Value Planning

Final Report

Lower Clear Creek Hydraulic Analysis
at Whiskeytown Dam

(A30-1741-6700-001-91-0-0 (2) - LCCHA)

October 22, 1999

Conducted for Bureau of Reclamation, Mid-Pacific Region

Bureau of Reclamation, Technical Service Center, Denver, Colorado

Table of Contents

United States Department of the Interior

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MEMORANDUM

To: D-8130 (Cohen) (2)

From: Christopher C. Morell
Reclamation Service Center, Value Program Coordinator

Subject: Transmittal of Revised Cost information on the Value Engineering Study Final Report, "Lower Clear Creek Hydraulic Analysis at Whiskeytown Dam"

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If you need additional information, please call me on (303) 445-3087.

Attachments

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Attention: NC-311 (DeStaso) (12)

Regional Director, Sacramento CA
Attention: MP-214 (Mourad) (2) (w/attach to each as indicated)

Life-Cycle Cost Estimate (Revised)

Examination of the 1999 Projected Central Valley Operations Office records shows that the volume of inflow into Whiskeytown Lake through the Clear Creek Tunnel and Judge Francis Carr Powerplant was 24,000 + 57,900 + 81,000 acre-feet = 162,900 acre-feet in January, February and March respectively. Of this, 36,900 acre-feet was released down Clear Creek and the remainder (126,000 acre-feet) was routed to the Sacramento River via Keswick Reservoir and the Spring Creek Tunnel and Powerplant. Once the flow passed the Spring Creek Powerplant, the water flows into Keswick Reservoir. There is a powerplant at Keswick which can produce 150,000 kW up to a maximum flow of 15,000 ft^3/s, and any excess flow is spilled. With the inflow from Shasta Dam during this same January through March time period, the volume of the spill at Keswick is 386,000 + 387,000 acre-feet = 773,000 acre-feet or more than the natural inflow in Clear Creek.

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LIFE CYCLE COST ANALYSIS - PRESENT WORTH COST (Revised)

PROJECT: Whiskey Town Dam
COMPONENT: Facility Overall
Discount Rate: 5.5%
Economic Life: 20

			PROPOSAL 1		PROPOSAL 2		PROPOSAL 3		PROPOSAL 4		PROPOSAL 5	
			Estimated Costs	Present Worth	Estimated Costs	Present Worth	Estimated Costs	Present Worth	Estimated Costs	Present Worth	Estimated Costs	Present Worth
INITIAL/COLLATERAL COSTS												
A. Proposal 1			$4,600,000	$4,600,000								
B. Proposal 2					$4,600,000	$4,600,000						
C. Proposal 3							$0					
D. Proposal 4									$28,000,000	$28,000,000		
E. Proposal 5											$53,000,000	$53,000,000
F.												
G.												
Total Initial/Collateral Costs				$4,600,000		$4,600,000				$28,000,000		$53,000,000
REPLACEMENT/SALVAGE (Single Expenditures By Year)	Year	PW Factor										
A. Scour Release (84,000 acre-feet)	4.0	0.8072	$1,587,600	$1,281,537	$1,587,600	$1,281,537	$1,587,600	$1,281,537	$1,587,600	$1,281,537	$1,587,600	$1,281,537
B. Scour Release (84,000 acre-feet)	8.0	0.6516	$1,587,600	$1,034,478	$1,587,600	$1,034,478	$1,587,600	$1,034,478	$1,587,600	$1,034,478	$1,587,600	$1,034,478
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D. Scour Release (84,000 acre-feet)	16.0	0.4246	$1,587,600	$674,065	$1,587,600	$674,065	$1,587,600	$674,065	$1,587,600	$674,065	$1,587,600	$674,065
E. Scour Release (84,000 acre-feet)	20.0	0.3427	$1,587,600	$544,117	$1,587,600	$544,117	$1,587,600	$544,117	$1,587,600	$544,117	$1,587,600	$544,117
F.												
G.												
Total Replacement/Salvage Costs				$4,369,245		$4,369,245		$4,369,245		$4,369,245		$4,369,245
ANNUAL COSTS	Escal Rate	PW Factor w/Escal.										
A. *Maintenance*		*11.950*										
B. *Operations*		*11.950*										
C. *Downtime Losses*		*11.950*										
D.		*11.950*										
E.		*11.950*										
F.		*11.950*										
Total Annual Costs												
PROJECT COST (PRESENT WORTH)				$8,969,245		$8,969,245		$4,369,245		$32,369,245		$57,369,245

Note: The value of power used in this revised analysis is $35/MWH. Based on 6,000 CFS releases for 7 days (45,360 MWH) in years 4, 8, 12, 16 and 20 the value of power lost during each of those releases would be $1,587,600 in current year dollars.

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Executive Summary

The Value Study Team met on May 3, 1999, for a 5-day planning study of the Lower Clear Creek below Whiskeytown Dam and upstream of the confluence with the Sacramento River. The objective of the study was to identify alternative ways to improve the anadromous fish habitat in the Lower Clear Creek downstream of Whiskeytown Dam and above the confluence with the Sacramento River, near Redding, California. This objective was more specifically identified as methods to recreate a more "natural" flow down the Clear Creek below Whiskeytown Dam. The post-construction operation of the dam typically provides low flows, with infrequent high and mid-range flows. This study evaluated structural and operational modifications at Whiskeytown Dam to control the releases such that a mid range flow, estimated to be 6000 ft³/s and to last for 7 days, would typically occur five times over a twenty year period. The design peak, duration, and frequency were assumed the same for all proposals.

- power impacts
- Riparian encroachment
- outmigration flow
- sediment management

The Team developed five proposals which are summarized below. Using the basic assumptions in this study, the data provided in the appendix will provide a starting point for other options using different peaks, volumes, durations, hydrograph shapes, etc. The lowest (life-cycle) cost proposal is number 3 at an estimated 20-year life-cycle cost of $2,300,000. This proposal, however, has a moderate confidence level based on undefinable development and maintenance costs. It must be tested for acceptability by all stakeholders.

Dependent Proposals: The following proposals are interdependent, each representing a complete solution and only one of the proposals could be implemented.

Proposal No. 1. Add Gates at the Morning Glory Spillway, With Flap in Throat. The estimated cost of this proposal is $6,900,000 including any study, implementation and/or life-cycle costs. This proposal has a moderate degree of flexibility in varying the size of the opening. The cost will not change significantly with different discharges, unless the design discharge changes by more than an estimated 1,500 ft³/s. The confidence of this proposal operating as described is high.

Proposal No. 2. Add Gates at the Morning Glory Spillway. The estimated cost of this proposal is $6,900,000 including any study, implementation and/or life-cycle costs. This proposal has a small degree of flexibility in varying the size of the opening due to the potential interference between the opening and flow over the crest. The cost will not change significantly with different discharges, unless the design discharge changes by more than an estimated 1,500 ft³/s. The confidence of this proposal operating as described is moderately-high.

Proposal No. 3. Increase Clear Creek Cleansing Flows Based on Reservoir Operational Modifications. The estimated cost of this proposal is $2,300,000 including any study, implementation and/or life-cycle costs. This proposal has a high degree of flexibility in varying the design discharge each year. There are high operational costs for this proposal but these costs will not change with different discharges. The confidence of this proposal operating as described is moderate due to limitations in modeling techniques and prediction capability.

Proposal No. 4. Modify the Outlet Works to Provide 6,000 ft³/s. The estimated cost of this proposal is $30,300,000 including any study, implementation and/or life-cycle costs. This proposal has a small degree of flexibility in varying the size of the outlet works due to the structural modifications required to enlarge the tunnel to accommodate the design flows. The cost will change significantly with different discharges, unless the design discharge is less than 2,000 ft³/s. If a design discharge of 2,000 ft³/s is acceptable, the cost of this proposal is estimated at $5,650,000 including study, implementation and/or life-cycle costs, because the modified proposal does not require modification to the tunnel. The confidence of this proposal operating as described is moderate due to uncertainty in foundation data.

Proposal No. 5. Increase Clear Creek Cleansing Flows with Additional Tunnel Outlet. The estimated cost of this proposal is $55,300,000 including any study, implementation and/or life-cycle costs. This proposal has a high degree of flexibility in varying the size of the additional tunnel outlet works. The proposal cost will be high but will not change significantly with different discharges. The confidence of this proposal operating as described is moderate due to uncertainty in design data.

Other Ideas: The Team identified one additional idea for further consideration and development that is listed in the "Disposition of Ideas" table near the end of this report.

Value Study Team Members

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Acknowledgment of Design Team and Consultant Assistance

The Value Study Team wishes to express their thanks and appreciation to the Project Leader, **Ms. Elisabeth Cohen**, who fully and cordially provided all needed information, consultation, and guidance to the team.

The Value Study Team wishes also to express their thanks and appreciation to those listed on the Consultation Record of this report. Their cooperation and help contributed significantly to the technical foundation and scope of the team's investigation and final proposals.

The goal of the value method is to achieve the most appropriate and highest value solution for the project. It is only through the effort of a diverse, high-performing team, including all those involved, that this goal can be achieved. This study is the product of such an effort.

Value Method Process

The Value Method is a decision making process, originally developed in 1943 by Larry Miles, to creatively develop alternatives that satisfy essential functions at the highest value. It has many applications but is most often used as a management or problem-solving tool.

The study process follows a Job Plan that provides a reliable, structured approach to the conclusion. Initially, the team examined the component features of the program, project or activity to define the critical functions (performed or desired), governing criteria, and associated costs. Using creativity (brainstorming) techniques, the team suggested alternative ideas and solutions to perform those functions, consistent with the identified criteria, at a lower cost or with an increase in long term value. The ideas were evaluated, analyzed and prioritized and the best ideas were developed to a level suitable for comparison, decision making and adoption.

This report is the result of a "formal" Value Study, by a team comprised of people with the diversity, expertise and independence needed to creatively attack the issues. The team members bring a depth of experience and understanding of the discipline they represent, and an open and independent enquiry of the issues under study, to creatively solve the problems at hand. Ideally, the team members have not been notably involved in the issues prior to the study. The team applied the Value Method to the issues and supporting information, and took a "fresh look" at the problems to create alternatives that fulfill the client's needs at the greatest value.

Current Description

The protection and restoration of natural channels and riparian habitat through habitat restoration actions is the focus of this study. This goal can be met by actions ranging from physical alterations to operational modifications of the Central Valley Project (CVP). This goal in general describes potential actions of the Secretary of the Interior in meeting Public Law 102-575 of October 30, 1992, which contains Title XXXIV, also known as the Central Valley Project Improvement Act (CVPIA). The amended purpose of the Central Valley Project is to make fish and wildlife mitigation, protection, and restoration purposes equal to irrigation and domestic (power generation and drinking water) CVP water uses.

The CVPIA authorizes the Secretary to modify CVP operation to provide flows of suitable quality, quantity, and timing to protect all life stages of anadromous fish. The program gives priority to measures which protect and restore natural channel and riparian habitat values through (1) habitat restoration actions, (2) modifications to CVP operations, and (3) implementing supporting measures.

Contained within the Act, in Section 3406 (b)(12) are measures specifically directed toward the Clear Creek and Whiskeytown Dam. This includes developing and implementing a comprehensive program to provide flows to allow sufficient spawning, incubation, rearing and out migration for Salmon and Steelhead from Whiskeytown Dam after Clear Creek has been restored.

Also contained within the CVPIA are other considerations that impact this study to a greater or lesser extent. The CVPIA authorizes and directs the Secretary of the Interior to dedicate and manage annually 800,000 acre-feet of CVP yield for the primary purpose of implementing fish, wildlife, and habitat restoration. The Act sets aside a minimum of 340,000 acre-feet for instream releases to the Trinity River, to make use of short pulses of increased water flows to increase the survival of migrating anadromous fish, eliminate losses of anadromous fish due to flow fluctuations, and reevaluate existing operational criteria at Sacramento and Trinity River reservoirs to protect and restore the anadromous fish of the Sacramento and Trinity Rivers.

Additional clarification of the CVPIA is provided by the Department of the Interior's Final Administrative Proposal on the Management of Section 3406(b)(12) Water. The Administrative Proposal identifies concerns by the agency stakeholders and public in meeting the goals of the CVPIA. The implementation of the various provisions requires a coordinated approach to the management of CVP water with continual refinement of the decision making process to account for the multiple and frequently competing objectives for the CVPIA.

The stakeholders have expressed in the Final Administrative Proposal a desire for "certainty" in terms of clearly defined actions consistent with the Act and a desire to clearly understand how the water will be managed and what the impact will be on each use.

Current Description

Some of the goals of the CVPIA have been delineated in the Revised Draft Anadromous Fish Restoration Plan (AFRP). Other impacts have not been addressed. Some of the methods suggested in the Draft Administrative Proposal incorporate the use of a water reserve account. Water would be stored in designated storage locations as a "reserve account." The reserve account could then be flexibly used to respond to opportunities during the course of the year.

During critically dry years, water deliveries for implementing fish, wildlife and habitat restoration will be reduced to the greater of 600,000 acre-feet or the percentage of deliveries to the agricultural service contractors.

The Trinity River Flow Evaluation Study identified "Extremely Wet Years" as occurring 12 percent of the time, "Wet Years" as 28 percent of the time, "Normal Years" as 20 percent of the time, "Dry Years" as 28 percent of the time, and "Extremely Dry Years" as 12 percent of the time. Some of these distinctions are used in the report.

Appendix A of the Final Administrative Proposal clearly stated specific goals. These goals included Keswick flow releases from 9,000 to 15,000 cubic feet per second (ft^3/s) (7-day average) and release changes of 1,000 to 2,000 ft^3/s for one week periods over a 30-day period (typically May).

Appendix A of the Final Administrative Proposal also included summaries of the current status of the AFRP flow-related actions. Upstream Reservoir Actions No.1 and No. 2 provide improved flows in the CVP-controlled steams of Clear Creek and the Sacramento River, which were considered during the study. Action No.1 provides minimum instream flow requirements below Whiskeytown Dam based on the thresholds of Clair Engle storage ranging from 100 to 200 ft^3/s. Action No. 2 provides minimum instream flow requirements below Keswick Dam for October through April based on thresholds of Shasta storage. These flows range from 3,250 ft^3/s to 6,000 ft^3/s. Note, however, the instream flow requirements are based on Shasta storage and do not include inflow from Trinity diversions.

Future implementation will need to consider the potential operational impacts between Trinity River Division Operations and Shasta Reservoir operations, when the Trinity River flow regime is implemented. This aspect requires operational evaluations and could not be fully evaluated during this study.

The Lower Clear Creek Hydraulic Analysis study delineates some potential methods to alter discharges at Whiskeytown Dam in an effort to improve the environment in the Clear Creek between Whiskeytown Dam and the confluence with the Sacramento River, and what the costs and uncertainties associated with these methods would be.

Current Description

The study then evaluates both structural and operational methods to provide flows for protecting the anadromous fish, the natural channel, and the riparian habitat below Whiskeytown Dam in and along Clear Creek above the confluence with the Sacramento River.

Whiskeytown Dam and Lake is an element of the Bureau of Reclamation's Trinity River Division, Central Valley Project. Some of the other elements of the Trinity River Division include Trinity Dam and Lake, Lewiston Dam and Lake, Clear Creek Tunnel, Judge Francis Carr Powerplant, and Spring Creek Tunnel and Powerplant. Whiskeytown Dam is located on Clear Creek, as shown on Figure 1.

Whiskeytown Dam provides regulation for Trinity River flows discharged from Judge Francis Carr Powerplant and regulates the runoff from the Clear Creek drainage area. Figure 4 provides a graphic overview of the relationship and interconnections between Whiskeytown Dam, Lewiston and Keswick Dams and Lakes, Clear Creek and Spring Creek interconnecting tunnels, and Judge Francis Carr and Spring Creek Powerplants.

Whiskeytown Dam is an earth fill structure 282-foot high with a crest length of 4,000 feet that was constructed from 1960 to 1963. (See Figures 2 and 3) The dam includes a "Morning Glory" spillway with a crest elevation of 1210.0 feet and a discharge capacity of 28,000 ft^3/s at reservoir water surface elevation 1220.5. Judge Francis Carr Powerplant has two generators with a total "nameplate" generating capacity of 141,444 kW. Spring Creek Powerplant has two generators with a total "nameplate" generating capacity of 150,000 kW. The lake has a capacity of 241,100 acre-feet at elevation 1210.0 and is operated as a part of the Whiskeytown Unit Recreation Area by the National Park Service.

The current safe downstream channel capacity is estimated to be 1,250 ft^3/s for Clear Creek below Whiskeytown Dam. In this case, the safe downstream channel capacity is also approximately the bank-full channel capacity. Modifications at Whiskeytown arising from this study may ultimately modify the safe downstream channel capacity or the bankful channel capacity of the Clear Creek. The study anticipates higher releases on a greater frequency without damages to property. These flows are not necessarily limited to channel capacity but may be intentionally designed to overflow into the flood plain areas outside the channel. The optimum magnitude and frequency of these releases has not be determined for the Clear Creek, For purposes of this planning study, it was assumed that a flow of 6,000 ft^3/s every three to five years would not cause any damages between Whiskeytown Dam and the confluence with the Sacramento River.

Whiskeytown Lake does not have flood control as one of its authorized functions. Operation of the lake from November 15th through March 31st maintains the reservoir water surface as near as possible to elevation 1197.5 (or 1198 for maximum power production from Clear Creek inflows). That operation reduces the probability of high releases in the Clear Creek channel from uncontrolled spills providing some protection.

Current Description

For the last four years, 1995 through 1998, Whiskeytown Dam has been operated to achieve a reservoir water surface elevation of approximately 1209 feet by May 1 and to hold it at a constant elevation for the summer recreation season through September. Beginning in October, the reservoir is drawn down to approximately elevation 1198 until the reservoir is filled again in the spring.

The flood routings assumed an initial reservoir water surface elevation of 1,197.5 or 1,210.0 feet, top of active conservation from November through March and April through October, respectively. Flood flows in excess of the approximately 36,900 acre-feet of storage available from elevation 1197.5 to 1210 will be discharged through the spillway and outlet works, as well as through Spring Creek Powerplant. The Standing Operating Procedures state that in the event of sudden high runoff into the reservoir, Judge Francis B. Carr Powerplant (which outlets into Whiskeytown Lake) is to be shutdown, the outlet works is to be operated fully open, and discharges through Spring Creek Powerplant are to be increased to the maximum. Present operation for high runoff uses the Spring Creek Tunnel and outlet works for releasing water until the water surface exceeds elevation 1210. At that reservoir water surface elevation, the Spring Creek tunnel is shut down and the excess flows are allowed to flow past Whiskeytown Dam using the morning glory spillway.

The critical threshold flood (i.e., the flood that generates a reservoir water surface equal to the crest of the dam at 1228.0 feet) is 53 percent of the 1995 General Storm PMF with 100-year Snowmelt Standard Arrangement. The critical threshold floods are the same for an initial reservoir water surface at either elevation 1197.5 or elevation 1210.0. *(Flood Routing Memorandum of December 1996)*

Current 1999 projected operations of the Whiskeytown Dam, flow on Clear Creek (CC), Clear Creek Tunnel (CCT) and Judge Francis Carr Powerplant, and Spring Creek Tunnel and Powerplant are outlined in the table on the following page. The months of May through September inclusive are excluded, because the recreational use of Whiskeytown Lake during that period effectively precludes significant variations in water surface elevation, and were not considered during this study. All values in the following table are volumes in thousands of acre-feet unless otherwise indicated:

Current Description

	FEB	MAR	APR	MAY - SEP	OCT	NOV	DEC	JAN
Inflow CCT (af)	15.5	7.9	44.2	*(Excluded)*	31.3	17.2	15.0	20.1
Inflow Creek (af)	12	20	16		2	2	4	8
Evaporation (af)	0.4	0.6	1.1		0.9	0.4	0.3	0.5
Release (af)	26	27	27		52	31	19	27
Clear Creek (af)	11.1	12.3	11.9		12.3	12.3	12.3	12.3
Spring Creek (af)	15	15	15		40	19	6	15
Storage (af)	205.7	205.7	237.9		218	205.7	205.7	203
Elevation (ft)	1198.5	1198.5	1209.1		1202.6	1198.5	1198.5	1198.6
CC (ft^3/s)	200	200	200		200	200	200	200
CC - AFRP (ft^3/s)	200	200	200		200	200	200	200
Total Inflow (af)	27.5	27.9	60.2		33.3	19.2	19.0	28.1

(af = acre-feet, CC - ft^3/s indicates the release to Clear Creek in cubic feet per second, and CC - AFRP is the release to Clear Creek under the Anadromous Fish Restoration Plan in cubic feet per second)

The objective of this project is to improve the anadromous fish habitat by removing vegetation growth and deposited fines from the spawning beds by restoring the natural scouring flows. The scope of this project covers the reach of Clear Creek from Whiskeytown Dam to the confluence of Clear Creek and the Sacramento River. The channel improvements to that reach are being designed separately. The team estimated flow required to scour the beds is 6,000 ft^3/s for a period of 7 days and will occur five times in a 20-year period. The scope of the scour flow will be revised after further studies have been completed.

The configuration of the morning glory spillway is not conducive to adding any power production. The spillway was designed as a free-flow conduit and cannot be easily modified to accommodate a pressure system, hence no power was considered in conjunction with the spillway.

Power generation facilities could be added to the existing outlet works or any new construction at Whiskeytown Dam. This study used a 20-year period for cost evaluation. The cost associated with building a powerplant would probably not be paid back in that period of time so it was not included in any alternative and would have increased the cost of the proposals. However, power production facilities will payback all costs eventually. Further studies should revisit the assumptions made for power production and evaluate the proposals over a longer period before any decision about power production viability is made.

Figure 1. Location Map

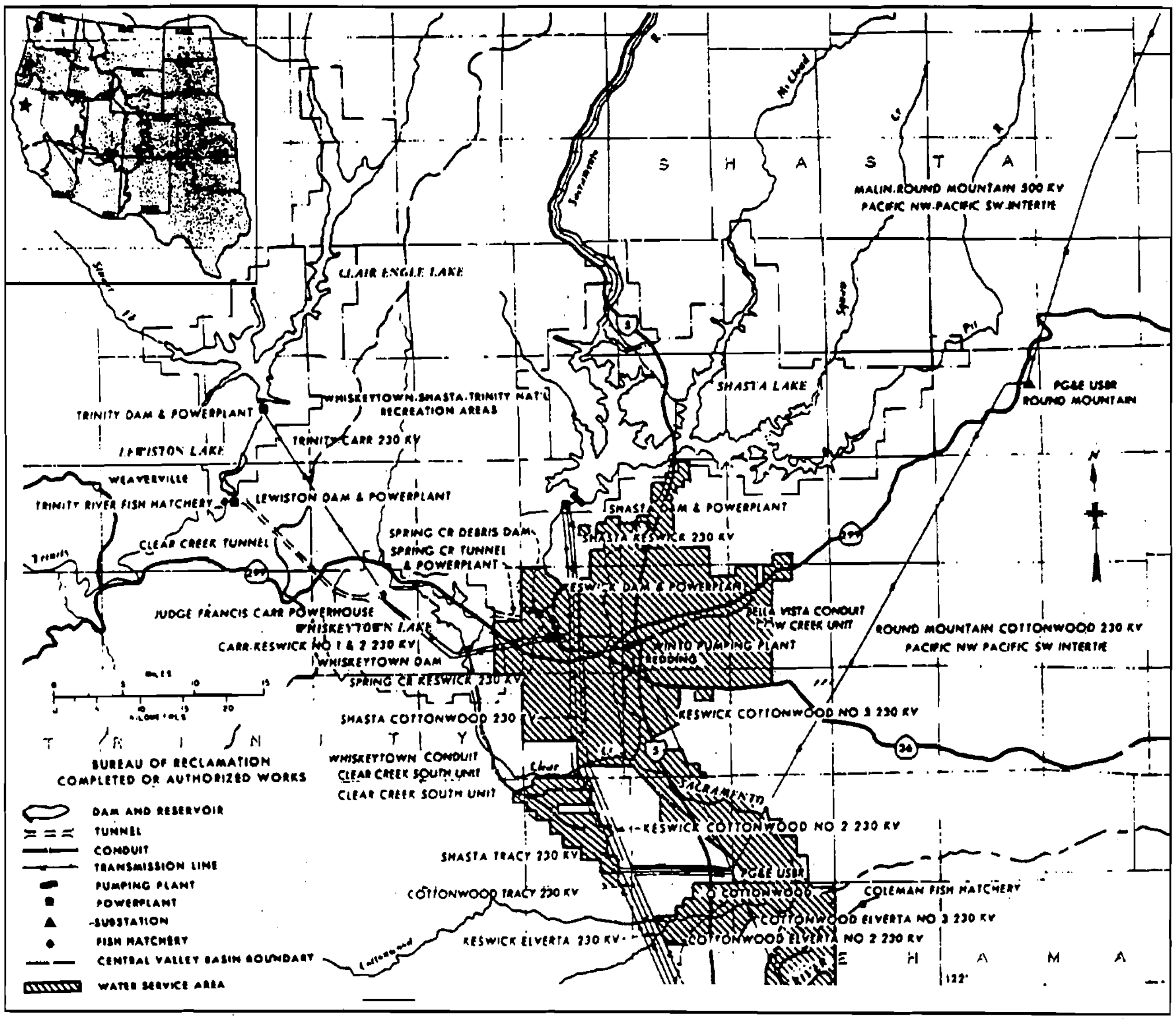


Figure 2. Whiskeytown Plan

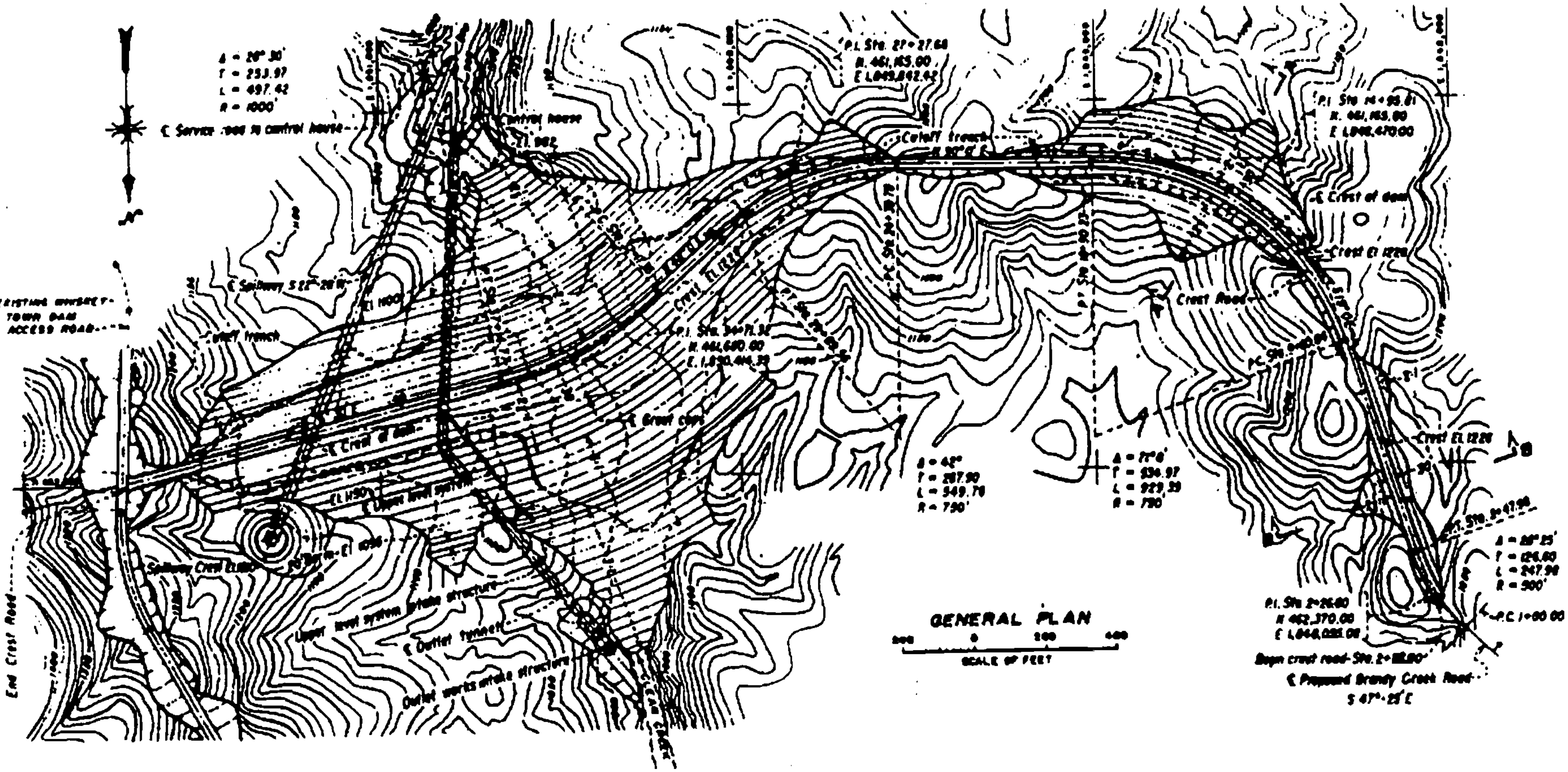


Figure 3. Whiskeytown Section.

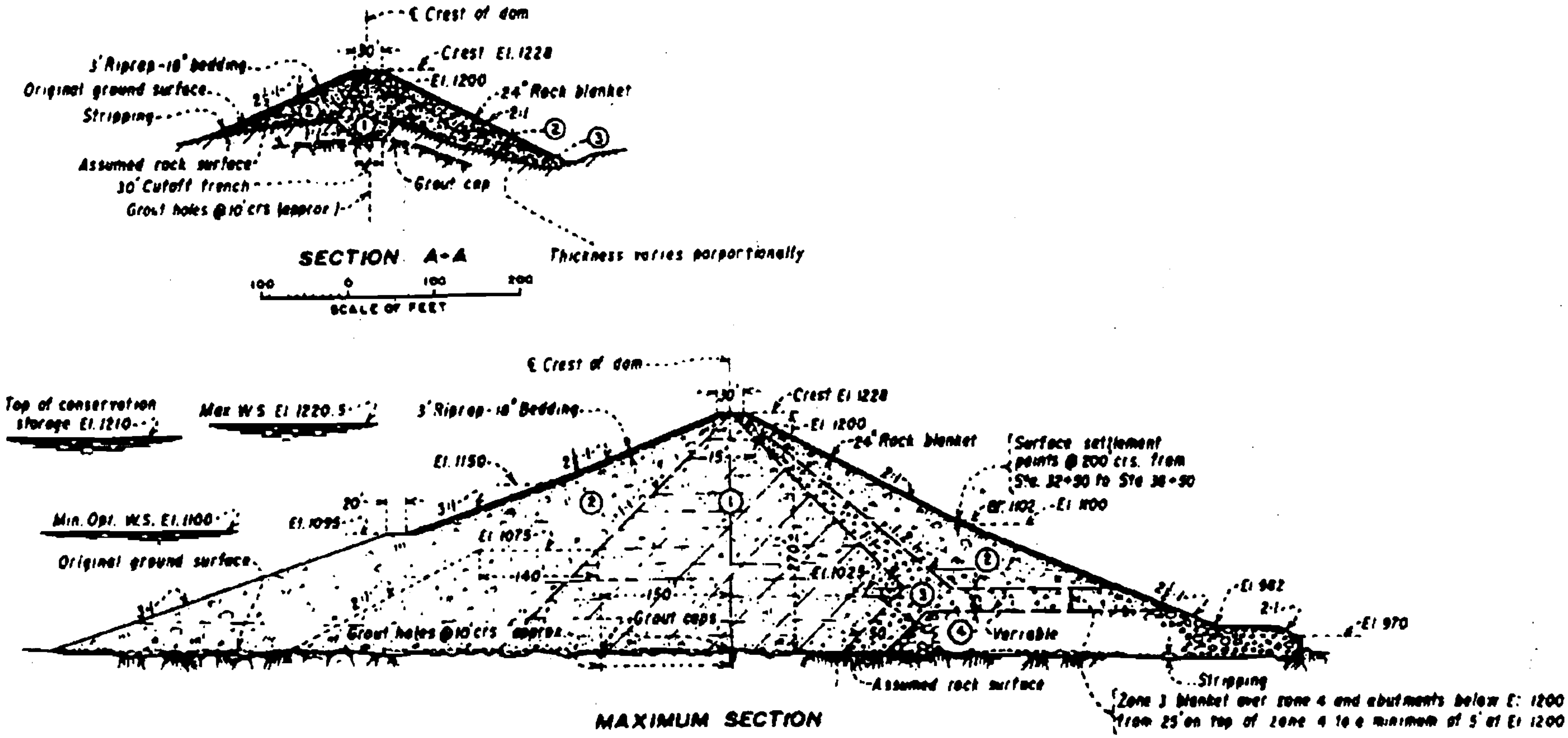
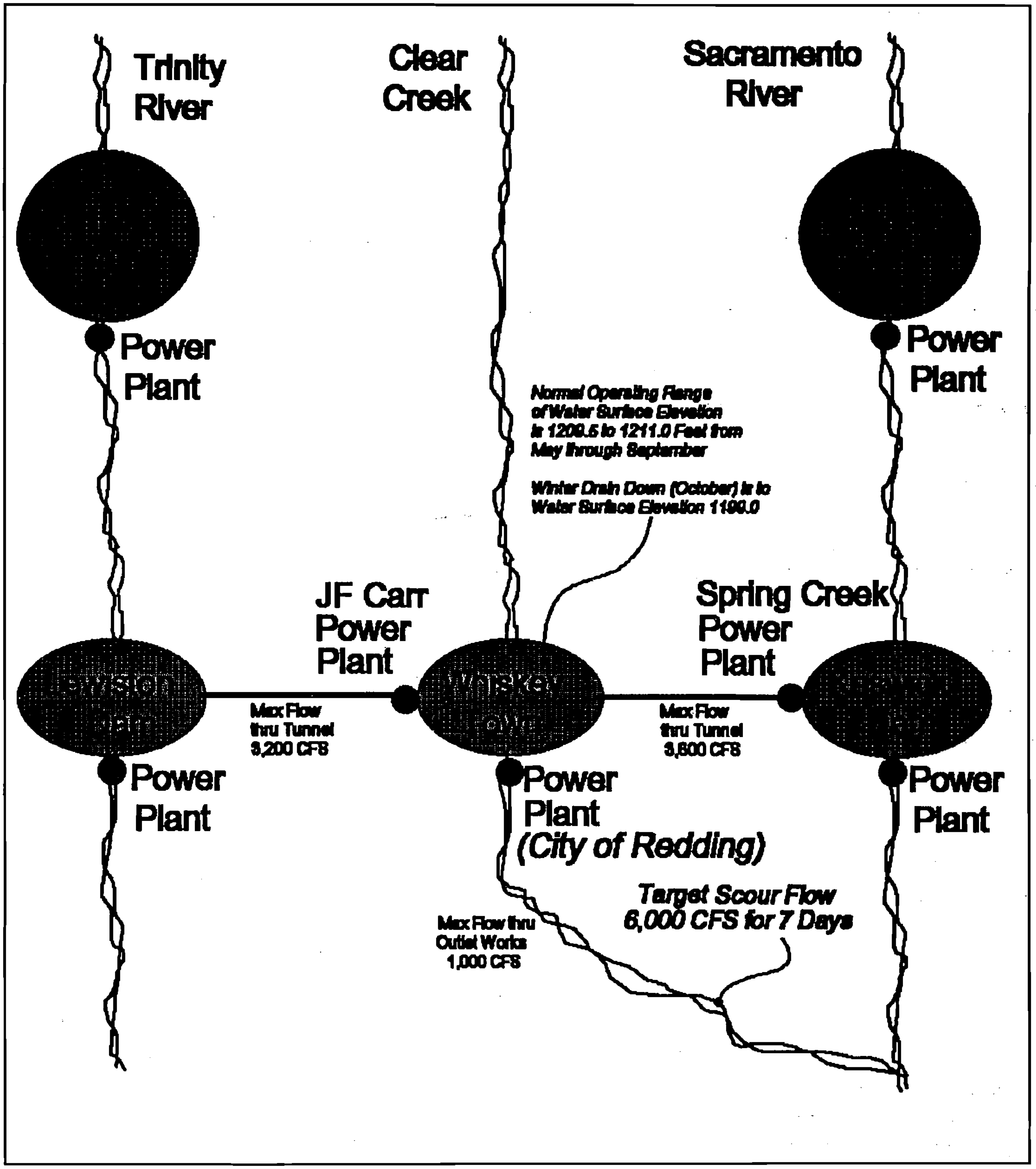


Figure 4. Graphic Flow Diagram.



Special Criteria Summary

Users

- National Park Service (Whiskeytown Unit, Whiskeytown, Shasta, Trinity National Recreation Area) and Recreation Area users.
- Power Customers supported by Judge Francis Carr and Spring Creek Powerplants
- City of Redding (Power).
- Irrigation Water users supported by Trinity, Shasta, Lewiston, Whiskeytown and Keswick.

Code Requirements

Bureau of Reclamation and Federal Dam Safety Requirements

Restrictions and Limits

- Desirable range of reservoir water surface elevation (May - September) is 1209.5 to 1211.0 feet.
- Maximum range of reservoir water surface elevation - All year is 1199.0 to 1221.0 feet.
- Target release for channel scour is 6,000 ft^3/s for 7 days (84,000 acre feet of water) on a frequency of 3 to 5 years.
- Assume 6,000 ft^3/s will not cause damage to property along the Clear Creek.
- Existing capacity of Whiskeytown Outlet Works is 1,000 ft^3/s at reservoir water surface elevation 1150.
- Existing capacity of Whiskeytown Spillway is 28,000 ft^3/s at reservoir water surface elevation 1220.5.
- Assume that the operations of Judge Francis Carr and Spring Creek Powerplants could be modified.
- Assume that any water diverted through the Clear Creek Tunnel for scour flow would detract from the Spring Creek Powerplant generating capacity and would reduce flows in the Sacramento River from below Keswick Dam to the confluence with Clear Creek.

Design History

None - This is an initial planning study. Hydrologic data, facilities information, and the planned annual operating budget for Whiskeytown related facilities is identified in the reference materials and documents listed in the table at the end of this report.

Special Criteria Summary

Design Flow

Discussion of the determination of the design flow range for structural or operational modifications.

No specific flows were identified prior to this study. Conversations with project personnel indicated that the goal was to restore Clear Creek to its natural flow regimes. This would benefit the anadromous fish populations, the channel bed, and the riparian habitat along the creek. The post construction operation of the dam provides low flows and infrequent high flows, but the mid-range flows have been reduced in frequency and need to occur more frequently to recreate the natural flow regimes.

There are gage records for the Clear Creek at French Gulch, California (United States Geological Survey (USGS) Gage Station 1137100) and near Igo, California (USGS Gage Station 11372000). The gage at French Gulch records runoff from a drainage area of 115 square miles and this is unregulated flow. The gage near Igo, California records runoff from a drainage area of 228 square miles but this is regulated flows due to Whiskeytown Dam. These gage records were evaluated to ascertain an estimated target mid-range for flows.

Examination of the historical streamflow daily gage values of Clear Creek at Igo, California from 1941 through 1997 indicated that prior to construction of Whiskeytown Dam the stream experienced floods of 6,000 ft^3/s or greater at least every 3 to 5 years. Larger magnitude floods of 9,000 ft^3/s or greater were experienced about four times, and three times there were floods greater than 14,000 ft^3/s over the 23 years of gage record from 1941 to 1963. Since completion of the dam, flows of 6,000 ft^3/s at Igo were experienced twice, 8,500 ft^3/s once, and there was one flood of 14,000 ft^3/s (using the gage record from 1964 to 1997). The majority of the flows in the Clear Creek since 1964 have been 2,000 ft^3/s or less.

The historical streamflow daily gage records at French Gulch, which has a drainage area approximately half that of Igo, cover the period from 1951 to 1993. During this period the flow exceeded 3,000 ft^3/s in 13 out of 43 years or about once every 3 to 5 years. Doubling that drainage area, to reflect the Whiskeytown drainage area, would double the flow.

The team also examined the Trinity River Flow Evaluation study. In that study, the water years were divided into extremely wet, wet, normal, dry, and extremely dry water categories. Each year is classified as a water year type and the percentage of years that fall into each category was computed. The team used this same approach for the Clear Creek and assumed that the percentage of the time the flow will be in these water year types would be consistent from the Trinity basin to the Clear Creek. The team used these percentages, computed the number of occurrences for each water year type based on the historical records of the Clear Creek near Igo, California, and determined the number of occurrences with the following results.

Special Criteria Summary

The percentage of time was taken from the Trinity River Study, and the number of occurrences and the flow ranges are based on the historical streamflow daily values for the Clear Creek at Igo, California and applied to discharges at Whiskeytown Dam.

Water Year	Percentage of Time	Number of Occurrences	Flow ranges
Extremely Wet	12	6	>13,000 ft^3/s
Wet	28	13	7,000 to 13,000
Normal	20	9	4,000 to 7,000
Dry	28	13	2,800 to 4,500
Extremely Dry	12	6	0 to 2,800

Using the above information, 6,000 ft^3/s provides control of flows for the extremely dry, dry, and normal years and appears to have the potential to occur about once every three to five years. The flows necessary to mimic a wet or extremely wet water year type would occur with natural flooding and use of the morning glory spillway.

The study needed to target a specific flow rate for structural design alternatives. The 6,000 ft^3/s is an initial estimate of the flow to control the mid-range floods. The team selected 6,000 ft^3/s as a reasonable initial estimate for the maximum flows for structural modifications. This flow provides at a minimum a mid-range level for control, which was a goal of the study.

Future work needs to be done to address the desired design flow regimes. This includes identifying the peak discharge, durations, frequencies, volume, shape of the design outflow hydrograph, and the acceptable variations. The ultimate flow regime may be smaller or larger and involve a range of choices depending on the type of water runoff year expected. The optimum modification at Whiskeytown Dam may require the ability to create a wide range of discharges with accompanying volumes. This study used only a peak discharge and volume to reduce the total number of design variations.

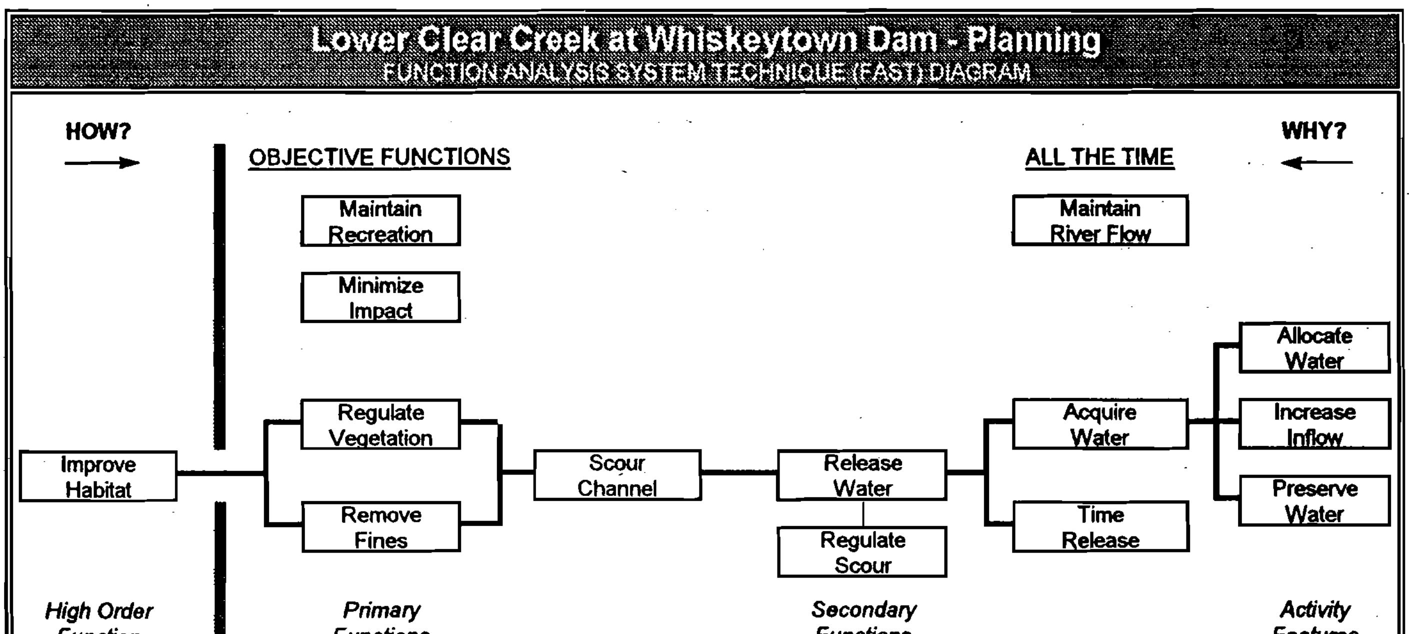
It is assumed that with additional work on this project, a major factor will involve the refinement of design flow regimes. This document will provide some input to what direction these refinements might take but should not be considered the final authority.

Function Analysis

Component	Active Verb	Measurable Noun
Critical Functions	Improve Regulate Remove Scour Release Acquire Time Allocate Increase Preserve Maintain Minimize	Habitat Vegetation Fines Channel Water Water Release Water Inflow Water Recreation Impact
Supporting Functions	Maintain Regulate	River Flow Scour

Function Analysis System Technique (FAST)

The Value Study Team used the function-analysis process to generate a Function Analysis System Technique (FAST) diagram, to describe the present solution from a functional point of view. The FAST diagram helped the Team identify those design features that support critical functions and those that satisfy noncritical objectives, focus on potential value mismatches, and generate a common understanding of how project objectives could be met.



Activity-Oriented FAST Diagram

Proposal No. 1

Description

Proposal No. 1. Add Gates at the Morning Glory Spillway, With Flap in Throat.

- Proposal Description: This proposal involves adding two rectangular gates at the morning glory spillway. This is accomplished by cutting an opening on the side of the spillway and adding a conduit, two gates, and a flap valve. The flap would be located in the throat of the spillway. The downstream surface of the flap valve would be fabricated to the same shape as that of the interior surface of the spillway. (See Figure 5.) The use of bulkhead slots and a rented floating bulkhead would eliminate the need for one of the slide gates. This variation should be considered in future studies and incorporated to reduce costs.

  The work would require excavating an approach channel at approximately elevation 1160, constructing a gate structure for a trashrack, a 25-foot by 10-foot guard gate and a 25-foot by 10-foot regulating slide gate. The gates are sized to provide a flow of 5,000 ft^3/s at reservoir water surface elevation 1201. This would supplement the outlet works flow (of 1,000 ft^3/s) for a total discharge past Whiskeytown Dam of 6,000 ft^3/s. There would be a concrete conduit from the gate structure to the spillway. It would enter the spillway on the side wall. The flap valve, or pivoting gate, would preserve the morning glory spillway hydraulic characteristics, keep flow out of the conduit when the morning glory is operating, allow flow from the conduit into the spillway, and help redirect flow from the conduit into the spillway. A control platform at elevation 1222 would have to be built with a walkway to access the gates from the top of the dam. The outlet works would have to be used in conjunction with these gates to achieve 6,000 ft^3/s.

  The construction of this option would require a sheetpile cofferdam constructed off barges to isolate the work area. The reservoir would be able to continue the normal operations with flood flows passing over approximately one half of the morning glory spillway crest, while work continued uninterrupted on the other half of the spillway crest. The excavation of the new opening in the spillway will involve cutting a square opening into the elliptical face of the spillway. The work in the spillway wall will be structurally exacting, and additional support for the spillway will be required around the opening to accommodate the opening and loads.

- Critical Items to Consider: This proposal has a moderate degree of flexibility in varying the size of the opening for both larger and small design discharges. No limiting maximum discharge was identified due to the need for structural studies and hydraulic modeling. The initial cost is not expected to change significantly with different discharges, unless the design discharge changes by more than an estimated 1,500 ft^3/s. Modification to design flows after construction would be very expensive. The confidence of this proposal operating as described is high.

Proposal No. 1

Advantages	Disadvantages
• Maintain reservoir elevations and operations during construction. • Preserves the current hydraulic behavior of the dam and reservoir during floods with only minimal impacts. • Power will only be required during annual testing of the gates or during operation. • Increasing the design flows above 5,000 ft^3/s may be possible by enlarging the size of the opening in the spillway wall.	• Modifying the spillway will be a structurally difficult design and construction will be exacting. • There is an upper limit to what flows can be passed using this modification. Structural and hydraulic studies would be required to verify flow levels. • Exploration would probably be required around the morning glory for installation of the sheetpile cofferdam and construction of the concrete conduit and gate structure foundations. • It will be very difficult to increase flows above the 5,000 ft^3/s after construction is complete will require significant cost and redesign.

Potential Risks

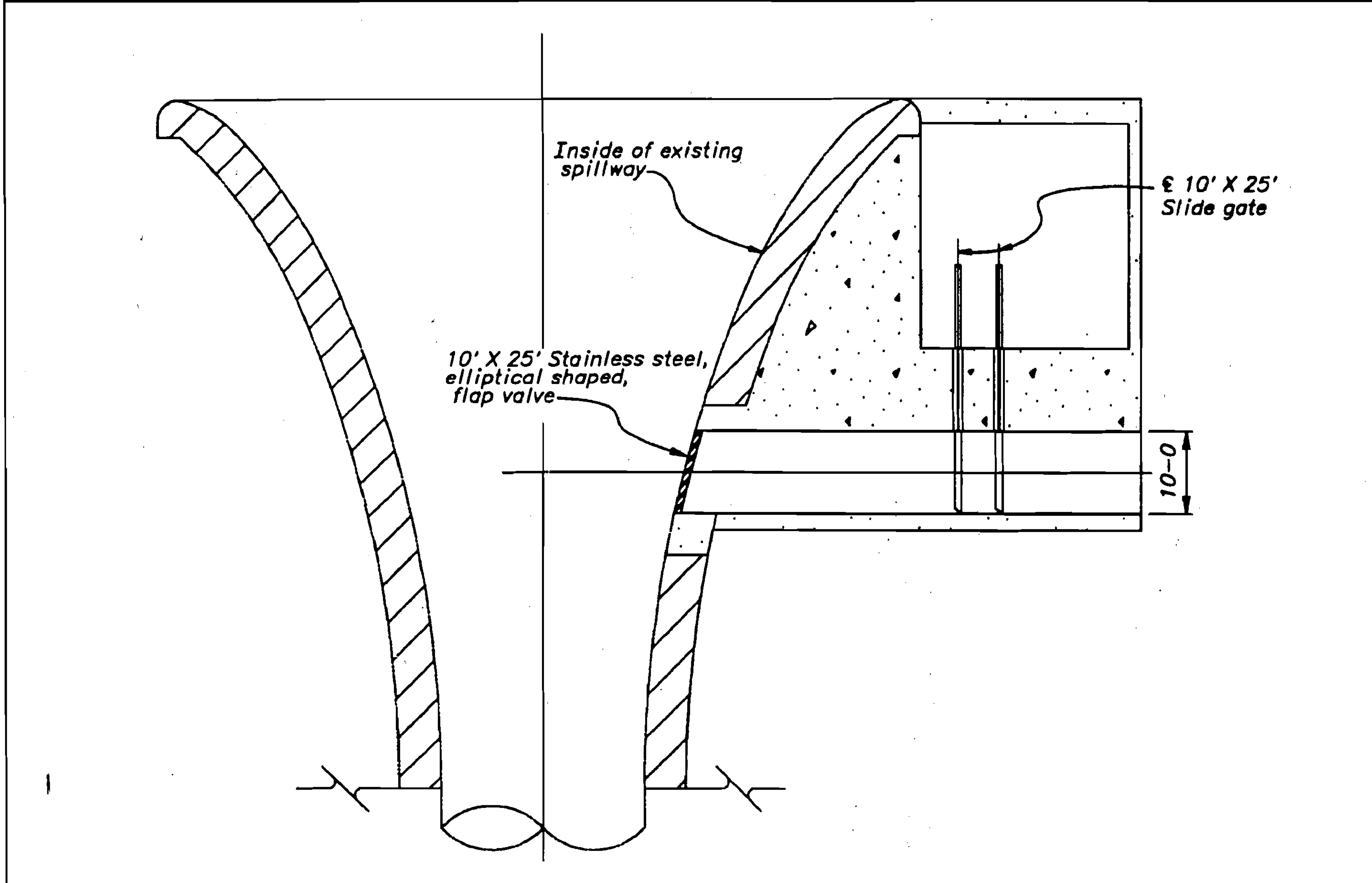
- There may be an upper limit to the size of opening that will be hydraulically and structurally acceptable. The size of opening may compromise the structural integrity of the spillway. This will have to be studied and determined during future design work.
- Hydraulic impact loading of the flow from the conduit against the far side of the spillway walls has not been addressed and may be excessive without additional modifications. If these loadings are too great, this may make the option infeasible.
- A model study will be necessary to verify acceptable hydraulic performance of modification and ogee crest after modification.

Cost Items	Life-Cycle Costs	
Value Concept Construction Cost	$	4,600,000
Value Concept Life-Cycle Cost*	$	2,250,000
Value Study Costs**	$	47,000
Implementation Costs	$	0
Total Cost of the Proposal	**$**	**6,897,000**

* See Life-Cycle Cost Estimate in Appendix

** Although the five member, 5-day study cost was $20,000, additional preparation and research, post-study coordination, and field presentation costs raised the total study cost to $47,000.

Figure 5. Proposal No. 1 - Section at Spillway Intake



Proposal No. 2

Description

Proposal No. 2. Add Gates at the Morning Glory Spillway.

- Proposal Description: This proposal involves adding two rectangular gates at the morning glory spillway. This is accomplished by cutting an opening on the side of the spillway and adding a conduit and two gates. (See Figure 6.) The use of bulkhead slots and a rented floating bulkhead would eliminate the need for one of the slide gates. This variation should be considered in future studies and incorporated to reduce costs.

  The work would require excavating an approach channel about elevation 1160, constructing a gate structure for a trashrack, a 25-foot by 10-foot guard gate and a 25-foot by 10-foot regulating slide gate. The gates are sized to provide a flow of 5,000 ft^3/s at reservoir water surface elevation 1201. This would supplement the outlet works flow (of 1,000 ft^3/s) for a total discharge past Whiskeytown Dam of 6,000 ft^3/s. There would be a concrete conduit from the gate structure to the spillway. It would enter the spillway on the side wall. A control platform at elevation 1222 would have to be built with a walkway to access the gates from the top of the dam.

  The construction of this option would require a sheetpile cofferdam constructed off barges to isolate the work area. The reservoir would be able to continue the normal operations with flood flows passing over approximately one half of the morning glory spillway crest, while work continued uninterrupted on the other half of the spillway crest. The excavation of the new opening in the spillway will involve cutting a square opening into the elliptical face of the spillway. The work in the spillway wall will be structurally exacting, and additional support for the spillway will be required around the opening to accommodate the opening and loads. This option, without a flap valve, involves additional concrete to provide a passage for water to enter from the side opening rather than a flap valve.

  This option is very similar to Proposal No. 1, without a flap, but with additional concrete and flow passage. This option was not priced specifically, since it was considered to be approximately the same or less than Proposal No. 1. Therefore, the price for this option are the same as for Proposal No. 1.

- Critical Items to Consider: This proposal has a small degree of flexibility in varying the size of the opening due to the potential interference between the opening without the flap valve and the flow over the crest. The cost will not change significantly with different discharges, unless the design discharge changes by more than 1,500 ft^3/s. No upper limit of flow could be identified in this study (see Potential Risk). The confidence of this proposal operating as described is moderately-high.

Proposal No. 2

Advantages	Disadvantages
• Maintain reservoir elevations and operations during construction. • Power will only be required during annual testing of the gates or during operation. • Increasing the design flows above 5,000 ft^3/s may be possible by enlarging the size of the opening in the spillway wall. • Preserves the current hydraulic behavior of the dam and reservoir during floods with only minimal impacts, assuming no interference in flows due to opening in morning glory spillway.	• Modifying the spillway will be a structurally difficult design and construction will be exacting. • Exploration would probably be required around the morning glory for installation of the sheetpile cofferdam and construction of the concrete conduit and gate structure foundations. • Increasing flows above the 5,000 ft^3/s after construction is completed will require significant cost and redesign. • Hydraulic laboratory model study and structural analysis study of the morning glory spillway would be required to verify desired performance. • The structural analysis study of the morning glory spillway may indicate that this proposal may have much variability in design flow.

Potential Risks

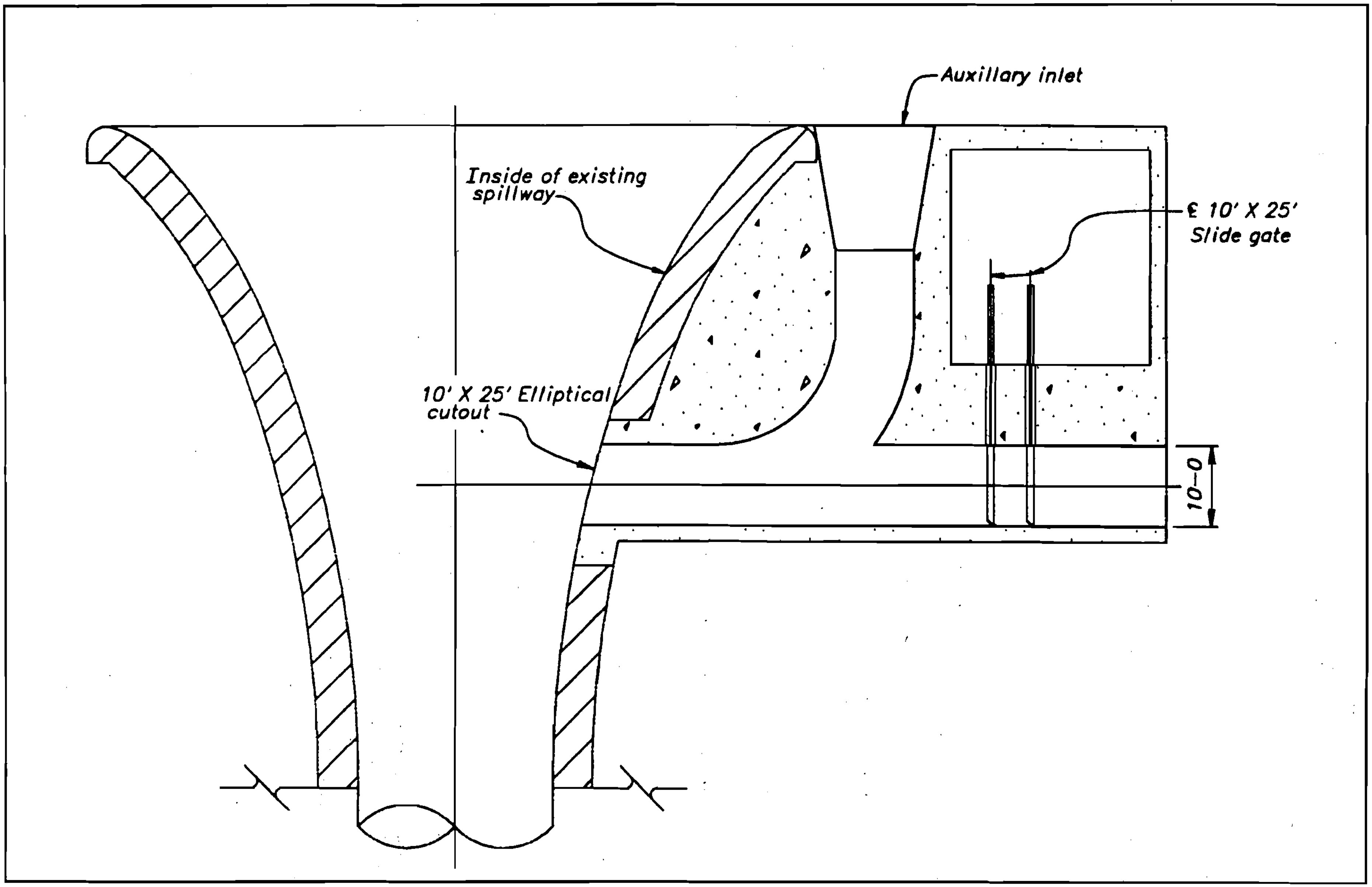
- There may be a size of opening that will compromise the structural integrity of the spillway. This will be determined during design.
- Hydraulic impact loading of the flow from the conduit against the far side of the spillway walls have not been addressed and may be excessive without additional modifications. If these loadings are too great, this may make the option infeasible.
- Hydraulic laboratory model study and structural analysis study of the morning glory spillway would be required to verify acceptable desired performance.

Cost Items	Life-Cycle Costs
Value Concept Construction Cost	$ 4,600,000
Value Concept Life-Cycle Cost *	$ 2,250,000
Value Study Costs **	$ 47,000
Implementation Costs	$ 0
Total Cost of the Proposal	$ **6,897,000**

* See Life-Cycle Cost Estimate in Appendix

** Although the five member, 5-day study cost was $20,000, additional preparation and research, post-study coordination, and field presentation costs raised the total study cost to $47,000.

Figure 6. Proposal No. 2 - Section at Spillway Intake



Proposal No. 3

Description

Proposal No. 3. Increase Clear Creek Cleansing Flows Based on Reservoir Operational Modifications.

- Proposal Description: The proposal for the rehabilitation of Clear Creek consists of conditioning and cleansing the spawning areas through operational modifications only. In this proposal the reservoir would be held at a constant elevation during periods of anticipated high runoff, maintaining the passage of water to Spring Creek Powerplant and Keswick Reservoir, and allowing the excess outflows (flood waters) to became 'natural', thus mimicking the natural state of Clear Creek before the dam was constructed. These natural flows would be supplied by that water coming off the Clear Creek drainage basin which should be adequate to develop and maintain spawning beds for the downstream fishery. This is similar to the way Whiskeytown has been operating since 1993 with spills in 1995, 1997, and 1998. (See Figures 7 and 8.)

  Historical streamflow daily values and the attendant hydrographs of Clear Creek from 1941 to 1963 (measured at Igo, California) show flows of 6,000 ft^3/s or greater have occurred 9 times out of a possible 22. After the dam was constructed (1963), downstream flows in excess of 6,000 ft^3/s have occurred only three times, due to reservoir operation. However, the historical streamflow daily values from the Clear Creek at French Gulch indicated that there continues to be sufficient flows (by doubling these to adjust for area) to have a flood of 6,000 ft^3/s on a regular basis at Whiskeytown Dam. (See Figures 9 and 10.)

  The PMF routing overtops the dam at 53 percent of the PMF, whether the routing begins with a reservoir pool at elevation 1210 or elevation 1198. This operation is considered acceptable in terms of a risk analysis which was performed for Whiskeytown Dam. There would be little change in the safety of Whiskeytown Dam in maintaining the reservoir at elevation 1210 until the desired discharge is accomplished based on flood routing results.

  The operation of the reservoir could remain similar to the present manner in May through November. In December, based on the predicted water year, the reservoir at Whiskeytown could be allowed to rise from elevation 1198 to some higher elevation (say elevation 1210). Then the storms that occur during December, January, February and March could spill rehabilitating the Clear Creek. If the desired runoff for both the Clear Creek and Trinity basins come in December, excess flows could be held in Trinity for use later in the year and the reservoir at Whiskeytown emptied to allow for any additional runoff from the Clear Creek basin to be stored.

  This proposal allows for the operation of Whiskeytown Dam to remain similar to current operation when no mid-range floods are planned. The mid-range floods are only expected to occur on a three to five year frequency. This proposal has the greatest flexibility in operation in flood flows and for determining which year is most desirable to capture the mid-range flood.

Proposal No. 3

The elevation of the higher winter pool at Whiskeytown could be adjusted to reflect the anticipated water year type (wet, normal, dry, etc.). Thus, the operation of Whiskeytown would be determined by initially determining if this is a year to achieve higher flood flows, and what the predicted water year is classified. The reservoir operation would have to be modeled to balance the anticipated drainage basin flows with needs of power and diversions from the Trinity Basin to the Sacramento Basin.

During years of low precipitation and low runoff releases up to 1,000 ft^3/s can be maintained through the existing outlet works to accommodate the fishery downstream.

Ideally, the larger flows should occur in April or May, so an alternate operational scenario would involve raising Whiskeytown Reservoir to elevation 1209 by April 1st, reducing flows to Spring Creek and allowing inflows from Trinity added to flows on the Clear Creek basin to create the desired design spill flows. By using this variation, operation of the system remains the same for May through February, filling of Whiskeytown occurs in March, and the spill event occurs in April based on runoff from the Clear Creek basin and inflows from Trinity.

- Critical Items to Consider: The proposal, as stated, could be considered unacceptable due to the uncertainty of the anticipated flows over the spillway at Whiskeytown Dam. This would have to be addressed by running various operational studies modifying the current reservoir operations at Whiskeytown from October through April. For example, the spill event doesn't occur every year. So in those wet years when a spill event is desired, raise the reservoir operational level from elevation 1198 to elevation 1203 for wet years, 1205 for normal years, and 1208 for dry years beginning in February. This would decrease some of the uncontrolled releases from Whiskeytown during the high runoff season. The risks could also be minimized by the confidence of the normal operation for those years when no mid-range flood was planned. This limits the uncertainty to an estimated one or two years out of five.

This proposal has the greatest degree of flexibility in varying the design discharge each year and being modified to meet a changing environment. There are high operational costs for this proposal, but these costs will not change with different discharges. The confidence of this proposal operating as described is moderate due to limitations in modeling techniques and prediction capability. This proposal has the potential to be used as an interim design to verify design flow through the use of full scale prototype testing prior to any large scale expenditures or structural modifications.

Advantages	Disadvantages
• No initial expense for construction or during the conditioning and cleansing of the Clear Creek downstream from Whiskeytown.	• Weather dependent. • Dependent on prediction methods, which are not exact.

Proposal No. 3

- Spring Creek Powerplant and Keswick Reservoir operations do not change except during the actual flooding periods. It might be that if flooding is occurring on the Clear Creek there might be higher than anticipated flows on the Sacramento at Keswick.
- Water does not have to be released every year, rather every 3 to 5 years to be timed with normal or wet year runoff.
- This is sufficient volume to provide the flows from the runoff of the Clear Creek Basin. (See Figure 11.)

- Undefined amount of loss of control of water depending on final design flow criteria, frequency, and prediction capability versus what actually is in creek.
- Loss of power revenue during period of flooding.
- If reservoir is lowered during a 'low precipitation year' the reservoir may not be suitable for spills down the Clear Creek until the following year (pool level needs to come back to elevation1210).
- There may be limited control if the predicted storm runoff from the Clear Creek produces a 6,000 ft^3/s flow but based on actual runoff a 10,000 ft^3/s flow occurs.

Potential Risks

- There is a loss of control of water in those years when a mid-range flood is planned (or approximately two out of five years), because this proposal depends to some degree on natural events, prediction capabilities, and the ability to rapidly adjust operations due to these changes. It is possible that more or less water will flow down the Clear Creek than was expected due to a larger or smaller storm than predicted. This translates to potential additional power loss from Spring Creek Powerplant if more water than predicted flows down the Clear Creek causing lost water for power production.
- There is a loss of control of the time water will be flowing through the spillway due to the uncontrolled ogee crest of the morning glory spillway. Flows join back into the Sacramento River at Redding, but there are potentially impacts to the Sacramento River below Keswick, if flows in the Sacramento River are low. This may require release of storage from Shasta during the spill with the loss of the use of that water later in the season.
- The ability to model and predict flows for the CVP is a highly developed and complex activity. This effort involves a large number of staff and impacts a great number of stakeholders. If sufficient confidence of the ability of these models to predict the flows is lacking, this option may not be acceptable to the various stakeholders.

Proposal No. 3

- This proposal would require additional time every year for modeling, prediction, and updating of the operations. The operation of the CVP is already a complex effort and this additional effort might require the need for additional permanent staff. These cost are not included in the estimate due to the high uncertainty. These costs will have to be evaluated in further efforts.

Cost Items	Life-Cycle Costs	
Value Concept Construction Cost	$	0
Value Concept Life-Cycle Cost *	$	2,250,000
Value Study Costs**	$	47,000
Implementation Costs	$	0
Total Cost of the Proposal	**$**	**2,297,000**

* See Life-Cycle Cost Estimate in Appendix

** Although the five member, 5-day study cost was $20,000, additional preparation and research, post-study coordination, and field presentation costs raised the total study cost to $47,000.

Figure 7. Proposal No. 3 - Whiskeytown Dam Reservoir Elevation

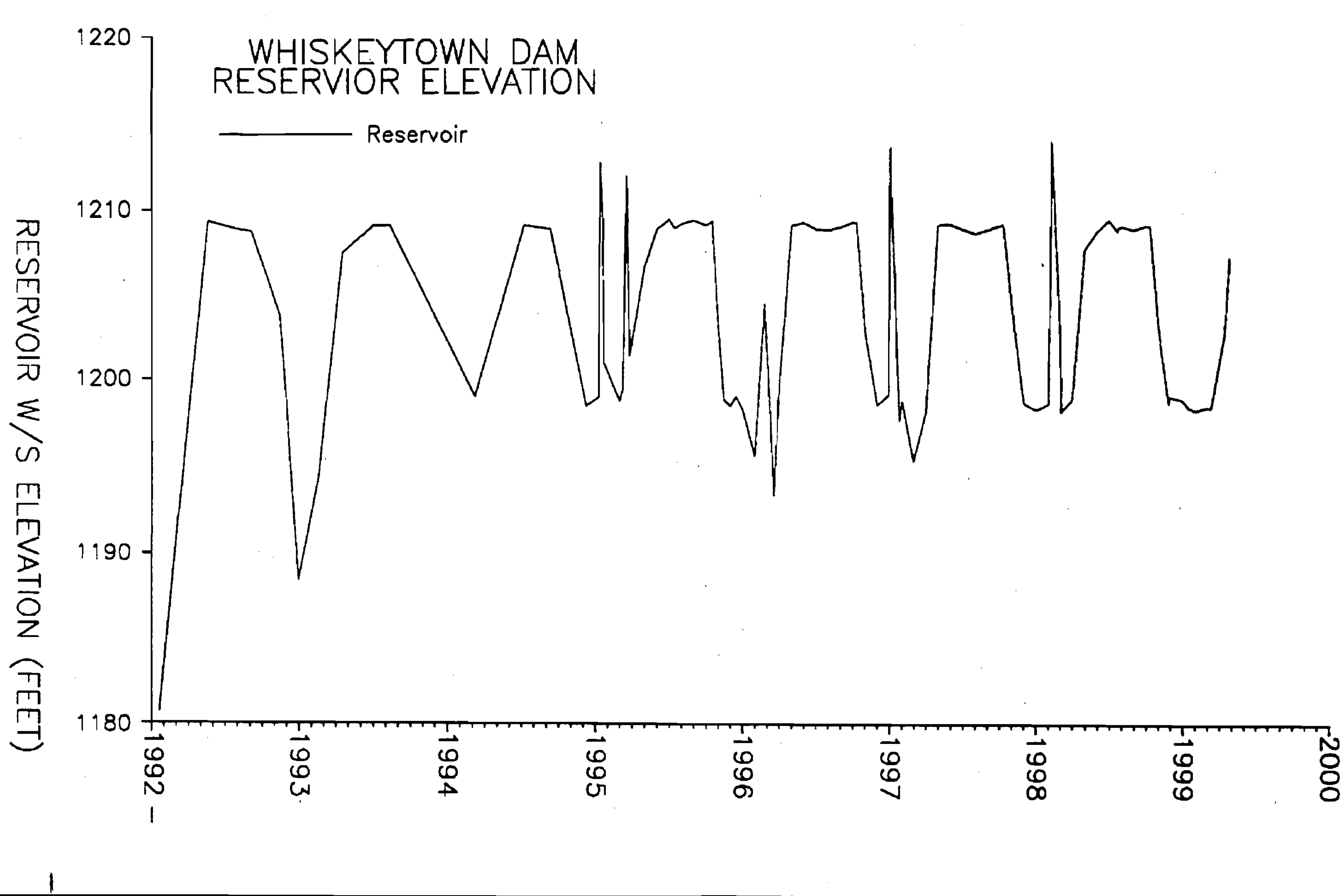


Figure 8. Proposal No. 3 - Daily Discharges

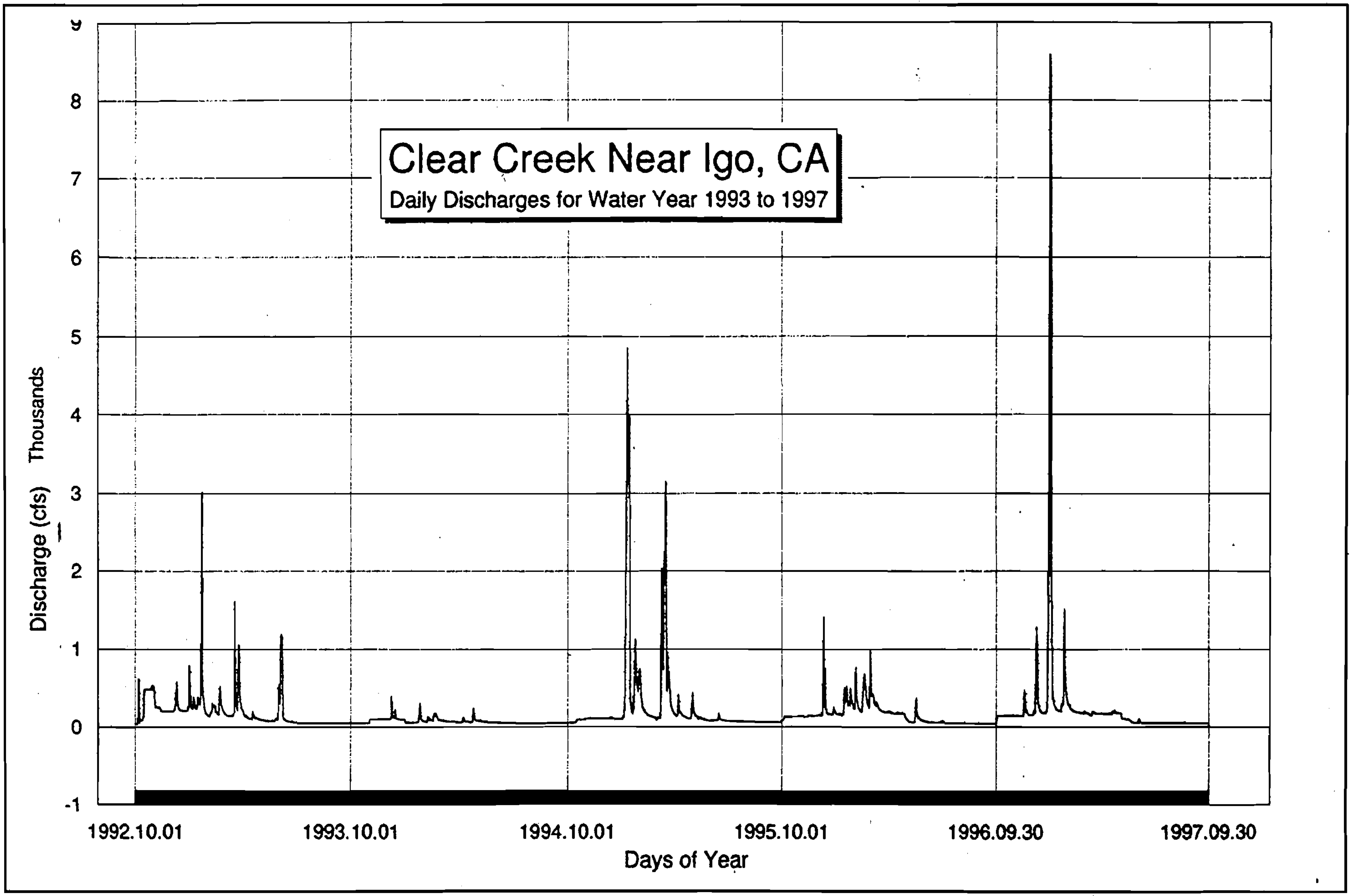


Figure 9. Proposal No. 3 - Historical Streamflow Near Igo, CA

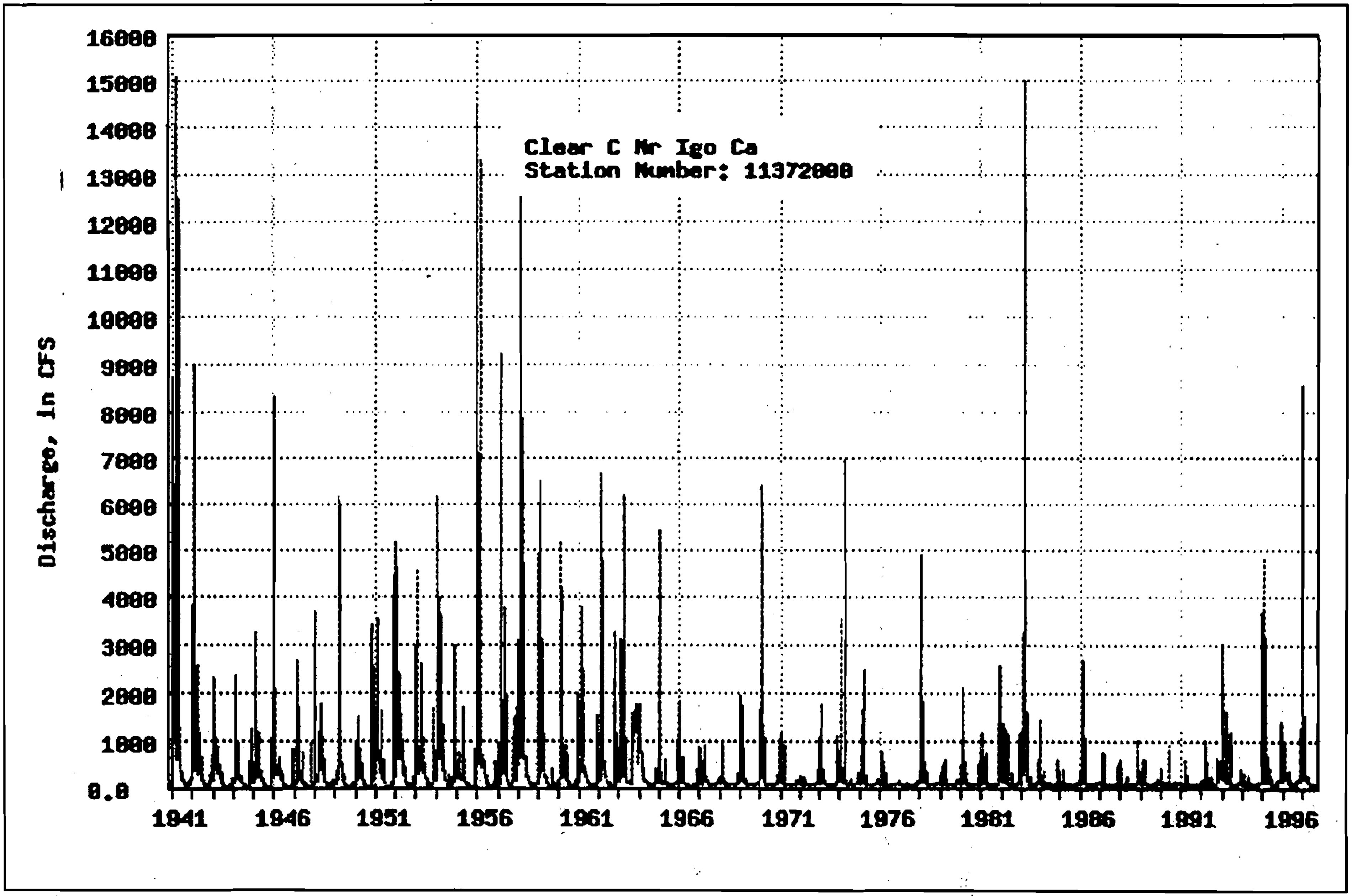


Figure 10. Proposal No. 3 - Historical Streamflow at French Gulch, CA

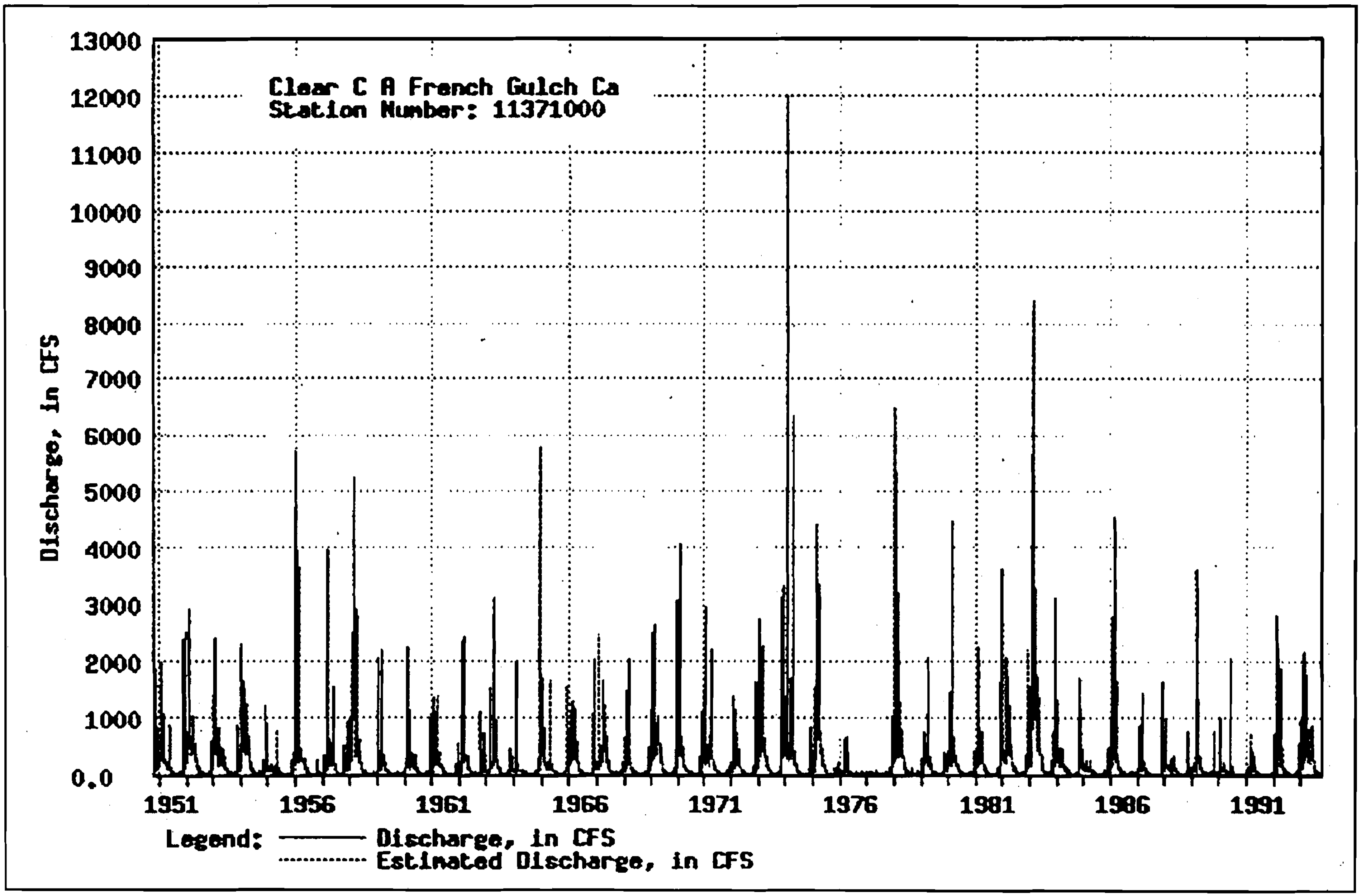
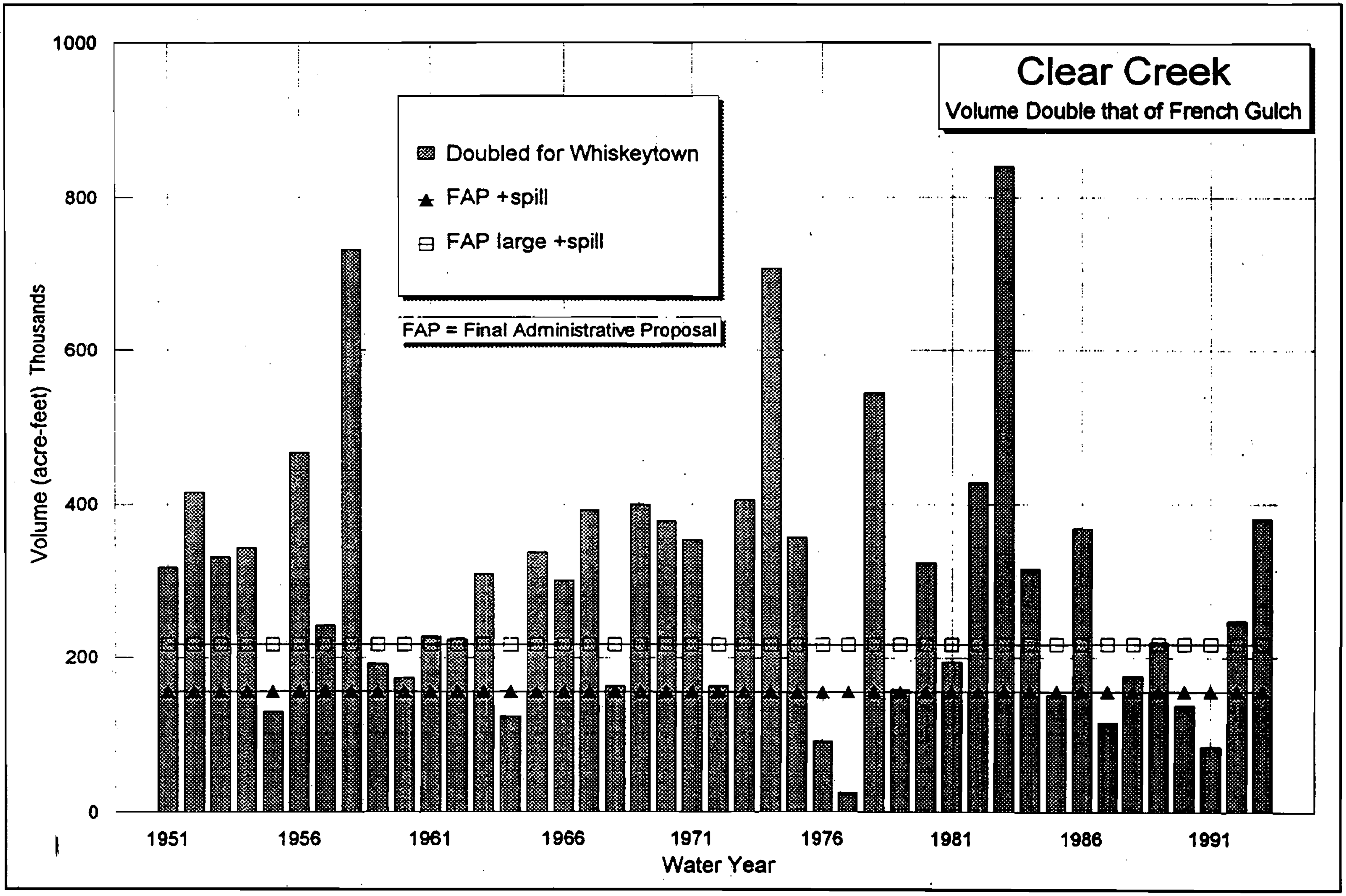


Figure 11. Proposal No. 3 - Scenario With Volume Doubled



Proposal No. 4

Description

Proposal No. 4. Modify the Outlet Works to Provide 6,000 ft^3/s.

- Proposal Description: This option involves passing the entire 6,000 ft^3/s through the outlet works. This requires enlarging the downstream portion of the outlet works beginning at the gate chamber and continuing to the downstream end of the outlet works.

  Flow would enter the existing 19-foot diameter upstream concrete conduit. At the gate chamber the flow would go through a 19-foot diameter butterfly guard valve, then into a 19-foot diameter steel pipe. The 19-foot diameter steel pipe was sized to carry the 6,000 ft^3/s. At the downstream end, the pipe would bifurcate into two steel pipes with regulating control provided by two 78-inch diameter clamshell gates. This option would provide 6,000 ft^3/s at elevation 1190 with a velocity of 90 ft/s at the clamshell gates.

  This option would take the outlet works out of operation during the period of construction. Construction would involve enlarging the downstream tunnel from the existing 19-foot diameter tunnel to a 30-foot horseshoe tunnel for maintenance reasons. The gate chamber would have to be enlarged to an estimated 45-foot wide by 40-foot high by 50-feet long to accommodate construction and maintenance of the valve and pipe. These enlarged sections would then have to be concrete lined with grouting and drainage as necessary. There are numerous shears and faults in the dam foundation which may cause this tunnel enlargement option to be very difficult. Enlargement, however, it was assumed possible since the tunnel was constructed and has been operating successfully.

  During construction the reservoir could be maintained at full pool, however, provisions would have to be made to provide the required Clear Creek releases, as well as releases into the outlets of the Redding Powerplant located near the downstream end of the outlet works.

  This alternative was investigated to provide the option of modifying the outlet works without excavating out the tunnel and rebuilding the outlet works. The team estimated that only up to the maximum flow rate of about 2,000 ft^3/s would be possible by modifying the piping and gates. The limitation of 2,000 ft^3/s was due to maintenance and access for new butterfly valve and new penstock. The existing guard gates, regulating gates and existing 45-inch steel pipes would be removed. The new outlet works would consist of a 10-foot diameter butterfly valve, 96-inch steel penstock, and one 78-inch diameter clamshell gate. The existing tunnel would not have to be modified for this option. This cost of this variation was estimated (see Life-Cycle Cost) but it was not determined that 2,000 ft^3/s would be an acceptable design flow and no other proposal considered 2,000 ft^3/s as the maximum flow.

Proposal No. 4

The advantages of the original proposal still apply. The disadvantages of the original proposal apply, except for the stilling basin issue. The potential risk of the original proposal, however, is almost totally eliminated in this modification by leaving the existing tunnel intact. However, the cost associated with a 2,000 ft^3/s design flow is substantially less than that for the 6,000 ft^3/s proposal with less concerns about foundation data.

- Critical Items to Consider:
This proposal has a small degree of flexibility in varying the size of the outlet works due to the structural modifications required to enlarge the tunnel to accommodate the design flows. The cost will change significantly with different discharges, unless the design discharge is less than 2,000 ft^3/s, which does not require modification to the tunnel. The confidence of this proposal operating as described is moderate due to uncertainty in foundation data.

Advantages	Disadvantages
• The reservoir can be maintained at normal operating levels during construction. • Transfer of water from the Trinity River to the Sacramento River will be uninterrupted. • Flood flows during construction would be diverted using the morning glory spillway with no significant impacts. • This option can be modified to provide for additional power production from the enlarged outlet works. This will ultimately reduce the cost of this proposal.	• Special provisions must be made to provide for 200 ft^3/s releases to the Clear Creek during construction. This may involve pumping or other methods. • Power production by the City of Redding Powerplant would be discontinued during construction. Provisions might be required to offset this loss. • Releases to Clear Creek Community Services District would also be interrupted and provisions to supply this might be required. • A stilling basin at the end of the outlet works to dissipate the high velocities and energy may be necessary, but was not included in this estimate.

Potential Risks

- There would be significant foundation exploration required for the enlargement of the tunnel and gate chamber. The ability of the rock formation to support this large gate chamber would have to be verified.

- The response of the embankment dam to the tunneling operations would have to be evaluated. The tunnel was originally constructed prior to the dam. The ability of the embankment to withstand disturbances from tunneling operations is currently unknown.

Proposal No. 4		
Cost Items	**Life-Cycle Costs**	
Value Concept Construction Cost	$	28,000,000
Value Concept Life-Cycle Cost*	$	2,247,000
Value Study Costs**	$	47,000
Implementation Costs	$	0
Total Cost of the Proposal	**$**	**30,294,000**

* See Life-Cycle Cost Estimate in Appendix.

** Although the five member, 5-day study cost was $20,000 additional preparation and research, post-study coordination, and field presentation costs raised the total study cost to $47,000.

Proposal No. 5

Description

Proposal No. 5. Increase Clear Creek Cleansing Flows with Additional Tunnel Outlet.

- Proposal Description: The rehabilitation of Clear Creek for fish habitat is assumed to be achieved by a 7-day flood of about 6,000 ft^3/s. Historically, the maximum discharge to Clear Creek was approximately 15,000 ft^3/s. The actual discharge of Whiskeytown Dam is about 1,000 ft^3/s through the existing outlet works. Therefore, to achieve the rehabilitation flows of 6,000 ft^3/s an additional discharge flow of about 5,000 ft^3/s is required. The addition of a 550-foot long and 18.5-foot diameter tunnel through the far right abutment would accomplish the additional discharge. (See Figure 12.) If pursued, power could be generated from this flow and although the initial costs will be higher, ultimately there would be some cost savings due to the power.

  Considerations and components influencing the cost of this proposal include: Rock type, jointing and local geologic structures; drill and blast construction or tunneling machines; reinforced concrete tunnel (about 560-foot long, 22-foot outside diameter); steel lining (18.5-foot inside diameter); reinforcement (rock bolting or steel sets); intake and outlet structures (30-foot x 30-foot x 20-foot = approximately 1,000 cubic yards); cofferdam (elevation 1150, 450 foot long, maximum 20-foot high = 27,000 cubic yards); gates (two - 18.5 foot butterfly valves); discharge chute (approximately 1,000 foot long, 20-foot high walls, 25-foot wide floor, 3-foot thick = approximately 195,000 cubic yards reinforced concrete); short construction season; and a reservoir restriction during construction (drawdown to elevation 1140).

- Ways to Implement: The implementation of this proposal starts with a reservoir elevation to be maintained at elevation 1140.0 during the construction of the tunnel.

- Critical Items to Consider: This proposal has a high degree of flexibility in varying the size of the additional tunnel outlet works. The cost will be high, but not change significantly with different discharges. The confidence of this proposal operating as described is moderate due to uncertainty in design data.

Advantages	Disadvantages
• Discharges can be regulated to achieve the required conditioning and cleansing flow. • The cleansing (scour) flow can be used whenever needed.	• Size of pipe needed to obtain required flows (at relative low head) • The cost of tunneling by boring may be high; blasting may not be possible. • Lowering reservoir and maintaining pool.

Proposal No. 5	
	• Short construction time during the dry period. • Severe scour may develop at the downstream end of the discharge chute

Potential Risks

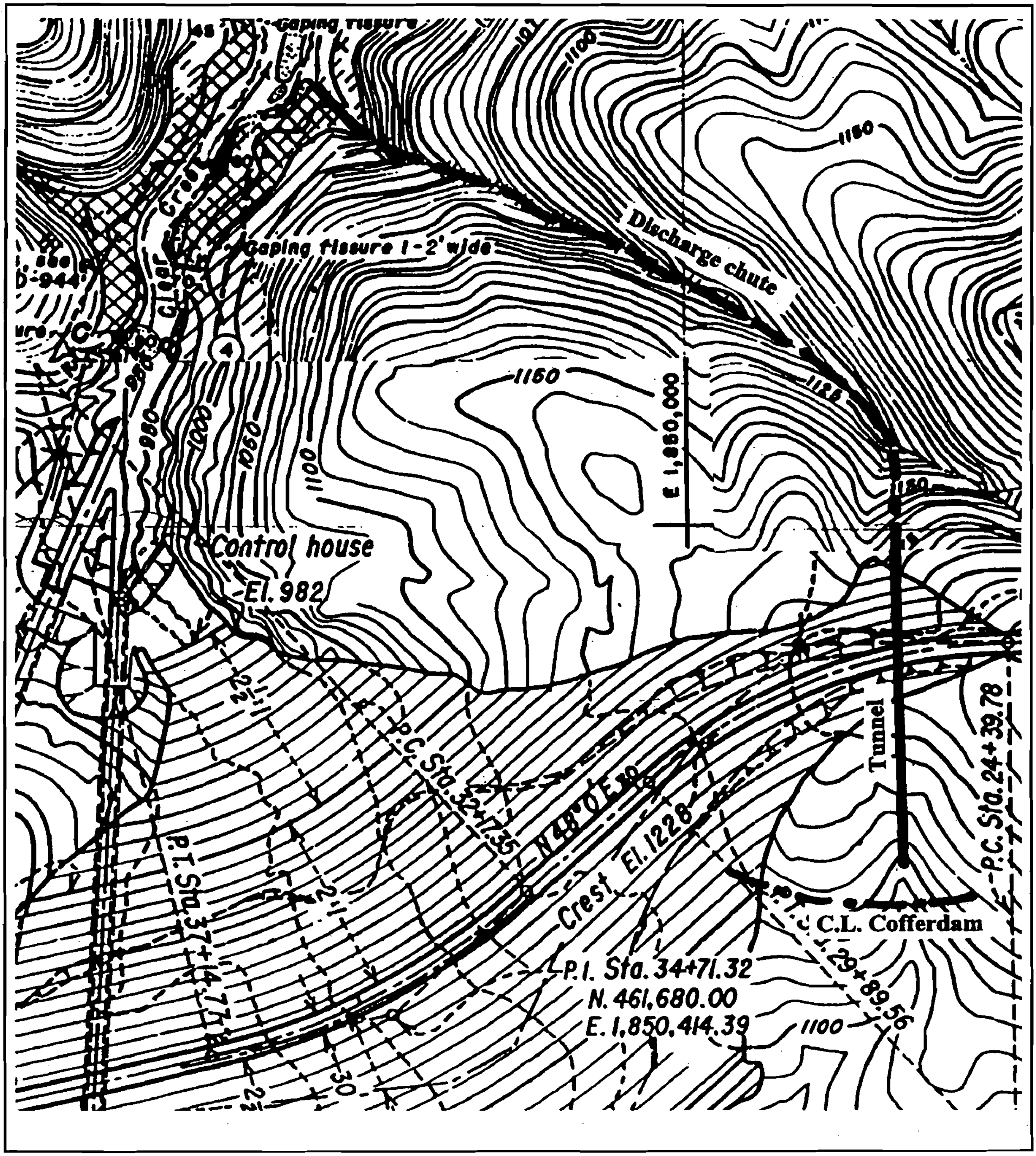
- Blasting may damage the existing structure.

Cost Items	Life-Cycle Costs
Value Concept Construction Cost	$ 53,000,000
Value Concept Life-Cycle Cost *	$ 2,247,000
Value Study Costs**	$ 47,000
Implementation Costs	$ 0
Total Cost of the Proposal	**$ 55,294,000**

* See Life-Cycle Cost Estimate in Appendix.

** Although the five member, 5-day study cost was $20,000, additional preparation and research, post-study coordination, and field presentation costs raised the total study cost to $47,000.

Figure 12. Proposal No. 5 Plan



Value Study – Life-Cycle Cost Analysis

USING PRESENT WORTH (PW) COSTS

Date: 10/20/99

PROJECT: Whiskeytown Dam

COMPONENT: Facility Overall

Discount Rate: 5.5%

Economic Life: 20

			ORIGINAL CONCEPT		ALTERNATIVE 1		ALTERNATIVE 4A		ALTERNATIVE 4B	
			Estimated Costs	Present Worth	Estimated Costs	Present Worth	Estimated Costs	Present Worth	Estimated Costs	Present Worth
INITIAL/COLLATERAL COSTS										
A. Existing Facilities & Current Operations										
B. Proposal Number 1					$4,600,000	$4,600,000				
C. Proposal Number 2										
D. Proposal Number 3										
E. Proposal Number 4 (Pass 2,000 ft^3/s)							$3,400,000	$3,400,000		
F. Proposal Number 4 (Pass 6,000 ft^3/s)									$28,000,000	$28,000,000
G. Proposal Number 5										
Total Initial/Collateral Costs						$4,600,000		$3,400,000		$28,000,000
REPLACEMENT/SALVAGE	Year	PW Factor								
(Single Expenditures)										
A. Scour Flow Release (84,000 acre feet)	4.0	0.8072			$816,480	$659,076	$816,480	$659,076	$816,480	$659,076
B. Scour Flow Release (84,000 acre feet)	8.0	0.6516			$816,480	$532,017	$816,480	$532,017	$816,480	$532,017
C. Scour Flow Release (84,000 acre feet)	12.0	0.5260			$816,480	$429,453	$816,480	$429,453	$816,480	$429,453
D. Scour Flow Release (84,000 acre feet)	16.0	0.4246			$816,480	$346,662	$816,480	$346,662	$816,480	$346,662
E. Scour Flow Release (84,000 acre feet)	20.0	0.3427			$816,480	$279,831	$816,480	$279,831	$816,480	$279,831
F.										
G.										
H.										
Total Replacement/Salvage Costs						$2,247,039		$2,247,039		$2,247,039
ANNUAL COSTS	Escal. Rate	PWA Facto w/Escal.								
A. *Maintenance*		11.950								
B. *Operations*		11.950								
C.										
D.										
E.										
F.										
Total Annual Costs										
TOTAL PRESENT WORTH COSTS						$6,847,039		$5,647,039		$30,247,039
LIFE-CYCLE (PW) SAVINGS						($6,847,039)		($5,647,039)		($30,247,039)

Value Study – Life-Cycle Cost Analysis
USING PRESENT WORTH (PW) COSTS

Date: 10/20/99

PROJECT: Whiskeytown Dam
COMPONENT: Facility Overall
Discount Rate: 5.5%
Economic Life: 20

			ORIGINAL CONCEPT		ALTERNATIVE 2		ALTERNATIVE 3		ALTERNATIVE 5	
			Estimated Costs	Present Worth	Estimated Costs	Present Worth	Estimated Costs	Present Worth	Estimated Costs	Present Worth
INITIAL/COLLATERAL COSTS										
A. Existing Facilities & Current Operations										
B. Proposal Number 1										
C. Proposal Number 2					$4,600,000	$4,600,000				
D. Proposal Number 3										
E. Proposal Number 4 (Pass 2,000 ft^3/s)										
F. Proposal Number 4 (Pass 6,000 ft^3/s)									$53,000,000	$53,000,000
G. Proposal Number 5										
Total Initial/Collateral Costs						$4,600,000				$53,000,000
REPLACEMENT/SALVAGE	Year	PW Factor								
(Single Expenditures)										
A. Scour Flow Release (84,000 acre feet)	4.0	0.8072			$816,480	$659,076	$816,480	$659,076	$816,480	$659,076
B. Scour Flow Release (84,000 acre feet)	8.0	0.6516			$816,480	$532,017	$816,480	$532,017	$816,480	$532,017
C. Scour Flow Release (84,000 acre feet)	12.0	0.5260			$816,480	$429,453	$816,480	$429,453	$816,480	$429,453
D. Scour Flow Release (84,000 acre feet)	16.0	0.4246			$816,480	$346,662	$816,480	$346,662	$816,480	$346,662
E. Scour Flow Release (84,000 acre feet)	20.0	0.3427			$816,480	$279,831	$816,480	$279,831	$816,480	$279,831
F.										
G.										
H.										
Total Replacement/Salvage Costs						$2,247,039		$2,247,039		$2,247,039
ANNUAL COSTS	Escal. Rate	PWA Facto w/Escal.								
A. *Maintenance*		11.950								
B. *Operations*		11.950								
C.										
D.										
E.										
F.										
Total Annual Costs										
TOTAL PRESENT WORTH COSTS						$6,847,039		$2,247,039		$55,247,039
LIFE-CYCLE (PW) SAVINGS						($6,847,039)		($2,247,039)		($55,247,039)

Disposition of Ideas

Value Study Elements Considered as Potential Proposals and Their Disposition	
Idea	**Disposition**
Maintain Whiskeytown Lake at elevation 1210 so natural Clear Creek flows will pass through the spillway to scour the channel. This would eliminate the winter drawdown.	Incorporated in Proposal No. 3.
Use water from Lewiston (via Clear Creek Tunnel) as required, up to 3,200 ft^3/s, to supplement water stored in Whiskeytown Lake or coming down Clear Creek to create the downstream scour release into Clear Creek.	Incorporated in all proposal concepts as a supplemental part of the solution.
Create a controllable spillway crest to be able to release a controlled scour flow.	Incorporated in Proposals No. 1 and 2.
Construct a 32-inch diameter "micro-tunnel" to supplement the outlet works release capacity.	Eliminated from consideration because 32 inches is far too small to provide a significant increase in the release flow capacity.
Modify the spillway to store additional water, up to elevation 1213, for release to scour the Clear Creek channel.	Incorporated in Proposal No. 1.
Add a gate to the spillway tunnel to release scour flows as needed without impacting the operation of the spillway.	Incorporated in Proposal No. 1.
Construct a lake tap.	Considered in Proposal No. 5.
Extend the boat ramps and ensure facilities are above high water (elevation 1221) to increase the acceptable range of the lake's water surface elevation.	Another idea that could be applied where variations in lake surface would be needed during the recreation season (May to October).
Optimize the design of the Clear Creek channel so that smaller (less than 6,000 ft^3/s) flows will effectively scour the vegetation and fines from the beds.	Submitted as another idea.
Replace the outlet works pipes with larger pipes.	Considered in Proposal No. 4.
Combine the outlet works pipes into a single large pipe.	Considered in Proposal No. 4

Disposition of Ideas	
When considering modifications to the outlet works and gate chamber, maintain access for maintenance and the ability to remove and replace all elements.	Considered in Proposal No. 4.
Pipe jack a new outlet pipe.	Eliminated as a dam safety issue - it would create a potential conduit for piping.
Time the scour release to take advantage of any water that may be available and at a time that would not impact either recreation or fish spawning. Note that threshold flows on Clear Creek would need to be defined to make this a viable operational scheme.	Considered in Proposal No. 3.
Shutdown the Spring Creek Tunnel and Powerplant during the period of the scour release to get the maximum scour flow.	Incorporated in all proposal concepts as a supplemental part of the solution.
Pump water from Keswick to Whiskeytown (off-peak) to be used for scour flow.	Eliminated as too expensive.
Lower the spillway crest for scour release and restore the crest elevation for normal operation.	Considered in Proposals No. 1 and 2.
Try to limit construction to one year during August to October which is typically the lowest period of flow in Clear Creek.	Submitted as another idea to be used in Proposals Nos. 1, 2, and 5
Use large pumps (5,000 ft^3/s) from Whiskeytown Lake into the channel below the dam to supply the scour flows.	Eliminated as too expensive.
To control the water temperature of the release, increase the size of the outlet pipe and add a controllable gate at the spillway.	Submitted as another idea if the water temperature of the release is an issue.
Enlarge the outlet works gate chamber to install a larger gate and larger outlet pipe.	Considered in Proposal No. 4.
Create an inflatable rubber dike at the spillway.	Considered in Proposal No. 2

Disposition of Ideas

Build another dam on Clear Creek and/or its tributaries upstream of Whiskeytown Dam to capture a supply of water for use as a source of scour flow (about 40,000 acre-feet) with the ability to release flows of 2,800 ft^3/s.	Assuming that Whiskeytown Dam was built at the best site for water retention, its area-capacity curve was used to determine how high a dam would have to be to retain 40,000 acre-feet of water. Based on that curve, it appeared that a new upstream dam would have to be 150-foot high to store about 40,000 acre feet. The curve also showed that a 50-foot dam would store only 1,000 acre feet. Therefore, it does not appear that additional small dams upstream of the reservoir could provide the required storage at reasonable cost. Similarly, raising Whiskeytown Dam by 9 feet would be prohibitively expensive.

List of Consultants

Consultant or Contact	Topic or Information
Mary Johannis Mid-Pacific Regional Office (MP-400) (916) 978-5202	Information on the cost of power. Referred to Internet Site of the California Energy Commission, Alternative Value of Power, Projection of Market Clearinghouse. (Use the WAPA rate.) See the prices used on the "Battle Creek" analysis.
Bess Briley Mid-Pacific Regional Office (MP-400) (916) 978-5200 Kelly Kennedy Mid-Pacific Regional Office (MP-400) (916) 978-5209	Value of water - may not need to replace the water since it ends in the Sacramento River. Water released through Clear Creek may be able to replace water that would normally be released from Shasta Dam.
Craig Grace Mid-Pacific Region Central Valley Operations (916) 979-3005	Efficiency of Spring Creek and Keswick Powerplants, operation of Whiskeytown Dam, value of power, how to compute the value of water going through Spring Creek and Keswick Powerplants.
Jeff Sandberg Mid-Pacific Region Central Valley Operations (916) 979-2185	General water operations for Central Valley Project and requirements of flows below Keswick.
Scot McBain McBain and Trush	Discussion of the target flows down Clear Creek.

List of Consultants

Dave Pugh, Superintendent, National Park Service, Whiskeytown Unit, NRA	Park Facilities around reservoir and impacts of fluctuating water surface

Data and Documents Consulted

Title, Author, and Date	Information
Trinity River Division Features of the Central Valley Project, Technical Record of Design and Construction, USBR, Vol I and Vol II, Denver, Colorado 1965	Project description and authorized purpose.
Standing Operating Procedures for Clair A. Hill Whiskeytown Dam, Central Valley Project, CA, Sept 1991	Area Capacity Table.
USBR Dataweb site	Description of project.
USBR Mid-Pacific Region Web site, Central Valley Operations Office	Information on past operation and projected operation.
Title XXXIV - Central Valley Project Improvement Act, Public Law 102-575, October 30, 1992	Goals and background.
US Dept of the Interior, Final Administrative Proposal on the Management of Section 3406(b)(2) Water, November 20, 1997	Potential constraints.
Trinity River Flow Evaluation, Final Report, Chapter 8, Recommendations for Restoring the Fishery Resources of the Mainstem Trinity River	Flows for improving Trinity River for comparison with Clear Creek. Potential objectives of various flow regimes.
USGS Web site for Historical Streamflow Daily Values and Peak Flow Data	Daily and Peak streamflow gage data.

APPENDIX

Rejected Proposals

Description

- <u>Proposal Description</u>: This option involves removing the top of the morning glory spillway and rebuilding it to include a cylinder or ring gate. This option would be similar to the cylinder gated intake towers at Hoover Dam. After further investigation, this option was dropped from serious considerations in favor of the Proposal No. 1. The factors against this option included anticipated costs, construction concerns, and operational considerations.

  The cost of a cylinder gate, (280 feet circumference and 13 feet tall) will be very high. In addition, this gate would require either a super-structure or base in which to retract the gate from its normal position. It was estimated that the cost of the gate, when compared to the 25-foot by 10-foot slide gate used in Proposal No. 1, would make this option prohibitively expensive. The construction of this option is very difficult from the aspect of addressing diversion flood flows. During construction, the reservoir would have to be emptied (which impacts diversions from the Trinity River to the Sacramento River); otherwise, the construction site would be vulnerable to flooding since the outlet works capacity is limited to approximately 1,000 ft^3/s. Finally, the operation and maintenance of a cylinder gate would be very costly in terms of yearly maintenance, and the power required to operate the gate would be significant. <u>Therefore, this option was not considered further in favor of Proposal No. 1.</u>

- <u>Proposal Description</u>: Another proposal considered but dropped, involved adding flap gates with a rubber bladder or a rubber dam to the top of the morning glory spillway.

  This option was considered to be technically difficult as well as very expensive when compared to Proposal No. 1. The design involves the structural design of flap gates 13 feet tall and 280 feet long in a circular configuration. This design is anticipated to be difficult. The hydraulic design of these gates and support structure, in order to make them as efficient as the morning glory spillway, was also considered to be technically difficult. The top of the morning glory spillway would have to be excavated to allow for the installation of this option. The support structure for the flap gates or rubber dam would be extensive.

  These gates would be inflated most of the time and the power requirements for this would be significant.

  The protection of the work area during construction would be very difficult. The work area would be at risk during floods because there is no feasible method to accommodate them except for emptying the reservoir and storing the volumes. This may not be feasible during wet years so the work area would be damaged with the potential for additional damage in the spillway tunnel. The transfer of water from the Trinity River to the Sacramento River may not be possible during the construction.

Life-Cycle Cost Estimate

Examination of the 1999 Projected Central Valley Operations Office records shows that the volume of inflow into Whiskeytown Lake through the Clear Creek Tunnel and Judge Francis Carr Powerplant was 24,000 + 57,900 + 81,000 acre-feet = 162,900 acre-feet in January, February and March respectively. Of this, 36,900 acre-feet was released down Clear Creek and the remainder (126,000 acre-feet) was routed to the Sacramento River via Keswick Reservoir and the Spring Creek Tunnel and Powerplant. Once the flow passed the Spring Creek Powerplant, the water flows into Keswick Reservoir. There is a powerplant at Keswick which can produce 150,000 kW up to a maximum flow of 15,000 ft^3/s, and any excess flow is spilled. With the inflow from Shasta Dam during this same January through March time period, the volume of the spill at Keswick is 386,000 + 387,000 acre-feet = 773,000 acre-feet or more than the natural inflow in Clear Creek.

The diversion of a scour flow from Whiskeytown Dam down the Clear Creek is estimated to involve 84,000 acre-feet of water. This volume of flow could be withheld in Shasta Lake rather than releasing it to Keswick where it was released through the outlet works, as is projected now. Since there is surplus flow above power production at Keswick and above the FAP flows for the Sacramento River below Keswick during this time, <u>the diverted water is assumed to have no value as either power or irrigation water other than the value of power generated at the Spring Creek Powerplant.</u> The 1999 projected operation may be for a wet year, but since the flows down the Clear Creek do not have to happen every year, it was assumed the flows could be timed for a normal or wet year and similar in nature to 1999.

The power generated at Spring Creek Powerplant with 84,000 acre-feet of water is estimated as 45,360 MegaWatt-Hour (MWH) at an efficiency of 0.54 MWH/acre-foot of water. The value of power over the 20-year life of this project (1999 -2008) ranges from $18.00/MWH in 1999 to $28.00 in 2008. The project would intend to release scouring flows of 6,000 ft^3/s for 7 days (84,000 acre-feet of water) every three to five years, or five times over the life of the project. Accordingly, the following calculations provide the estimated current value of lost power caused by the project:

Year	Current Cost of Power	Power Lost	Current Value of Power Lost
4	$18.00/MWH	45,360 MWH	$816,480
8	$18.00/MWH	45,360 MWH	$816,480
12	$18.00/MWH	45,360 MWH	$816,480
16	$18.00/MWH	45,360 MWH	$816,480
20	$18.00/MWH	45,360 MWH	$816,480

7-1654 (11-94)
Bureau of Reclamation

COMPUTATION SHEET

BY BC	DATE	PROJECT	SHEET ____ OF ____
CHKD BY	DATE	FEATURE	
DETAILS			

10/21

Jim –

The computer system is not working today at all – so you get to see my handwriting.

I thought you'd like to see a copy of the full report, prior to my sending it officially.

As I think I indicated, I propose to send this out, we can finalize it as is & address comments in an accountability report.

Bxxxy

From: Bitsy Cohen
To: James DeStaso
Date: Tue, Jan 11, 2000 3:12 PM
Subject: Whiskeytown VE Report

Hi Jim,

I wanted to follow up our phone conversation (of a while ago) with some additional comments and discussion about the VE report. I've tried to frame the discussions in an informal way, like the way I would explain in person. This is a little different so I hope it helps.

First to explain the changes in the Executive summary and why we dropped some of the discussion about alternative 4. Alternative 4 is the enlargement of the existing outlet works to accommodate the flows. I will label alt 4A as the option for a flow of 6000 cfs and alt 4B as an option for a flow of 2000 cfs. We dropped the discussion of alt 4B and the cost to modify the outlet works for only 2000 cfs from the executive summary in the final report. That's because it really isn't looking at the same level of modification as the other alternatives discussed in the executive summary. Putting alt 4B there is like comparing an orange to other apples. The pertinent information is still very important in the overall discussion and especially to document how much flow we could get through the outlet works by incorporating relatively minor modifications rather than enlarging the tunnel. So, alt 4B was retained in the final report. It is at the end of the report under rejected proposals but not in the executive summary. We had to reject it since the proposal was not consistent with the other proposals (see page 46 at the end of the report). There it is explained that it did not meet the criteria for 6000 cfs. No other proposal considered 2000 cfs so exactly, and so this discussion didn't belong in the executive summary. Which isn't to say that some of the proposals couldn't be modified to reflect a 2000 cfs flow if we wanted to use that as our flow criteria, but we didn't price them.

As regards our thinking for the Alternative 3 (re-operation). This alternative needs additional work in a feasibility study framework. The value planning study wasn't expected to go into all the details of how things will work. In general what was projected for this alternative was that the reservoir would be held at the spillway crest in anticipation of a large storm. The storm would come and precipitate the "natural" higher flows down Clear Creek. This makes it an operational change rather than a structural modification. The potential items that have to be resolved include (but certainly are not limited to): if anticipation of storms can be made with reasonable certainty (which is based on the weather forecasts), and if the shareholders are comfortable with not being able to control the exact discharge (big volume storm versus little volume storm).. In the feasibility we would need to look at the additional modeling requirements and labor involved in this alternative. The scheduling of the flow would also have to be addressed. By that I mean, do you hold the reservoir high in the fall and take the first storm of the year? Do you draw the reservoir down in the fall, and refill the reservoir (hopefully from Trinity reservoir reserves) early to take advantage of a March or April storm? These types of scenarios need to consider the power community's needs, the water user's needs, how the water and power availability has shifted, Reclamation's need, and I'm sure there are many other interests who would also be affected by this alternative.

A suggestion I would make is that we need to start keeping a list of all these questions and make sure we address them in the feasibility study, if we proceed with this study. By no means do I want to suggest that a feasibility study of this alternative or any of the alternatives are a must. I would like to see a feasibility study come out of these work but that is a decision that is yet to be made.

I hope this helps you with understanding the report a little more. I had chosen not to go into these additional studies in the report because at that time we were trying to keep the discussion lengths down to reflect the degree of effort that went into the report. By that I mean we were looking at possible ways to augment flows but without a guarantee that they are economical, acceptable to all stake holders, or technically feasible. In a feasibility level effort, we would certainly want to expand on many of these issues and add to the text writeup of each alternative.