

*RINDGE DAM REMOVAL STUDY:
AN EFFORT TO REDUCE THE
DECLINE OF THE MALIBU CREEK
STEELHEAD TROUT POPULATION
IN SOUTHERN CALIFORNIA*

APPRAISAL REPORT

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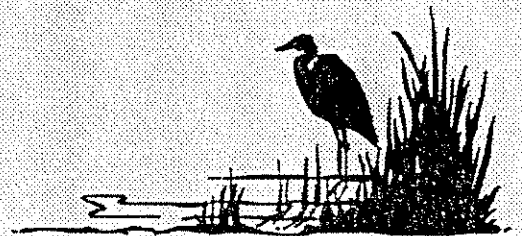


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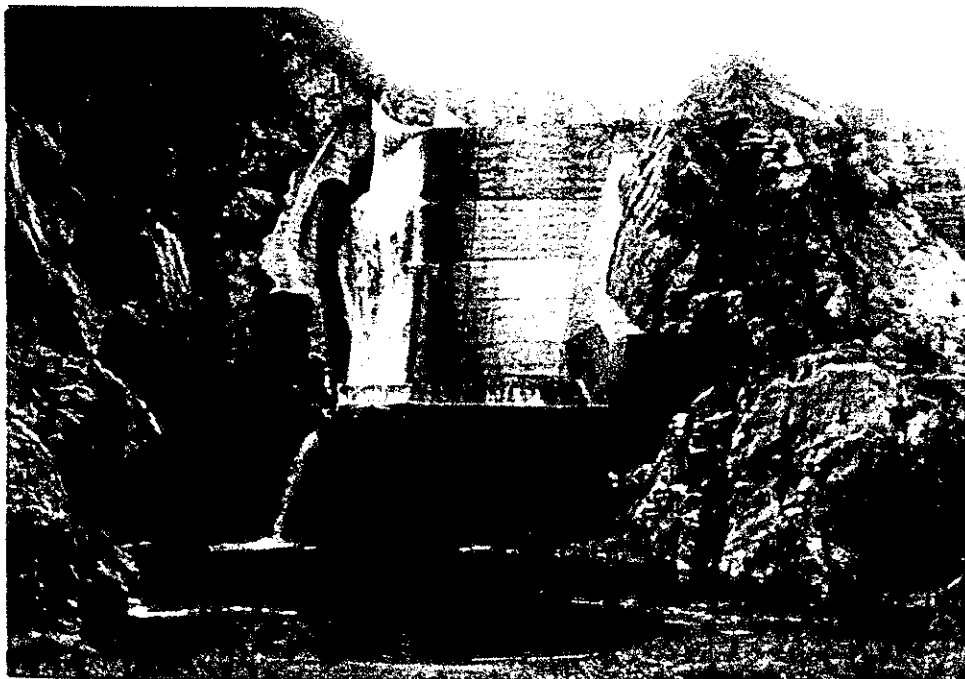
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CHAPTER 1

SUMMARY



CHAPTER 1: SUMMARY

LOCATION

Malibu Creek drains lands in portions of the Santa Monica Mountains, the Simi Hills, and the Conejo Valley. A number of different slope aspects of the Santa Monica Mountains are included. The watershed is located in Los Angeles and Ventura Counties, some 35 to 50 miles west of downtown Los Angeles. Flowing generally in a southerly direction, Malibu Creek runs through Malibu Creek State Park before emptying into the Pacific Ocean at the beach town of Malibu. The location map (Figure 1, Page 2) provides additional details.

The California Department of Parks and Recreation (Parks and Recreation) owns approximately 10,000 acres, or one-seventh of the watershed, making it the largest landowner. Malibu Lagoon is home to a number of environmentally sensitive animal species and is the subject of a number of ongoing habitat and water quality studies. Malibu Lagoon is one of only two significant coastal wetlands remaining in Los Angeles County.

DESCRIPTION OF AREA

The Santa Monica Mountains rise steeply to the northwest from their base at the ocean shoreline. Periods of intense precipitation and steep side slopes provide opportunity for rapid runoff during the rainy winter and spring seasons. Annual rainfall varies from 12 inches near the coast to 22 inches along the crest of the Santa Monica Mountains. Topography, surface cover, and rapid runoff are features conducive to significant soil erosion and sediment-laden streams.

Historically, flows in the lower reaches of Malibu Creek ceased during dry periods, but some tributaries maintained perennial flows. Discharge from an upstream wastewater treatment plant and irrigation with imported water now supplements the natural flows. Flows as high as 33,000 cubic feet per second have been recorded.

While rainfall can be heavy from October to May, summer and fall months are hot and dry. Temperatures are typical of the southern California coastal areas with mild winters and summer temperatures moderated by on-shore ocean breezes.

The availability of beach-front and ocean-view building sites have contributed to high property values. An affluent community has been built adjacent to Malibu Creek at the upstream edge of Malibu. Residents in this community have an interest in any impacts removal of Rindge Dam might have on the area.

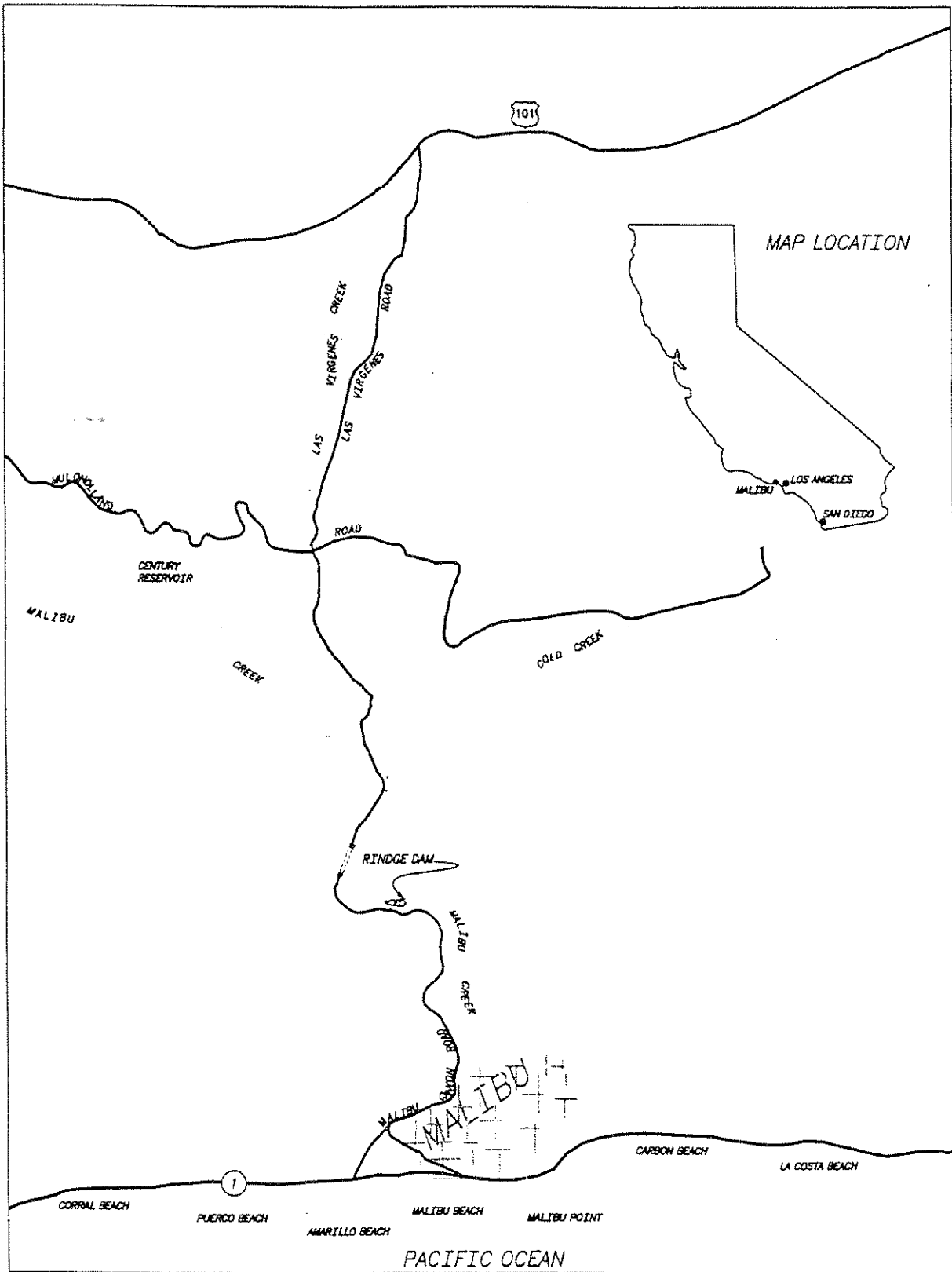
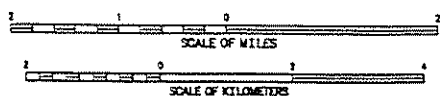


FIGURE 1: LOCATION MAP
 RINDGE DAM REMOVAL STUDY
 AN EFFORT TO REDUCE THE DECLINE OF
 THE MALIBU CREEK STEELHEAD TROUT POPULATION
 IN SOUTHERN CALIFORNIA



LEGEND
 U.S. ROUTE
 STATE ROUTE

DESCRIPTION OF RINDGE DAM

Constructed in a narrow canyon about 2½ miles upstream from the Pacific Ocean, Rindge Dam was built in 1926 to store water for agricultural irrigation on lands along the coast and at the mouth of Malibu Creek. Heavy silt loads in the Creek resulted in sediment deposition in the reservoir. By the mid-1950's, the reservoir was completely filled with sediment. The dam was declared non-jurisdictional by the State of California in 1967. The dam is a concrete arch structure 100 feet high with an arc length of 175 feet at its crest and 95 feet at its base. The thickness of the dam at its crest is 2 feet and 12 feet at its base. It is reinforced both vertically and horizontally with 60 pound per foot railroad rails. A gated spillway was built in a rock outcrop adjacent to the right dam abutment.

The Rindge family, who originally built the dam, sold the property the dam is located on to the State. However, the family still maintains an interest in the structure and its disposition. Although Rindge Dam is on the National Register of Historic Places, the Rindge family has also initiated efforts to designate the dam as historical by Los Angeles County.

The reservoir behind Rindge Dam was originally able to store up to 574 acre-feet of water. Today, the reservoir contains at least 800,000 cubic yards of sediment.

STUDY PURPOSE AND SCOPE

Southern steelhead trout are the most jeopardized of all of California's steelhead stocks. It is thought that Malibu Creek historically supported runs of up to 1,000 adults; presently, the Creek supports a self-sustaining population estimated between 20 and 50 adult southern steelhead. A study (Franklin and Dobush, 1989) has shown that the steelhead trout population could increase threefold if habitat upstream of Rindge Dam could be accessed.

Local fishery interests and the California Departments of Fish and Game (Fish and Game) and Parks and Recreation are among the entities that hope to achieve self-sustaining natural steelhead trout runs in Malibu Creek. In January 1994, Fish and Game requested assistance from the Bureau of Reclamation (Reclamation) to complete an appraisal-level technical evaluation of options for fishery restoration, particularly the removal of Rindge Dam and the sediment behind it. This report contains the results of that effort.

While several alternatives for restoring the fishery are available and some are mentioned in this report, removal of Rindge Dam and the sediment behind it was emphasized during the study. Reclamation only addressed technical alternatives for dam and sediment removal and costs of those alternatives. No attempt was made to evaluate biological resources, determine impacts upon them, or estimate costs for any mitigation measures that may be necessary.

ALTERNATIVES CONSIDERED

Three methods of dam and sediment removal were considered. One alternative consists of removing the dam and sediment from Malibu Canyon through mechanical means. Sediment and dam rubble would be hauled out of the canyon to an undetermined disposal site. Another alternative would involve moving the sediment downstream to an engineered landfill site along

the Creek. The third alternative would entail removing the dam in segments and allowing natural Creek flows to move sediment downstream. Each alternative is described in detail in the following chapters.

Other options for promoting the re-establishment of steelhead trout access to habitat upstream of the dam have been considered by other agencies. Fish ladders, lifts, and flumes; a V-notch in the top of the dam; hydraulic dredging (natural and artificial); and a V-section on one side of the dam were all considered, but were not pursued. These alternatives, along with the reasons for their elimination, are briefly addressed in this report.

During the course of this preliminary investigation it became apparent that there was a discrepancy on the amount of sediment deposited behind Rindge Dam. Reclamation originally calculated a quantity of about 1,600,000 cubic yards, while a State contractor estimated a quantity of 801,500 cubic yards. A description of Reclamation's computation methodology and a comparison with the contractor's numbers are included in the Appendices.

Although the volume of sediment is critical to determining an accurate cost estimate, existing data are inadequate to provide a specific quantity with appropriate confidence. Given this dilemma, one of several approaches could be taken. The high number could be used to provide an upper limit to estimated project costs; a number in the middle of the range could be used as a reasonable average; or the low number could be used because actual on-site drilling has supported calculations that led to that estimate.

At the request of Fish and Game, the lower number was used in this report. Reclamation drawings and calculations were adjusted to accommodate this request. However, this adjustment does not constitute Reclamation's endorsement of the lower number. The discrepancy points out the necessity of additional field investigation and verification. If the project is pursued, Reclamation recommends a more detailed engineering effort, including a task specifically designed to verify the sediment quantity.

CHAPTER 2

ALTERNATIVE #1

MECHANICAL REMOVAL OF DAM AND SEDIMENT FROM THE CANYON



CHAPTER 2: ALTERNATIVE #1

MECHANICAL REMOVAL OF DAM AND SEDIMENT FROM THE CANYON

DESCRIPTION

This alternative consists of mechanical removal of the dam and all sediment deposited in the reservoir. A temporary haul road into the canyon upstream of the dam would be constructed. To divert flows away from the construction site, a temporary cofferdam and bypass pipeline would be constructed. After blasting the dam in segments, concrete and sediment would be hauled to an off-site disposal.

The temporary haul road would be built at a 6 to 8 percent grade from Malibu Canyon Road to the top of the existing sediment. This access road would be widened where it connects to Malibu Canyon Road to improve the access of equipment and to allow a greater turning radius for haul trucks. The amount of widening would depend on the type of equipment used for construction and the direction the trucks turn onto the road.

A temporary cofferdam would prevent stream flows from entering the construction site. A pipeline would convey diverted flows around the construction site along the side of the canyon closest to Malibu Canyon Road and discharge water over the spillway. The pipeline would consist of a 36-inch-diameter corrugated metal pipe with a thrust block constructed at each bend to resist forces. Drawing No. X-LC-214 (Page 6) shows the proposed location of the haul road and diversion pipeline.

The dam would be removed by blasting in 10-foot lifts, or vertical segments. A trench would be excavated along the upstream face to a depth of 20 feet. The trench would be 10 feet wide at the base and slope back to daylight at a slope of 1:1 (1 foot horizontal to 1 foot vertical). Holes would be drilled into the dam at an angle as shown on Drawing No. X-LC-217 (Page 7) to blast the appropriate lift. The concrete blocks would fall into the excavated trench for removal by the contractor. The contractor would be required to minimize the amount of concrete and rubble falling down the face of the dam. Any reinforcement (i.e., railroad rails) would be removed by cutting and hauling to an approved landfill.

It is anticipated that the contractor would use self-loading scrapers and bulldozers to transport sediment to a movable conveyor belt to fill bottom-dump trucks. Restrictions at the site would necessitate the use of smaller than normal self-loading scrapers, (i.e., 11 cubic yard capacity). The self-loading scrapers would excavate sediment and pile it at a point near the center of mass of the sediment as shown on Drawing No. X-LC-214 (Page 6). Bulldozers would separate larger rocks from the pile and push the remaining material into a movable conveyor belt feeder. The sediment would then be conveyed to trucks to be hauled out of the canyon, via the temporary haul road, to a designated disposal site.

SEDIMENT QUANTITY

Fish and Game contracted with Law/Crandall, Inc. to conduct a geological investigation of the sediment located behind Rindge Dam (Law/Crandall, 1993). From this study, Law/Crandall estimates that there is 801,500 cubic yards of sediment.

DISPOSAL OF MATERIAL

The following three sites were identified as potential locations for disposing sediment:

1) Malibu beaches located approximately 2 miles from the project site; 2) Calabasas Landfill located approximately 10 miles from the project site; and 3) a fill site approximately 1 mile downstream from the dam.

If the material meets sand specifications (material containing 70% sand or better), the California Coastal Commission prefers that the portion of sediment classified as such be used for beach nourishment. However, to use the material for this purpose, permits from the California Coastal Commission and the Army Corps of Engineers must be obtained. The concept of using the sediment for beach nourishment is ideal because material at an unwanted site (Malibu Creek) would be moved to a site which would greatly benefit from the material (Malibu beaches). Based upon the geological report completed by Law/Crandall, the chances of using sediment located behind Rindge Dam for this purpose are very good. The table below (reproduced from the Law/Crandall report) presents the estimated volume and percentage of the total volume for each material type:

MATERIAL VOLUMES		
SEDIMENT TYPE	VOLUME (yd ³)	% TOTAL
Silt and Clay	123,000	16
Silty Sand and Sandy Silt	276,000	34
Sand and Gravel	339,000	42
Cobbles and Boulders	63,500	8
Total Volume	801,500	100

The Calabasas Landfill has confirmed that it will currently accept the material at a rate of \$22.24 per ton, but this figure is likely to change as the amount of mud slide waste material in the area decreases. Eventually, the landfill will accept fine clay material from the reservoir site at no cost to be used as a protective cover for refuse. As shown above, Law/Crandall estimates 123,000 cubic yards of material will be available that is suitable for protective cover. Disadvantages of this site are that current charges make disposal very expensive and its remote location increases transportation costs.

COSTS

Costs associated with this alternative are listed by line items on Table 1 (Page 10). At the bottom of the table, the item identified as "Additional items (+10%)" accounts for items not listed because they have minimal impact to the overall estimate. The item "Unknown contingency (+ approx. 25%)" accounts for items not estimated due to the preliminary nature of this proposal versus a final design. Table 2 (Page 11) provides supporting information used to arrive at the costs generated in Table 1.

The cost estimate in Table 1 is based upon Law/Crandall's estimated quantity of 801,500 cubic yards of sediment. Using this sediment volume, the estimated total costs would be \$17.5 million.

Two major locations were considered during this effort—the Calabasas Landfill and Malibu Beach. The two locations have an 8-mile hauling difference. The cost estimate given in this report reflects the longer hauling distance, which is the Calabasas Landfill location. If Malibu Beach, located approximately 2 miles from the construction site, becomes the actual location for sediment disposal, the revised cost estimate would be \$11 million. The most attractive scenario, then, is a sediment volume of 801,500 cubic yards transported to Malibu Beach for beach nourishment.

Other beach sites south of Malibu are experiencing serious erosion problems and may be more appropriate locations for beach nourishment operations than Malibu beaches. Use of these sites should be investigated further during more detailed studies.

CONSTRUCTION IMPLICATIONS

Removal of sediment by excavation and hauling would create traffic congestion and delays on Malibu Canyon Road. For purposes of this study, sediment hauling was assumed to be limited to the hours of 9 a.m. to noon and 1 to 4 p.m. to minimize traffic interference. Because of this restriction, the estimated time to complete the project is 2 years. Actual construction hours may expand during certain periods of the year or during weekends. In that event, the construction period would be shortened.

After removing sediment and dismantling the dam, significant amounts of vegetation would be lost in what is now the reservoir area. Re-establishment of riparian vegetation along the streambed would be required. Nuisances occurring during construction could be dust and noise from equipment, which could be managed to minimize their significance.

TABLE 1: COST ESTIMATE FOR ALTERNATIVES

AMOUNT in \$1,000's

ITEM	WORK OR MATERIAL	QUANTITY/UNIT	UNIT PRICE	ALT#1	ALT#2	ALT#3
1	Mobilization & prep work	For the lump sum of		1,100	606	443
2	Clearing	32 / acre	725.00	23.2	23.2	23.2
3	Water for dust abatement	For the lump sum of		250	250	
4	Construct Access/haul road	For the lump sum of		300		
5	Dewatering sediment in reservoir area	For the lump sum of		750	750	
6	Demolition of dam	4,200 / cubic yard	50.00	210	210	210
7	Remove, haul, dispose of concrete waste	4,200 / cubic yard	10.00	42	42	42
8	Furnish and install diversion pipe	5,000 / linear foot	46.00	230	230	
9	Excavate sediment	801,500 / cubic yard	2.38	1,907.6	1,907.6	
10	Haul sediment	801,500 / cubic yard	9.24	7,405.9		
11	Maintain access/haul road	801,500 / cubic yard		43.3		
12	Mitigation at landfill site/rehab at reservoir	For the lump sum of		500	500	
13	Recondition access road	For the lump sum of			200	200
14	Construct maint. road	For the lump sum of				2,000
15	Install conveyor system	For the lump sum of			3,000	
16	Conveyor system O&M	2,400,000 / ton	.24		600	
17	Prep engineered landfill site	For the lump sum of			1,000	
				ALT#1	ALT#2	ALT#3
SUBTOTAL				12762.0	9318.8	2918.2
Additional Items (+ 10%)				1276.2	931.9	291.8
TOTAL FOR SCHEDULE				14038.2	10250.7	3210.0
Unknown contingency (+ Approx 25%)				3461.8	2549.3	790.0
TOTAL ESTIMATED COST				17,500	12,800	4,000

TABLE 2: SUPPORTING INFORMATION FOR COST ESTIMATES

ITEM	COMMENTS	Ref.
Mobilization and preparatory work	The Contractor is paid to bring equipment to the site and set up construction operations.	
Clearing	It is necessary to remove vegetation before construction operations begin. Estimated equipment needed for this task includes a dozer with ball and chain.	(1)
Water for dust abatement	Water is applied to dry soil to keep undisturbed dust particles from entering the atmosphere. Water trucks are needed for this operation. (Average of bids for similar projects were used.)	(3)
Construction access/haul roads	Access/haul road is required to access the construction site. (Insufficient topography information for detailed estimate; therefore, the cost for this item was inferred from difficulty of terrain in the area.)	
Dewatering sediment in reservoir area	Water must be removed from the sediment before the contractor can remove the material from the reservoir. (Geology report not available at time estimate was prepared, cost based on a proposed system of horizontal drains through the base of the dam into sediment in the reservoir area.)	
Explosive demolition of dam	The dam will be removed in segments by blasting. (Cost was based upon a previous bid item cost to blast the south tailrace retaining wall at Headgate Rock Dam.)	
Remove, haul, dispose of concrete waste	Disposal of concrete blocks from excavated trench and hauling to a predetermined disposal site. The cost was slightly increased to incorporate a long haul distance. (The haul distance was assumed to be 10 miles.)	(1)
Furnish & install diversion pipe	36-inch piping will be used to divert river flows around the construction site to allow the contractor to work in dry conditions. (The costs assume piping, storm drainage, corrugated metal, 36" diameter, 12 gauge.)	(1)
Excavate sediment	To excavate the sediment from behind the dam, it was assumed that the contractor would use an elevating scraper with a capacity of 11 cubic yards and a haul distance limited to 1500 feet.	(1)
Haul sediment	To haul sediment out of Malibu Canyon, a 16.5 cubic yard bottom dump trailer was used, assuming a 10-mile round trip journey. (The price was increased by 17 percent for medium traffic along Malibu Canyon Road.)	(1)
Maintain access/haul road	To continue access into and out of Malibu Canyon, the contractor will need to maintain the access/haul road by motor graders. (The cost was based upon a 1978 cost of \$0.027 per cubic yard x 801,500 cubic yards = \$21,640.50. Double the estimates for flooding repairs and 1994 costs.)	(2)
Additional items	Minor items not covered in these estimates because individually they have minimal impact on the Total Estimated Cost.	
Unknown contingency	Items not accounted for in these estimates due to preliminary nature of proposals versus final designs.	
Mitigation and rehabilitation at reservoir area	Following construction, the contractor will be required to rehabilitate the reservoir area. It is unknown at this time the extent of reservoir area rehabilitation required; therefore, a lump sum value was assumed. Should this amount be insufficient, the money set aside under the unknown cost would cover the remaining amount of money required.	

REFERENCES USED IN TABLE 2

- (1) 1994 Means Heavy Construction Cost Data
- (2) Excavation Handbook by Horace K. Church
- (3) Abstract of bids for Salt-Gila Aqueduct Reach 4 project

bids

CHAPTER 3

ALTERNATIVE #2

ENGINEERED LANDFILL IN MALIBU CANYON



CHAPTER 3: ALTERNATIVE #2

ENGINEERED LANDFILL IN MALIBU CANYON

DESCRIPTION

This alternative consists of mechanically excavating material behind the dam and transporting it downstream to an engineered fill in Malibu Canyon. The existing access road to the construction site would be reconditioned and a temporary cofferdam and bypass pipeline would be constructed to divert river flows. A conveyor belt system would be used to transport material to the fill site. The dam would be dismantled by blasting and the resulting rubble would be hauled out of the canyon.

The conveyor system would begin at a sediment removal site just upstream of the dam. The first section of the conveyor system would be built on a steep incline up the canyon to the Malibu Canyon Road. The conveyor would then follow the road to the fill site. This would permit construction and maintenance without the need for a new temporary road.

The access road into the canyon above the dam would need to be widened where it connects to Malibu Canyon Road to improve access for equipment. The amount of widening would depend on the type of equipment used during construction.

A temporary cofferdam would prevent stream flows from entering the construction site. A pipeline would convey diverted flows around the construction site along the side of the canyon closest to Malibu Canyon Road and discharge water over the spillway. The pipeline would consist of one 36-inch-diameter corrugated metal pipe with a thrust block constructed at each bend to resist forces. Drawing No. X-LC-215 (Page 13) shows the proposed location of the haul road and diversion pipeline.

The dam would be removed by blasting in 10-foot lifts. A trench would be excavated along the upstream face to a depth of 20 feet. The trench would be 10-feet wide at the base and slope back to daylight at a slope of 1:1 (1 foot horizontal to 1 foot vertical). Holes would be drilled into the dam at an angle as shown on Drawing No. X-LC-217 (Page 7) to blast the appropriate lift. The concrete blocks would fall into the excavated trench for removal by the contractor. The contractor would be required to minimize the amount of concrete and rubble falling down the face of the dam. Any reinforcement (i.e., railroad rails) would be removed by cutting and hauling to an approved landfill.

A conveyor belt system would be constructed from the dam to an approved engineered fill site. Self-loading scrapers and bulldozers would be used to transport the sediment to a conveyor belt feeder. Large rocks would be separated from the material before feeding it into the conveyor belt. At the engineered fill, the sediment would be spread by bulldozers and compacted with water trucks and sheeps-foot rollers to achieve optimum compaction.

CHAPTER 5

OTHER ALTERNATIVES



Following its completion, the engineered fill would be landscaped to match the natural conditions of the immediate area. Larger rocks removed from the sediment would be placed on the slope for erosion protection and natural vegetation (trees, grasses, and shrubbery) would be planted to enhance the appearance of the site.

DISPOSAL OF MATERIAL

Two potential locations have been selected for placing an engineered fill downstream of the dam. The first location is approximately $\frac{3}{4}$ of a mile downstream; the second location is approximately $1\frac{1}{4}$ miles downstream. Because these two locations have gentle slopes and large enough areas to easily blend material into the hillside, the engineered fill could be made—with proper re-vegetation and earth placement—to look like a natural land form. The slope of the engineered fill would begin at 3:1 (3-foot horizontal to 1-foot vertical), transition to 2:1, and top out at a 10:1 slope. The base of the fill would be protected by large rocks and, to control drainage, mid-size rocks would be placed to form natural appearing channels. Anticipated landfill placement sites are subject to the California Coastal Act and, as they are also within the State Park boundaries, would require State approval.

COSTS

The costs associated for this alternative are listed by line item on Table 1 (Page 10). Table 2 (Page 11) provides supporting information used to arrive at the costs generated in Table 1.

Cost estimates given in Table 1 (Page 10) are based on the Law/Crandall sediment volume estimate of 801,500 cubic yards. The cost estimate for an engineered landfill in Malibu Canyon is \$12.8 million.

CONSTRUCTION IMPLICATIONS

Removal of sediment by excavation and conveying the material to an engineered fill would cause minimal disruption to traffic on Malibu Canyon Road. An added benefit is that construction can continue for longer periods of time, (i.e., 10- to 12-hour work days as opposed to 6-hour work days) due to hauling limitations on the road. The estimated time to complete the project is 1 year.

Since construction would cause a significant loss of vegetation in the reservoir area, re-establishment of riparian vegetation along the streambed would be required. After project completion, the conveyor system would be removed and this area restored to natural conditions. To minimize environmental disruption and alleviate the need for an access road in the lower reaches of the canyon, compaction, earth moving, and rock placement equipment would be winched down to the fill site from Malibu Canyon Road. Nuisances occurring during construction could be dust and noise from equipment, but these could be managed to minimize their significance.

Disposal at a site within the canyon downstream of the dam would require coordination with a variety of Federal, State, and local agencies. This option is less expensive and involves less time to complete than other disposal options, but it comes with more environmental and aesthetic concerns.

CHAPTER 4: ALTERNATIVE #3

REMOVAL OF SEDIMENT BY STREAM EROSION

DESCRIPTION

Under this alternative, the dam would be removed in 6 lifts over a number of years and sediment behind the dam would erode under natural stream flow. After each lift, construction equipment would demobilize from the canyon and the stream would be directed toward the dam. Natural flows would transport the sediment downstream. Berms would be constructed to divert flows away from construction crews.

To move equipment into the canyon for dam removal, the existing access road would be reconditioned. The access road would be widened where it connects to Malibu Canyon Road to allow haul trucks a wider turning radius. The amount of widening would depend on the type of equipment used in construction.

Temporary berms would be constructed with sediment excavated from behind the dam to divert river flows. River flows must be diverted so construction crews removing the dam can work in dry conditions. After removal of half a lift, the river would be diverted to the opposite side while the workers remove the remaining half of the dam. Drawing No. X-LC-216 (Page 17) shows the project location.

The dam would be removed by blasting in 6 lifts. A trench would be excavated along the upstream face to a depth 10 feet lower than the height of the lift as described by Drawing No. X-LC-217 (Page 7). The trench would be 10 feet wide at the base and slope back to daylight at a slope of 1:1 (1 foot horizontal to 1 foot vertical). Holes would be drilled at an angle as shown on Drawing No. X-LC-217 (Page 7) to blast the appropriate lift. The concrete blocks would fall into the excavated trench for removal by the contractor. The contractor would be required to minimize the amount of concrete and rubble falling down the face of the dam. Any reinforcement, (i.e., railroad rails) would be removed by cutting and hauled to an approved landfill.

DISPOSAL OF MATERIAL

This alternative requires natural stream flows to transport sediment to the ocean. If flows do not remove all the reservoir sediment in a lift, the stream would be rerouted to dislodge the remaining sediment. It is possible that not all the sediment would move into the ocean, creating depositional bars in the lower stretch of the river. A previous sediment transport analysis (Trihey, 1989) verified the possibility of pools being filled by sediment when high flows are carrying significant sediment loads. Additional sediment transport work would be necessary to clarify potential impacts of this alternative.

COSTS

Costs associated with this alternative are listed by line items on Table 1 (Page 10). Table 2 (Page 11) provides supporting information used to arrive at the costs generated in Table 1 (Page 10).

Costs given in Table 1 (Page 10) are based on Law/Crandall's sediment volume estimates of 801,500 cubic yards. The cost estimate for removal of sediment by stream erosion is \$4 million.

CONSTRUCTION IMPLICATIONS

This sediment removal method could result in sediment accumulation in downstream pools that would have to be removed by mechanical methods. Elevated stream sediment loads could also impact aquatic species and, at this time, it is unknown whether the aquatic life could withstand the changes caused by stream sediment transfer.

Construction costs to remove portions of the dam would be minimal, resulting in a low cost estimate for this alternative. However, the project duration would range between 8 to 18 years depending upon natural hydrology. Dust and noise pollution would only occur during actual construction and would not significantly impact local residents.

CHAPTER 5: OTHER ALTERNATIVES

The following alternatives were considered but not pursued for the reasons listed below. The benched flume and the hydraulic dredge and slurry operation were developed by Reclamation; the remaining options were previously developed and considered by Fish and Game.

HYDRAULIC DREDGE AND SLURRY

One option for removing sediment behind the dam is to use a hydraulic dredge to remove the material and pump it to another location.

Hydraulic dredging requires a dredging machine to operate in a streambed with continuously flowing water. The machine moves the saturated sediment to a pipeline where additional water is added to make a slurry that is transported to a disposal site. The key to this operation is having enough water to dredge and slurry the sediment to a disposal site. Malibu Creek does not have the required flows for both this operation and the maintenance of downstream aquatic life; therefore, this alternative was eliminated from further consideration.

FISH LADDERS

A Borland fish lift and a benched flume were considered for transporting native steelhead trout upstream for spawning. Primary reasons these alternatives were eliminated from further consideration included: 1) operation and maintenance required at a time when it would be unsafe to access the facilities; 2) earthquakes, rock, and debris slides would require constant reconstruction of the structures; and 3) difficulty in achieving site access for construction, maintenance, and operation.

OTHER NATURAL EROSION OPTIONS

Several options were considered for removal of sediment through "natural" erosion in addition to "Alternative #3, Removal of Sediment By Stream Erosion". One of these options was to allow stream erosion through a V-notch cut into the dam, rather than removing the entire dam. And, in an effort to accommodate the historical perspective of the dam, Fish and Game considered the option of cutting a hole in the base of the dam to create a more natural stream flow condition without removal of the dam.

Each of these proposals had the unfortunate potential for creating irretrievable harm to the existing fish habitat between the dam and the creek mouth. In addition, the logistics of removing sediment through a hole in the dam base and the high variability of flows create conditions that make it difficult to implement such an option without jeopardizing the structural integrity of the dam.

CHAPTER 6

ALTERNATIVE EVALUATION



CHAPTER 6: ALTERNATIVE EVALUATION

THEORY

The preceding chapters presented several alternatives for removal of Rindge Dam and sediment in the reservoir. This chapter describes the method used to determine a relative ranking among the alternatives.

The method used here makes use of two tools—the Paired Comparison Matrix and the Analysis Matrix. The Paired Comparison Matrix is used to determine the order of importance of a list of evaluation parameters, while the Analysis Matrix is used to determine the order of preference of a number of solution alternatives.

The first step in the evaluation process is to define a list of parameters that are used to evaluate the alternatives. Some of these parameters are, no doubt, more important than others. To determine that relationship, each parameter is compared with the others. The comparison determines which parameter is more (or less) important than the other and by how much. If there are only two parameters, the problem is minimal, but when the list of parameters is long, the Paired Comparison Matrix can help keep the process straight.

As an example of how this is done, consider a problem with two alternative solutions and three evaluation parameters. Assume the three evaluation parameters are:

PARAMETER IDENTIFICATION LETTER	PARAMETER
A	color
B	price
C	speed

When color and price are compared, price is determined to be much more important. So, on a random scale of 1 to 4, price would be given a score of 4. When color and speed are compared, speed is determined to be more important by a score of 3. Comparing price to speed results in price being more important by a score of 2. A Paired Comparison Matrix with these parameters would look like this:

	B: Price	C: Speed	Subtotal	Ranking
A: COLOR	B4	C3	0	3
B: PRICE		B2	6	1
C: SPEED			3	2

The letter shown in each cell is the identification letter of the parameter that was determined more important and the number is the score given to this parameter. The "subtotal" column is obtained by finding all the cells in the matrix where the parameter identification letter is shown and adding numbers in those cells. For the row "A: Color", for example, there are no cells that contain the letter A, so that parameter receives a subtotal of 0. Row "B: Price", however, receives a subtotal of 6 because there are two cells that contain the letter B and the numbers in those cells add up to 6.

Whenever two parameters are equivalent in terms of importance, the cell will contain the letter designation for both parameters and no numeric score is given.

Numbers in the ranking column are determined by simply equating the highest subtotal with a ranking of 1, the second highest subtotal with 2, and so on.

An Analysis Matrix is now used to rank the alternatives in order of preference. First, alternatives are evaluated as to how well they meet each parameter, typically on a scale of 1 to 4. Let us assume that alternative 1 is cheap and slow, but the right color; while alternative 2 is more expensive and ugly, but faster. For this example, assume subject matter specialists determine that alternative 1 meets the price parameter by a score of 3 on a scale of 1 to 4, meets the speed parameter by a score of 2, and meets the color parameter by a score of 4. Alternative 2 meets the price parameter by a score of 2, the speed parameter by a score of 3, and the color parameter by a score of 1. Here is how the Analysis Matrix would look:

	Price	Speed	Color	Total	Alternative Ranking
	6	3	0		
Alternative 1	3 / 18	2 / 6	4 / 0	24	1
Alternative 2	2 / 12	3 / 9	1 / 0	21	2

The alternatives are displayed in the left column. Evaluation parameters are displayed, in rank order, on the top row along with their weights as obtained from the Paired Comparison Matrix. Two numbers appear in each matrix cell. The number to the left is the score obtained when comparing the alternative with the evaluation parameter; the number to the right is obtained by multiplying this score times the weighing factor for the parameter. Adding along the row gives a total "grade" for the alternative. The alternative with the highest grade receives the highest ranking and is, therefore, the preferred alternative.

The following section applies this technique to the Rindge Dam/sediment removal alternatives.

APPLICATION

Evaluation parameters for the Rindge Dam/sediment removal alternatives were determined at a February 17, 1994 meeting among representatives of Fish and Game, Parks and Recreation, and Reclamation.

The ten parameters are shown below:

PARAMETER
IDENTIFICATION
LETTER

PARAMETER

A	Minimize cost
B	Minimize community and fishery impacts
C	Minimize regulatory constraints
D	Minimize impacts to Malibu Lagoon
E	Minimize impacts to Malibu Canyon traffic
F	Maintain historical significance
G	Simplify steelhead fishery restoration process
H	Protect riparian habitat
I	Simplify public awareness process
J	Minimize risks of downstream property damage

After formulating the parameters, the group went through the comparison exercise. As each parameter was compared with the others, the group discussed the relative merits and came to consensus on a comparison score. The results of that effort are shown on the Paired Comparison Matrix presented on Table 3 (Page 23).

The comparison exercise resulted in minimizing impact to Malibu Lagoon as being the most important parameter, followed by minimizing impacts to the residential community and the fishery, protecting riparian habitat, and minimizing the risk of downstream property damage. Other parameters, including cost, were deemed to have much lower importance.

Table 4 (Page 24) shows the Analysis Matrix. When the three alternative methods of removing Rindge Dam and sediment were evaluated against the weighted parameters, removal of the dam and sediment from the canyon was the preferred alternative. Use of an engineered fill in the canyon was a close second, while removal of the sediment by stream erosion was a distant third.

The outcome of the alternative evaluation process obviously depends upon the evaluation parameters selected, the weight given to each parameter, and the determination of how well an alternative meets each parameter. If evaluation parameters are added or subtracted to the list or if changes are made to scores on the matrices, the alternative ranking outcome could change, particularly since only a small difference separates the top two alternatives.

TABLE 3

PAIRED COMPARISON MATRIX

	B	C	D	E	F	G	H	I	J	Subtotal	Ranking
Minimize Cost of Removal A	B3	A/C	D3	E2	A3	G2	H3	I2	J3	3	8
Minimize Impact of Removal B		B3	D2	B3	B3	B3	B1	B3	B/J	19	2
Minimize Regulatory Constraints C			D3	E3	C2	G1	H3	I1	J3	2	9
Minimize Impacts to Malibu Lagoon D				D3	D3	D3	D2	D3	D/J	22	1
Minimize Impacts to Malibu Canyon Traffic E					E3	E/G	H3	E/I	J3	8	5
Maintain Historical Significance F						G3	H3	I3	J3	0	10
Simplify Removal Process G							H3	G2	J3	8	6
Protect Riparian Habitat H								H3	H/J	18	4
Simplify the Process of Public Awareness I									J3	6	7
Minimize the Risk of Downstream Property Damage J										18	3

TABLE 4
ANALYSIS MATRIX

ALTERNATIVES	Minimize Impacts to Malibu Lagoon		Min. Residential Disruptions & Fishery Impacts	Minimize the Risk of Downstream Property Damage	Protect Riparian Habitat	Minimize Impacts to Malibu Canyon Traffic	Simplify Process of Restoring Steelhead Fishery	Simplify the Process of Public Awareness	Minimize Costs	Minimize Regulatory Constraints	Maintain Historical Significance	TOTAL	FINAL RANKING
	22	4	19	18	18	8	8	6	3	2	0	329	
1. Removal of sediment by excavation and hauling.	4	88	3	4	2	2	3	4	2	3	3	329	1
2. Excavate and conveyor sediment to engineered fill.	4	88	3	3	2	4	3	3	3	2	3	322	2
3. Remove portions of dam and displace sediment by stream erosion.	2	44	2	2	2	4	4	3	4	2	3	252	3
4. Remove entire dam and displace sediment by stream erosion.	1	22	1	1	1	4	4	3	4	1	3	173	5
5. Hydraulically dredge and slurry sediment to disposal site.	1	22	1	4	2	3	1	3	2	2	3	209	4

CHAPTER 7

RECOMMENDATIONS AND CONCLUSION



CHAPTER 7: RECOMMENDATIONS AND CONCLUSION

POSSIBILITY FOR ALTERNATIVE COMBINATIONS

During this study, several alternatives for removing the dam and sediment were considered as individual, stand-alone projects. However, opportunities may be optimized by combining several alternatives. For example, sediment material behind the dam that has economic value could be used to provide an economic return (or, at least, minimize cost), while other material could be disposed of in an engineered landfill.

Various alternative combinations should be formulated during more detailed studies. Significant cost savings could be achieved through such combinations and other advantages may exist in formulating an alternative that combines several possibilities considered during this study.

During this study, impacts to the environment were included in the evaluation parameters—specifically the aquatic environment, the terrestrial environment in Malibu Canyon, and the transportation environment on Malibu Canyon Road. Combining several alternatives may provide the opportunity to balance impacts to these environments such that the overall effects are minimized.

Another prime consideration is the "recycling" of the sediment material behind the dam. Instead of placing the material in a landfill (and, in essence, wasting it), it may be used for beneficial purposes. Construction material, beach replenishment, and sanitary landfill covering are several of the possible uses.

Prior to deciding on a final dam and sediment removal plan, additional analyses of alternative combinations should be pursued. This can be done only as more information is obtained on specific uses of the sediment material.

FUTURE WORK REQUIREMENTS

During the study process, it became obvious that development or analysis of some significant items were beyond the scope of this effort. As these items could influence the selection of the final construction alternatives and could make consequential changes in funding requirements, each will need further study during a more detailed planning/design effort.

Location of a sediment disposal site also needs to be specifically identified. During this study, numerous locations for sediment disposal were addressed, but none were evaluated to the extent that one could be identified as preferred over another. More detailed studies are needed to determine the disposal location.

Environmental, social, and economic impacts could also affect the selection of a preferred alternative and the design of that alternative. Thus, these impacts will need to be addressed. Fish and Game will be responsible for pursuing these topics of concern. It is anticipated that

should the Reclamation be involved in any further planning or design efforts, its responsibilities will be limited to determination of disposal sites and technical aspects of sediment and dam removal.

CONCLUSION

This study has identified and evaluated several alternatives for removing Rindge Dam and sediment behind the dam. Two alternatives stand out as the most desirable: "Mechanical Removal of Dam and Sediment from Malibu Canyon" and "Engineered Landfill in Malibu Canyon". These alternatives can be implemented within constraints established for the project, but both are relatively expensive. However, opportunities for significant cost savings may be realized through formulation of a combined alternative. Any further investigation of this project should pursue that possibility.

It should also be emphasized that data used as a basis for the analyses performed for this report are preliminary. More detailed engineering and economic analyses and the addition of environmental and social analyses may affect the final selection of a project.

APPENDIX A:
ANALYSIS OF SEDIMENT
QUANTITY DEPOSITED UPSTREAM OF
RINDGE DAM

APPENDIX A: ANALYSIS OF SEDIMENT QUANTITY DEPOSITED UPSTREAM OF RINDGE DAM

Introduction

This appendix addresses a discrepancy between sediment volume behind Rindge Dam originally estimated by Reclamation and an estimate made by Law/Crandall, a geotechnical consultant under contract with Fish and Game.

First, it must be emphasized that this Reclamation report documents results of an appraisal level study only. Quantities and costs are estimates based on data available to Reclamation at the time the study was done, from the following sources: USGS map dated 1950 (photo-revised 1967), Attachment A; as-built drawings of Rindge Dam dated March 1924 and October 1961, Attachments B and C; and photographs of the area taken by Reclamation personnel in 1993. Funding was not available to perform on-site investigations or surveys.

In estimating costs and time for removing Rindge Dam and sediment deposited behind the dam, the volume of sediment is the most important quantity common to all removal alternatives. Initial Reclamation calculations indicated that the volume of sediment is approximately 1.6 million cubic yards. Subsequently, Law/Crandall, a contractor hired by Fish and Game to provide a geotechnical report of the area, estimated the volume of sediment to be approximately 800,000 cubic yards. This appendix explains Reclamation's process to arrive at its sediment volume of 1.6 million cubic yards and compare that figure with the estimate made by Law/Crandall.

Reclamation Method of Estimating Sediment Deposited Upstream of Dam

- (1) Reclamation used a USGS map dated 1950. The area around Rindge Dam was enlarged by 400 percent on a photocopy machine.
- (2) The elevation contours and other features (highways and streams) from the enlarged portion of the map of the area around Rindge Dam were digitized into an Autocad 12 computer drawing file.
- (3) The 1950 USGS map did not show the contours of the original Malibu Creek streambed upstream of the dam because a substantial quantity of sediment had already been deposited by that time. Nor did the contours of the area reflect the current elevation of the top of sediment since considerable sediment has been deposited since 1950.
 - (a) To establish approximate contours for the natural streambed, Reclamation assumed a constant slope stream gradient from a point immediately downstream of the dam to a point immediately upstream of the limits of the deposited sediment.
 - (b) An average elevation of the top of sediment was approximated as follows:

Elevations of the top of dam and spillway were taken from as-built engineering drawings dated March 1924 and October 1961. Elevation of top of dam: 335
Spillway Elevation: 327

Photographs show the sediment upstream of the dam. At the spillway, the top of sediment elevation is 327. The top of sediment elevation rises northward across the valley to the far end of the dam. Due to the manner in which sediment tends to be deposited in valleys subject to periodic flooding, it is reasonable to expect (and is evident in the photographs) that the top of sediment elevation will be higher outside the main channel of Malibu Creek.

The photographs show that the top of sediment elevation remains below the top of the dam, but is, on average, higher than the spillway. These observations were confirmed during a visit to the site by Reclamation personnel in May 1994.

Based on the above information, Reclamation considered it reasonable to assume an average elevation of 330 for the top of sediment.

Reclamation applied the above approximations to the Autocad drawing created in (2) to produce a topographical map of the area reflecting conditions current as of March 1994. (See Drawing No. X-LC-219, Attachment F.)

(4) Reclamation used the Autocad drawing and a Reclamation computer program to calculate the volume of sediment deposited upstream of Rindge dam.

(a) The program used the Autocad drawing data to generate cross sections of the valley at 200 foot intervals and to calculate the area of the sediment in each cross section (see Drawing Nos. X-LC-219 and X-LC-220, Attachments F and G). It should be noted that the depth of sediment reflected in these cross sections reasonably agrees with the depth of sediment reported by Law/Crandall.

(b) The program then used the average end-area formula to calculate the volume of sediment based on the area of the cross sections. The average end-area method is commonly used to calculate earthwork quantities. This generated the 1,624,500 cubic yard figure used as the original Reclamation estimate for the volume of sediment.

(5) The program used in (4) was similarly applied to calculate the volume of sediment in each of six lifts shown on Drawing No. X-LC-217 (Page 7).

Quick Check of Reclamation Quantity Estimate

In the interest of verifying the general magnitude of the 1.6 million cubic yard figure as the volume of sediment deposited upstream of the dam, Reclamation noted that construction and design reports for Rindge Dam indicated that the dam was expected to impound approximately 574 acre-feet of water.

Conversion of 574 acre-feet yields a volume of 926,053 cubic yards. This would be the volume of water impounded behind the spillway with a water surface elevation 327. As noted in (3)(b) above, Reclamation estimated the elevation of the top of sediment to be 330. This indicates that one should expect a volume of sediment somewhat more than 926,053 cubic yards. It should be noted that even a variation of a few feet of sediment around elevation 330 can result in a difference of 100,000 cubic yards.

The 926,053 cubic yard figure is substantially less than the 1.6 million cubic yards Reclamation calculated and more closely agrees with the Law/Crandall estimate.

The Law/Crandall Quantity Estimate

Site investigations conducted by Law/Crandall were for the purpose of producing a geotechnical report. The contractor took four borings to analyze and provide a description of the sediment layers deposited upstream of the dam.

The depth of sediment at the four borings reasonably agrees with Reclamation cross sections developed at these points. (See Drawing No. X-LC-219, Attachment F).

The contractor provided an estimate of the volume of sediment by: 1) using the depth of the four borings; and 2) calculating the areal extent of the deposited sediment by using a planimeter.

There is no indication that a site survey was employed to establish either the elevation of the top of sediment or the extent of the deposited sediment.

Quick Check of Law/Crandall Quantity Estimate

Checking Law/Crandall's quantity estimate by applying the average-end-area method of estimating sediment deposited behind the dam (Attachments D and E were used to determine the sediment length and cross-sectional areas, respectively), yielded a calculated quantity of 1.16 million cubic yards. This value in itself varies from the Law/Crandall estimate of 0.8 million cubic yards. The values and calculations used to arrive at the 1.16 million cubic yards are listed in Attachment F. This indicates that the quantity of sediment located behind the dam varies depending upon the method of calculation used. The estimated areas for Law/Crandall cross-sections are shown on Drawing No. X-LC-219 (Attachment F), and Drawing No. X-LC-220 (Attachment G), contains the calculated sediment volume.

Source of the Discrepancy

The discrepancy between the volume of sediment estimated by Law/Crandall and Reclamation appears to have resulted from a combination of differences, including calculation methodology, length of sediment deposited upstream of the dam, top elevation of sediment, and cross sectional areas. The Law/Crandall drawing shows an elevation of 285 for top of sediment, while Reclamation estimated the top of sediment elevation to be 330; Reclamation used the average-

end-area method, while Law/Crandall calculated soil layer volumes; Reclamation used 4400 feet as the distance sediment is deposited upstream of the dam, while Law/Crandall used 2870 feet; Reclamation's cross sectional areas are larger than Law/Crandall's areas at similar locations.

The Malibu Creek Sediment Transport Analysis

Mr. E. Woody Trihey, P.E., published the Malibu Creek Sediment Transport Analysis report, March, 1989. In the report, Mr. Trihey estimated the volume of sediment behind Rindge Dam to be 1.169 million cubic yards. The method Mr. Trihey used to calculate the sediment quantity was by the average-end-area method.

Initial Decision to Use 1.6 Million Cubic Yards Figure

Given the information available at the time Reclamation developed the estimate (prior to receiving the Law/Crandall report), it appeared that the volume of the sediment deposited upstream of the dam was between 1.0 and 1.6 million cubic yards.

Reclamation used the higher figure as it was derived from data taken from a USGS map (modified to approximate existing conditions) and from as-built engineering drawings. The possibility of seriously underestimating the quantity of the item that would most impact cost and time estimates was also avoided.

Reclamation acknowledges that there are weaknesses with the methodology described above. In particular:

(1) The USGS topographic map used to create the Autocad drawing provided elevation contours at only 25 foot intervals, requiring considerable interpolation of intermediate elevations. As discussed elsewhere in this report, differences in elevation of only a few feet will drastically effect the quantity of sediment estimate.

(2) Photocopy enlargement of the USGS map undoubtedly produced some distortion of the elevation contours.

(3) The actual profile of the natural streambed may differ considerably from the one Reclamation assumed based on a constant gradient.

(4) The actual average top of sediment elevation and extent of sedimentation may differ considerably from what Reclamation assumed based on photographs and as-built engineering drawings.

Conclusion

Reclamation believes the quantities and costs contained in this report should be used only for relative comparisons of the options evaluated herein. Considering the uncertainty inherent in all the quantities involved (not just the volume of sediment), it would be misleading to represent the cost estimates in this report as anything more than preliminary.

At the request of Fish and Game, Reclamation used the quantity of deposited sediment value from the Law/Crandall report as the basis for the estimates of cost and construction time in this report. Fish and Game is attributed as the source of the value, as Reclamation has no technical basis for confirming or disputing the figure.

CHAPTER 4

ALTERNATIVE #3

REMOVAL OF SEDIMENT BY STREAM EROSION



APPENDIX B: REFERENCES

APPENDIX B: REFERENCES

- Franklin, Robert F. and Soyka S. Dobush, Malibu Creek Steelhead Habitat Assessment Report, ENTRIX, Inc., 1989.
- Law/Crandall, Inc., Report of Geotechnical and Environmental Study, Malibu Creek Steelhead Restoration Project, Malibu Area, Los Angeles County, California, May 23, 1993.
- Trihey, E. Woody, P.E., Malibu Creek Sediment Transport Analysis, March 1989.

