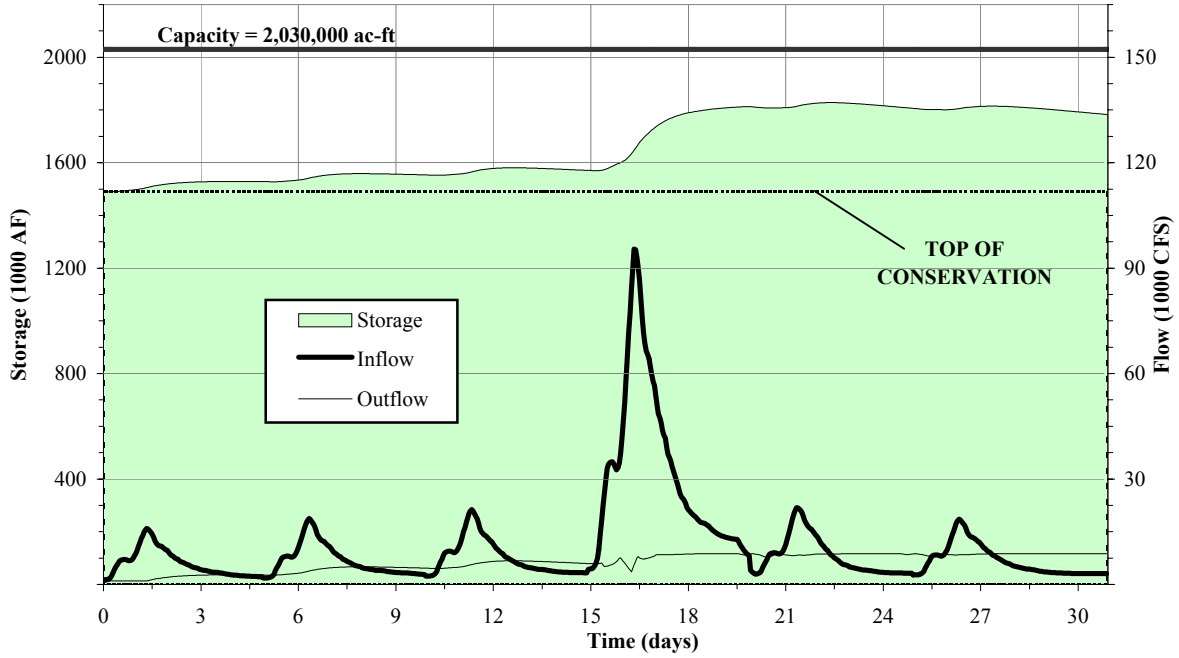


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Figure C.4-9h Reservoir Simulation Hydrographs Alternative Scenario SJQ-B05A
US Army Corps of Engineers The Reclamation Board, State of California
December 2002

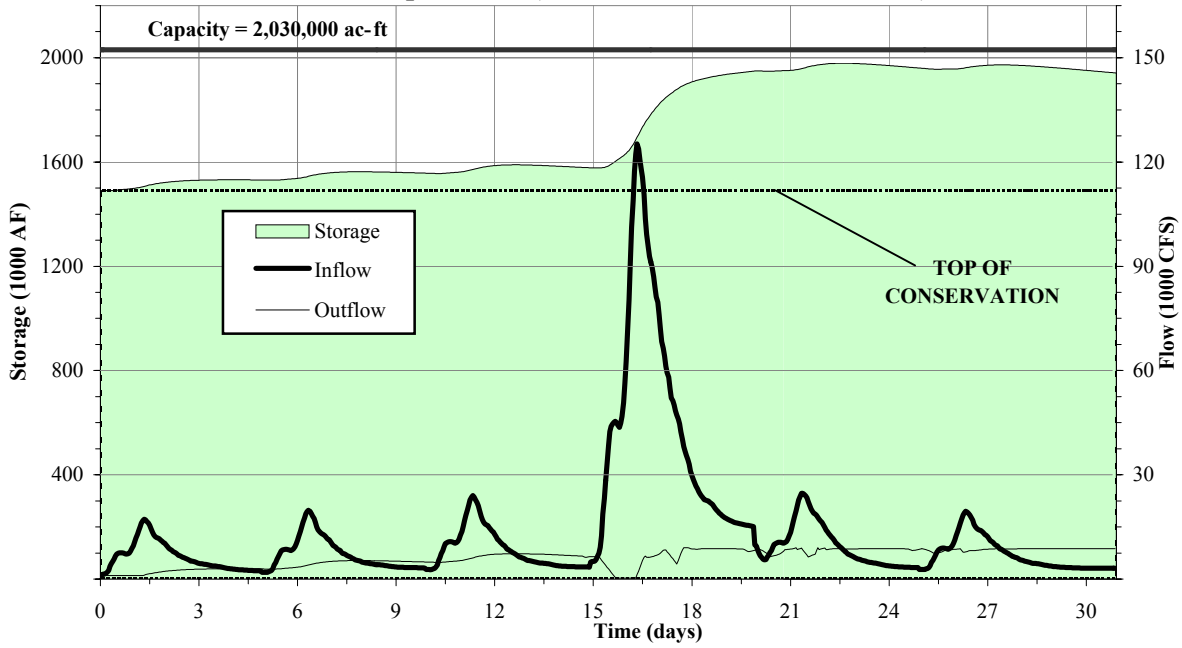


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Figure C.4-9i Reservoir Simulation Hydrographs Alternative Scenario SJQ-B05A	
US Army Corps of Engineers The Reclamation Board, State of California	December 2002

Don Pedro Operations (4% Chance Exceedence Event)



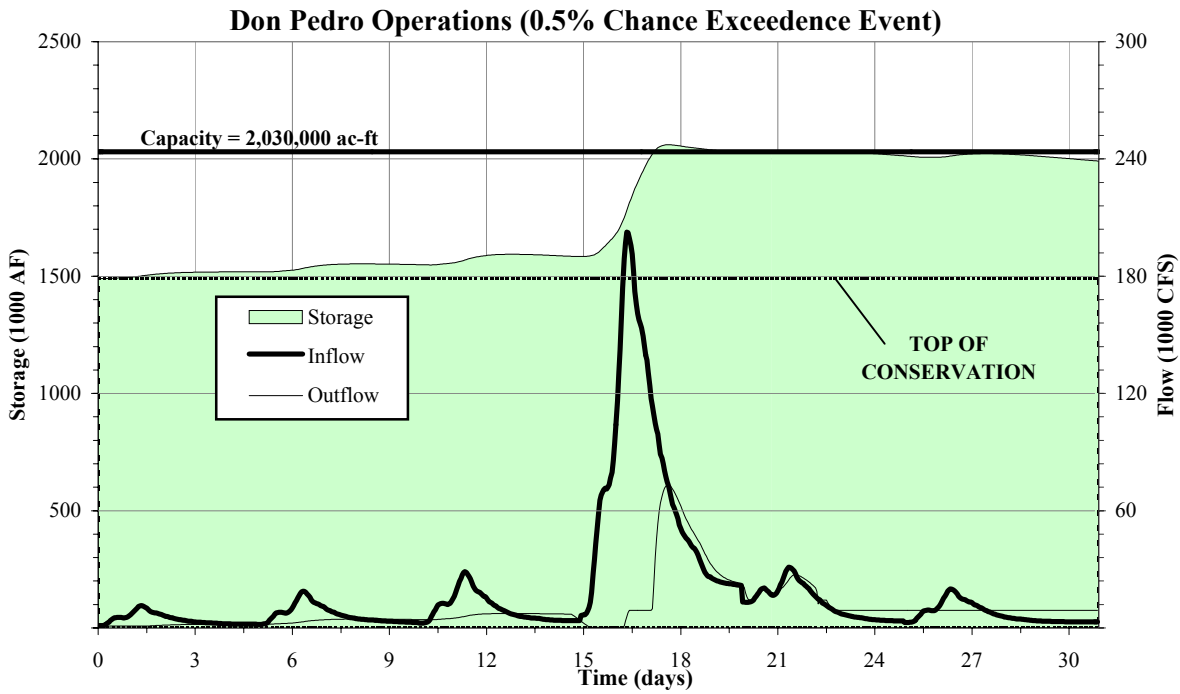
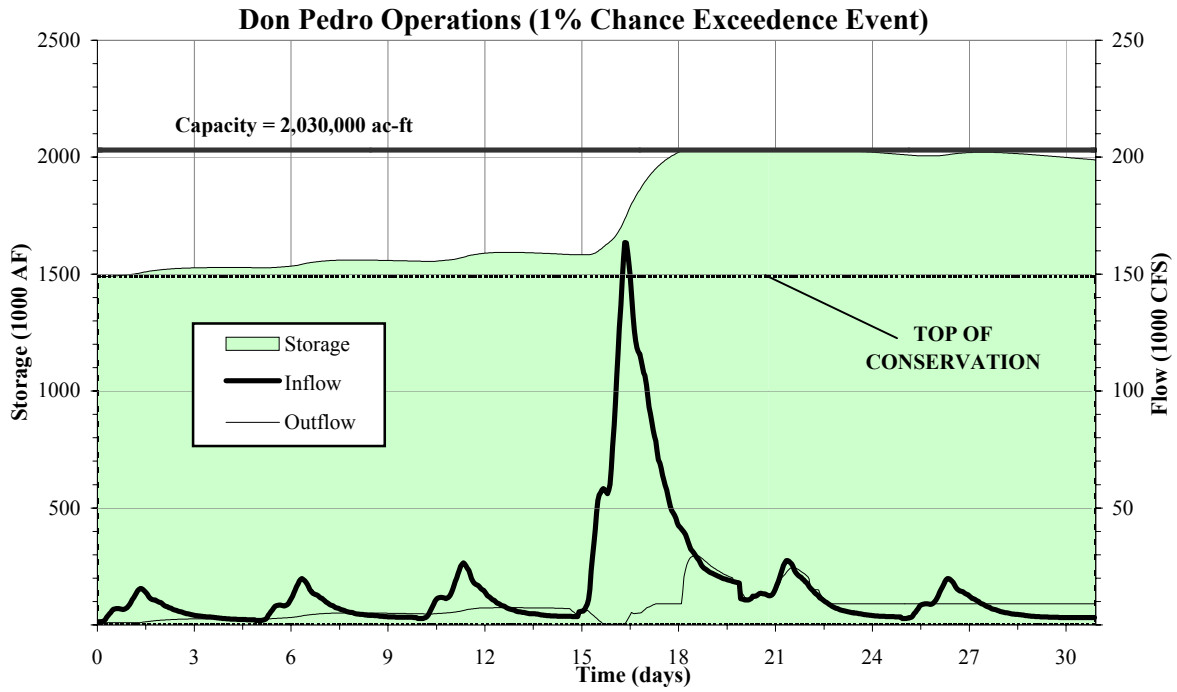
Don Pedro Operations (2% Chance Exceedence Event)



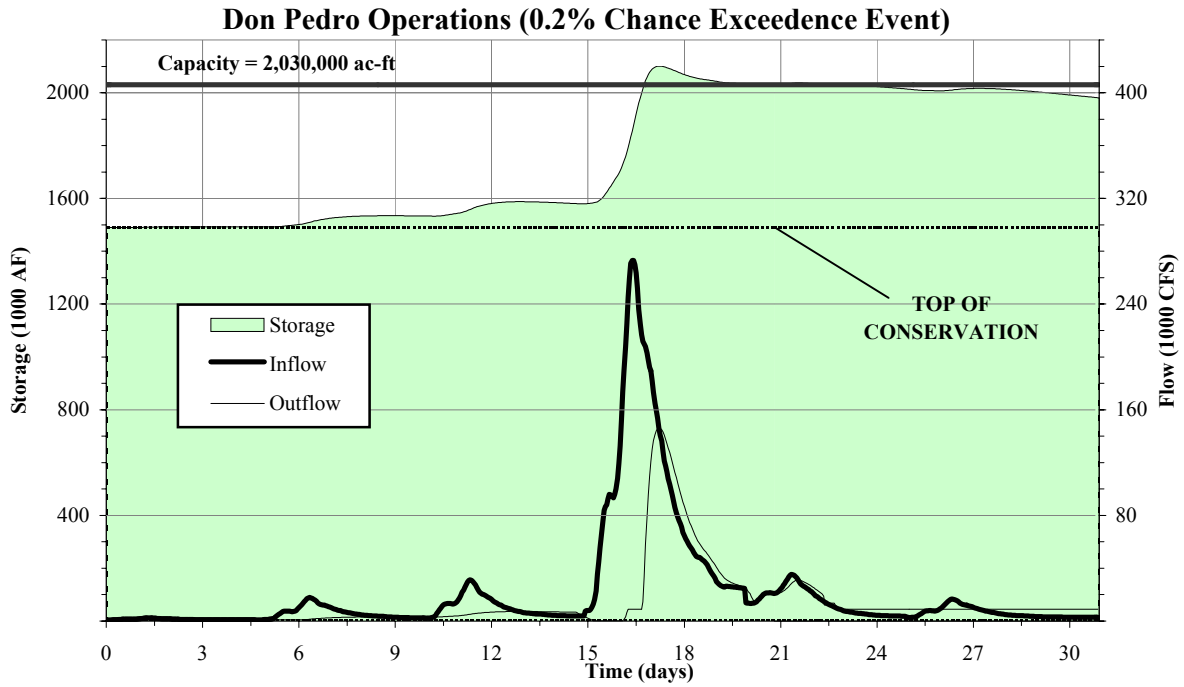
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Comprehensive Study

Figure C.4-9j
Reservoir Simulation Hydrographs
Alternative Scenario SJQ-B05A

US Army Corps of Engineers
The Reclamation Board, State of California December 2002



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Figure C.4-9k Reservoir Simulation Hydrographs Alternative Scenario SJQ-B05A	
US Army Corps of Engineers The Reclamation Board, State of California	December 2002



Sacramento & San Joaquin River Basins Comprehensive Study	
Figure C.4-9I Reservoir Simulation Hydrographs Alternative Scenario SJQ-B05A	
US Army Corps of Engineers The Reclamation Board, State of California	December 2002

TABLE C.4-10a

**COMPARISON OF MAXIMUM RELEASE OF BASELINE AND ALTERNATIVE SCENARIO (SJQ-B06A)
SIMULATIONS FOR SPECIFIC ANNUAL PERCENT CHANCE EXCEEDENCE EVENTS**

	50% Chance Exceedence Event		10% Chance Exceedence Event		4% Chance Exceedence Event		2% Chance Exceedence Event		1% Chance Exceedence Event		0.5% Chance Exceedence Event		0.2% Chance Exceedence Event		
	Baseline	Alternative	Baseline	Alternative	Baseline	Alternative	Baseline	Alternative	Baseline	Alternative	Baseline	Alternative	Baseline	Alternative	
Friant Centering															
Friant															
Max. Release:	8,000 to 16,000	3,032	4,643	7,971	15,935	9,001	16,000	25,481	19,246	71,093	48,106	108,585	105,447	139,402	140,364
New Exchequer															
Max. Release:	6,000	1,976	1,976	1,976	1,976	3,080	3,080	5,478	5,478	5,766	5,766	5,768	5,768	21,381	21,381
Don Pedro															
Max. Release:	9,000	3,903	3,903	3,903	3,903	5,894	5,894	9,000	9,000	9,000	9,000	9,000	9,000	42,291	42,291
New Exchequer Centering															
Friant															
Max. Release:	8,000 to 16,000	2,164	3,043	6,785	7,699	7,985	15,944	8,366	16,000	15,006	16,801	51,568	39,583	110,315	108,005
New Exchequer															
Max. Release:	6,000	3,080	3,080	5,766	5,766	5,769	5,769	21,381	21,381	45,533	45,533	81,574	81,574	141,306	141,306
Don Pedro															
Max. Release:	9,000	3,903	3,903	8,604	8,604	8,738	8,738	9,000	9,000	38,874	38,874	80,647	80,647	139,910	139,910
Don Pedro Centering															
Friant															
Max. Release:	8,000 to 16,000	2,164	3,043	5,346	5,810	8,000	14,240	8,000	15,819	8,630	15,988	30,749	19,111	92,384	75,836
New Exchequer															
Max. Release:	6,000	1,976	1,976	5,077	5,077	5,766	5,766	5,769	5,769	6,617	6,617	35,028	35,028	83,919	83,919
Don Pedro															
Max. Release:	9,000	5,894	5,894	8,737	8,737	9,000	9,000	39,630	39,630	80,821	80,821	126,377	126,377	185,449	185,449

	Maximum Baseline
	Maximum Alternative

TABLE C.4-10b
EFFECTS OF ALTERNATIVE SCENARIO SJQ-B06A

Friant Dam Storm Runoff Centering									
Percent Chance Exceedence	Index Gage Location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	-53.1	-15.6	0.0	-10.1	0.0	0.0	-7.8	-6.5
	Peak Attenuation (AF)	-4,288	-3306	0	-3,123	0	0	-3,192	-3,176
10%	% Peak Reduced	-99.9	-67.8	0.0	-54.6	0.0	0.0	-44.6	-40.3
	Peak Attenuation (AF)	-42,451	-41,774	0	-40,846	0	0	-40,966	-40,868
4%	% Peak Reduced	-77.8	-41.5	0.0	-34.4	0.0	0.0	-28.2	-25.7
	Peak Attenuation (AF)	-46,348	-66,354	0	-65,824	0	0	-65,657	-65,570
2%	% Peak Reduced	24.5	1.6	0.0	-0.2	0.0	0.0	-0.6	-0.7
	Peak Attenuation (AF)	11,931	20,373	0	-17,099	0	0	-22,436	-22,402
1%	% Peak Reduced	32.3	14.5	0.0	9.8	0.0	0.0	8.0	7.1
	Peak Attenuation (AF)	38,799	21,484	0	17,957	0	0	17,043	16,599
0.5%	% Peak Reduced	2.9	5.5	0.0	4.7	0.0	0.0	4.2	3.9
	Peak Attenuation (AF)	29,507	19,567	0	17,986	0	0	17,571	17,365
0.2%	% Peak Reduced	-0.7	0.2	0.0	1.2	0.0	0.0	1.2	1.1
	Peak Attenuation (AF)	-67,052	15950	0	15,197	0	0	19,192	19,075

El Nido Storm Runoff Centering									
Percent Chance Exceedence	Index Gage Location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	-70.3	-7.6	0.0	-3.8	0.0	0.0	-2.9	-2.4
	Peak Attenuation (AF)	-1,369	-957	0	-924	0	0	-911	-904
10%	% Peak Reduced	-91.8	-50.3	0.0	-30.1	0.0	0.0	-22.5	-19.4
	Peak Attenuation (AF)	-32,371	-32,072	0	-31,448	0	0	-31,257	-31,156
4%	% Peak Reduced	-98.2	-33.4	0.0	-23.3	0.0	0.0	-18.2	-16.1
	Peak Attenuation (AF)	-50,136	-52,119	0	-51,181	0	0	-50,962	-50,855
2%	% Peak Reduced	-12.0	-6.9	0.0	-5.3	0.0	0.0	-3.8	-3.2
	Peak Attenuation (AF)	-24,130	-21,991	0	-26,229	0	0	-26,019	-25,913
1%	% Peak Reduced	33.7	11.1	0.0	6.0	0.0	0.0	5.4	5.0
	Peak Attenuation (AF)	38,161	18,571	0	15,457	0	0	14,649	14,250
0.5%	% Peak Reduced	16.7	10.0	0.0	6.1	0.0	0.0	5.1	5.0
	Peak Attenuation (AF)	29,040	22,714	0	20,933	0	0	20,426	20,171
0.2%	% Peak Reduced	0.0	1.1	0.0	1.6	0.0	0.0	-0.7	-0.8
	Peak Attenuation (AF)	0	16,615	0	15,731	0	0	-19,958	-19,886

	Maximum peak flow reduction %
	Maximum peak volume attenuation

Notes:

- 1) Flow at mainstem points are estimated by HEC-5, which assumes all flows remain in channel (bypasses were treated as channels).
Flows at mainstem points are taken "at latitude" (See Chapter III of Appendix B).
- 2) % Peak Reduced = ((Maximum Regulated Baseline Inflow)-(Maximum Regulated Alternative Inflow))/(Maximum Regulated Baseline Inflow) X 100%.
- 3) Peak Attenuation = (Σ attenuated peak volume)*(0.08265 ac-ft/cfs)

TABLE V.4-10b (CONT.)
EFFECTS OF ALTERNATIVE SCENARIO SJQ-B06A

Newman Storm Runoff Centering									
Percent Chance Exceedence	Index Gage Location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	-48.7	1.0	0.0	0.0	0.0	0.0	0.0	0.0
	Peak Attenuation (AF)	-878	831	0	0	0	0	0	0
10%	% Peak Reduced	-69.2	-46.6	0.0	-21.4	0.0	0.0	-15.2	-13.3
	Peak Attenuation (AF)	-20,688	-19,335	0	-18,915	0	0	-18,785	-18,718
4%	% Peak Reduced	-100	-43.9	0.0	-28.4	0.0	0.0	-21.4	-16.2
	Peak Attenuation (AF)	-66,818	-70,268	0	-70,114	0	0	-70,080	-70,061
2%	% Peak Reduced	-45.8	-16.3	0.0	-9.7	0.0	0.0	-9.3	-8.1
	Peak Attenuation (AF)	-32,532	-29,542	0	-33,335	0	0	-33,044	-32,898
1%	% Peak Reduced	35.3	9.2	0.0	0.5	0.0	0.0	0.3	0.2
	Peak Attenuation (AF)	31,485	14,831	0	891	0	0	797	750
0.5%	% Peak Reduced	29.0	11.1	0.0	0.4	0.0	0.0	-0.1	-0.2
	Peak Attenuation (AF)	35,347	12,922	0	3,546	0	0	-12,927	-12,872
0.2%	% Peak Reduced	0.0	1.3	0.0	-0.8	0.0	0.0	-1.2	-1.1
	Peak Attenuation (AF)	0	14,532	0	-18,455	0	0	-18,315	-18,242

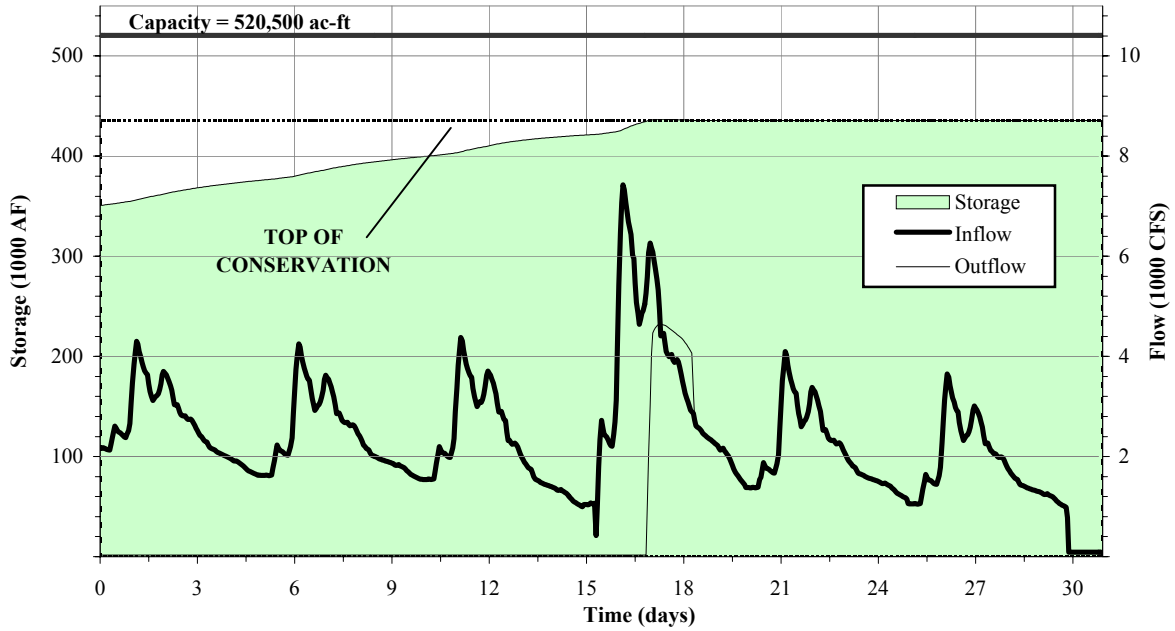
Vernalis Storm Runoff Centering									
Percent Chance Exceedence	Index Gage Location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	-47.3	1.1	0.0	0.0	0.0	0.0	0.0	0.0
	Peak Attenuation (AF)	-819	755	0	0	0	0	0	0
10%	% Peak Reduced	-53.5	-30.7	0.0	-12.2	0.0	0.0	-8.6	-7.7
	Peak Attenuation (AF)	-13,551	-12,091	0	-11,681	0	0	-11,570	-11,515
4%	% Peak Reduced	-96.5	-45.6	0.0	-25.5	0.0	0.0	-15.8	-13.1
	Peak Attenuation (AF)	-57,674	-56,921	0	-61,633	0	0	-61,530	-61,480
2%	% Peak Reduced	-84.6	-26.3	0.0	-18.8	0.0	0.0	-4.2	-3.6
	Peak Attenuation (AF)	-77,848	-45,079	0	-44,234	0	0	-43,991	-43,869
1%	% Peak Reduced	44.1	7.9	0.0	3.2	0.0	0.0	-0.6	-0.5
	Peak Attenuation (AF)	24,367	10,059	0	8,453	0	0	-5,815	-5,808
0.5%	% Peak Reduced	32.9	14.4	0.0	0.6	0.0	0.0	-1.6	0.0
	Peak Attenuation (AF)	41,141	22,299	0	2,592	0	0	-11,090	-11,043
0.2%	% Peak Reduced	1.2	0.0	0.0	-0.5	0.0	0.0	-1.1	-1.1
	Peak Attenuation (AF)	19,445	9,826	0	-16,765	0	0	-16,627	-16,555

	Maximum peak flow reduction %
	Maximum peak volume attenuation

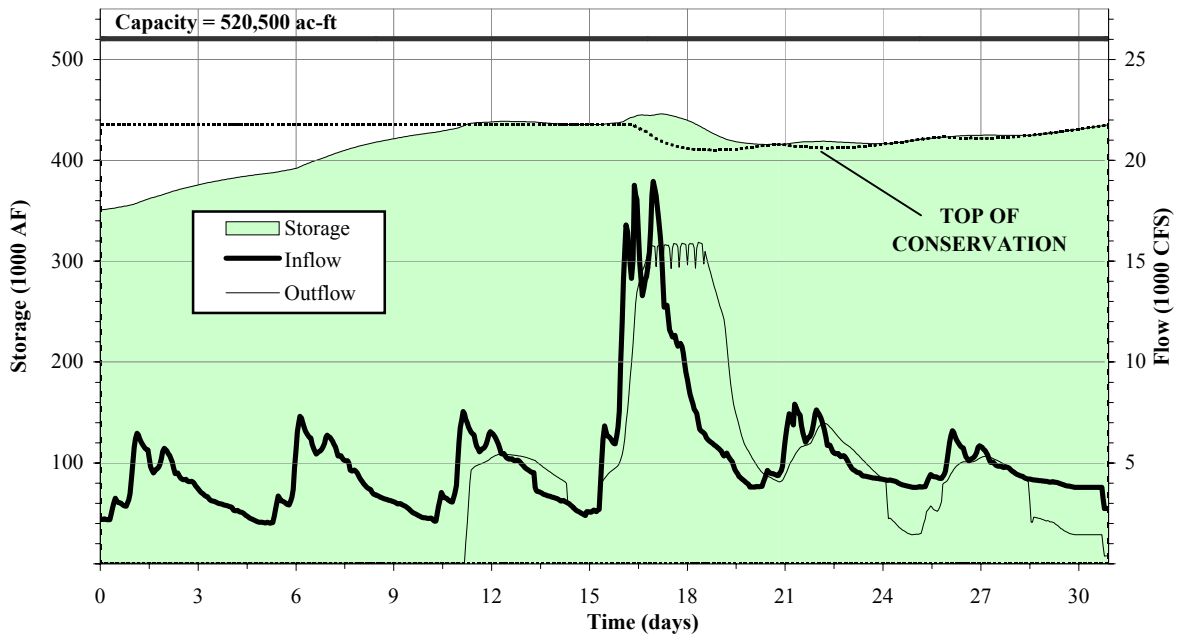
Notes:

- 1) Flow at mainstem points are estimated by HEC-5, which assumes all flows remain in channel (bypasses were treated as channels).
Flows at mainstem points are taken "at latitude" (See Chapter III of Appendix B).
- 2) % Peak Reduced = ((Maximum Regulated Baseline Inflow)-(Maximum Regulated Alternative Inflow))/(Maximum Regulated Baseline Inflow) X 100%.
- 3) Peak Attenuation = (Σ attenuated peak volume)*(0.08265 ac-ft/cfs)

Friant Operations (50% Chance Exceedence Event)



Friant Operations (10% Chance Exceedence Event)

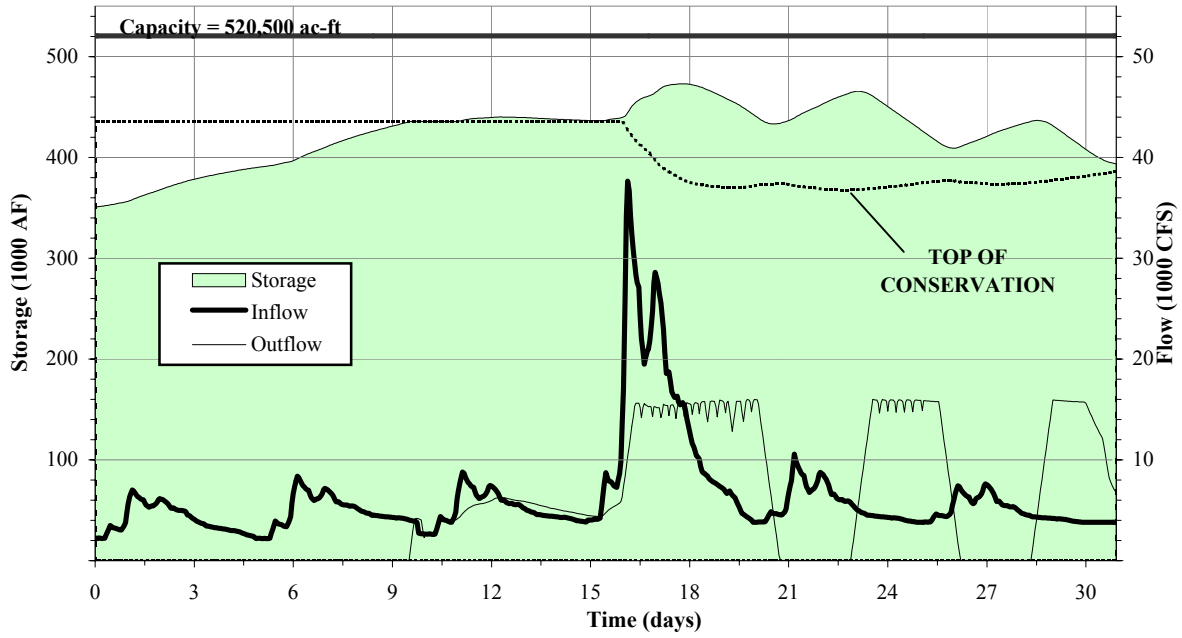


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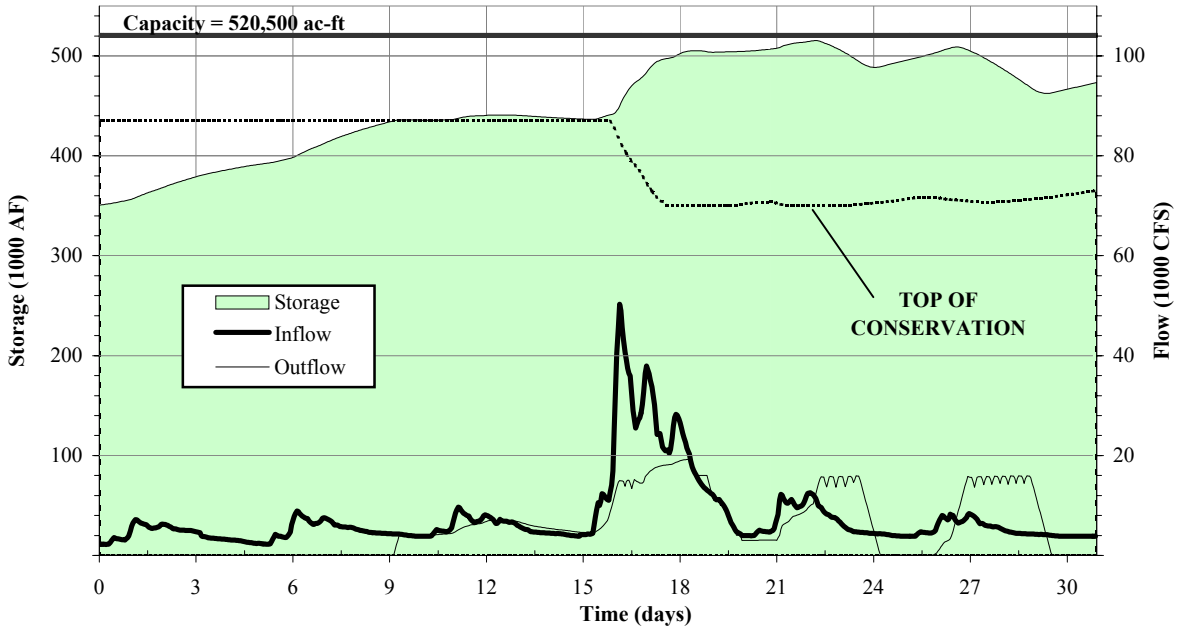
Figure C.4-10a
Reservoir Simulation Hydrographs
Alternative Scenario SJQ-B06A

US Army Corps of Engineers
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Friant Operations (4% Chance Exceedence Event)



Friant Operations (2% Chance Exceedence Event)

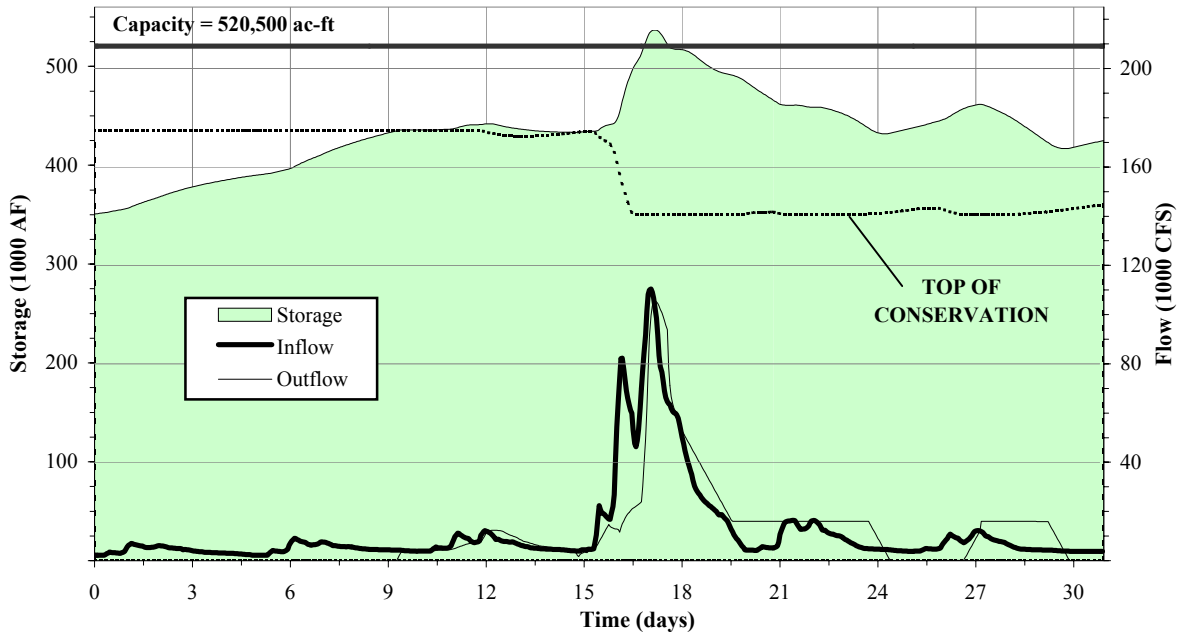


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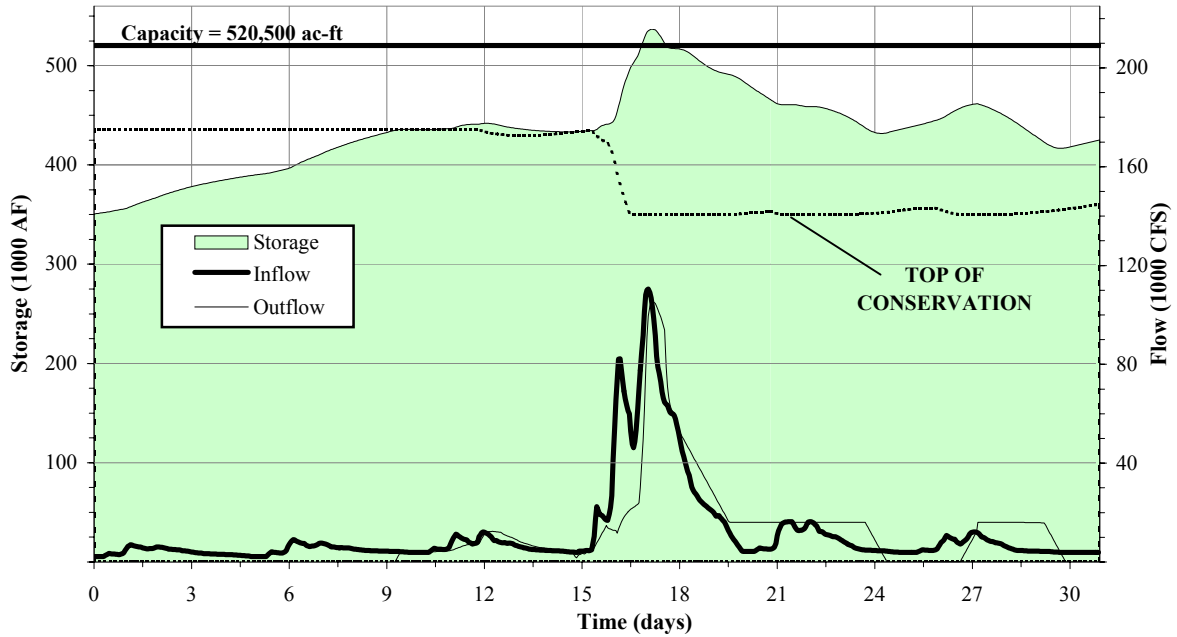
Figure C.4-10b
Reservoir Simulation Hydrographs
Alternative Scenario SJQ-B06A

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Friant Operations (1% Chance Exceedence Event)



Friant Operations (0.5% Chance Exceedence Event)

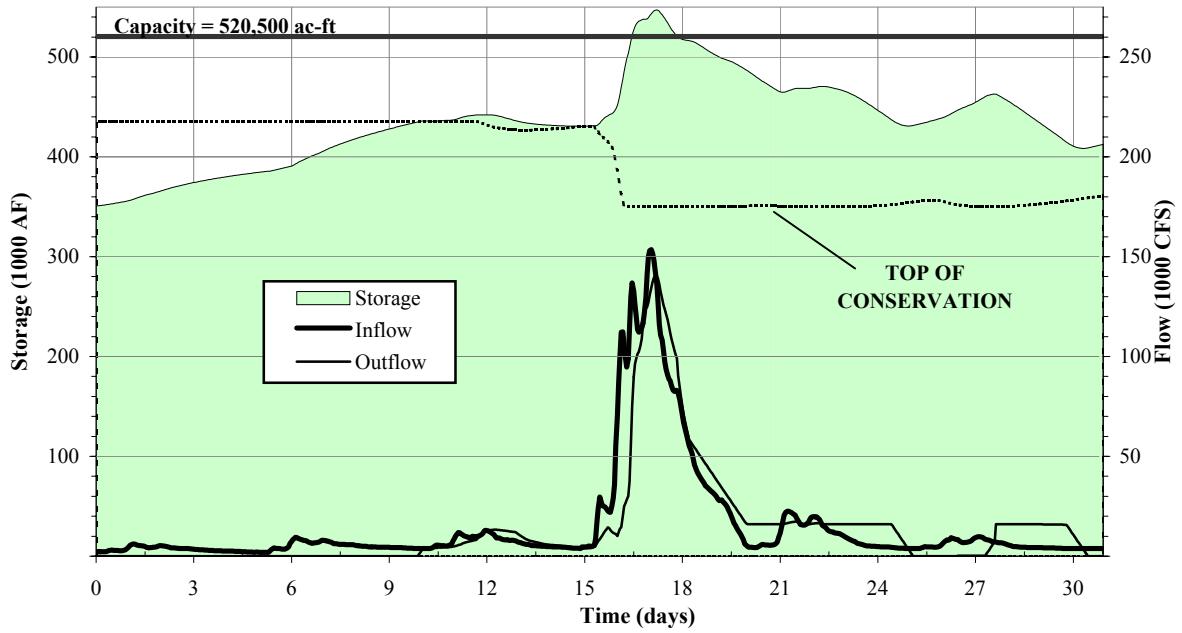


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Figure C.4-10c
Reservoir Simulation Hydrographs
Alternative Scenario SJQ-B06A

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Friant Operations (0.2% Chance Exceedence Event)



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Figure C.4-10d
Reservoir Simulation Hydrographs
Alternative Scenario SJQ-B06A

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TABLE C.4-11a

**COMPARISON OF MAXIMUM RELEASE OF BASELINE AND ALTERNATIVE SCENARIO (SJQ-B07A)
SIMULATIONS FOR SPECIFIC ANNUAL PERCENT CHANCE EXCEEDENCE EVENTS**

	50% Chance Exceedence Event		10% Chance Exceedence Event		4% Chance Exceedence Event		2% Chance Exceedence Event		1% Chance Exceedence Event		0.5% Chance Exceedence Event		0.2% Chance Exceedence Event		
	Baseline	Alternative	Baseline	Alternative	Baseline	Alternative	Baseline	Alternative	Baseline	Alternative	Baseline	Alternative	Baseline	Alternative	
Friant Centering															
Friant															
Max. Release:	8,000	3,032	3,032	7,971	7,971	9,001	9,001	25,481	25,481	71,093	71,093	108,585	108,585	139,402	139,402
New Exchequer															
Max. Release:	6,000 to 8,000	1,976	2,300	1,976	2,300	3,080	3,596	5,478	6,854	5,766	7,741	5,768	7,744	21,381	7,739
Don Pedro															
Max. Release:	9,000	3,903	3,903	3,903	3,903	5,894	5,894	9,000	9,000	9,000	9,000	9,000	9,000	42,291	42,291
New Exchequer Centering															
Friant															
Max. Release:	8,000	2,163	2,163	6,785	6,785	7,985	7,985	8,366	8,366	15,006	15,006	51,568	51,568	110,315	110,315
New Exchequer															
Max. Release:	6,000 to 8,000	3,080	3,596	5,766	7,741	5,769	7,745	21,381	7,739	45,533	37,130	81,574	74,524	141,306	130,448
Don Pedro															
Max. Release:	9,000	3,903	3,903	8,604	8,604	8,738	8,738	9,000	9,000	38,874	38,874	80,647	80,647	139,910	139,910
Don Pedro Centering															
Friant															
Max. Release:	8,000	2,163	2,163	5,346	5,346	8,000	8,000	8,000	8,000	8,630	8,630	30,749	30,749	92,384	92,384
New Exchequer															
Max. Release:	6,000 to 8,000	1,976	2,300	5,077	6,121	5,766	7,741	5,769	7,744	6,617	7,738	35,028	24,421	83,919	77,221
Don Pedro															
Max. Release:	9,000	5,894	5,894	8,737	8,737	9,000	9,000	39,630	39,630	80,821	80,821	126,377	126,377	185,449	185,449

	Maximum Baseline
	Maximum Alternative

TABLE C.4-11b
EFFECTS OF ALTERNATIVE SCENARIO SJQ-B07A

Friant Dam Storm Runoff Centering									
Percent Chance Exceedence	Index Gage Location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	0.0	0.0	-16.4	-1.5	0.0	0.0	-1.0	-0.9
	Peak Attenuation (AF)	0	0	-2,652	-2,620	0	0	-2,607	-2,601
10%	% Peak Reduced	0.0	0.0	-16.4	-0.7	0.0	0.0	-0.6	-0.5
	Peak Attenuation (AF)	0	0	-2,652	-2,620	0	0	-2,607	-2,601
4%	% Peak Reduced	0.0	0.0	-16.7	-0.7	0.0	0.0	-0.6	-0.5
	Peak Attenuation (AF)	0	0	-5,835	-5,797	0	0	-5,783	-5,776
2%	% Peak Reduced	0.0	0.0	-25.1	-1.6	0.0	0.0	-1.3	-1.2
	Peak Attenuation (AF)	0	0	-18,320	-20,294	0	0	-20,289	-20,286
1%	% Peak Reduced	0.0	0.0	-34.3	-3.2	0.0	0.0	-2.8	-2.6
	Peak Attenuation (AF)	0	0	-58,635	-58,578	0	0	-57,972	-57,454
0.5%	% Peak Reduced	0.0	0.0	-34.2	-2.1	0.0	0.0	-1.9	-1.8
	Peak Attenuation (AF)	0	0	-56,510	-66,511	0	0	-63,245	-61,938
0.2%	% Peak Reduced	0.0	0.0	63.8	3.6	0.0	0.0	3.5	3.3
	Peak Attenuation (AF)	0	0	23,723	21,872	0	0	21,284	21,006

El Nido Storm Runoff Centering									
Percent Chance Exceedence	Index Gage Location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	0.0	0.0	-16.0	1.6	0.0	0.0	-1.5	-1.5
	Peak Attenuation (AF)	0	0	-2,896	-2,877	0	0	-2,871	-2,869
10%	% Peak Reduced	0.0	0.0	-26.0	-3.3	0.0	0.0	-2.4	-2.6
	Peak Attenuation (AF)	0	0	-20,990	-23,059	0	0	-23,047	-23,041
4%	% Peak Reduced	0.0	0.0	-34.3	-6.5	0.0	0.0	-5.1	-4.5
	Peak Attenuation (AF)	0	0	-64,685	-63,902	0	0	-62,213	-61,356
2%	% Peak Reduced	0.0	0.0	-34.3	-5.1	0.0	0.0	-4.2	-3.6
	Peak Attenuation (AF)	0	0	-56,557	-67,558	0	0	-64,292	-62,986
1%	% Peak Reduced	0.0	0.0	38.1	4.7	0.0	0.0	3.9	3.4
	Peak Attenuation (AF)	0	0	7,278	6,028	0	0	5,576	5,360
0.5%	% Peak Reduced	0.0	0.0	32.5	-0.1	0.0	0.0	0.1	0.1
	Peak Attenuation (AF)	0	0	26,544	-22,836	0	0	2,135	1,999
0.2%	% Peak Reduced	0.0	0.0	8.3	-0.3	0.0	0.0	5.3	4.8
	Peak Attenuation (AF)	0	0	29,685	-10,132	0	0	35,253	35,199

	Maximum peak flow reduction %
	Maximum peak volume attenuation

Notes:

- 1) Flow at mainstem points are estimated by HEC-5, which assumes all flows remain in channel (bypasses were treated as channels).
Flows at mainstem points are taken "at latitude" (See Chapter III of Appendix B).
- 2) % Peak Reduced = ((Maximum Regulated Baseline Inflow)-(Maximum Regulated Alternative Inflow))/(Maximum Regulated Baseline Inflow) X 100%.
- 3) Peak Attenuation = (Σ attenuated peak volume)*(0.08265 ac-ft/cfs)

TABLE C.4-11b (CONT.)
EFFECTS OF ALTERNATIVE SCENARIO SJQ-B07A

Exchequer Dam Storm Runoff Centering									
Percent Chance Exceedence	Index Gage Location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	0.0	0.0	-16.7	-8.4	0.0	0.0	-5.2	-4.4
	Peak Attenuation (AF)	0	0	-5,835	-5,797	0	0	-5,783	-5,776
10%	% Peak Reduced	0.0	0.0	-34.3	-11.0	0.0	0.0	-7.7	-6.5
	Peak Attenuation (AF)	0	0	-58,635	58,578	0	0	-57,972	57,454
4%	% Peak Reduced	0.0	0.0	-34.3	-7.9	0.0	0.0	-5.9	-5.0
	Peak Attenuation (AF)	0	0	-56,551	-67,270	0	0	-64,004	-62,697
2%	% Peak Reduced	0.0	0.0	63.8	25.3	0.0	0.0	19.2	16.1
	Peak Attenuation (AF)	0	0	23,723	21,872	0	0	21,284	21,006
1%	% Peak Reduced	0.0	0.0	18.5	10.1	0.0	0.0	9.4	8.6
	Peak Attenuation (AF)	0	0	25,816	25,630	0	0	25,593	25,570
0.5%	% Peak Reduced	0.0	0.0	8.6	4.2	0.0	0.0	5.2	4.9
	Peak Attenuation (AF)	0	0	30,140	26,618	0	0	25,813	25,422
0.2%	% Peak Reduced	0.0	0.0	7.7	4.4	0.0	0.0	5.2	4.7
	Peak Attenuation (AF)	0	0	37,578	91,634	0	0	91,387	91,248

Newman Storm Runoff Centering									
Percent Chance Exceedence	Index Gage Location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	0.0	0.0	-15.8	-6.5	0.0	0.0	-3.9	-3.3
	Peak Attenuation (AF)	0	0	-5,262	-5,223	0	0	-5,209	-5,202
10%	% Peak Reduced	0.0	0.0	-34.4	-8.8	0.0	0.0	-6.3	-5.5
	Peak Attenuation (AF)	0	0	-45,989	-45,944	0	0	-45,923	-45,911
4%	% Peak Reduced	0.0	0.0	-34.2	-7.1	0.0	0.0	-5.4	-4.5
	Peak Attenuation (AF)	0	0	56,524	-66,752	0	0	-63,486	-62,180
2%	% Peak Reduced	0.0	0.0	48.1	14.2	0.0	0.0	-3.7	-3.3
	Peak Attenuation (AF)	0	0	13,088	11,498	0	0	-36,764	-36,627
1%	% Peak Reduced	0.0	0.0	20.9	3.6	0.0	0.0	6.4	6.0
	Peak Attenuation (AF)	0	0	25,747	22,721	0	0	22,547	22,491
0.5%	% Peak Reduced	0.0	0.0	8.5	4.2	0.0	0.0	5.5	5.3
	Peak Attenuation (AF)	0	0	29,060	25,630	0	0	24,782	24,377
0.2%	% Peak Reduced	0.0	0.0	8.1	4.7	0.0	0.0	5.5	5.1
	Peak Attenuation (AF)	0	0	36,335	77,985	0	0	77,702	77,548

	Maximum peak flow reduction %
	Maximum peak volume attenuation

Notes:

- 1) Flow at mainstem points are estimated by HEC-5, which assumes all flows remain in channel (bypasses were treated as channels).
Flows at mainstem points are taken "at latitude" (See Chapter III of Appendix B).
- 2) % Peak Reduced = ((Maximum Regulated Baseline Inflow)-(Maximum Regulated Alternative Inflow))/(Maximum Regulated Baseline Inflow) X 100%.
- 3) Peak Attenuation = (Σ attenuated peak volume)*(0.08265 ac-ft/cfs)

TABLE C.4-11b (CONT.)
EFFECTS OF ALTERNATIVE SCENARIO SJQ-B07A

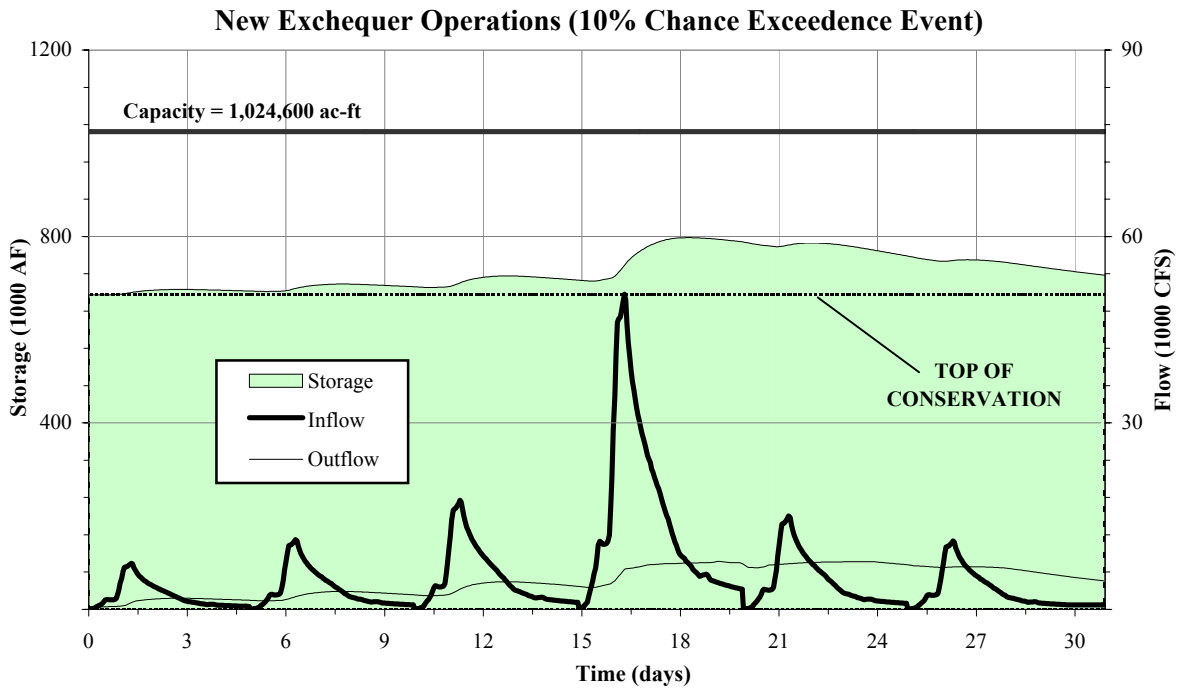
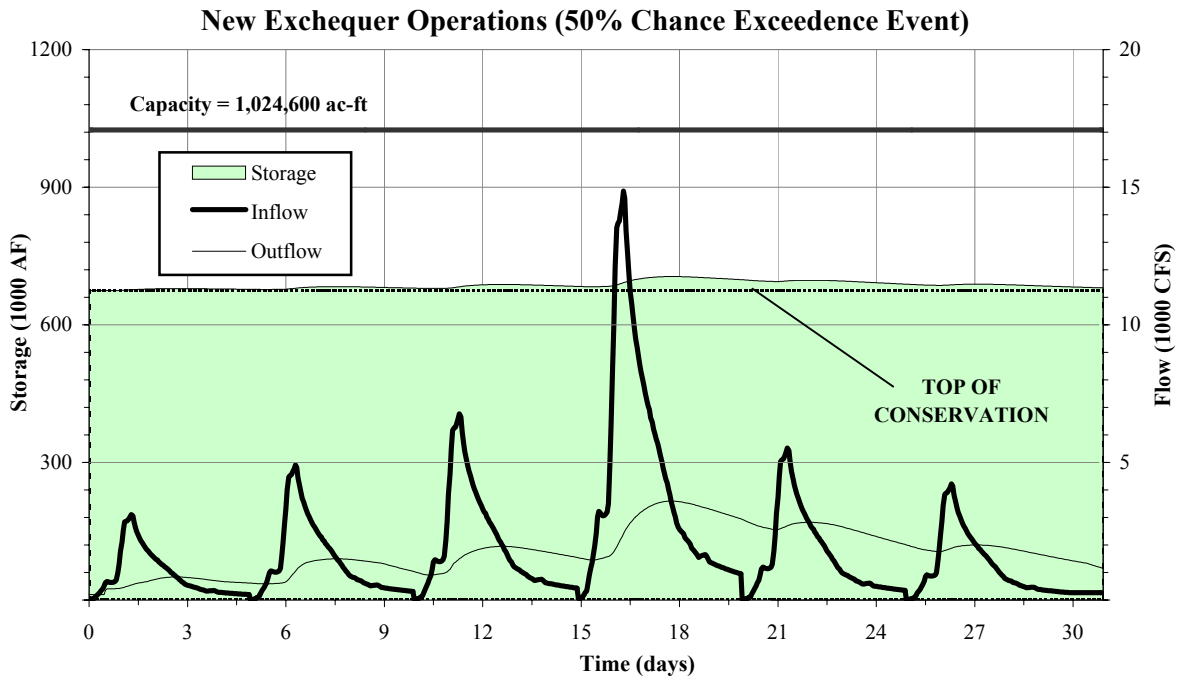
Don Pedro Storm Runoff Centering									
Percent Chance Exceedence	Index Gage Location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	0.0	0.0	-16.4	-6.6	0.0	0.0	-3.1	-2.6
	Peak Attenuation (AF)	0	0	-2,652	-2,620	0	0	-2,607	-2,601
10%	% Peak Reduced	0.0	0.0	-20.6	-3.6	0.0	0.0	-2.0	-1.6
	Peak Attenuation (AF)	0	0	-14,581	-14,557	0	0	-14,547	-14,542
4%	% Peak Reduced	0.0	0.0	-34.3	-11.1	0.0	0.0	-7.4	-5.9
	Peak Attenuation (AF)	0	0	-61,143	-60,965	0	0	-59,918	-59,249
2%	% Peak Reduced	0.0	0.0	-34.2	-8.9	0.0	0.0	-2.4	-2.2
	Peak Attenuation (AF)	0	0	-56,519	-66,661	0	0	-63,395	-62,089
1%	% Peak Reduced	0.0	0.0	-16.9	-7.0	0.0	0.0	-0.9	-0.9
	Peak Attenuation (AF)	0	0	-54,614	-67,238	0	0	-64,483	-63,386
0.5%	% Peak Reduced	0.0	0.0	30.3	3.3	0.0	0.0	0.0	0.0
	Peak Attenuation (AF)	0	0	26,080	22,895	0	0	86	-20,986
0.2%	% Peak Reduced	0.0	0.0	8.0	5.0	0.0	0.0	0.1	0.2
	Peak Attenuation (AF)	0	0	30,226	35,472	0	0	35,403	35,350

Vernalis Storm Runoff Centering									
Percent Chance Exceedence	Index Gage Location →	Friant Dam	El Nido ¹	Exchequer Dam	Newman ¹	Don Pedro Dam	Modesto	Maze Rd ¹	Vernalis ¹
50%	% Peak Reduced	0.0	0.0	-15.7	-6.5	0.0	0.0	-3.6	-3.0
	Peak Attenuation (AF)	0	0	-4,879	-4,845	0	0	-4,833	-4,827
10%	% Peak Reduced	0.0	0.0	-34.0	-7.8	0.0	0.0	-5.6	-4.8
	Peak Attenuation (AF)	0	0	-39,262	-39,212	0	0	-39,201	-39,197
4%	% Peak Reduced	0.0	0.0	-34.2	-7.12	0.0	0.0	-5.3	-4.4
	Peak Attenuation (AF)	0	0	-56,502	-66,372	0	0	-63,106	-61,800
2%	% Peak Reduced	0.0	0.0	-34.3	-6.1	0.0	0.0	-3.2	-2.8
	Peak Attenuation (AF)	0	0	-57,431	-68,922	0	0	-65,656	-64,350
1%	% Peak Reduced	0.0	0.0	33.4	2.6	0.0	0.0	-0.1	-0.2
	Peak Attenuation (AF)	0	0	26,785	2,907	0	0	-985	-21,521
0.5%	% Peak Reduced	0.0	0.0	10.0	6.3	0.0	0.0	0.1	2.3
	Peak Attenuation (AF)	0	0	29,013	33,584	0	0	33,510	33,454
0.2%	% Peak Reduced	0.0	0.0	7.8	4.5	0.0	0.0	5.8	5.2
	Peak Attenuation (AF)	0	0	34,894	57,187	0	0	56,973	56,840

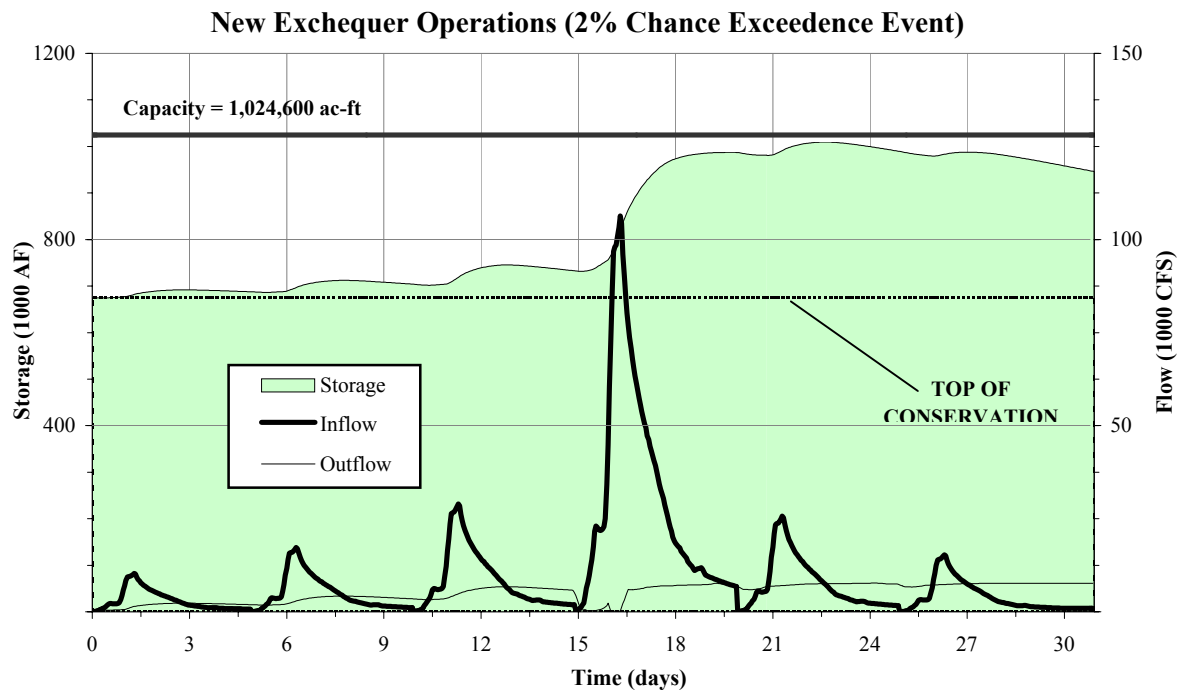
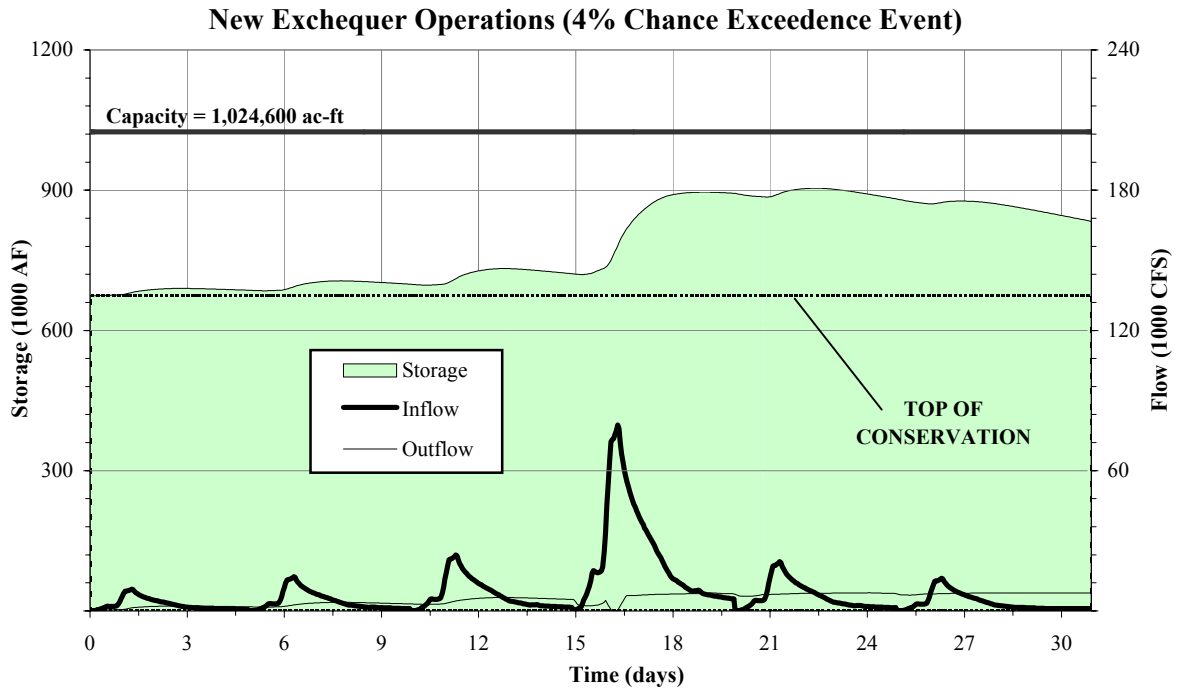
	Maximum peak flow reduction %
	Maximum peak volume attenuation

Notes:

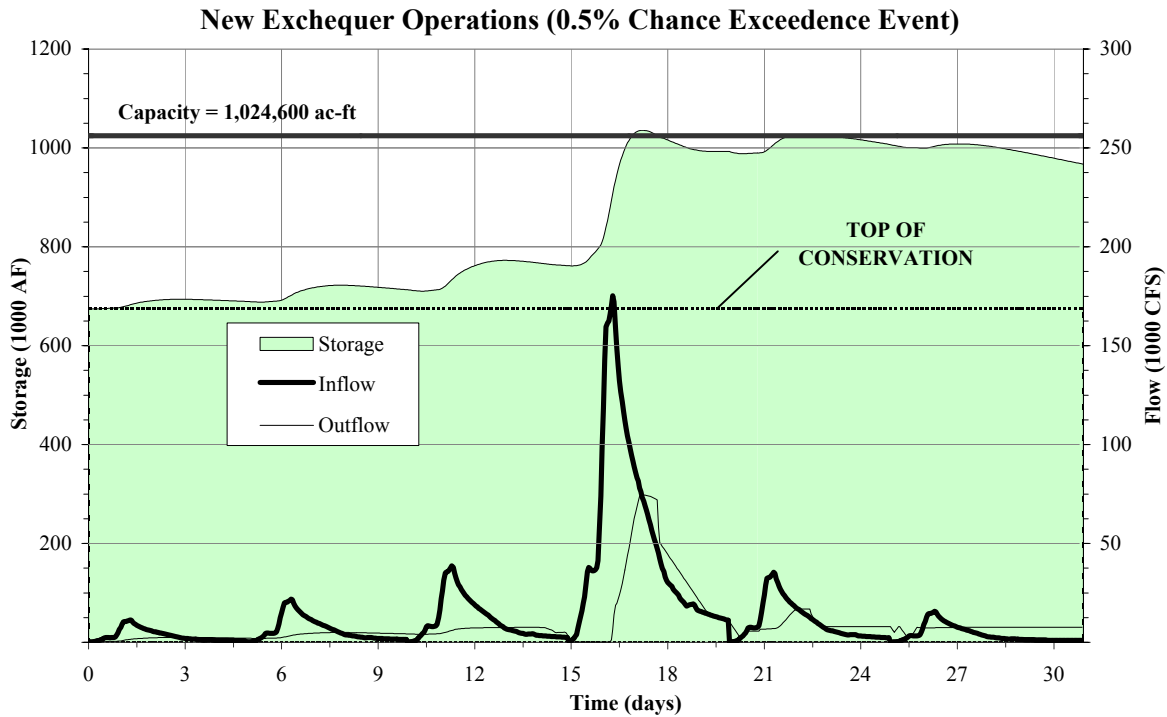
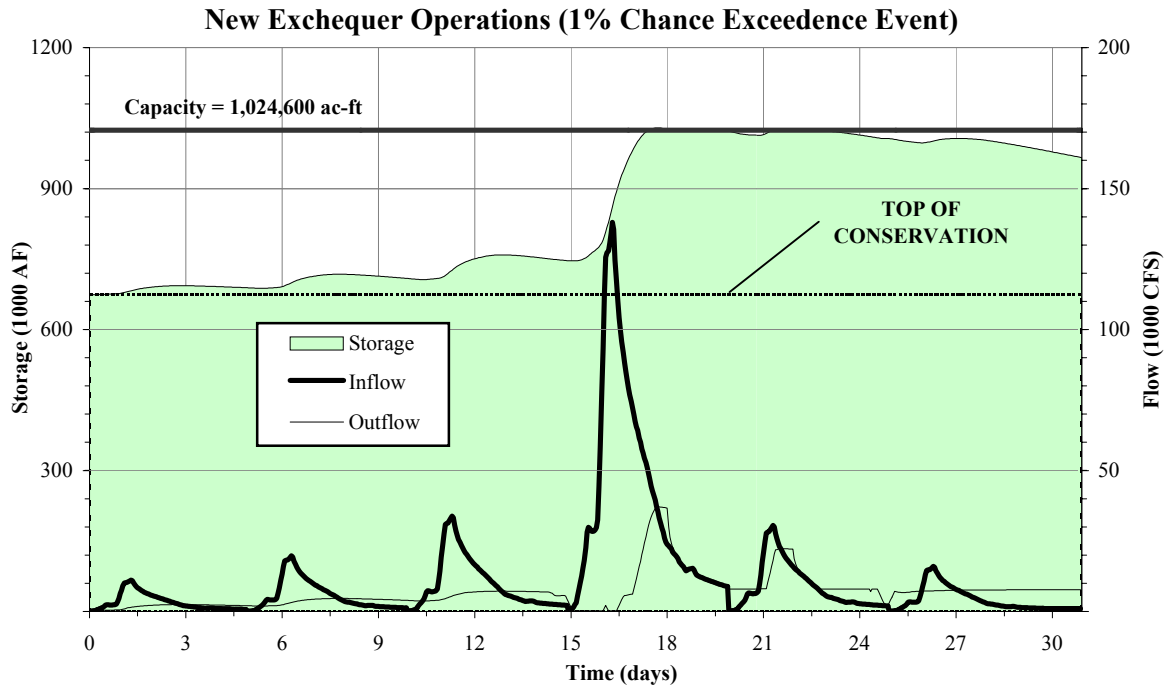
- 1) Flow at mainstem points are estimated by HEC-5, which assumes all flows remain in channel (bypasses were treated as channels).
Flows at mainstem points are taken "at latitude" (See Chapter III of Appendix B).
- 2) % Peak Reduced = ((Maximum Regulated Baseline Inflow)-(Maximum Regulated Alternative Inflow))/(Maximum Regulated Baseline Inflow) X 100%.
- 3) Peak Attenuation = (Σ attenuated peak volume)*(0.08265 ac-ft/cfs)



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Figure C.4-11a Reservoir Simulation Hydrographs Alternative Scenario SJQ-B07A	
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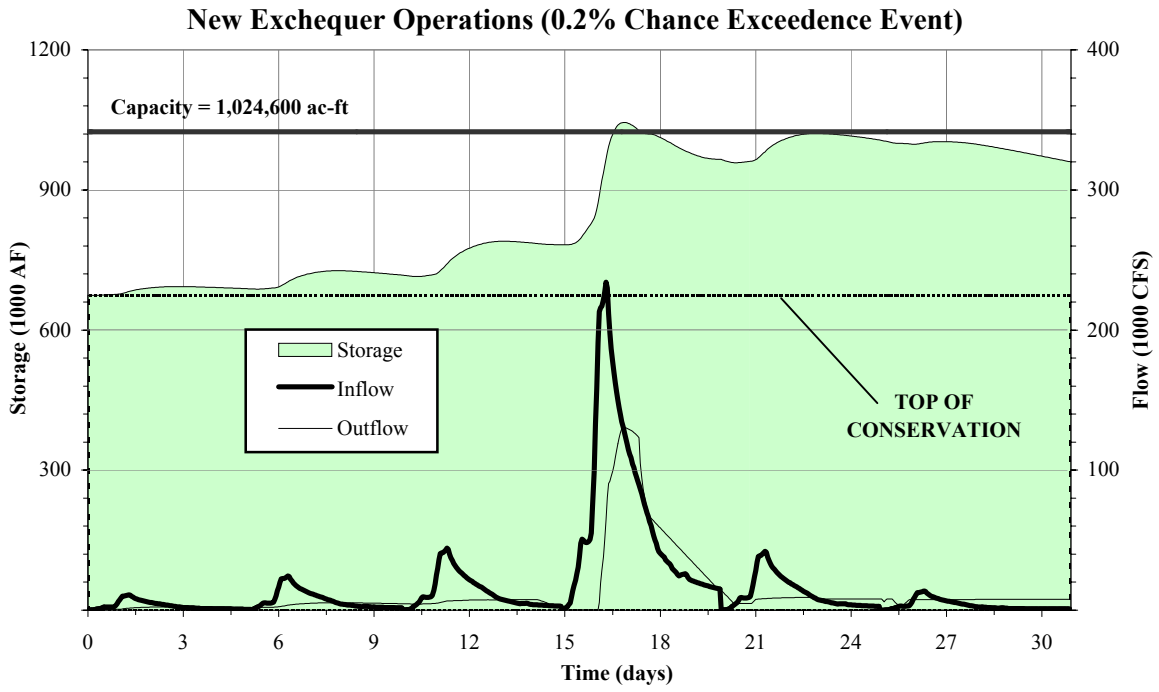
Sacramento & San Joaquin River Basins Comprehensive Study	
Figure C.4-11b Reservoir Simulation Hydrographs Alternative Scenario SJQ-B07A	
US Army Corps of Engineers The Reclamation Board, State of California	December 2002



Sacramento & San Joaquin River Basins
Comprehensive Study

Figure C.4-11c
Reservoir Simulation Hydrographs
Alternative Scenario SJQ-B07A

US Army Corps of Engineers
The Reclamation Board, State of California December 2002



Sacramento & San Joaquin River Basins Comprehensive Study
Figure C.4-11d Reservoir Simulation Hydrographs Alternative Scenario SJQ-B07A
US Army Corps of Engineers The Reclamation Board, State of California December 2002