Los Padres Dam:
Fish Passage Assessment

Prepared for:

California American Water

Prepared by:

HDR Engineering, Inc.

Administrative DRAFT

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Executive Summary

Steelhead populations in California have undergone a dramatic decline in the past 30 to 40 years and one major factor for this includes loss of spawning and rearing habitat due to impaired fish passage. The Carmel River is located within the South-Central California Coast ESU and contains a population of steelhead trout designated by the Endangered Species Act (ESA) as "Threatened." Section 7 of the ESA, the Salmon, Steelhead Trout, and Anadromous Fisheries Program Act of 1988, as well as California Department of Fish and Game Codes mandate the protection of this population.

California American Water (CAW) is committed to the evaluation and implementation of economically viable solutions that allow for both upstream and downstream migration of steelhead over or around Los Padres Dam. To accomplish this goal, HDR Engineering, Inc. (HDR) was tasked with producing a Fish Passage Alternatives Analysis to identify a fish passage solution that meets the goals and objectives CAW and the various stakeholders involved.

This Alternatives Analysis Report details an investigation into methods to facilitate passage of migrating steelhead at Los Padres Dam. Concepts are presented for four alternatives. The alternatives were comprised of: fish passage comprised of 8 upstream and 4 downstream options; dam removal; conservation hatchery, and no action. These alternatives were evaluated for advantages and disadvantages in consideration of their ability to: provide upstream passage during the critical flow range of 5cfs and 1,100 cfs; provide downstream passage for juveniles and post-spawn adults in consideration of the natural hydrograph and varying reservoir levels; withstand dewatering and vandalism; provide proven options based on existing technologies; be conducted within the limits of CEQA and federal and state dam safety regulations; and operate in an anticipated range of future operational changes.

Based upon the initial screening level evaluation, the alternatives were narrowed to two upstream and three downstream alternatives which were further considered. The two upstream alternatives include: 1) Direct Volitional Fish Passage and 2) Trap and Haul. The three downstream passage alternatives were: 1) Fixed Surface Collector at Reservoir Outlet; 2) Floating Surface Collector at Reservoir Outlet; and 3) Fixed Off-Channel Trapping Facility at Head of Reservoir. These alternatives were evaluated in detail considering the factors of cost, expected operation and maintenance effort, constructability, expected effectiveness in passing fish, and ability to safely pass fish without injury.

The viability of each of the five scenarios was evaluated with respect to facilitating upstream and downstream migration. The Opinions of Probable Construction Costs (OPCC) for upstream

passage options ranged from $760,000 to $4,920,000 these alternatives. The OPCCs for downstream passage ranged from $480,000 to $4,730,000. Operation and maintenance effort for upstream passage alternatives ranged from $34,000 to $70,000 per year. Operation and maintenance effort for downstream passage alternatives ranged from $29,000 to $108,000. The constructability of the alternatives ranged from low to high ranging from relatively simple improvements to major excavation and construction activities. The effectiveness of the alternatives ranged from moderate to high, as all alternatives considered were expected to perform relatively well in passing fish. Similarly the ability to safely pass fish ranged from moderate to high as some alternatives required little to no handling of fish, while others required significant amounts but used water to water transfers to minimize the potential for impact.

The results of the evaluation process indicated that two potential alternatives could best meet the objectives of this study. The recommended alternatives include a volitional and non-volitional option, both of which should be considered along with the long term fate of Los Padres Dam itself. The two recommended alternatives include: 1) upstream trap and haul with a fixed surface collector and fish bypass for downstream migration and 2) a hybrid vertical slot fish ladder with a fixed surface collector and fish bypass for downstream migration. The major advantages of Alternative 1 includes: effective passage of fish up and around Los Padres Dam; low capital and operation and maintenance cost; and ease of compliance with CEQA, state, and federal permitting requirements. The estimated order of magnitude capital costs associated with this alterative totals at $1,240,000 with a combined estimated O&M cost of $37,000 per year. Estimated implementation costs of Alternative 1, inclusive of engineering, permitting, and administrative costs, may be as much as $2,938,800. The major advantages of Alternative 2 include: effective passage of fish up and around Los Padres Dam; limited capital and operation and maintenance costs relative to other volitional passage options; fully volitional passage of upstream and downstream migrants without the need for handling; and ease of compliance with CEQA, state, and federal permitting requirements. The estimated order of magnitude capital costs associated with this alterative totals at $5,400,000 with a combined estimated O&M cost of $79,000 per year. Estimated implementation costs inclusive of engineering, permitting, and administrative costs may be as much as $11,934,000.

Both of the recommended alternatives could be implemented in compliance with all applicable CEQA documentation requirements as well as with all state and federal permitting requirements. The most appropriate CEQA document for each alternative would be a Negative Declaration. Permits that would be required include: The US Army Corps of Engineer 404 Permit and 401 water quality certification, National Marine and Fisheries Service Section 7 ESA

Consultation, State Department of Water Resources Division of Dam Safety compliance, and the Section 1602 Stream Alteration Agreement from the California Department of Fish and Game.

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1 Introduction

Steelhead populations in California have undergone a dramatic decline in the past 30 to 40 years and major factors in this are freshwater habitat loss, degradation, and impaired fish passage. The Carmel River is the southernmost significant steelhead run in the South-Central California coast. The river system includes 35 miles of mainstem river and 7 major tributaries within a 255 square mile watershed (Snider 1983). Water development has caused severe habitat impacts to the Carmel River, including dewatering, and loss of riparian habitat.

The numbers of returning steelhead adults in the Carmel River hit a low in the early 1990s, and the run was declared to be nearly extinct by the California Department of Fish and Game (McEwan and Jackson, 1996). Through restoration efforts, steelhead adult returns have rebounded somewhat to around 400 to 800 fish on an annual basis (MPWMD 2004).

Factors that continue to limit the steelhead population include obstructions of fish passage, water diversions from the basin, and degradation of spawning and rearing habitat. The most significant fish passage problems are at the main stem dams and reservoirs. At San Clemente Dam, the fish ladder is outdated and fish mortality occurs as downstream migrants plunge 70 feet over the dam spillway to the pool below (MPWMD 2004). At Los Padres Dam, a trap and truck operation is required for upstream migrants and downstream migrants must travel down a long concrete spillway with little water depth to prevent injuries. As well as the physical barriers, water diversions from the basin reduce flows for adult migration and juvenile rearing. Habitat degradation from within stream channels, loss of riparian vegetation, and reductions in water quality also limit the Carmel River population.

Los Padres Dam on the Carmel River is a documented upstream and downstream passage barrier to Endangered Species Act (ESA) "Threatened" steelhead trout migration. It has been estimated that the Carmel River mainstem could support a run of approximately 4,800 adults however about 50% of the spawning habitat is blocked by the Los Padres Dam (MPWMD 2004).

California American Water (CAW), which owns and operates Los Padres Dam, is committed to the identification and implementation of economically viable solutions that allow for both upstream and downstream steelhead migration at Los Padres Dam. To accomplish this goal, HDR Engineering, Inc. (HDR) has been tasked with performing a Fish Passage Alternatives Analysis to identify, evaluate, and recommend the permanent methods and facilities necessary to facilitate upstream and downstream migration of steelhead at Los Padres Dam.

This document describes the solutions considered during this analysis and the criteria upon which they were evaluated. A recommended solution is identified for implementation based on the results of this evaluation.

1.1 Organization of Technical Memo

This document begins with a description of Los Padres Dam site conditions and current facility operations. Next, site hydrology including a stage-duration analysis, a flood flow frequency analysis, and a flood hydrograph analysis is summarized. This is followed by a description of steelhead presence and run timing in the Carmel River and at Los Padres Dam and how this corresponds to the site specific hydrology. From this information target migration periods and flows are identified for use in development of alternatives. Then, using this information, the document provides an evaluation of each alternative based upon identified evaluation criteria. A brief description of each alternative is provided and considered for further evaluation. If examined further, alternatives are compared and contrasted in an evaluation matrix. Finally, recommendations for upstream and downstream passage alternatives are given along with a recommended plan to achieve stakeholder goals.

1.2 Purpose

The existing fish passage facilities at Los Padres Dam provide inadequate means for Threatened migrating steelhead of the South-Central California Coast Evolutionary Significant Unit (ESU) in the Carmel River. In order to meet requirements of Section 7 of the ESA Act of 1973 (19 USC § 1536(c)), as well as the Salmon, Steelhead Trout, and Anadromous Fisheries Program Act of 1988 (SB 2261) CAW is committed to the evaluation and implementation of economically viable solutions that facilitate effective upstream and downstream steelhead migration at Los Padres Dam. It is estimated that a restored steelhead run could result in access to 14.5 miles of spawning habitat upstream of Los Padres Dam which could increase the number of returning adult steelhead past Los Padres to around 1,200. This would represent 30% of the National Marine and Fisheries Service (NMFS) recovery goal in the watershed. The purpose of this document is to evaluate existing conditions, identify economically viable alternatives for upstream and downstream passage of steelhead at Los Padres Dam, and provide recommendations to CAW regarding implementation of such fish passage facilities.

1.3 Objectives

The goals and objectives of this project were identified through a multi-stakeholder forum which included the NMFS, California Department of Fish and Game (CDFG), United States Fish and Wildlife Service (USFWS), Monterey Peninsula Water Management District (MPWMD), the Carmel River Steelheaders Association, California CAW, and HDR. The development of these

objectives is summarized in a Problem Statement and Goals Memorandum developed by CAW and HDR dated April 8, 2009. The objectives included:

1. Provide upstream passage for adult steelhead during the critical migration periods.
2. Provide downstream migration for juvenile steelhead and post-spawn adults.
3. The fish passage solution should be based on existing technologies.
4. The fish passage project should, if possible, be conducted within the limits of a streamlined CEQA process, and in compliance with state and federal dam safety regulations.
5. The fish passage solutions should anticipate a range of future possible operations changes such as a modest raise in the dam crest elevation by flashboards, or reservoir sediment dredge/fill cycles.

1.4 Scope

The Los Padres Dam Fish Passage Alternatives Analysis project considers alternatives for improving upstream and downstream steelhead migration. The evaluation begins with identification of potential options to facilitate upstream and downstream migration of adult, post-spawn adult, and juvenile steelhead. Advantages and disadvantages of each option are addressed and the most viable options are brought forward for further evaluation. Alternatives composed of these potential options are then evaluated using an evaluation matrix based on criteria identified with CAW. Recommendations are made for alternatives that show the highest level of feasibility and potential for implementation. The alternative evaluation process will draw upon feedback from project stakeholders.

1.5 Regulatory Framework

Nehlson et al. (1991) listed the Carmel River steelhead stock as being at a high risk of extinction. In 1997, the National Marine Fisheries Service (NMFS) listed steelhead in the South-Central California Coast ESU/DPS as a "Threatened" species (NMFS 2002). In 2000, NMFS designated the Carmel River as critical habitat within the South-Central California Coast ESU (NMFS 2002).

Section 7 of the ESA of 1973 (19 USC § 1536(c)), as amended, requires that any actions authorized, funded, or carried out by a federal agency do not jeopardize the continued existence of a federally-listed endangered or threatened species, or result in the destruction or adverse modification of federally-listed designated critical habitat.

Restoration of California's anadromous fish populations is mandated by The Salmon, Steelhead Trout, and Anadromous Fisheries Program Act of 1988 (SB 2261) which states that it is a policy

of the State to significantly increase the natural production of salmon and steelhead. The California Fish and Game Code (Code) further describes the State's jurisdiction over such restoration of fisheries resources as follows:

- § 5930: The department shall, from time to time, examine all dams in all rivers and streams in this State naturally frequented by fish.
- § 5931: If, in the opinion of the commission, there is not free passage for fish over or around any dam, the department shall cause plans to be furnished for a suitable fishway, and order in writing the owner of the dam to provide the dam, within a specified time, with a durable and efficient fishway, of such form and capacity and in such location as shall be determined by the department. Such fishway shall be completed by the owner of the dam to the satisfaction of the department within the time specified.
- § 5932: When all of the provisions of this article have been complied with, if in the opinion of the commission changed conditions make additional structures desirable for the free passage of fish, the department may make such additional structures and may expend such sums of money as it deems necessary for such additional construction, including the cost of insurance against any liability which the department may incur in connection with such structures.

1.6 Background

CAW operates Los Padres Dam on the Carmel River at approximately RM 24.8. The Los Padres Dam poses a passage barrier to both upstream migrating adults and downstream migrating post-spawn adults and juvenile steelhead. To access the river upstream of Los Padres Dam, currently, adult steelhead enter a Denil type fish ladder and fish trap, located on the west bank, downstream of spillway tailrace. Steelhead are passively transferred from the fish trap to a truck, and released in the reservoir. Although the trap is in good condition, the fish ladder is not operating at peak efficiency. It is undersized, poorly oriented, and the outlet elevation is too high. Further, the existing trap and haul system is not sized to meet future recovery goals established for steelhead within the Carmel River.

The mouth of the Carmel River provides a temporal barrier to fish passage. Sand bars develop on a seasonal basis in the summer and fall and provide a physical barrier to upstream and downstream migration. When the sand bars are displaced in the winter and spring by increased flows within Carmel River, steelhead are able to migrate through the Carmel River mouth. Steelhead currently have access to historic spawning and rearing areas in the Carmel River and

tributaries downstream of Los Padres Dam. Access to spawning and rearing areas above Los Padres Dam is restricted since 1949 when the dam was built.

Steelhead face additional impediments to upstream migration at San Clemente Dam (RM 18.6), Old Carmel River Dam (RM 18.3), and experience seasonal river dewatering between Scarlett Narrows (RM 8.7) and the Pacific Ocean. Pumping of groundwater for water supply downstream of Los Padres Dam removes a significant amount of water from the river (MPWMD, 2004). The reduced river flows present migration barriers in the lower river when flows drop below 5 to 10 cfs. At this time however, the critical barrier to passage at low-flow conditions below Carmel River Dam has not been definitively identified. Peak winter storms and the hydrologic cycle of the Carmel River watershed play a critical role in the successful upstream migration of steelhead.

Currently, the only route for downstream fish migration at Los Padres Dam is via the spillway. Flow in the spillway is very shallow downstream of the crest, and consequently, fish are highly susceptible to contacting the concrete surface as they pass, which can cause physical injury and induce mortality (MPWMD 2004 and Wagner 1983). When the lake elevation falls below the spillway crest (1039.85'), no downstream migration pathway exists for steelhead. In recent years, a small notch has been cut in the spillway crest to provide outflow to a stage of 1039.12'. However, this 9-inch notch does not allow sufficient depth to pass fish without causing physical damage in the spillway (MPWMD 2004).

2 Study Area

2.1 Site Description

2.1.1 Location

The Carmel River is a central California coastal river that drains approximately 255 square miles to the Pacific Ocean (Figure 1). The river has three dams on its mainstem; Old Carmel River Dam (RM 18.3); San Clemente Dam at river mile (RM) 18.6, and Los Padres Dam at RM 24.8. The Carmel River is home to anadromous steelhead trout and California Red Legged Frog, both threatened species under the federal Endangered Species Act.

2.1.2 Access

Los Padres Dam is accessible by Nason Road. The gated access point is about 1 mile southwest of the community of Cachagua and about 12 miles from town of Carmel Valley. Upon entering CAW property, an unpaved road crosses the lower end of the spillway on a Bailey bridge, and continues up the embankment of the earth fill dam and across the dam crest. The length of the dam crest is accessible from the west hillslope abutment to the gravity wall located on the west

side of the spillway. Due to a vertical distance down from the west gravity wall, the spillway crest and east gravity wall are difficult to access. When water surface elevations exceed approximately 1,025 feet, the spillway crest is only accessible by boat via the forebay. The spillway is dry when the reservoir elevation is about 1,020 feet or below. At this point, the upstream face of the Ogee spillway can be accessed by land. On the downstream end of Los Padres Dam, the low-level outlet valves and the fish trap are accessible by road.

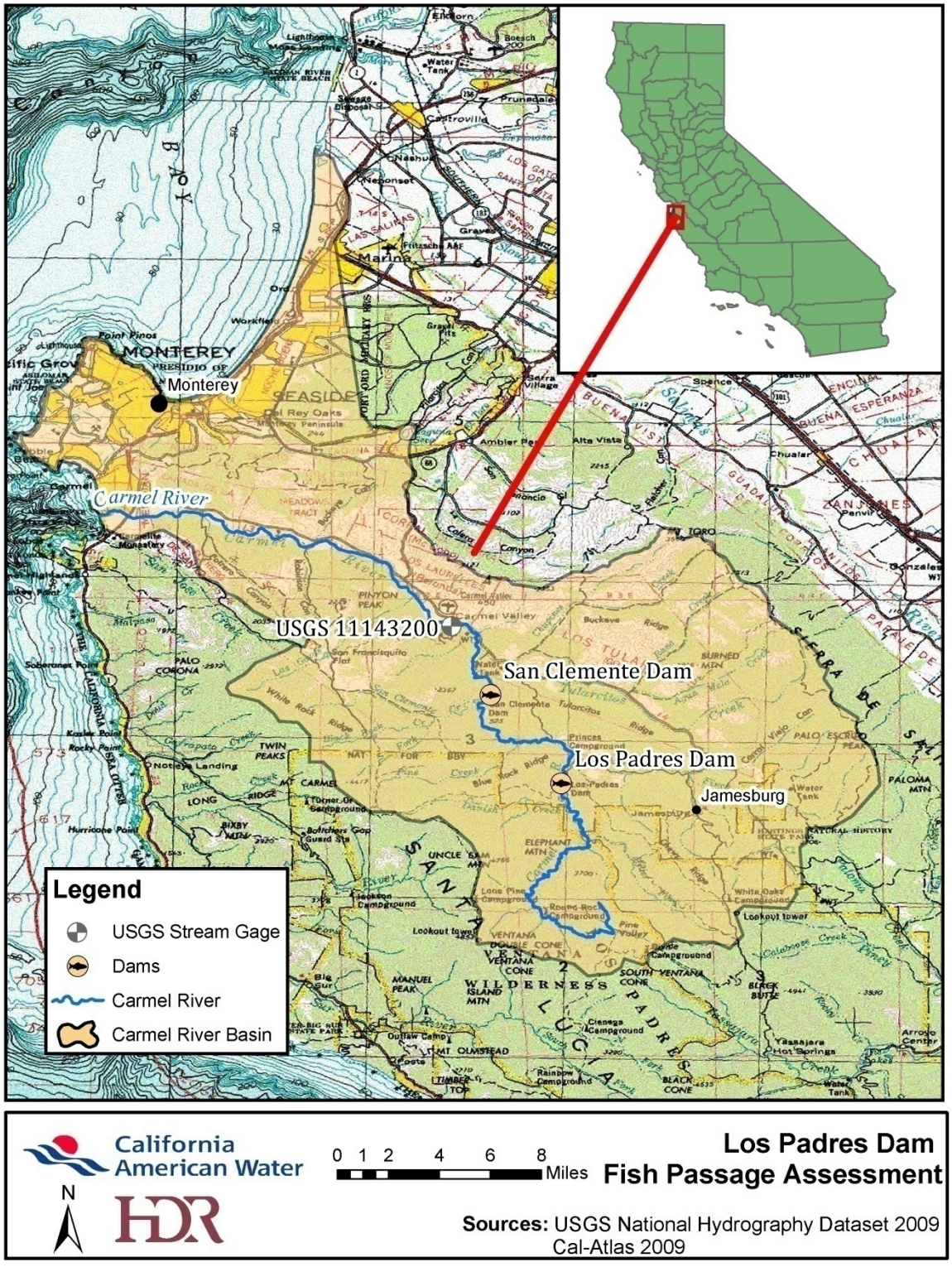


Figure 1. Site and vicinity of the Los Padres Dam and Reservoir project site.

2.2 Los Padres Dam Facility Description

Los Padres Dam is a 148-foot high earth fill dam on the Carmel River with an embankment crest elevation of 1,058 feet. The original storage capacity behind Los Padres Dam was 3,030 acre-feet at elevation 1040, but recent estimates indicate the current storage is 1,786 acre-feet due to sedimentation (Smith et al., 2009). Major site features are shown in Figure 2.

The spillway at Los Padres Dam is an Ogee crest with a crest elevation of 1039.85 feet (See Photograph 1). The concrete spillway is approximately 600 feet long and extends from the crest elevation of 1039.85 feet to 948.74 feet. Spillway flow drops approximately 30 feet from the end of the spillway to the tailrace (See Photograph 2). Since 1999, the water surface elevation in the reservoir has fluctuated between a low of 1006.60 and a high of 1042.95 (CAW, 2009). Based on the spillway discharge curve, a reservoir elevation of 1042.95 produces an approximate spillway discharge of 3,200 cubic feet per second. When the reservoir elevation falls below the spillway crest, the only outlet from the dam is a low-level release located on the west end of the dam.

Photograph 1. Ogee-crest spillway at reservoir outlet.

Photograph 2. Approximate 30-foot drop at tailrace, downstream of spillway.

In 1984, CAW modified the spillway with the addition of a concrete curb in the lower 200 feet of the spillway, added a 16-foot steel extension to the end of the spillway, and removed bedrock from the right bank of the downstream plunge pool (See Photographs 3 and 4). These improvements were intended to concentrate downstream passage of fish to the right side of the spillway, improve hydraulic depth, and to direct fish away from the bedrock at the end of the spillway and into the plunge pool.

Photograph 3. Spillway with concrete berm oriented on the left hand side of the photograph.

Photograph 4. Steel ramp attached to spillway outfall.

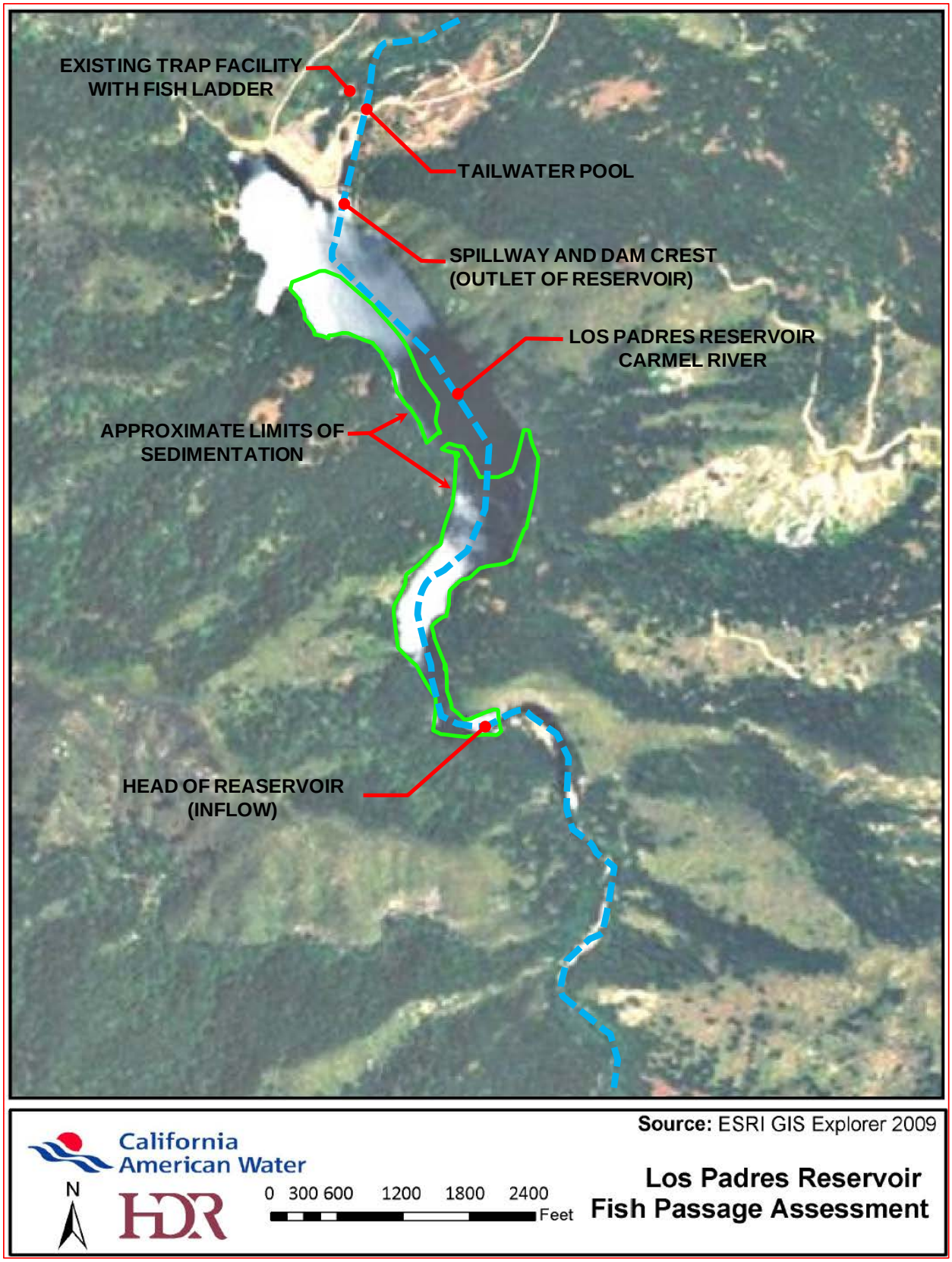


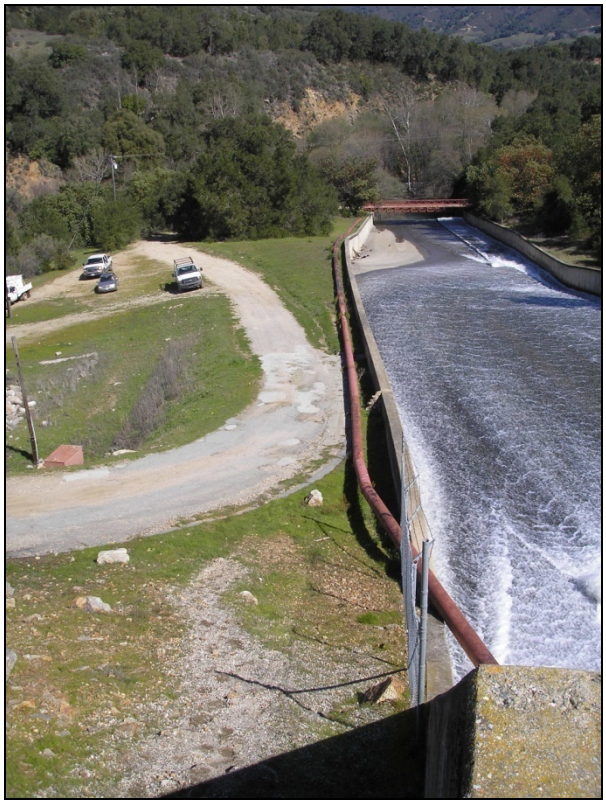
Figure 2. Major site features within the Los Padres Dam project area.

About 250 feet downstream of the dam on the left bank, a Denil ladder is in operation to transport upstream migrating steelhead to an adult fish trap (Photograph 5). Steelhead are transferred from the fish trap to a truck via water-to-water transfer, hauled upstream of the dam crest, and released in the reservoir. Two old upstream migration structures exist on the right bank downstream of the currently operating trap. In 1982, a low flow fish barrier made out of gabions (rock-filled wire baskets) was placed just upstream of the old ladder entrance to prevent fish from passing into the plunge pool below the spillway. The old ladder/trap structures were in use prior to the construction of the new trap in 1999 located on the left bank.

In 2003, CAW modified the gabion structure below the plunge pool to improve passage conditions, while retaining flexibility to use the older ladder on the right bank. This project involved removing rusted, broken sections of the gabion wire baskets, buttressing the fish ladder with boulders, removing several mid-channel willows and adjusting the gradient of the streambed above the older ladder (MPWMD 2004). The effectiveness of the current ladder structure is in question; future design should consider the ladder size and configuration, the elevation and orientation of the ladder entrance, and the bed and surface water elevations of the tailrace.

A water supply pipe provides water from the reservoir (forebay) to the existing fish trap. Water is siphoned from a small intake behind the spillway crest and is diverted to two points of discharge: the fish trap; and to a point about halfway up the Denil ladder to provide attraction flows for migrating adult steelhead. The water supply pipe runs along the outside of the west wall of the spillway for most of its length (Photograph 6). As mentioned previously, attraction flows at the fish ladder and water levels over the spillway have been inadequate for facilitating both upstream and downstream fish passage. When the reservoir level drops below the elevation of the spillway crest (1039.85 feet), water no longer flows over the spillway and effectively eliminates downstream passage. The existing notch provides some flow over the spillway until water surface elevations drop below 1039.95 feet. The water supply pipe also extends to one of the old fish traps, but this extension is no longer in operation.

Photograph 5. Denil type fish ladder, auxiliary water supply pipe (center), and adult fish trap (foreground).



Photograph 6. Water supply piping adjacent to existing spillway.

3 Hydrology

Hydrology for the Carmel River was determined by compiling data from several sources, including the United States Geological Survey (USGS) gage at Robles del Rio (No. 11143200), CAW, MPWMD, and the Western Regional Climate Center (WRCC). Stage duration, frequency analysis, and flow duration analyses using the aforementioned data are presented to identify critical flows and timing for fish passage.

3.1 Stage Duration Analysis of Forebay Elevations for Los Padres Reservoir

An automated stage recorder has been monitoring forebay stages since January 1, 1999. Prior to that date, stage recordings were logged manually. A stage-duration analysis of the data was conducted to determine what percent of the time the reservoir would be above certain levels during different migration periods. Table 1 presents details on the maximum and minimum annual forebay elevations and start/stop dates for flow over the spillway for water years 1999-2008.

Table 1. Summary of Los Padres Dam forebay stage data, for water years 1999-2008.

Water Year	Water Year Classification[1]	Start Spill	End Spill	Max Stage (ft)	Min Stage (ft)
1999	Normal	12/1/1998	7/7/1999	1,042.37	1,028.16
2000	Above Normal	1/23/2000	7/14/2000	1,042.95	1,020.78
2001	Normal	1/12/2001	6/2/2001	1,041.91	1,020.93
2002	Below Normal	12/2/2001	5/31/2002	1,041.60	1,015.17
2003	Normal	11/9/2002	7/1/2003	1,042.87	1,008.30
2004	Below Normal	12/30/2003	5/27/2004	1,042.30	1,006.60
2005	Wet	12/13/2004	7/14/2005	1,041.77	1,011.10
2006	Wet	12/22/2005	7/22/2006	1,042.49	1,009.18
2007	Critically Dry	1/1/2007	5/6/2007	1,040.55	1,018.33
2008	Normal	1/4/2008	5/17/2008	1,042.90	1,015.26

Source: California American Water Company
[1] – per "Classification of Unimpaired Carmel River Flows at San Clemente Dam Site" (MPWMD, 2009c)

Mean daily stage data was evaluated for the following time periods during the period of record (water years 1999-2008): Oct-Sept (12 months); January through June; and March through May. The time period January through June represents the overall time period of downstream migration of juvenile steelhead; March through May is considered to be the primary downstream migration period. The determinations of primary and total downstream migration periods were made in a stakeholder meeting at CAW office in Pacific Grove, CA on March 11, 2009.

The results of the stage-duration analysis are presented in Table 2, and a plot of the stage-duration curves for the above-mentioned time periods is presented in Figure 3. Evaluation of historical data indicates that 95 percent of the time, Los Padres Dam forebay elevations are lower than 1040.89 during the primary downstream migration period of March through May. During the same period, elevations are lower than 1039.77 feet for only 5 percent of the time, an operating difference of about 1.2 feet. During the entire downstream migration period January through June, the 5-95% range of elevations is 1040.94-1038.26, a difference of about 2.7 feet. The spillway crest is at elevation 1039.85 feet.

Table 2. Stage-duration table of mean daily forebay elevations for Los Padres Dam based on water years 1999-2008.

Time Period	Jan-Dec		Jan-Jun		Mar-May	
Probability of Exceedance (%)	**Stage (ft)**	**Depth of Flow[1] (ft)**	**Stage (ft)**	**Depth[1] (ft)**	**Stage (ft)**	**Depth[1] (ft)**
1	1,041.4	1.6	1,041.6	1.8	1041.6	1.8
5	1,040.7	0.9	1,040.9	1.1	1040.9	1.1
10	1,040.4	0.6	1,040.7	0.9	1040.7	0.9
25	1,040.2	0.4	1,040.4	0.6	1040.4	0.6
50	1,039.4	-0.5	1,040.2	0.4	1040.2	0.4
75	1,026.3	-13.6	1,040.0	0.2	1040.1	0.3
90	1,017.6	-22.3	1,039.4	-0.5	1040.0	0.2
95	1,014.6	-25.3	1,038.3	-1.6	1039.8	-0.1
99	1,008.3	-31.6	1,027.0	-12.9	1038.9	-1.0

[1] Positive depths indicate forebay conditions above the spillway crest (1039.85 feet) while negative values indicate forebay conditions below the spillway crest.

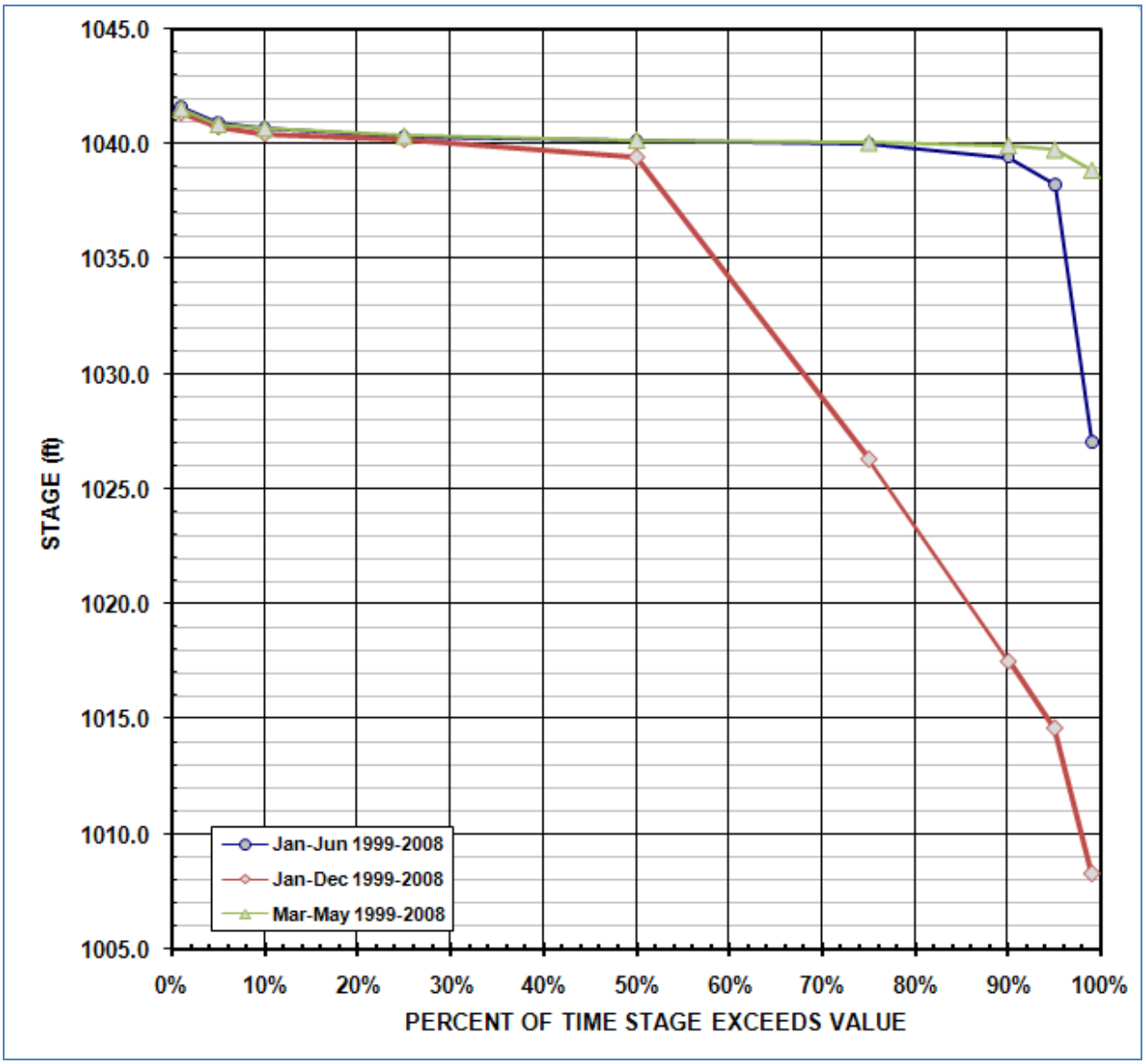


Figure 3. Los Padres Dam Stage Duration Curves for mean daily forebay elevations calculated over three specific time intervals for the period of record 1999 to 2008.

3.2 Carmel River Hydrology

Carmel River hydrology was evaluated at two locations in order to characterize annual and seasonal hydrologic trends that are anticipated to affect the operation and effectiveness of the proposed fish passage facilities. Hydrology was evaluated by determining the recurrence of annual peak instantaneous flows, exceedance of mean daily flow, and by examining flows associated with the 12-hour, 24-hour, and 36-hour storm durations. A summary of the methods and results for each hydrologic parameter is presented in this section.

Hydrology data used for the determination of Carmel River hydrology were collected at two locations: the USGS gage below San Clemente Dam (USGS No. 11143200, Carmel R at Robles

del Rio, period of record 1957-present); and a gaging station directly below Los Padres Dam operated by MPWMD (period of record 2001-present).

3.2.1 Contributing Basin Area of Los Padres Dam at USGS Gage

GIS-based spatial analysis was used to determine the contributing basin areas for the Carmel River watershed above the USGS Gage ID No. 11143200 and Los Padres Dam. Both values were compared to identify if there was a need to conduct a basin-area reduction of the recorded USGS flow data. The contributing basis area for the Carmel River watershed above the USGS gage was estimated to be 193.4 square miles while the contributing basin area above Los Padres Dam was calculated to be 44.2 square miles. Thus, the contributing basin area for Los Padres Dam is 23% of the total contributing basin area of the USGS gage. The contributing basin areas for each location are illustrated in Figure 4.

Comparison of the peak flows recorded at the USGS gage with those recorded at the MPWMD gage immediately downstream of Los Padres Dam for water years 2002-2008 reveal that the Los Padres basin contributes approximately 58% of the downstream peak. This hydrologic contribution is substantially higher than the 23% basin area contribution. The higher hydrologic contribution is likely due to higher values of mean annual precipitation in the Los Padres basin (37.6 in/yr vs. 33.6 in/year for the entire basin at the USGS gage).

A flow frequency analysis was performed for the USGS gage for water years 1956 through 2008 (exclusive of 1957, n=52) within the guidelines of Bulletin 17B (US Interagency Advisory Committee on Water Data 1981) by using the public domain software HEC-SSP Version 1.0, a program developed and issued by USACE. The 52-year period of record for the Carmel River USGS gage was used in the distribution. Because station skew is sensitive to extreme events, a generalized skew was used with the average skew coefficient for the region, presented in Plate 1 of Bulletin 17B (skew = -0.56, MSE = 0.302). The analysis predicted the following exceedance flows presented in Table 3.

Table 3. Peak flow frequency curve for Carmel River at USGS gage No. 11143200) for water years 1956-2008 (excl. 1957) using Bulletin 17b procedures.

Recurrence, years	Percent Chance Exceedance	Peak Discharge, cfs
2	50	2,300
5	20	5,700
10	10	8,500
20	5	11,700
50	2	16,200
100	1	19,800

The approximate flow at the MPWMD gage downstream of Los Padres Dam may be obtained by multiplying the values presented in Table 3 by the percentage of contribution of the Los Padres basin, 58%. The resulting frequency curve for the Carmel River at Los Padres Dam is presented in Table 4.

Table 4. Peak flow frequency curve for Carmel River below Los Padres Dam.

Recurrence, years	Percent Chance Exceedance	Peak Discharge, cfs
2	50	1,300
5	20	3,300
10	10	4,900
20	5	6,800
50	2	9,400
100	1	11,500

It is important to note that the peak flow analyses for both the USGS gage and Los Padres Dam do not consider attenuation from Los Padres Dam and San Clemente Dam, effectively assuming that the dams will operate run-of-river during the peak flow events.

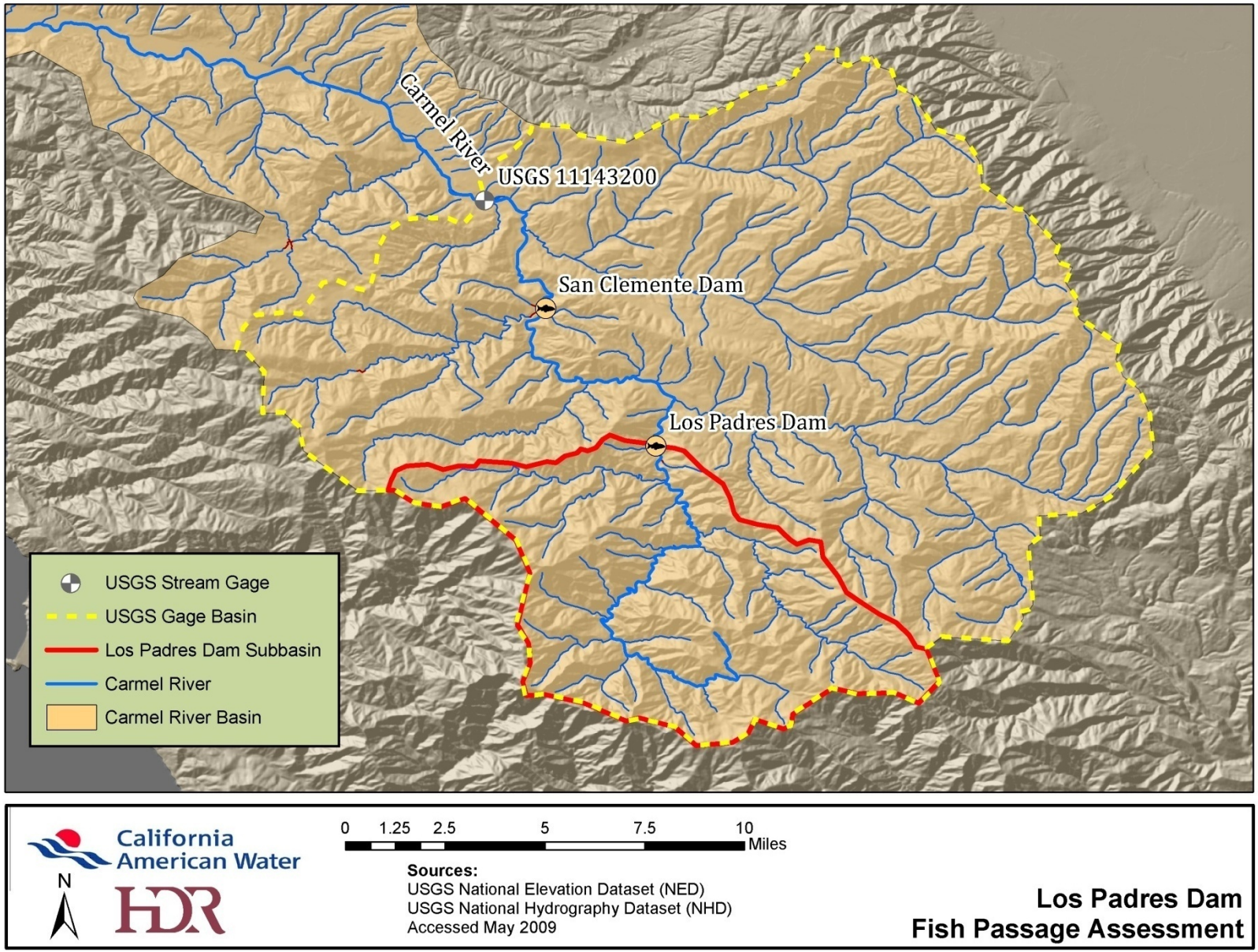


Figure 4. Contributing basin areas for Los Padres Dam and location of the USGS Gage ID No. 11143200.

3.2.2 Flow-Duration Analysis of Mean Daily Flows

A flow duration analysis for mean daily flows was calculated using daily average flows measured at the USGS gage downstream of San Clemente Dam. A 21-year period of record was used for the analysis (water years 1988-2008, n=7671).

This analysis results in the percent of time that flows may be exceeded during three time periods, including the primary steelhead upstream migration period of January through April, the general steelhead upstream migration period of mid-November through June, and the water year October through September. The results of the flow duration analysis are presented in and plots of these curves are presented in Figure 5. Evaluation of historical data for the January through April time period indicates that 90% of the mean daily flow is between 3.4 cfs (exceeded 95% of the time) and 879 cfs (exceeded 5% of the time). Evaluation of all historical water year data indicates that 90% of the mean daily flow is between 1.7 cfs and 424 cfs.

This information is used for the design of the fish trap, particularly the sizing of the ladder and in determining the tailwater elevation in the Carmel River for the exit elevation of the ladder.

Table 5. Flow duration results for mean daily flow in Carmel River at USGS gage (11143200) downstream of San Clemente Dam.

Percent of time flow is equaled or exceeded (%)	Flow (cfs)		
	Oct 1 to Sept 30	Nov 16 to Jun 30	Jan 1 to Apr 30
1	1,250.0	1,500.0	2,050
5	424.0	582.0	879
10	210.0	356.0	535
25	63.0	128.0	241
50	13.0	41.0	92
75	4.5	11.0	33
90	2.3	3.1	7.5
95	1.7	2.4	3.4
99	0.3	0.2	0.3

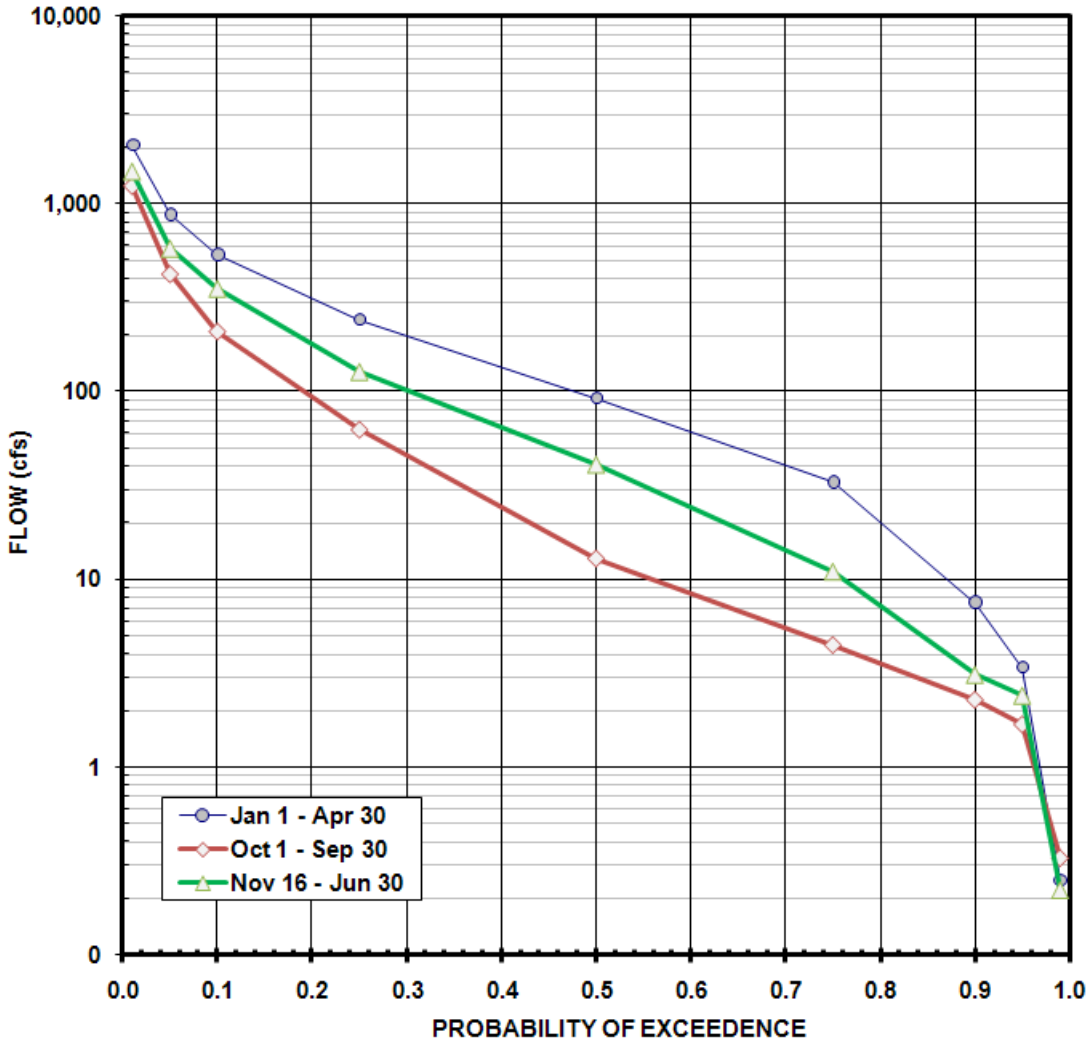


Figure 5. Flow Duration of for mean daily flow in Carmel River at USGS Gage ID No. 11143200.

3.2.3 Hydrograph Flow-Duration Analysis for Fish Passage Timing

This section describes a detailed examination of the response of the Carmel River to storm events in water years 2002-2008. Thirty events that resulted in substantially increased flows for greater than 12 hours were selected for flow-duration analysis. Fifteen-minute flow data provided by MPWMD (MPWMD 2009b) served as the data source.

Steelhead spawning migration is thought to be triggered by "pulses" of elevated, sustained river flows caused by storms (need a reference here). The purpose of the flow-duration analysis is to determine the frequency and magnitude of these flood "pulse" events. For this analysis, 12-, 24-, and 36- hour flow durations were selected for comparison. Each storm-related hydrograph occurring within the period of record was examined. Flows were recorded for each

flow event lasting for a continuous duration of 12, 24, and 36 hours. A schematic representing the three flow durations for two storm hydrographs is presented in Figure 6.

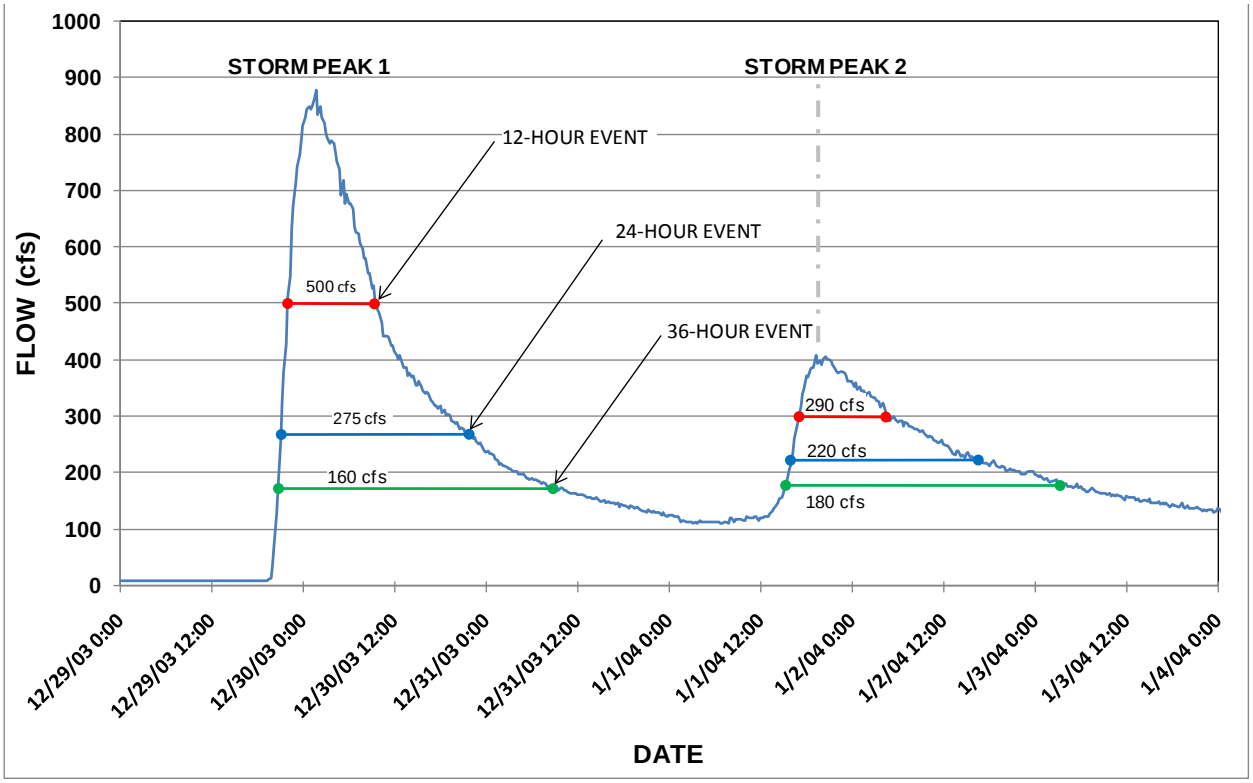


Figure 6. Schematic representation showing the 12-, 24, and 36-hour continuous flows for two example storm hydrographs.

Table 6 presents all 12-, 24-, and 36-hour discharges observed flood events throughout the period of record. As shown, 30 flow events occurred from 2002 to 2008 that were sustained for over 12 hours while 24 events were sustained for 24 hours, and 20 events for 36 hours. The average 12-, 24-, and 36- hour events were calculated to be 414, 323, and 259 cfs respectively. The average storm occurrence per year was calculated to be 5.0, 4.2, and 3.7 events per year for the 12-, 24, and 36- hour events, respectively. Three 12-hour events over 1,000 cfs occurred throughout the 7-year period of record, all of which occurred during Water Year 2006, a "Wet" water year. All other 12-hour events ranged from 890 to 75 cfs throughout "Below Normal," "Normal," and "Critically Dry" conditions, as classified by MPWMD (2009c).

Table 6. Summary of 12-, 24-, and 36- hour storm flows in Carmel River at MPWMD gage below Los Padres Dam, water years 2002-2008.

Storm Event	Water Year	Water Year Classification[1]	12-hr Flow (cfs)	24-hr Flow (cfs)	36-hr Flow (cfs)
1	2002	Below Normal	435	300	210
2	2002	Below Normal	175	145	115
3	2002	Below Normal	300	245	220
4	2002	Below Normal	310	260	225
5	2002	Below Normal	75	65	60
6	2002	Below Normal	100	100	95
7	2003	Normal	250	220	--
8	2003	Normal	320	--	--
9	2003	Normal	350	310	275
10	2003	Normal	335	265	235
11	2003	Normal	220	160	140
12	2003	Normal	85	--	--
13	2003	Normal	100	--	--
14	2004	Below Normal	445	275	160
15	2004	Below Normal	290	220	180
16	2004	Below Normal	890	780	640
17	2005	Wet	1,080	840	680
18	2005	Wet	310	250	220
19	2005	Wet	355	325	300
20	2006	Wet	85	70	60
21	2006	Wet	840	740	585
22	2006	Wet	1,100	790	650
23	2006	Wet	415	380	360
24	2006	Wet	1,060	--	--
25	2006	Wet	110	90	80
26	2007	Critically Dry	150	100	80
27	2007	Critically Dry	175	160	135
28	2008	Normal	610	--	--
29	2008	Normal	800	520	--
30	2008	Normal	655	475	--
Average Event Discharge (cfs)			414	323	259
Average Events Per Year			5.0	4.2	3.7

[1] – MPWMD 2009c.

Table 7 summarizes the minimum, maximum, and median 12-, 24-, and 36- hour continuous storm flows for each water year classification. Minimum values for all water year classes and all storm flow durations range from 60 to 160 cfs with the lowest values occurring during "Wet"

and "Below Normal" water years. Maximum values range from 135 to 1,100 cfs with the lowest values occurring during the "Critically Dry" water years and the highest values occurring during the "Wet" water years. Median values for all water year classifications and storm flow durations range from 108 to 415 cfs. As expected, the total number of storm events meeting the 12-hour duration is significantly fewer (2 events) during the "Critically Dry" years, while there are 9 events (average per year) that occur during the "Below Normal," "Normal," or "Wet" years.

Table 7. Summary of minimum, maximum, and median flows for flow durations of 12-, 24-, and 36-hours, sorted by water year class.

Water Year Class	Carmel River storm flows (cfs)								
	12-hr			24-hr			36-hr		
	min	**max**	**median**	**min**	**max**	**median**	**min**	**max**	**median**
Critically Dry	150	175	163	100	160	130	80	135	108
Below Normal	75	890	300	65	780	245	60	640	180
Normal	85	800	328	160	520	288	140	275	235
Wet	85	1,100	415	70	840	353	60	680	330

4 Fisheries Resources

4.1 Steelhead Presence in Carmel River

The Carmel River contains migrating ESA listed steelhead from the South-Central California coast ESU. According to the California Department of Fish and Game (CDFG), anecdotal estimates place the historical steelhead run prior to dam construction in the Carmel River at around 8,000 adults annually (Becker and Reining 2008). Other qualitative estimates place the pre-dam population closer to 12,000 (Snider 1983).

California Fish and Game records of adult steelhead at the Los Padres ladder fish trap from 1949 to 2008 ranged from 558 in 1962 to just 2 in 1973. The overall average during this monitoring period was approximately 100 adult steelhead per year (Figure 7). Fish counts were not conducted during 1953-1961, 1964, 1966 through 1970, 1978 through 1981, and 1987. In the drought years of 1976 to 1977, and the early 1990's, counting operations were implemented but no adult steelhead were captured in the Los Padres trap. Due to inefficiencies and problems with the original ladder and trap, the fish count data has become more reliable since the installation of an automatic counter in 1993 and construction of a new ladder and trap in 1999.

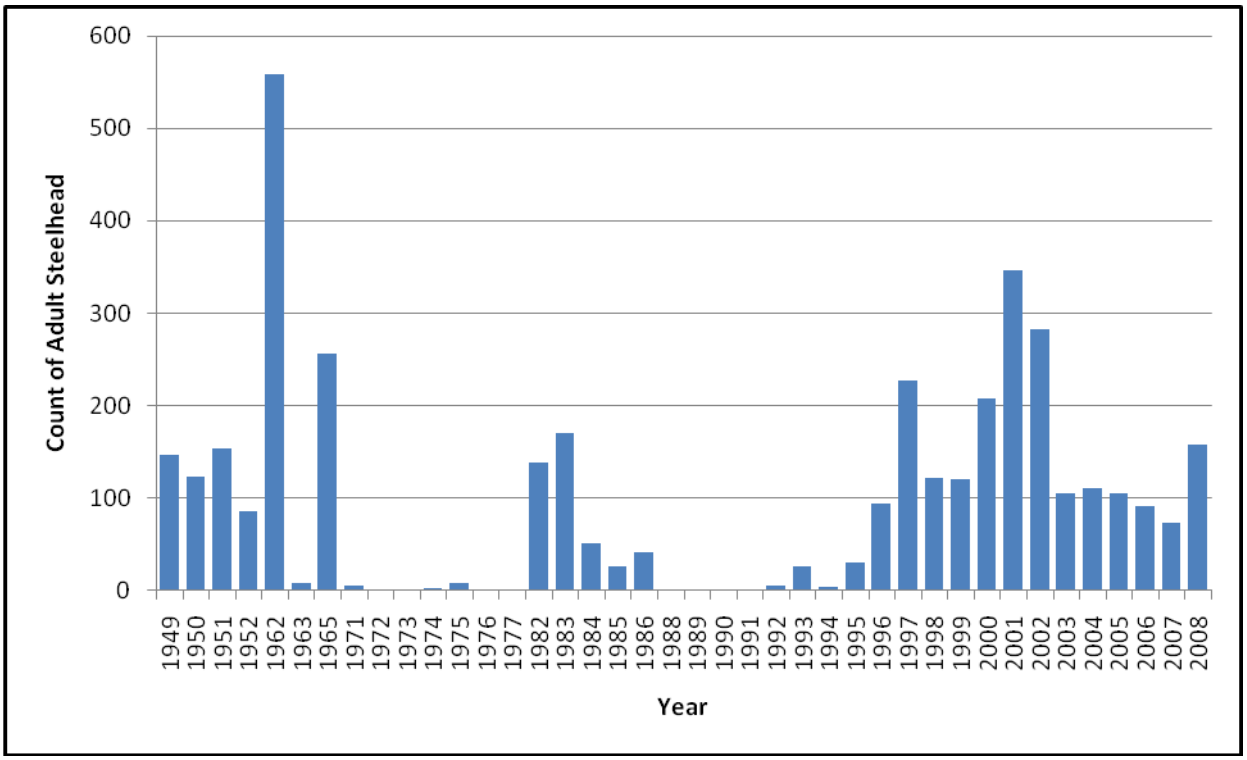


Figure 7. Historic data on the number of adult steelhead counted at the Los Padres Dam, Carmel River, CA from 1949 to 2008. Years when no data was reported (1953-1961; 1964; 1966-1970; 1978-1981; 1987) are omitted from the figure (MPWMD 2009d).

The number of adult steelhead below San Clemente dam is estimated to be much higher at 1,200 to 1,500 adults in 1984 (Kelly et al. 1987). The San Clemente ladder was equipped with a counter in 1974 and 1975 and counted 395 and 1287 adult steelhead respectively (Kelly et al. 1987). California American Water personnel also made twice daily counts of adults in the fish ladder at San Clemente between 1962 and 1973, which fluctuated between 94 and 1,350 fish (Kelly et al. 1987). Using observations from local field personnel, the CDFG estimated the annual steelhead spawning population in the mainstem Carmel River to be about 1,650 fish in 1965 (Titus et al. 2009).

Along with the dams, overall stream flow reductions due to drought and water withdrawals have played a large role in this decline. During the drought years of 1976 and 1977, zero adults were observed using the San Clemente Dam fish ladder. During the three-year period from 1988 to 1990, the river never breached the sand bar at the mouth, making the river inaccessible to adult steelhead.

In 2004, MPWMD reported that the number of returning adults had rebounded from the drought years of the early 1990's and appeared to have stabilized in the range of 400 to 800 fish (MPWMD 2004). Adult returns to the fish trap and transported upstream of Los Padres Dam, have averaged 190 fish since 1997. Between Los Padres Dam and San Clemente Dam, a

comparison of returns before and after 1980 indicates that the adult return to this portion of the basin has not recovered to levels that were common in the earlier period. Since 1997, the number of adults counted at San Clemente Dam has averaged 604 and ranged from 388 in 2004 to 861 in 1998, with a clear upward trend during the seven-year period immediately following the 1987 to 1991 drought. However, the overall population has not rebounded to levels that were common prior to the 1976-77 drought (MPWMD 2004).

The steelhead population upstream of Los Padres Dam is assumed to primarily express the resident life history strategy due to migration constraints linked to the dam (Snider 1983). The resident life history strategy is typically less prevalent in the presence of anadromous steelhead where the survival associated with migrating to the ocean and returning is greater than the survival associated with summer high temperature and low water conditions in the river. If upstream and downstream survival was improved at the dam the steelhead life history expressed above the dam would likely shift towards anadromous, instead of resident life histories. Snider (1983) estimated a range of juvenile density per mile to be between 2 to 1,371 per mile of stream. More recent surveys that were conduct in 1992 and 1994 estimated a density range of 5,269 and 4,528 juveniles per mile (CDFG 1995). Snider (1983) identified 14.75 miles of habitat for juvenile steelhead upstream of the dam. As a result, the area above the dam is estimated to have produced from 20,222 to 77,717 juveniles. If all resident life histories were converted to anadromous and the juveniles all smolted, than the basin would have produced between 400 and 1,500 additional anadromous steelhead adults (based on a 2% smolt to adult survival rate). This is consistent with NMFS recovery goals of 4,800 fish in the watershed, since an estimated 40% to 50% may spawn below San Clemente Dam and between 24.1% and 27.1% of fish passing San Clemente have also historically passed Los Padres Dam.

4.1.1 Upstream Adult Steelhead Migration Timing

Upstream adult steelhead migration occurs from December through May or June, with 95% of steelhead counted at San Clemente Dam from January through March (Wagner 1983). At the Los Padres fish trap, ocean-run adults were reported between January through mid-May from 1995 to present, with peak activity February through April (MPWMD 2009d). Arrival of the first adults observed between 1964 and 1975 was almost always preceded by flows of 200 cfs or greater, and the years where peak flows did not generally exceed 100 cfs had the lowest numbers of adult migrants reported (Snider 1983).

Recent data shows that peak adult upstream migration at Los Padres Dam occurred from mid February through March; however, in 2009 there had only been 21 fish counted at the trap as of May 6, 2009 (MPWMD 2009d). Figure 8 presents the adult count data from the Los Padres fish trap for 2007 to 2008 and 2008 to 2009.

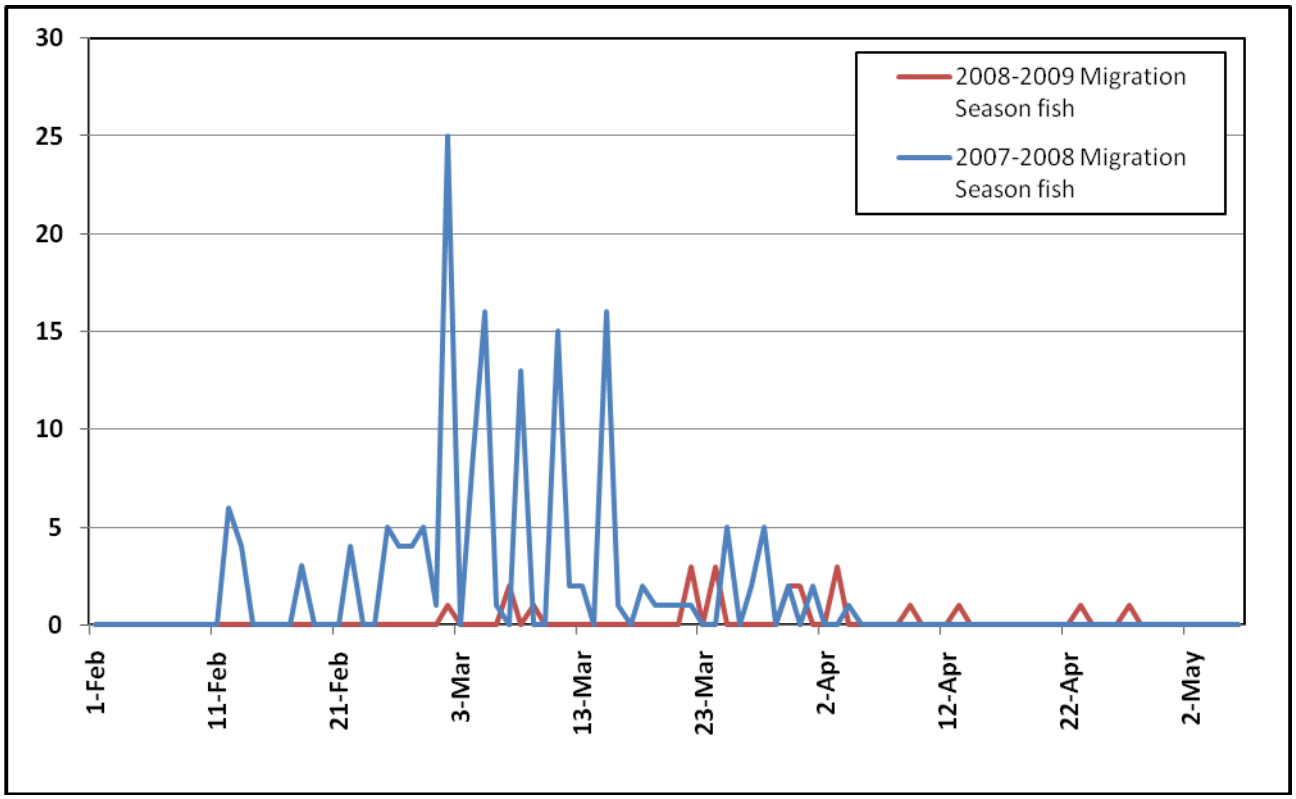


Figure 8. Adult steelhead counts at Los Padres Dam trap during the 2007-2008 and 2008-2009 migration periods on the Carmel River, CA (MPWMD 2009d).

4.1.2 Juvenile Downstream Migration

The period of active steelhead smolt downstream migration begins in December and continues through June, with the majority migrating in March, April, and May.

In 1973, surveys reported a total estimated population of juvenile steelhead above Los Padres Dam of just over 20,000, and close to 18,000 in 1974 (Snider 1983). Juvenile steelhead between San Clemente and Los Padres dams was estimated at approximately 33,000 in 1973, and close to 20,000 in 1974 (Snider 1983).

From CDFG surveys of juvenile steelhead in the reach downstream of Los Padres Dam, population density for the period prior to the 1987-1991 drought averaged 5,878 fish per mile (fpm) and ranged from a low of 3,648 fpm in 1974 to 9,307 fpm in 1986. Population density declined during the drought years of 1987-1991, averaging 683 fpm and dropping to a low of 22 fpm in 1989 (MPWMD 2004).

A CDFG report in 1993 found a yearling dominant population, and suggested there were inadequate hydraulic conditions to encourage outmigrating juvenile steelhead and post-spawn adults to pass over Los Padres Dam. This suggested that these life stages remained trapped in

the reservoir appeared to seek suitable spawning habitat in the upper river (Becker and Reining 2008).

Since the end of the 1987-1991 drought, population densities have ranged from about 4,000 to 6,000 fpm, except in two years, 2000 and 2003, when population density averaged 9,700 and 7,700 fpm, respectively, and now is similar to levels that were common in the 1970's and early 1980's (MPWMD 2004). Estimates of total numbers of juvenile steelhead for the entire mainstem Carmel River, based on annual adult counts and fall population surveys, put the juvenile population at between 89,000 and 94,000 fish (MPWMD 2004).

4.1.3 Anticipated Fish Passage Conditions

Anticipated target migration periods

Table 8 presents a summary of the anticipated migration periods for three life stages of steelhead within the Carmel River. Gray cells represent the general period of anticipated migration while the blue cells represent the anticipated periods of peak migration.

Table 8. Summary of baseline conditions for migration at the Los Padres Dam

Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult Migration												
Post-Spawn Adult Migration												
Juvenile Migration												

Anticipated migration flows

Selection of anticipated migration flows for steelhead within the Carmel River was performed using a combination of agency guidelines, hydrograph flow duration analysis for the MPWMD gage data, and anecdotal data gathered during preparation of this document. Although peak migration times differ slightly for all three steelhead life stages, the overall migration periods tend to overlap. Therefore, similar, more conservative fish passage flows were selected for each. Table 9 provides a summary of the selected migration flows for all three life stages.

Table 9. Summary of anticipated migration flows for three steelhead life stages.

Steelhead Life Stage	Selected Flow (cfs)	Relative Data
Upstream Adult	Max: 1,100 cfs	Max 12-hr storm event
	Min: 10 cfs	95% Exceedance for expected period of migration
Downstream Kelt	Max: 1,100 cfs	Max 12-hr storm event
	Min: 10 cfs	95% Exceedance for expected period of migration
Downstream Juvenile	Max: 1,100 cfs	Max 12-hr storm event
	Min: 5 cfs	95% Exceedance for expected period of migration

5 Fish Passage Options for Los Padres Dam

A number of methods and facilities are identified and evaluated based upon their ability to meet fish passage objectives over or around Los Padres Dam. Those fish passage options are categorized as:

- Upstream Fish Passage Options
- Downstream Fish Passage Options
- Dam Removal
- Conservation Hatcheries
- No Action

The following sections provide a description of each option as well their major advantages and disadvantages associated with implementation at Los Padres Dam.

5.1 Upstream Fish Passage Options

Eight potential options were formulated and evaluated based upon their ability to meet the objectives of this study with respect to upstream fish passage. These seven options are lumped into three general categories: Volitional Passage Options, Trap and Haul Passage Options, and Mechanical Fish Lift Options. Volitional Passage Options include fishways or fish ladders where both adult and juvenile steelhead are allowed to swim upstream around Los Padres Dam to the reservoir forebay where they can continue migration upstream. Trap and Haul Passage Options include systems where fish are collected, transferred into a transport vehicle, physically transported around Los Padres Dam to the reservoir forebay or reservoir inlet, and then released so that they can continue their migration upstream. Mechanical Fish Lift Options include mechanized equipment and facilities that collect and transport adult and juvenile steelhead upstream over the crest of Los Padres Dam to the reservoir forebay where they can continue migration upstream. The seven potential upstream fish passage options evaluated in

this document are summarized in Table 10. Descriptions for each option are provided in the following sections of this document.

Table 10. Summary of potential options for upstream fish passage at Los Padres Dam.

General Category	Fish Passage Option
Volitional Passage Options	Full-Scale Fishway Hybrid Fishway Reservoir Bypass
Trap and Haul Fish Passage Options	Trap and Haul to Reservoir Forebay Trap and Haul to Reservoir Inlet
Mechanical Fish Lifts	Trolley Type Mechanical Fish Lift Diagonal Lock Type Mechanical Fish Lift Pumps or Screw Type Mechanical Fish Lift

5.1.1 Volitional Fish Passage Options

Volitional fish passage options represent the construction of a direct volitional passage rout around Los Padres Dam for juvenile and adult upstream migrants. Direct volitional passage would be facilitated through construction of a fishway that traverses the vertical height of approximately 114 feet from the tailwater to the forebay. The intent of the fishway is to take a single vertical height of 114 feet, which steelhead cannot navigate, and distribute it into many pools with vertical heights of 0.5 to 1 feet which steelhead can navigate. The fishway would most likely be composed of a vertical slot design, but could include a combination of a pool and weir, pool and chute, or roughened chute or channel to facilitate existing site conditions.

As described in Section 3.1, the fluctuation in forebay elevations for 95% of observed conditions during the anticipated period of steelhead upstream migration allows for sufficient connectivity to a 6 to 10-foot tall fishway exit (hydraulic entrance). This may preclude the necessity to construct multiple or adjustable outlets to accommodate fluctuations in forebay water levels but may require inlet flow control depending on acceptable diversion rates.

There are two possible fishway configurations considered in this document as options at Los Padres Dam. Configuration One could include a full-scale fishway with 0.5 feet drops from pool to pool to accommodate upstream migration of juvenile and adult steelhead. For this option, the term "full-scale" refers to a fishway sized large enough to accommodate operational flows that meet attraction flow requirements at the fish inlet without the use of an Auxiliary Water Supply (AWS). Configuration Two could include a hybrid fishway which is constructed with pools having drops of 1-foot but also accommodates the use of stoplogs and weir boards to convert each pool to 0.5-foot drops when juvenile upstream migration is anticipated. Configuration Two would be sized smaller than Configuration One and would require an AWS

to meet attraction flow requirements. The following paragraphs describe each option in more detail.

Configuration One – Full Scale Fishway

Configuration one could include a fishway that is sized large enough to accommodate attraction flows at the fishway inlet without the use of an AWS. Per NMFS guidelines (NMFS, 1997), attraction flow shall range from 5 to 10 percent of the expected high fish passage flow. As summarized in Section 4.1.3 of this document, the high fish passage flow is anticipated to be 1,100 cfs. Given the hydrologic characteristics anticipated at Los Padres Dam, the required attraction flow would therefore be approximately 110 cfs. To accommodate flows of this magnitude, and to accommodate the inherent fluctuation of flows observed in the Carmel River itself, a vertical slot type fishway could be an appropriate option for this application. Using the design guidelines presented in Milo Bells' "Fisheries Handbook" (Bell 1991) this fishway would need to include a double vertical slot hydraulic control and would need to have pool dimensions of 8 feet wide by 10 feet long. At a water depth of 10 feet, each 1.5-foot wide slot would have an approximate hydraulic capacity of 57 cfs, which corresponds to an overall capacity of approximately 114 cfs. Sharp-crested sills could be placed at a height of 1.5-feet to accommodate low-flow conditions (i.e. 5 to 10 cfs) where juvenile fish may migrate upstream.

The major obstacle to this alternative is the distance required to traverse the elevation change (approximately 114 feet) from the tailwater to the forebay. With a 0.5-foot elevation difference from pool to pool, a total of 228 pools would be required to reach the forebay. Assuming each pool is 8 feet wide by 10 ft long, including concrete baffles, as well as entry and exit pools the total length of the fishway would need to be on the order of 2,500 feet. In addition, due to the energy expenditure of fish required to traverse such a long fishway, resting pools may need to be included, especially on directional changes, to allow fish to rest before resuming their upstream migration through the fishway. This may add an additional 500 feet of fishway. Therefore, the total fishway length could range from 2,500 to 3,000 feet.

In this configuration, the fishway would need to transverse the west bank of the Carmel River several times before descending to the tailrace. Each length of the fishway would "switchback" a minimum of four times with lengths ranging from 700 to 1,200 feet long in order to ascend the vertical difference to the tailrace.

Another challenge associated with this alterative is the water demand and potential temperature control needs. Long fishways have been abandoned in the past due to an inability to maintain safe water temperatures. Water tends to warm as it travels down the concrete fishway. Although, this could be studied in more detail during the design process, it is possible

that the water would warm to temperatures considered detrimental to steelhead. One example is the 3-mile long 200 foot tall fishway constructed on the Deschutes River at Pelton Dam by Portland General Electric in the 1950's (Idaho Power Company 2001). It has long been abandoned due to the inability to keep water temperatures cool enough for steelhead. However, a second ladder constructed by Portland General Electric on the Clackamas River in Oregon, continues to successfully facilitated passage of salmon and steelhead. This ladder is 1.9 miles long and ascends a height of 196 feet (Idaho Power Company 2001). It may be possible to use a more complex approach where water from a deep location in the reservoir is used to cool the fishway as needed. However the use of this water would require gas stabilization and oxygenation at the point of entry which may be difficult to accomplish.

Advantages:

- Fully volitional passage around Los Padres Dam with proven vertical-slot controlled fishway configuration,
- Limited operation and maintenance effort,
- Meets and exceeds required attraction flow requirements over the full range of anticipated migration flows, and
- Can conform to CEQA as well as state and federal permitting requirements with moderate level of effort.
- Entrance and exit could be modified as needed to operate under a number of future conditions.

Disadvantages:

- Requires significant capital investment for a structure that is 2,500 to 3,000 feet in length,
- Complex siting and layout may require some impact to the face of Los Padres dam, and
- Water temperature concerns would require careful evaluation during design which may require supplemental water system.

Configuration Two – Hybrid Fishway

Configuration Two could include a fishway that is sized smaller than Configuration One and would require supplemental water to accommodate attraction flows at the fishway inlet with the use of an AWS. The fishway would include a single vertical slot hydraulic control with pool dimensions of 6 feet wide by 8 feet long and a pool to pool height differential of 1-foot. At a water depth of 10 feet, the 1-foot wide slot would have an approximate operational capacity of 65 cfs. However, this configuration would include provisions for multiple guide slots where stoplogs and weir boards could be placed to convert the fishway into a pool and weir controlled fishway during the summer months when low-flow conditions are observed. While in a pool

and weir operational mode, each pool would be split in half to produce twice as many pools with 0.5 feet of height differential from pool to pool while still meeting the maximum 4 pounds per cubic foot-second energy dissipation guideline provided by NMFS (NMFS 1997). This optional configuration could facilitate juvenile upstream migration at flows as low as 0.5 cfs for as long as hydraulic connectivity is maintained at the fishway exit (i.e. at the reservoir forebay). In consideration of the forebay elevation data presented in Section 3.1, connectivity to the fishway may be maintained through the month of June whereas the forebay elevations tend to drop more rapidly through the month of July to a point well below the possible opening of a single inlet fishway.

One advantage to Configuration Two is that the overall length of the fishway is reduced by as much as half of Configuration One. With a 1.0-foot elevation difference from pool to pool, a total of 114 pools would be required to reach the forebay. Assuming each pool is 6 feet wide by 8 ft long, including concrete baffles, as well as entry and exit pools the total length of the fishway would need to be on the order of 1,050 feet. As with Configuration One, resting pools may need to be included to allow fish to rest before resuming their upstream migration through the fishway. This could add an additional 200 feet of fishway. Therefore, the total fishway length of Configuration Two could range from 1,050 to 1,250 feet while Configuration One would range from 2,500 to 3,000 feet.

In this configuration, the fishway would need to transverse the west bank of the Carmel River twice before descending to the tailrace. The fishway would "switchback" once in order to ascend the vertical distance to the tailrace. A schematic layout of a fishway extending from the reservoir forebay to the tailrace is shown in (Figure 9).

Advantages:

- Fully volitional passage around Los Padres Dam with proven vertical-slot controlled fishway configuration,
- Required less initial capital investment than a full-scale fishway,
- Easier to fit within existing site conditions with a length much shorter than a full-scale fish ladder,
- Can conform to CEQA as well as state and federal permitting requirements with limited level of effort, and
- Entrance and exit could be modified as needed to operate under a number of future conditions.

Disadvantages:

- Additional operation and maintenance is required to configure weir panels, move stoplogs, and modify AWS settings.
- Requires an AWS to meet agency guidelines for 10% attraction flow.

Figure 9. Schematic of hybrid vertical slot fishway extending from tailrace to reservoir forebay.

A third option for volitional passage could be the construction of a reservoir bypass. This would likely extend from either fish ladder (Configuration One or Two) described previously by incorporating a roughened channel to the head of the reservoir, allowing fish to swim from

the tailwater, entirely around the reservoir, and into the Carmel River above the hydraulic influence of Los Padres Dam. This structure could consist of roughened channel, prefab concrete box, and/or cylinder which could be open or completely buried. Flow sufficient to attract and maintain passage through the channel would probably need to be supplied either by gravity and augmented with properly screened pumps during low forebay conditions. An advantage to this alternative is that it would serve as both an upstream and downstream passage route for adults, juveniles, and post-spawn adults. Disadvantages of this full reservoir bypass in conjunction with a fish ladder include a very high cost of construction, difficult accessibility, remote pump station location along with the challenging topography and geology along the shorelines. Due to these constraints, this system a reservoir bypass is not considered in the remainder of this assessment.

Advantages:

- Fully volitional passage around Los Padres Dam and reservoir,

Disadvantages:

- Requires significant capital investment for a structure that is 3 to 4 miles in length,
- Complex siting and layout at the face of Los Padres dam as well as around the steep hill slopes of the Carmel River, and
- Water temperature concerns would require careful evaluation during design which may require supplemental water system.

5.1.2 Trap and Haul

The trap and haul option is generally composted of three main components. First, a short ladder and trapping facility could be placed at the tailrace located below the existing spillway outfall. Migrating steelhead would ascend the ladder and stage within the trapping facility. Second, steelhead present in the trap would be transferred to a vehicle retrofitted with a transport tank. The transport tank would then be hauled to a pre-determined release point. At the pre-determined release point, steelhead would be transferred back to the Carmel River where they would be able to continue their migration upstream. The release point could be at the reservoir forebay just upstream of the existing dam crest or it could be at the head of reservoir.

As described earlier in this document, a trap and haul system currently exists at Los Padres Dam. The existing facility is operated, maintained, and monitored by the MPWMD. Through evaluation of the existing facility the fish ladder to the existing trap could benefit from improved siting and increased capacity. Placing the fish ladder (trap entrance) entrance nearer to the barrier and orienting attraction flow so that velocity is directed downstream will be likely

to result in a more effective system for attracting migrants. The current Denil type ladder, as well as the trap itself, is undersized for both current conditions and for achieving future stakeholder goals associated with recovering steelhead populations in the Carmel River. As part of this fish passage option, a new ladder could replace the current Denil configuration with a vertical slot type or pool and weir type fish ladder which would further improve passage success.

The existing trap would need to be modified and or replaced as part of this option as well. The stakeholder goal is to restore the migrating population to 4,800 fish at Los Padres Dam. This increased capacity should be carefully considered if design and construction of a new trap and haul facility should occur. Further evaluation would be required to determine the required capacity and operational flows to effectively trap and hold the anticipated migrating population of adult steelhead that would be passing the dam due to the improvements in fish passage throughout the watershed.

The method of transporting fish as part of this option would continue to be via truck or truck and trailer. The capacity of such a vehicle would need to be considered should this option move foreword. The volume and life support conditions for improved transfer operation would also need to be considered. The potential use of a helicopter to transport fish upstream was considered in this evaluation. Due to concerns regarding cost, the use of a helicopter was not moved forward in this evaluation. Preliminary cost estimates for renting a helicopter for transport were on the order of $4 to $5 million per year (See Cost Data Appendix A)not including the other typical operational and maintenance costs required for implementation.

The option of transferring steelhead to the head of reservoir was also considered as part of this evaluation. Implementing trap and haul to the head of the reservoir would be desirable because it would reduce disorientation and potential for fallback of upstream migrating steelhead while navigating through the reservoir. Currently, access to the head of reservoir does not exist. Therefore, this option would need to consider the logistics of siting and constructing a road used to transport the fish to the head of the reservoir. The existing steep hill slope topography surrounding Los Padres dam would make it difficult for road construction. Rough estimates for routing a road around the reservoir result in minimum road lengths of approximately 3 to 4 miles through difficult terrain.

The disadvantage of a trap and haul system for upstream migration is that migration is not volitional, therefore fish a required to experience additional stresses associated with increased holding, handling and transportation.

Advantages to the trap and haul alternative include the potential use of existing facilities which would increase the speed of implementation and reduce costs.

Advantages:

- Limited capital investment and operation and maintenance effort when implemented to the reservoir forebay,
- Requires a relatively minimum level of construction and materials to implement,
- Improvement of existing facility using methods already being implemented,
- Facilitates passage around Los Padres Dam with limited potential for injury to fish when water to water transfers are used,
- Can conform to CEQA as well as state and federal permitting requirements with limited level of effort, and
- Facilitates continued monitoring of migrating steelhead stocks.

Disadvantages:

- Trap and haul is non-volitional and requires transport of fish around Los Padres Dam and
- Capture in a collection facility may delay upstream migration by as much as 24 hours.

5.1.3 Mechanical fish lift

Mechanical fish lifts include mechanized equipment that automatically move steelhead from the tailrace below the spillway to the reservoir forebay where they could continue migration upstream. In general, there are three main components to the mechanical fish lift. At the tailrace, a jet of water is used to attract fish to a collection area. The jet of water is sized similar to what is needed for attraction flow at a fish ladder. The collection area may be configured similar to a short fishway and trap such as in the trap and haul options. From the collection area, fish are transported up the face of the dam via: (1) a trolley tank system; (2) a series of diagonal fish locks; or (3) a large diameter cylinder with an Archimedes type screw that acts as a "fish pump." The transport device is actuated at regular intervals throughout the day to move fish upstream. When they reach the crest of the dam, they are transferred into the reservoir forebay with a fish bypass pipe or directly lowered into the reservoir and released. The three methods of transporting fish upstream using fish lifts are described in more detail in the following paragraphs:

Trolley Tank System

One means of transporting fish from the tailrace to the forebay is to carry them up over the dam in transportation tanks or elevators either suspended from cables, or pulled along rail tracks similar to a trolley system. This system would include design and construction of hoists, concrete foundations, rails, structural members, ramps, pumps, and piping along the face and crest of Los Padres Dam.

The main advantages to this alternative over a traditional trap and haul facility is that the system can be operated with minimal staff, transportation vehicle requirements are limited, and no roads or new access points would not need to be constructed. The construction of such a system would also have a much smaller footprint than the volitional control alternatives discussed previously.

However, considerable capital, operations, and maintenance costs would be associated with this option. Additionally, the power requirements could be substantial for operation as transport tanks would need to be large enough to contain water to support low stress water-to-water transfers. Also in relation to fish health, excessive temperature and support of adequate oxygen levels are also considerations that would need to be addressed in this system.

Diagonal Fish Lock System

Another mechanical lift option is a diagonal fish lock. This option would require a short fishway with attraction flow, a holding chamber, and filling-lock. Fish are crowded into the lock chamber and raised to the forebay release point by a submerged brail through the water column as the lock chamber is flooded. This alternative would reduce power requirements compared to the trolley system discussed above. It would also facilitate a water-to-water transfer of fish from a trap facility in the tailwater to the forebay. Like the trolley system, this alternative would likely need minimal staffing.

Disadvantages of this alternative include high capital costs and the potentially slow transfer of only a few fish at a time up through the lift, increasing holding time and stress levels.

Fish Pumps

Another possible option is the use of a series of fish pumps to raise the adult fish in increments up to a release outlet in the forebay. Discussions with fish pump vendors have indicated that the technology exists and is capable of handling large fish, the size of steelhead adults. However, recent applications of this technology involve only juvenile fish transfer or terminal adult hatchery fish collection. Conservatively, each pump could move the fish up a 30-foot

increment in elevation, therefore requiring four individual lifts and holding pools on the face of Los Padres Dam.

Advantages to this system are the potential for a relatively lower capital cost (when compared with other fish lift systems) and a relatively quick transfer of fish from the tailwater to the forebay.

The limitations with this alternative include high power demands to operate and the potential need to handle fish between pumping stations in order to move them to the next pump. The potential for fish injury is not known at this time. It is not clear whether pumping adult fish a vertical distance of more than 100 feet would result in barotrauma from the pressure differentials associated with the pump. Also, fish pumps of this size have not been used in passage type applications such as this.

Advantages:

- May operate around the clock limiting the direct interaction between people and fish as well as limiting the potential for migration delay.

Disadvantages:

- Moderate to high initial capital investment associated with construction,
- Ongoing power requirements associated with complex system of moving parts and pumped water,
- High annual operation and maintenance costs, and
- Safety concerns associated with construction of facility within or on-top of earthen dam in seismically active are of California. May be difficult to permit through the Department of Safety of Dams (DSOD).

5.2 Downstream Fish Passage Alternatives

Four potential options were formulated and evaluated based upon their ability to meet the objectives of this study with respect to downstream fish passage. These four options are lumped into two general categories: Volitional Passage Options and Trap and Haul Passage Options. Volitional Passage Options include collectors and fish bypasses where post-spawn adults and juvenile steelhead are allowed to swim downstream around Los Padres Dam to the spillway tailrace where they can continue migration downstream. Trap and Haul Passage Options include systems where fish are collected, transferred into a transport vehicle, physically transported around Los Padres Dam to the spillway tailrace and then released so that they can continue their migration downstream. The four potential downstream fish passage options

evaluated in this document are summarized in Table 11. Descriptions for each option are provided in the following sections of this document.

Table 11. Summary of potential options for upstream fish passage at Los Padres Dam.

General Category	Fish Passage Option
Volitional Passage Options	Fixed Surface Collector at Reservoir Spillway
	Floating Surface Collector at Reservoir Spillway
Trap and Haul Fish Passage Options	Fixed Trapping Facility at Head of Reservoir
	Floating Trapping Facility at Head of Reservoir

5.2.1 Fixed surface collector at reservoir spillway

This option is similar to the interim solution currently under design to facilitate downstream migration of juvenile and post-spawn adult steelhead. The fixed surface collector provides facilities for an inlet and collector upstream of the existing spillway crest along the west concrete abutment. Stoplogs or an upward operating slide-gate would be used to control flow into the collector at forebay elevations above and below the spillway crest. Multiple guideslots and stoplogs would be incorporated to divide the vertical drop into smaller multiple drops if required. The collector would be attached to the west concrete abutment with a mooring system that will allow passive adjustment within acceptable forebay elevation fluctuations. This is intended to ensure sufficient attraction and access to juveniles during target tailwater conditions.

A physical guidance system – used to direct he fish to the collector - would be oriented approximately 45 degrees from the surface collector and would run the width of the spillway. The system would be anchored on the east bank of the spillway and would have a quick disconnect at the collector. When major flood events occur, the disconnect will allow the guidance system to swing across the spillway thus reducing the potential for debris capture and subsequent damage while at the same time remain anchored to the opposite bank. The guidance system could be composed of a floating boom system with narrow panes of steel plate or perforated-plate that would extend into the top 6 to 9 feet of the water column. After the flood event the end of the guidance system could be recovered and reconnected to the collector.

Water and fish entering the collector would be conveyed in an open channel flow condition via circular pipe or "fish bypass." The fish bypass would be constructed through the spillway and route fish down to the existing tailrace in a similar alignment to the existing auxiliary water pipe. The bypass would ascend the slope, to the extent possible, at a constant gradient until it ends at the tailrace. Here the bypass could outfall directly to the tailwater pool. The outfall could be anchored with a series of steel pilings and could be adjusted to remain within 3 to 5 feet of the tailwater pool elevation to reduce the potential for injury.

The capture efficiency of this system could be improved with the addition of pumps to produce a downstream oriented attraction flow to the collector. Although the initial configuration for this option does not include pumped water, this enhancement could be incorporated in the future if efficiency levels are not adequate.

An advantage to this alternative is that it provides a permanent fixed structure at the dam with easy access during all seasons. Additionally this system precludes any handling of downstream migrants minimizing the potential for injury and stress.

It would be possible to incorporate this system with upstream trap and haul options. The fish bypass outfall can be joined with the improved ladder and trap proposed as part of the adult upstream passage option. The outfall could supply water to the adult trap while allowing juveniles to move downstream through improved ladder entrance conditions. The spacing of an adult fyke trap would allow juveniles to pass while the trap is in operation. This approach could have several advantages including overall cost efficiency and ability to monitor upstream and downstream migration success.

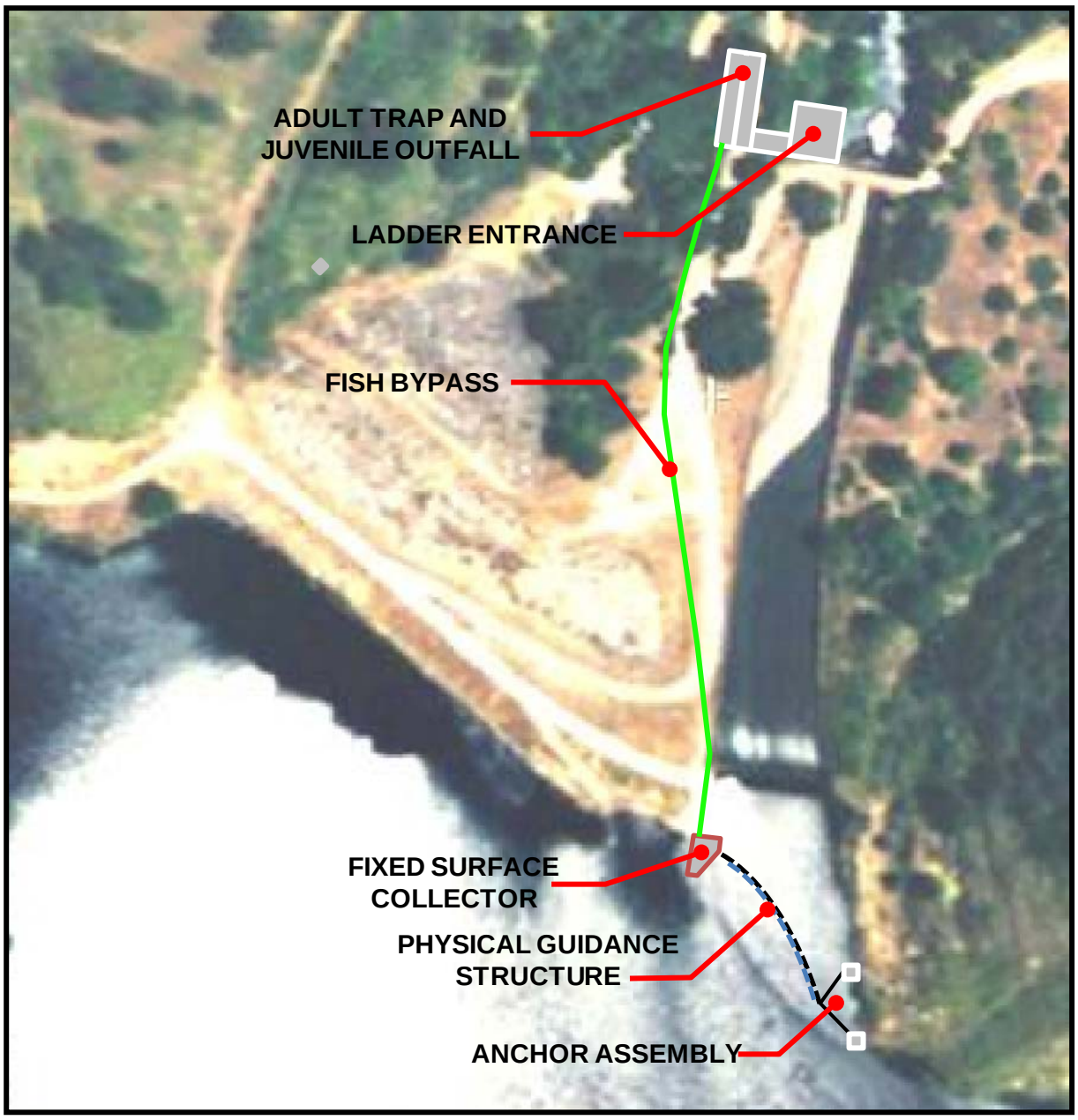


Figure 10. Fixed surface collector with physical guidance structure, fish bypass, and outfall.

Advantages:

- Documented effectiveness when physical guidance structure is in place,
- Fully volitional passage for outmigrating juvenile and post-spawn adult steelhead,
- Can be operated within guidelines provided by NMFS,
- Relatively limited capital investment associated with construction,
- Limited level of operational and maintenance effort,

- When integrated with upstream trap and haul, juveniles, adults, and post spawn adults can be monitored using the safe facility,
- When integrated with volitional passage alternatives, fish bypass flow can supplement fishway attraction flow, and
- Can conform to CEQA as well as state and federal permitting requirements with limited level of effort.

Disadvantages:

- Facilities sighted near the spillway can be subjected to debris fouling and possible separation of the quick disconnect safety mechanism during flood events rending it inoperable until maintenance occurs,
- Possible collection and downstream transport of non-target species such as red-legged frogs.

5.2.2 Floating surface collector at reservoir outlet

Similar to the fixed surface collector at the reservoir outlet described above, this alternative provides a passage route to outmigrating fish at varying forebay elevations through use of a floating entrance. The floating entrance could include a section of flexible piping routing fish from the floating entrance to a bypass pipe while still allowing for pool fluctuations. Alternatively a live box could be used to facilitate trap and haul operations using the same floating collector concept. A schematic plan of this option is pictured in Figure 11.

The floating entrance would be anchored approximately 50 feet upstream of the center of the spillway. When incorporating a bypass system, flow into the entrance would be controlled through the use of adjustable weirs or gates and buoyancy adjustment. If a trap and live box is used, flow through the facility would be based upon the current flow over the spillway or an existing auxiliary water supply siphon.

As with the previous alternative a physical guidance system would be used to increase guidance efficiency of outmigrating juvenile steelhead. In this case the guidance system would consist of two sections each oriented approximately 45 degrees from the surface collector extending in front of the forebay to the east and west banks respectively. The guidance system would be composed of a "Tuff-boom" system with narrow panes of steel plate or perforated plate that would extend into the top 6 to 9 feet of the water column. When major flood events occur, it is likely that the entire floating collector and physical guidance system structures would need to be removed or moved out of the main spillway flow.

The capture efficiency of this system could be improved with the addition of pumps to produce an attraction flow to the collector. This pumped system is sometimes referred to as a "Gulper."

Advantages of this system include the fact that it can be added on to the interim alternative previously developed, by routing fish from the floating surface collector to the fixed surface collector. Additionally, this alternative provides flexibility in the placement of the collector which could maximize capture efficiency based on flow and fish migration patterns exiting the reservoir. Another advantage is that the collector is not fixed and therefore can be removed if needed for debris management or repair.

A disadvantage to this system is that it is not permanently fixed and is susceptible to flow fluctuations which could affect its moorings and anchors. This alternative is also more suited to trap and haul than the fixed collector due to difficulties associated with connections to a floating and repositionable trap to a fixed pipe leading to the tailwater. In the few examples where this type of system has properly worked, the structures are expensive and require the collection system to float along with the collector. Power is also a big factor due to the amount of attraction flow that would be required. Due to these considerations, alternative configurations requiring power or flow enhancement are not considered for further evaluation in this assessment.

Advantages:

- Documented effectiveness when physical guidance structure is in place,
- Can be configured for fully volitional passage for outmigrating juvenile and post-spawn adult steelhead,
- Can be operated within guidelines provided by NMFS,
- When integrated with volitional passage alternatives, fish bypass flow can supplement fishway attraction flow, and
- Can conform to CEQA as well as state and federal permitting requirements with limited level of effort.

Disadvantages:

- Facilities sighted near the spillway can be subjected to debris fouling during flood events until maintenance occurs,
- Possible collection and downstream transport of non-target species such as red-legged frogs.
- Higher capital cost and more complex design relative to a fixed surface collector,
- Higher level of operation and maintenance effort than a fixed surface collector, and

- Limited increase in potential collection and passage efficiency relative to increase in capital cost when compared to fixed surface collector.

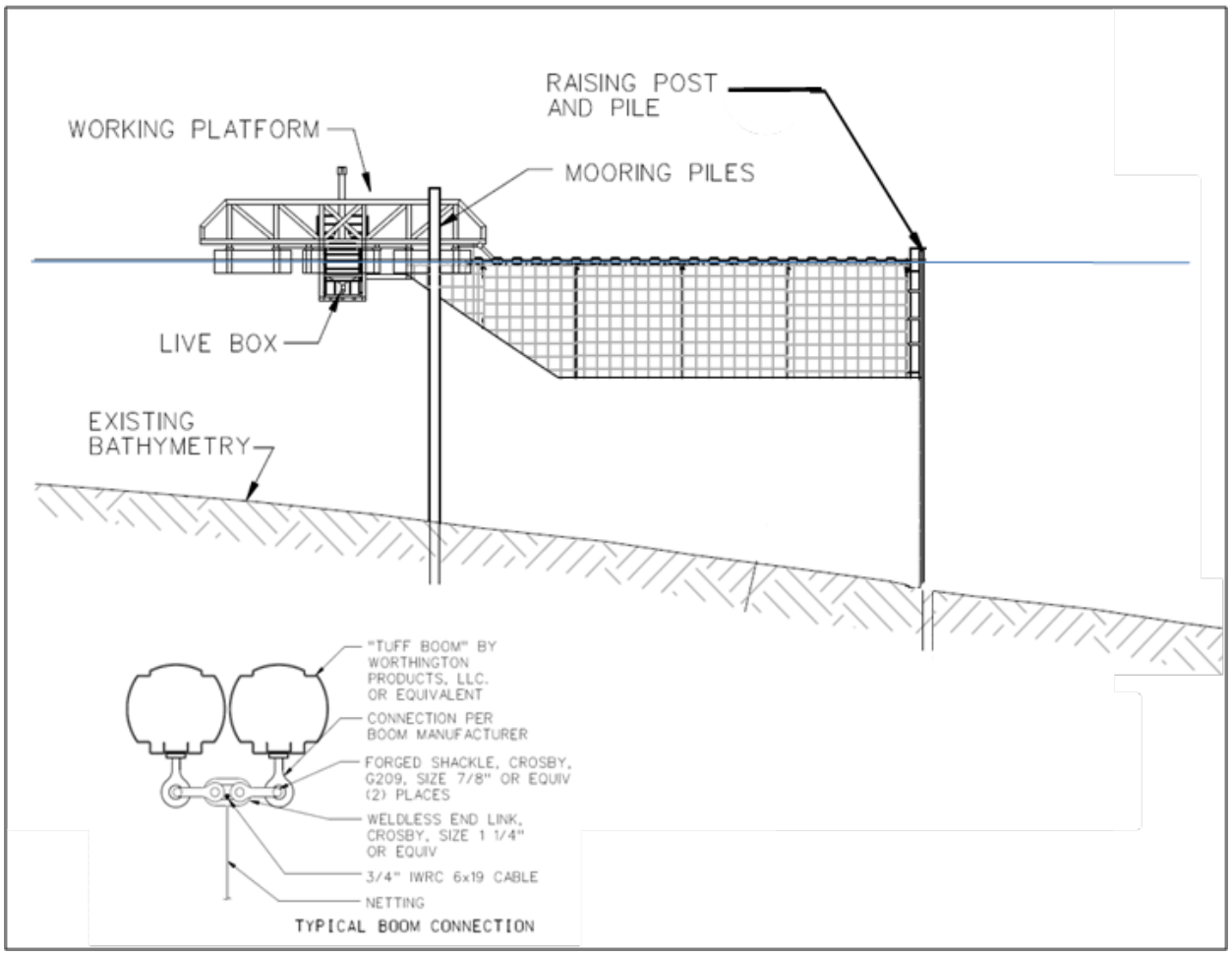


Figure 11. Schematic of the floating surface collector alternative.

5.2.3 Head of Reservoir Fixed Trapping Facility

This alternative consists of a fixed trapping facility implemented in- or off-channel. The in-channel alternative would include physical barrier panels composed of 1/4th to 3/32nds inch screen or perforated plate. The plates would be fixed to the channel bed and angled at 20 to 30 degrees facilitating fish movement toward the trap or bypass in the center. At the center, fish would enter a pipe to fyke or a simple fyke inlet into a live box. Because the system is fixed, there would be the possibility of connecting the trap to a bypass channel or pipe to carry the fish 3 to 4 miles downstream to the reservoir outlet. However, a more likely method would be to retrieve fish from the live box and haul them either by truck, boat, or helicopter below Los Padres Dam. This alternative was deemed infeasible for the main reason that it would not be effective at all outmigration flows and it would be difficult to deal with flood flows, high debris loading, and bedload movement.

A fixed trapping facility that is situated off channel represents a more viable option than an in-channel facility. This alternative would include an instream low-head adjustable dam and off channel screen and trap with live box. The off channel trap would include a ladder and pool to accommodate upstream migrant adults as well as outmigrating juveniles, as shown in Figure 12. Fish collected in the downstream juvenile live box would be removed and transported to the dam tailrace.. Upstream migration would also be possible by providing passage for adults over the low-head dam. However some downstream migrants will also use this passage. One possible modification is to hold upstream migrants in the entrance area of the downstream migrant trap facility and periodically release the adult fish to proceed upstream. This system concept could also facilitate the use of a bypass channel or pipeline to carry the downstream migrants past the reservoir and dam, to the tailrace. The options to haul the captured fish downstream via truck, boat, or helicopter is another option with this alternative. However, a road would need to be constructed for truck access and boating access will be seasonally restricted. An advantage to this alternative is that it would be functional over the full range of anticipated outmigration flows. However, the trapping efficiency of downstream migrants would be greatly decreased at the higher end of flow regime as the dam capacity is exceeded. Additionally, access to the head of the reservoir for installation and operation would be challenging and potentially costly.

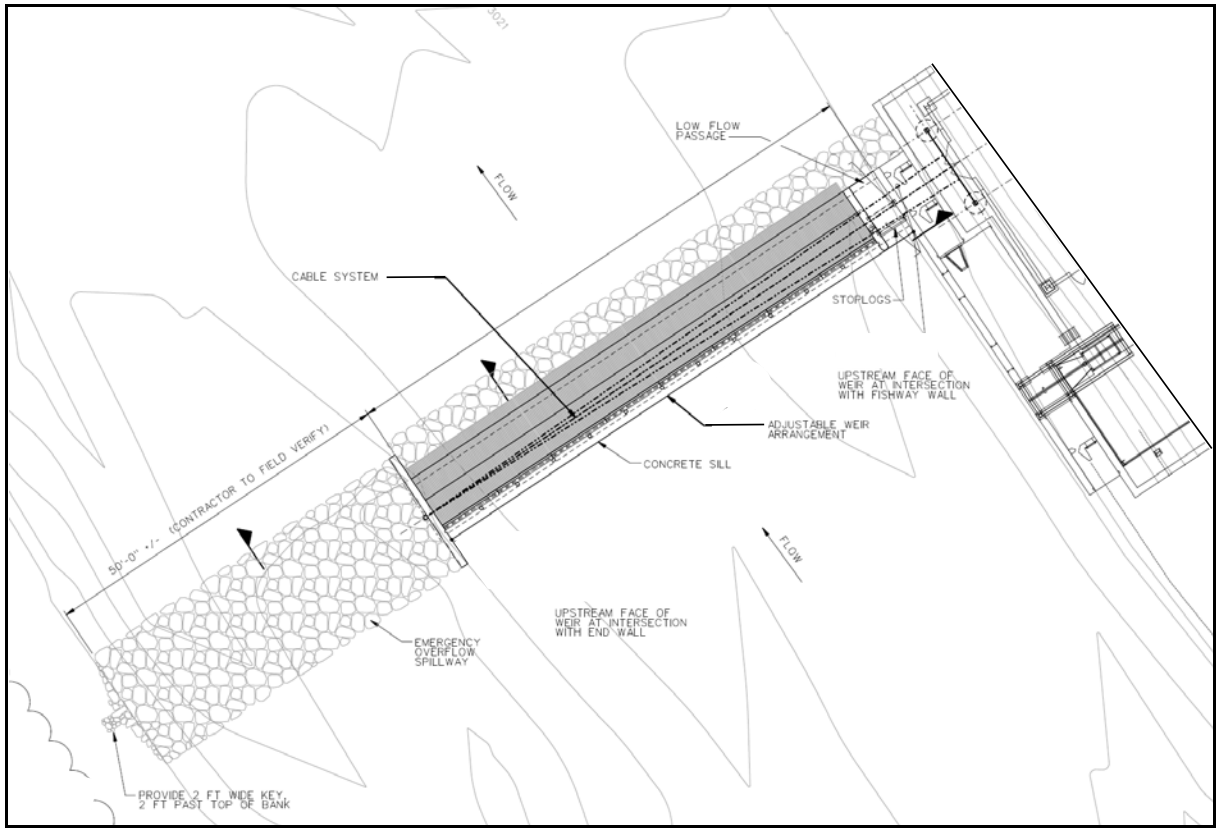


Figure 12. Schematic plan representing an off-channel trapping facility.

Advantages:

- Construction of a reservoir bypass haul road would provide access to adult and juvenile trap and haul facilities whereby adults can be hauled to the head of reservoir,
- The off-channel facility can be configured in-place to endure large flood events while collection of juveniles continues, whereas an in-channel facility could only operate under flow conditions less than 30 to 50 cfs,
- Facilitates monitoring of downstream juvenile and post-spawn adult migration,
- Reduces exposure to predation, poor water quality, and lethal water temperatures which can be seasonally observed within the reservoir,
- Limits delay in migration associated with navigation of the reservoir.

Disadvantages:

- High capital cost associated with construction with major components including a 3 to 4 mile haul road, a low-head dam spanning the channel, a small fishway, and a trapping facility,
- Highest operation and maintenance effort due to location at head of reservoir and long travel time to and from facility,
- Capture efficiency decreases as river flow increases, and
- Would be more difficult to permit a new facility at the head of reservoir due to potential impacts to red-legged frogs and introduction of fill within the ordinary high water mark. Would require additional Section 10 consultation by the US Fish and Wildlife Service.

5.2.4 Head of Reservoir floating trap and haul

This alternative would involve the development and implementation of a trap and haul program at the reservoir inlet. A floating screw trap (Figure 13) would be anchored in a location that exhibits the best probability of success as determined by horizontal fish distribution and/or hydraulic patterns. During flow conditions of 50 cfs and below, when in-stream velocities are more manageable and floating debris is less of an issue, a physical guidance system would be installed to better direct outmigrating fish into the trap entrance. Access to the trap and transport of fish from the trap would be facilitated by a boat or truck equipped for fish transfer. Required equipment would include a transfer and holding tank, temperature control equipment and aeration equipment. Transfer by truck would require that a 3 to 4 mile haul road be constructed around the reservoir.

Problems with this alternative include lack of capture efficiency at all flows, and the necessity to regularly evaluate trap citing effectiveness and maintenance upstream of the sediment field at

the reservoir head. This method would necessitate the fish being hauled to the tailrace, unlike some of the other alternatives discussed that use a bypass system. Capture of post-spawn adults in this system would also pose a problem as they are not likely to enter the trap. This alternative would also need to be moved and or re-installed each season and does not provide a good permanent solution to downstream passage. Due to these constraints this system is not considered in the remainder of this assessment.

Figure 13. Photograph of typical screw trap that may be used at the reservoir inlet.

Advantages:

- Floating surface collectors such as screw traps can be moved to improve capture efficiency as needed and
- Screw traps would require less capital investment than other downstream passage options if accessible by boat.

Disadvantages:

- Capture efficiency decreases as river flow increases,
- If inaccessible by boat, a 3 to 4 mile reservoir bypass haul road would need to be constructed to facilitate trap and haul operation, and

- Would be more difficult to permit a due to potential impacts to red-legged frogs. Would require additional Section 10 consultation by the US Fish and Wildlife Service and acquisition of incidental take permit.

5.3 Dam Removal

Conceptually, the removal of Los Padres dam alternative could include two potential options. Option one would be to remove Los Padres dam entirely. The second option would be to create a large 150 to 200-foot wide notch in the existing earthen embankment to an elevation that would mimic the vertical profile of the historic Carmel River reach. The intent of both options would be to restore volitional passage for upstream and downstream migration of adults and juvenile steelhead.

A screening level estimate of dam notching costs was developed by CAW in an effort to evaluate the economic viability of the potential dam removal option. Notching components included removal of the earthen embankment, removal of the existing concrete spillway, bank stabilization, removal of sediments trapped behind the dam, disposal and stabilization of remaining materials, erosion control measures, and revegetation of disturbed areas. The estimated capital cost of the notching option was on the order of $XXXX. This estimate does not include permitting, design, and administrative costs which may also be extensive depending upon the duration required to implement the option.

Although both such options would be most beneficial to the overall recovery of steelhead as well as the overall ecologic health of the watershed, they would require a significant level of permitting to implement. As has been observed with the San Clemente Dam, just five miles downstream, permitting efforts may be extensive and last for one to three decades.

[in progress and supporting information provided by CAW]

5.4 Conservation Hatchery

Stakeholder and agency committees within several watersheds within the State of California have concluded that implementation of a conservation hatchery is the most cost effective means to sustain steelhead populations. However, it is the position of the agencies that implementation of a conservation hatchery will not be acceptable substitute for providing effective fish passage facility. Therefore, implementation of a conservation hatchery is not carried forward in this document.

5.5 No Action

The no action alternative involves no-further implementation of fish passage measures at Los Padres Dam. The existing upstream trap and haul program would remain as the only available means for upstream migration of adult steelhead. This alternative would also limit the ability of juvenile and post-spawn adults to negotiate the reservoir forebay and safely travel down the existing concrete spillway without injury. Habitat occurring above Los Padres Dam would not be used to its fullest extent and would not effectively contribute to the recovery of steelhead within the Carmel River watershed.

5.6 Discussion of Viable Alternatives

The intent of this document is to evaluate fish passage options and bring forward alternatives which appear to best meet the objectives of this study. The options described previously in this report were considered independently based upon their individual advantages and disadvantages. Options which appeared to be relatively more advantageous than others were selected for further analysis. Options which presented significant disadvantages and a much higher level of uncertainty with regards to cost, effectiveness, and permitting were removed from further evaluation. Combinations of the selected options were used to develop viable fish passage alternatives. This section provides a summary of the selection process and provides a description of the five fish passage alternatives selected for further evaluation.

Upstream Volitional Passage Options

Volitional fish passage options included a full-scale and a hybrid vertical slot type fishway. Both options provide an effective means of facilitating juvenile and adult steelhead passage around Los Padres Dam. Both options can be operated to meet agency guidelines with respect to through-slot swimming velocities, energy dissipation, inlet and outlet conditions, vertical drops from pool to pool, and attraction flows. The full-scale fishway is at a disadvantage in that it would require a length of 2,500 to 3,000 feet versus 1,500 feet required for the hybrid vertical slot design. Thus, capital costs would be much greater for the full-scale facility. From an operational standpoint, the hybrid vertical slot facility has greater seasonal flexibility to provide effective passage over a wide range of low and high flow events whereas the full-scale facility would operate more effectively within the mid range fish passage flows greater than 100 to 150 cfs. Given, the flashy nature of this watershed and the duration at which flows are below 100 to 150 cfs during anticipated periods of migration, the smaller hybrid facility may have the overall advantage from a cost effectiveness perspective. Given that it's overall footprint is half that of the full-scale version, the ability to limit impacts and obtain all necessary permits is greater overall. Due to the reasons listed above, the hybrid vertical slot fishway design was therefore selected for further evaluation.

This option should be evaluated in combination with other alternatives to address the need for supplemental water and implementation of an AWS.

Upstream Trap and Haul Options

Upstream trap and haul to the reservoir forebay was selected for further evaluation. Although this option does not provide volitional passage, it does provide effective passage for a low capital investment. Further, similar methods are currently being implemented at Los Padres Dam by the MPWMD. This option provides other advantages such as the ability to monitor upstream migration. Construction of an improved collection facility would improve monitoring effectiveness without the use of electronic monitoring equipment which would be a likely monitoring approach at the entrance or exit to a fish ladder. When coupled with other downstream options, both upstream and downstream migration of steelhead can be monitored which is advantageous from a scientific perspective and would coincide with current recovery efforts. This option should require the least effort to obtain necessary permits due to its similarity with existing operations at Los Padres Dam.

Construction of a haul road to the head of reservoir was not selected for further evaluation. At this time, there are too many uncertainties associated with constructability, and the capital investment necessary to implement such an option. Screening level estimates for a 3 to 4 mile haul road construction around the reservoir are on the order of $2.2 million. However, that number could be greater as layout, siting, and design activities progressed.

Upstream Mechanical Fish Lift Options

Mechanical fish lifts were not selected for further evaluation. Both trap and haul and volitional options provide many advantages over fish lift options for less capital investment. Overall, the ability to permit such facilities on the face of an earthen dam is questionable from a dam safety perspective. Annual operation and maintenance requirements would be greater than other viable options as well.

Downstream Fixed Surface Collector at Reservoir Spillway

A fixed surface collector at the reservoir spillway would include a collector, fish bypass, and fish bypass outfall. All three components are relatively easy to permit, construct, and operate when compared to the other options. Implementation of a physical guidance structure has been documented to improve the effectiveness of such facilities. If this option was coupled with the upstream trap and haul option, monitoring of downstream migrants could be used to monitor effectiveness and make improvements if necessary. This option is also anticipated to require a relatively low capital investment. Operation and maintenance activities could coincide with

potential trap and haul operations which would also limit the overall operation and maintenance effort. This option was selected for further evaluation.

Downstream Floating Surface Collector at Reservoir Spillway

The floating surface collector option reflects many of the same advantages as the fixed surface collector. An additional advantage is its ability to be oriented upstream of the center of the spillway which may improve its overall effectiveness. As mentioned previously, it is possible that one could start with the fixed surface collector and move to the floating surface collector if passage effectiveness does not meet agency expectations. However, the overall improvement may not be known until implementation is accomplished. Capital costs is expected to be higher than the fixed surface collector option but still relatively low in comparison with other downstream passage options. Due to the overall advantages of this option, it was selected for further evaluation.

Downstream Fixed Trapping Facility at Head of Reservoir

A fixed trapping facility at the head of reservoir would include: a 3 to 4 mile haul road, a low-head dam spanning the channel, a small fishway, and a trapping facility. Overall this alternative would require a relatively high capital investment and may include a high operational and maintenance effort. It may also have some level of impact upon wetland and red-legged from resources in the reservoir inlet which could require much more permitting effort than the other downstream fish passage alternatives. However, this alternative does pose several significant advantages that other options do not. A trapping facility at the head of the reservoir would benefit outmigrating juvenile and post-spawn adult steelhead by eliminating the potential predation, poor water quality, and high water temperatures that are observed in the reservoir. In addition, this option has greater effectiveness over a larger portion of the anticipated migration hydrograph. Such a facility can be configured to collect outmigrating juveniles and post-spawn adults even during significant flood events whereas the floating facility would not. Despite the potential for high costs associated with this option, it was selected for further evaluation based upon its potential effectiveness and merit associated with reducing passage issues through the reservoir.

Downstream Floating Trapping Facility at Head of Reservoir

The viability of this option is heavily dependant upon access to the proposed collection location at the inlet to the reservoir. Currently, it is uncertain whether or not effective transportation to and from the site could be made by boat throughout the period of anticipated downstream migration. As the reservoir elevations decrease, large deposits of sediment create impassible shallow bars at distances up to a mile away from the trapping site. Road construction may add

$2.2 million or more to provide sufficient access to upstream trapping locations at the reservoir inlet. Further, the option of using a screw trap in place of permanent trapping facility would be at a disadvantage due to reduced effectiveness during a large portion of the migration hydrograph. As mentioned in previous sections, fish present in only a portion of the water column could be collected while the remainder would be allowed to bypass the trap and enter the reservoir. In effect, this option is much more suited to fill the need for a temporary solution or to perform scientific monitoring experiments rather than as a permanent solution. Therefore, this option was not carried forward for further evaluation.

Dam Removal

Conservation Hatchery

Implementation of a conservation hatchery will not be an acceptable substitute for providing fish passage and therefore is not carried forward in this document.

No Action

5.7 Selected Alternatives for Further Evaluation

Results from the discussion above effectively eliminate nine out the of the original 14 potential passage options. Two upstream alternatives and three downstream alternatives are selected for further evaluation. They include:

Upstream

1. Direct volitional passage: Hybrid fishway assuming sufficient water supply from existing surface collector constructed as part of interim passage solution.
2. Trap and haul to reservoir forebay: design elements include new trap, new fishway to trap, ramp at forebay.

Downstream:

1. Fixed surface collector at reservoir outlet: Surface collector, fish bypass, physical guidance structure, outfall at proposed trapping facility.
2. Floating surface collector at reservoir outlet: Surface collector, fish bypass, physical guidance structure, outfall at proposed trapping facility.
3. Fixed off-channel collection facility at head of reservoir: low-head dam, trap and collection facility, and haul road around reservoir.

6 Fish Passage Alternative Evaluation

Each of the selected alternatives was evaluated based upon their ability to meet five evaluation criteria. An evaluation matrix was developed and used to compare how well each alternative met the constraints of those criteria. Alternatives which appeared to best meet the criteria were given a rating of high while alternatives which did not meet the specific criterion were given a rating of low. Alternatives where The evaluation of each alternative along with a summary of alternative cost development is provided in the following paragraphs.

6.1 Alternative Evaluation Criteria

The evaluation criteria were formulated to directly reflect the objectives identified for this study. These objectives were formulated within a multi-stakeholder forum. The process was documented in a Problem Statement and Goals Memorandum developed by CAW and HDR dated April 8, 2009. An evaluation criterion was added for permitting and environmental documentation of such alternatives to account for the level of effort required. Table 12 provides a summary of the resulting evaluation criteria and a brief definitions of each.

Table 12. Summary of potential options for upstream fish passage at Los Padres Dam.

Evaluation Criteria	*Description*
Capital Cost	Estimated annual amortized costs for the life of the facility in US 2009 dollars.
Operation and Maintenance Effort	The number and difficulty of activities required to operate and maintain an alternative to remain effective. Annual costs in US 2009 dollars.
Effectiveness	Ability of an alternative to attract fish and facilitate upstream or downstream migration. It should be noted that in determining effectiveness a general evaluation of water volume was used and a 1:1 ratio for fish:flow was assumed.
Constructability	Difficulty associated with alternative construction and related activities.
Potential for Safe Passage	Ability of an alternative to transport fish either upstream or downstream in a healthy state.
Permitting and Environmental Documentation	Ability to comply with state and federal CEQA and permitting requirements in a timely manner.

6.2 Summary of Costs for Fish Passage Alternatives

Preliminary order of magnitude capital and operation and maintenance costs were developed for each fish passage alternatives selected in the previous section. The intent of these costs is to

provide a relative basis of comparison between each option. Such costs as final engineering, permitting, and administrative costs were not included and may therefore vary as an alternative is implemented. The costs presented are developed from a number of different sources including (in order of preference): contractor bids resulting from projects of similar scope; bids directly obtained from vendors and material suppliers; engineer's opinion of probable construction costs from projects of similar scope that have not yet been constructed; RS Means National Cost Data (RSMeans, 2008); and professional judgment. Table 13 summarizes the costs for each of the fish passage options evaluated in this document. Assumptions, line items, and a detailed summary of capital and operation and maintenance costs for each option is provided in Appendix A.

Table 13. Order of magnitude costs for potential fish passage options.

Fish Passage Alternatives	*Capital Cost*	*Operation and Maintenance*
	Upstream Options	
Direct Volitional Fish Passage		
Hybrid fishway with surface collector flow in lieu of AWS (Optional Configuration)	$ 4,920,000	$ 70,000
Trap and Haul		
Trap and haul to forebay	$ 760,000	$34,000
	Downstream Options	
Volitional Passage		
Fixed surface collector at reservoir outlet	$ 480,000	$29,000
Floating surface collector at reservoir outlet	$ 710,000	$ 42,000
Trap and Haul		
Head of Reservoir fixed trapping facility	$ 4,730,000	$108,000
Dam Removal	[CAW to provide]	[CAW to provide]
No Action Alternative	$ 0	$ 0

6.3 Upstream Assessment and Evaluation Matrix

Table 14 provides an evaluation summary of for upstream passage alternatives.

Table 14. Assessment and evaluation matrix of upstream passage alternatives.

Alternative	Direct Volitional Fish Passage (ladder)	Trap and Haul
Capital Cost	**Rating: Low** Initial capital investment will be on the order of $ 4.92 million. The majority of construction costs are due to large material quantities (concrete and steel) and an extensive construction effort.	**Rating: High** Initial capital investment will be on the order of $760,000. These costs include cost to construct a new fish ladder and trapping facility.
O and M Effort	**Rating: Moderate** Minimal monitoring required. Will require periodic inspection and debris removal throughout period of migration. Weir boards and stoplogs will be reconfigured twice a year. Anticipated annual costs are approximately $70,000.	**Rating: High** Daily collection and transport of fish. Enumeration and recording of trapped fish. Removal of debris each collection day. Anticipated annual costs are $34,000.
Constructability	**Rating: Low** Major excavation and construction effort. Fish ladder will need to be approximately 1,500 feet to accommodate vertical distance. Temporary construction impacts may be larger than other alternatives.	**Rating: High** Construct an improved fish ladder with an entrance location near the base of the dam. Potential impact is less than other alternatives.
Effectiveness	**Rating: High** Favorable hydraulic conditions allow for volitional migration beyond Los Padres Dam. Flexibility such that it can be adjusted to suit seasonal hydrologic trends. Requires the fewest anthropogenic influences post-construction.	**Rating: Moderate** A well-designed entrance ladder and trap with sufficient supplementary water drives the effectiveness of this alternative.
Potential For Injury	**Rating: High** No handling or trapping of fish is required. Fish passage is volitional. Need properly designed fishway with resting pools. The shorter configuration would negate any temperature concerns.	**Rating: Moderate** Migration is not volitional, so fish experience additional stresses. The potential injury to fish is limited when water-to-water transport equipment is used. Trapping facility would be adequately sized for 24-hour holding period.
Permitting	**Rating: Moderate** Permitting and CEQA documentation is anticipated to be relatively easy. Careful consideration of seismic design and impact to dam must take place to obtain concurrence from DSOD.	**Rating: High** The relative level of effort required to complete CEQA documentation and permitting is anticipated to be relatively low.

6.4 Downstream Assessment and Evaluation Matrix

Table 15 provides an evaluation for downstream alternatives.

Table 15. Assessment and evaluation matrix of downstream passage alternatives.

Alternative	Fixed Surface Collector at Reservoir Outlet	Floating Surface Collector at Reservoir Outlet	Fixed Off-Channel Trapping Facility at Head of Reservoir
Capital Cost	**Rating: High** Initial capital investment is estimated to be on the order of $480,000. Short-term passage facility will be in place and be retrofitted to make permanent, resulting in lower initial capital costs.	**Rating: Moderate** Initial capital investment is estimated to b on the order of $1.1 million. New infrastructure will need to be constructed which may include retrofitting temporary surface water collector and installation of flexible pipe infrastructure.	**Rating: Low** Initial capital investment is estimated to be on the order of $4.7 million. Access to the site is limited in this alternative. Access limitations will increase overall capital cost.
O and M Effort	**Rating: Moderate** Daily observation of inlet and adjustment of flow control gate. Removal of debris from fixed bypass platform when required. Periodic debris removal may be required. Anticipated annual costs are estimated to be on the order of $29,000.	**Rating: Moderate** Daily observation of inlet. No flow adjustment necessary after initial set point is configured. Removal of debris when required. Debris removal would be accomplished from a boat. Potential for trap and haul operation. Anticipated annual costs are estimated to be approximately $42,000.	**Rating: Low** Monitoring of the trap will be required daily. Debris management is required. Removal and transport of the trapped juvenile fish. Crowding and management of adults migrating upstream. Anticipated annual costs are estimated to be $108,000.
Constructability	**Rating: High** Construction can occur in late summer when the forebay elevations are low. Some components may be prefabricated prior to installation. Construction would require new fish bypass pipe. May be constructed in conjunction with adult trap and haul facility.	**Rating: Moderate** Construction can occur in late summer when the forebay elevations are low. Some components may be prefabricated prior to installation. Construction would require pile and anchor placement which may require additional dewatering efforts.	**Rating: Low** Access to the site could be quite difficult and would require construction of a haul road. Barrier dam and concrete trapping facility built off channel dependent on shoreline topography and presence of suitable location.

Alternative	Fixed Surface Collector at Reservoir Outlet	Floating Surface Collector at Reservoir Outlet	Fixed Off-Channel Trapping Facility at Head of Reservoir
Effectiveness	**Rating: High** Initial capture effectiveness may range from 10% to 50% when water is flowing over the spillway. Implementation of a guidance system or flow enhancement measures may improve efficiencies to a range of 60% to 90% (USGS 1998). Effectiveness is expected to increase as flows over the spillway decrease due to an increased ratio of water passing through the bypass versus the spillway	**Rating: High** Initial capture effectiveness may range from 10% to 50% when water is flowing over the spillway. Implementation of a behavior guidance system or flow enhancement measures may improve efficiencies to a range of 60% to 90% (USGS 1998). Effectiveness is expected to increase as flows over the spillway decrease due to an increase ratio of water passing through the bypass versus the spillway.	**Rating: Moderate** Functional over the majority of anticipated outmigration flows. The trapping efficiency of downstream migrants is less at higher flows as the low-head dam capacity is exceeded.
Ability to Provide Safe Passage	**Rating: Moderate** The potential for injury is low. Drop heights may range from 3 to 5 feet with velocities within agency guidelines. Smooth walled pipe would be used to transport fish with free water surface depth of approximately 40% pipe diameter. Outlet of fish bypass can be located within 5 feet of proposed tailrace or incorporated into adult trapping facility.	**Rating: Moderate** The potential for injury is low. Drop heights may range from 3 to 5 feet with velocities within agency guidelines. Smooth walled pipe would be used to transport fish with free water surface depth of approximately 40% pipe diameter. Outlet of fish bypass can be located within 5 feet of proposed tailrace or incorporated into adult trapping facility.	**Rating: Moderate** The potential injury to fish is limited when trained personnel handle the fish and the proper transport equipment is used. The potential for injury is reduced when transport of fish incorporates water-to-water transfers. Trapping facility would be adequately sized for 24-hour holding period.

Alternative	Fixed Surface Collector at Reservoir Outlet	Floating Surface Collector at Reservoir Outlet	Fixed Off-Channel Trapping Facility at Head of Reservoir
Permitting	**Rating: High** The relative level of effort required to complete CEQA documentation and permitting is anticipated to be relatively low.	**Rating: High** The relative level of effort required to complete CEQA documentation and permitting is anticipated to be relatively low.	**Rating: Moderate** The level of effort required to complete permitting and CEQA documentation is anticipated to be relatively moderate. Impacts to wetlands and red-legged frogs at the reservoir inlet may require additional mitigation and application for take permits. Section 10 ESA review by USFWS would be required in addition to what would be required for other alternatives.

7 Recommended Alternatives

Alternatives selected for recommendation include a non-volitional and a volitional option. The Non-volitional recommendation includes a trap and haul with fixed surface collector. The fully volitional option includes a hybrid fishway with fixed surface collector. The recommended alternatives are discussed in the sections below.

7.1 Recommended Non-Volitional Passage Alternative

The first recommended alternative includes a trap and haul for upstream migration of adults with a fixed surface collector at the reservoir outlet to facilitate downstream migration of juveniles and post-spawn adults. Specific design components for this alternative include: a new ladder and trap facility; a ramp located at the reservoir forebay for fish transfer; a new truck and tank or trailer and tank; a new surface collector; a new fish bypass; a new fish bypass outfall. All components shall be designed sufficiently to facilitate fish passage in accordance with future steelhead recovery goals as wall as all applicable state and federal fisheries design guidelines. This alternative assumes that the fish bypass outfall would occur at the proposed trap facility to facilitate ongoing recovery monitoring efforts and to take advantage of a stable outfall conditions. The combined OPCC for this alternative is summarized in Table 16 below. The anticipated annual operation and maintenance costs associated with this alternative are anticipated to be $37,000. Drawings for this alterative are presented in Appendix B.

Table 16. Summary of potential capital costs for recommended non-volitional fish passage alternative.

Alternative Component	*Capital Cost*
Upstream Trap and Haul Facility	$ 760,000
Downstream Fixed Surface Collector	$ 480,000
Subtotal Construction Costs	$ 1,240,000
Anticipated Engineering Costs (10%)	$ 124,000
Anticipated Permitting Costs (6%)	$ 74,400
Construction Management Cost (7%)	$ 86,800
Administrative Costs (14%)	$ 173,600
Total Anticipated Implementation Cost	$ 2,938,800

7.2 Recommended Volitional Passage Alternative

The second recommended alternative includes a hybrid vertical slot controlled fishway to facilitate upstream migration of adults and juveniles with a fixed surface collector at the reservoir outlet to facilitate downstream migration of juveniles and post-spawn adults. Specific design components for this alternative include: a new vertical slot ladder with inlet and outlet structures; a new surface collector; a new fish bypass; a new fish bypass outfall. For this alternative, it is assumed that the existing siphon as well as the proposed fish bypass would supplement attraction flow, precluding the need for an AWS. All components shall be designed sufficiently to facilitate fish passage in accordance with future steelhead recovery goals as wall as all applicable state and federal fisheries design guidelines. The combined OPCC for this alternative is summarized in Table 17 below. The anticipated annual operation and maintenance costs associated with this alternative are anticipated to be $79,000. Drawings for this alterative are presented in Appendix B.

Table 17. Summary of potential capital costs for recommended non-volitional fish passage alternative.

Alternative Component	*Capital Cost*
Hybrid Vertical Slot Fishway	$ 4,920,000
Downstream Fixed Surface Collector	$ 480,000
Subtotal Construction Costs	$ 5,400,000
Anticipated Engineering Costs	$ 324,000
Anticipated Permitting Costs	$ 216,000

Alternative Component	*Capital Cost*
Construction Management Cost	$ 216,000
Administrative Costs	$ 378,000
Total Anticipated Implementation Cost	$ 11,934,000

8 Recommendations

Recommendations for implementation of the selected alternatives include:

1. Continue ongoing stakeholder collaboration with the technical work group formulated for this study. Incorporate comments as they are received from participating representatives.
2. Identify appropriateness and select either volitional or non-volitional alternatives for implementation in consideration of cost effectiveness, agency preference, biological benefit, socioeconomic concerns, and potential for dam removal.
3. Proceed with engineering related investigations including topographic surveys and geotechnical investigations as needed for the selected alternative.
4. Proceed with engineering, permitting, and construction in conformance with state and federal requirements and guidelines.

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