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Los Padres Dam and Reservoir Alternatives and Sediment Management Study Draft Alternatives Descriptions Technical Memorandum

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List of Acronyms and Abbreviations

AF	acre-feet
AFY	acre-feet per year
BGS	behavioral guidance system
Cal-Am	California American Water
cfs	cubic feet per second
CY	cubic yards
DSOD	Division of Safety of Dams
HMR	Hydrometeorological Report
LiDAR	Light Detection and Ranging
LP Alternatives Study	Los Padres Dam and Reservoir Alternatives and Sediment Management Study
LPD	Los Padres Dam
LPR	Los Padres Reservoir
MCE	Maximum Credible Earthquake
MPWMD	Monterey Peninsula Water Management District
NAVD	North American Vertical Datum of 1988
NGVD	National Geodetic Vertical Datum of 1929
NMWS	normal maximum water surface
PMF	Probable Maximum Flood
RCC	roller-compacted concrete
RM	River Mile
SWRCB	State Water Resources Control Board
TAF	thousand acre-feet
TM	Technical Memorandum
TRC	Technical Review Committee

1. Introduction

This Technical Memorandum (TM) is the deliverable for Task 2-2 of the Los Padres Dam and Reservoir Alternatives and Sediment Management Study (LP Alternatives Study). It is provided in draft form prior to Technical Review Committee (TRC) Meeting No. 2. The content of the TM will be updated and developed further based on TRC input, to next be presented in the Draft Alternatives Development TM developed under Task 4. The intent of this TM is to provide conceptual descriptions of alternatives to remove Los Padres Dam (LPD) and Los Padres Reservoir (LPR), recover or increase storage at LPR, and manage sediment deposition and future sediment inflow to the reservoir. This TM also identifies potential effects, both positive and negative, from each alternative. Feedback on this TM will be solicited from the TRC and used to inform further alternatives development in subsequent tasks. Favorable alternatives will be further developed in two additional draft documents (Draft Alternatives Development TM and Draft Final Report), and discussed at two TRC meetings, before they are finalized in the Final Report. Additional description of the LP Alternatives Study and the background information considered in preparation of these concepts is available in the LPD and LPR Alternatives and Sediment Management Study, Study Preparation TM (AECOM 2017a).

1.1 Purpose and Scope

The purpose of this alternatives descriptions study is to develop alternatives for LPD and LPR and sediment management options that could be used in combination with the LPD and LPR alternatives. This document begins to answer two questions that have been identified as key to the overall LP Alternatives Study: (1) “Is it feasible to expand reservoir capacity?”, and (2) “Are there feasible alternatives to manage existing sediment deposition and future sediment inflow to the reservoir?” LPD and LPR alternatives include no sediment management, dam removal, restoring reservoir capacity, and storage expansion. Options for managing sediment in the reservoir include performing periodic dredging, sluicing sediment through the reservoir using a new sluicing tunnel, and constructing a new bypass tunnel to transport sediment around the reservoir. Each LPD alternative and sediment management option is developed with enough detail to adequately understand the following:

- Alternative location;
- Potential effects;
- Complexity;
- Longevity;
- Potential impacts and benefits; and
- Relative cost (low to extremely high).

1.2 Document Organization

This TM is organized into the following sections:

- Section 1 is the introduction, including purpose and scope;
- Section 2 describes the conceptual alternatives for LPD and LPR;
- Section 3 describes sediment management alternatives that could be used in combination with some of the conceptual alternatives for LPD and LPR described in Section 2;
- Section 4 is a summary of the draft LPD and LPR alternatives and sediment management options;
- Section 5 is a statement of limitations for this TM; and
- Section 6 lists references used to prepare this TM.

2. Conceptual Alternatives Descriptions

The discussion of each alternative presented in this section is intended to provide enough detail to understand the approximate location of a proposed alternative, the potential extent of effects, the technical complexity, and whether the alternative is short term or long term; and to list the potential impacts and benefits. The alternatives are presented as concepts to be developed further in subsequent tasks based on input from the TRC. A preliminary, relative characterization of costs has been developed to help screen alternatives from relatively low to high cost. The relative cost, which will be revised as the alternatives are developed further in subsequent tasks, is based on a 60-year planning horizon that includes an estimated 3 to 5 years, depending on the alternative, to begin to implement a project using the following order-of-magnitude costs:

- Very low – $0 to $10M
- Low – $10M to $30M
- Moderate – $30M to $70M
- High – $70M to $150M
- Very High – Greater than $150M

Any of these alternatives may require fish passage improvements that have not been included in the relative cost. Alternatives addressed in this section are listed below:

1. No Sediment Management
2. Dam Removal
3. Restore Reservoir Capacity
4. Storage Expansion

2.1 No Sediment Management (Alternative 1)

No Sediment Management (Alternative 1) is based on a scenario where no action is taken to manage the existing sediment accumulation in the reservoir, or future sediment inputs. This alternative may become the baseline for comparing alternatives.

Under Alternative 1, the reservoir would continue to fill in with sediment. During the past 70 years, an estimated 1,110 acre-feet (AF) of reservoir storage has been lost due to sedimentation (AECOM 2017b). This equates to an annual average of approximately 15.9 AF of sedimentation and loss of storage capacity per year. An estimated 590 AF of sediment was transported into the reservoir during the winter following the 1977 Marble Cone fire (MWH 2013). Discounting this particular event—which was the result of an extremely hot fire covering the majority of the watershed, followed immediately by an extremely wet year (MWH 2013, Hecht 1981)—the annual sedimentation rate and loss of storage capacity would be approximately 7.5 AF per year (AFY). Based on the two rates of sedimentation, the remaining approximately 1,600 AF of reservoir storage capacity would be filled approximately 100 to 210 years from now.

In terms of tonnage, an estimated 300,000 to 440,000 tons of silt and clay and an estimated 1,090,000 to 1,630,000 tons of sand and coarser material have been trapped behind LPD since its construction in 1947 (AECOM 2017b), equating to between 4,290 to 6,290 tons of silt and clay and 15,570 to 23,290 tons of sand and coarser material annually. Analyses have not been performed to differentiate the estimated 590 AF of sediment in the reservoir that resulted from the Marble Cone fire into tons of fines and tons of sand and gravel. Using the ratio (0.475) of the sedimentation rate per year excluding the 1978 winter (7.53 AFY) to the sedimentation rate per year including the 1978 winter (15.86 AF), the estimated annual tonnage of sand and gravel trapped in the reservoir excluding the 1978 winter is 7,500 to 11,200 tons.

In terms of relative cost, Alternative 1 would be very low assuming that significant modifications to LPD are not required during the 60-year planning horizon. Alternative 1 may require implementation of fish passage improvements that have not been included in the relative cost.

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2.1.1 Alternative 1 Considerations

Considerations relevant to Alternative 1 include:

1. Effects on the downstream behavioral guidance system (BGS);
2. Effects on steelhead migration over LPD and through LPR;
3. Effects on downstream channel geometry and habitat for steelhead;
4. Streamflow effects on steelhead;
5. Compliance with State Water Resources Control Board (SWRCB) water rights permit conditions;
6. Effects on the water supply for the Monterey Peninsula; and
7. Dam safety.

These considerations are described further in the following sections.

Effects on Downstream Behavioral Guidance System

The downstream BGS might begin to be affected when the toe of the sediment delta reaches the spillway location. It is estimated that this might occur when the current reservoir storage has been halved from 1,100 AF to 550 AF, which would occur in 50 to 105 years. In summary, the BGS includes a 30-foot-long by 22-foot-wide floating collection barge fixed into horizontal position on four steel pilings located within the spillway approach channel. An articulated pipe bridge support structure connects to the spillway face, which allows for a vertical floatation range of approximately 10 feet. Water and fish that enter the collector are conveyed by gravity downstream via a 1,100-foot-long steel fish bypass conduit to a release point approximately 175 feet downstream of the spillway.

Steelhead Migration over Los Padres Dam and through Los Padres Reservoir

Steelhead migration over LPD and through LPR would continue in its current form, as described in Section 2.4.1.8 of the Study Preparation TM (AECOM 2017a). Fish passage at LPD is currently provided via trap-and-haul in the upstream direction, and via the spillway and the BGS in the downstream direction. In summary, trap-and-haul involves collection of the fish with a fish ladder and trap prior to transport. Approximately 250 feet downstream of the dam, on the left bank, a steeppass fish ladder allows upstream migrating steelhead to ascend into a small trapping facility. Steelhead are transferred from the fish trap to a truck via water-to-water transfer, hauled upstream of the dam crest, and released into the reservoir.

Effects on Downstream Channel Geometry and Habitat for Steelhead

Under Alternative 1, LPD would continue to prevent the transport of coarse sediment downstream of LPD through the Carmel River, especially the upstream section of Reach 1 (as described in Section 2.5.1.1 in the Study Preparation TM [AECOM 2017a]), between LPD and Cachagua Creek. Coarse sediment contributes to suitable spawning and rearing habitat for steelhead, so preventing coarse sediment from transporting downstream would continue to have a negative effect on downstream spawning habitat.

Streamflow Effects on Steelhead

As the reservoir is filled in with sediment, the ability to enhance summer rearing habitat for steelhead in the Carmel River downstream of LPD through flow releases from LPR would be incrementally reduced. As previously indicated for Alternative 1, the storage capacity of the reservoir will continue to decrease by an estimated 7.5 to 15.9 AFY. The reservoir is currently operated using a target minimum pool level of El. 1,005.9 North American Vertical Datum of 1988 (NAVD) (El. 1,003 National Geodetic Vertical Datum of 1929 [NGVD]). In very dry years, the minimum pool level is reduced to El. 982.9 NAVD (El. 980 NGVD). Current storage capacity between the normal maximum water surface (NMWS) and minimum pool elevations El. 1,005.9 (NAVD) and El. 982.9 (NAVD) based on 2017 bathymetry is 1,168 AF and 1,512 AF, respectively. Based on the current reservoir storage, average releases of 3.2 cubic feet per second (cfs) to 4.1 cfs can be made through the 6 months between April 15 and October 15. Over 60 years, the reservoir storage would be reduced by an estimated 450 AF to 950 AF, thereby reducing average releases during the same 6-month period to an estimated 1.3 cfs to 2.2 cfs. Also, as sediment fills the reservoir, the short delay that occurs between the onset of winter precipitation and when the reservoir spills would be decreased; on average, attraction and passage flows for steelhead could occur earlier in the wet season.

Compliance with State Water Resources Control Board Water Rights Permit Conditions

Alternative 1 would result in the gradual sedimentation of LPR. This sedimentation would cause a reduction in reservoir storage capacity that would further limit California American Water's (Cal-Am's) ability to release at least 5 cfs directly below LPD. Release of 5 cfs at all times during which water is being stored in the reservoir is a requirement of License 11866. The ability to release 5 cfs would primarily be affected during summer months, when reservoir storage is at its minimum. Because the requirement is for release when water is being stored, it may not apply when storage is reduced and the reservoir is near empty.

In addition to affecting Cal-Am's ability to meet SWRCB water rights permit conditions, Alternative 1 may also result in a reduction in Cal-Am's water rights. Cal-Am's water rights have been reduced due to siltation in LPR in the past. Under License 11866, Cal-Am was originally authorized to divert 3,030 AFY from the Carmel River to LPR. This water right was reduced to 2,179 AFY in 1995 (SWRCB Order WR 95-10) due to siltation in LPR. Therefore, it is possible that, as LPR fills with sediment, the SWRCB would reduce Cal-Am's current water right allowing diversion of 2,179 AFY from the Carmel River to LPR.

Effects on the Water Supply for the Monterey Peninsula

Water supply operations for LPD and LPR are described in Section 2.4.2.2 of the Study Preparation TM (AECOM 2017a). There is no direct connection to a municipal supply system, and re-diversion of flow released occurs at Cal-Am-owned municipal production wells downstream of Carmel Valley Village, primarily between River Mile (RM) 3 and RM 8, and at other private surface diversions and wells. The amount of water available for release and re-diversion downstream under Alternative 1 would be reduced incrementally over time, consistent with the storage and release reductions described above under "Effects on Downstream Channel Geometry and Habitat for Steelhead." However, the impact of this change on water supply would be moderated because Cal-Am intends to reduce its dry season diversion from the lower Carmel River to 1 cfs when replacement water supplies are available (Cal-Am and MPWMD 2016).

Dam Safety

From the standpoint of dam safety, the reservoir could not be allowed to completely fill with sediment. The ability to draw down the reservoir through the low-level outlet works during an emergency would need to be maintained. Encroachment of sediment into the upper reservoir will also continue to reduce the capacity of the reservoir above the spillway crest, which may increase the water surface during the Probable Maximum Flood (PMF). Based on previous analyses of the spillway capacity, the water surface level during the PMF is at the dam crest level (MWH 2012). Therefore, any increase in water surface level during the PMF would require modification of the dam crest or the spillway to increase its capacity.

Given that sedimentation in the area of the low-level outlet works intake has been minimal in the 40 years since the Marble Cone Fire event (AECOM 2017b), it is assumed that significant impacts on the low-level outlet works intake and flood capacity of the spillway would not occur until the current reservoir storage has been halved from 1,100 AF to 550 AF, which could occur in 50 to 105 years. However, if another event similar to the Marble Cone Fire and subsequent wet winter were to occur, the intake to the low-level outlet would likely be buried and require remediation (dredging to clear intake).

2.2 Dam Removal (Alternative 2)

Dam removal alternatives include full dam removal (Alternative 2a) or partial dam removal (Alternative 2b) down to the original river channel. Phased removal of the embankment dam over multiple years was also considered but determined to be not feasible because it would not be possible to convey flood flows past the dam without an active spillway. Therefore, removal of the embankment (full or partial) would need to be completed in a single 6-month construction period (assumed to be between April 15 and October 15).

Development of the Dam Removal alternative (Alternative 2) considered removal of the dam with and without removing sediment in the reservoir prior to dam removal. The reservoir sediment has been characterized as three zones; Zone 1 (clay/silt/fine sand), Zone 2 (predominately silt and sand), and Zone 3 (sand and coarser materials) (AECOM 2017b). Removal of the dam prior to removal of sediment (particularly Zones 1 and 2) would expose the reservoir sediment to low flows that would erode through the sediment and severely degrade water quality in a manner similar to that which occurred in October 1981. At that time, the reservoir emptied and river flows cutting through the reservoir sediment resulted in highly sediment-laden water passing through the outlet pipe into the river downstream of the dam (Buel 1981). Degraded water quality impacts would likely continue until a large flow event occurred that would erode the majority of the Zone 1 and Zone 2 sediment from the reservoir. Removal of the dam by excavating a notch to allow overtopping dam failure and accompanying sediment erosion and removal from the reservoir during a high-flow event would not be feasible, due to the size of the dam and the flood (estimated peak flowrate of 177,000 cfs) that would occur as the dam fails, as described in the draft Emergency Action Plan for LPD dated December 15, 2015. Therefore, dam removal requires, at a minimum, removal of the Zone 1 and Zone 2 sediment prior to dam removal. Removal of the sediment could be done either by dredging (described in Section 2.3) or mechanical removal and placing in permanent disposal sites (described in Section 2.2.1), or by sluicing through a sluicing tunnel (described in Section 3.3), but associated impacts would need to be considered.

The two sub-alternatives, Full Dam Removal and Partial Dam Removal, are described in the next two sections.

2.2.1 Full Dam Removal (Alternative 2a)

Removal of the 148-foot-high LPD would require excavation of about 460,000 cubic yards (CY) of zoned embankment (DSOD 2015) for full removal, and removal of about 300,000 CY for partial removal. Conceptually, full dam removal in profile is shown on Figure 2-1. Approximately two-thirds of the excavated embankment materials would be relatively impervious materials that were primarily placed in the downstream portion of the dam. These materials, which are variously described in compaction tests during construction as “sandy soil,” “organic soil,” “sandy loam,” or “sandy organic soil” (AECOM 2017a), would be placed in permanent disposal sites that are discussed below. The remaining embankment materials are sand, gravel, cobbles, and boulders that could either be placed in upland disposal locations or at locations along the river where they could be accessed and entrained into the river system during high flows (described in Section 3.2). The spillway would be removed in its entirety so as to not pose a health and safety risk to the public. Based on other experience from similar projects, it is likely that concrete debris generated during spillway demolition could be buried in the excavated materials being disposed in permanent disposal sites. The intake and outlet structures for the low-level outlet would be demolished and the 30-inch-diameter outlet conduit abandoned by filling with controlled low-strength material or by plugging each end with concrete. The reinforced outlet conduit encasement would be abandoned in place because its removal could destabilize portions of the rock slope in which the encasement was built.

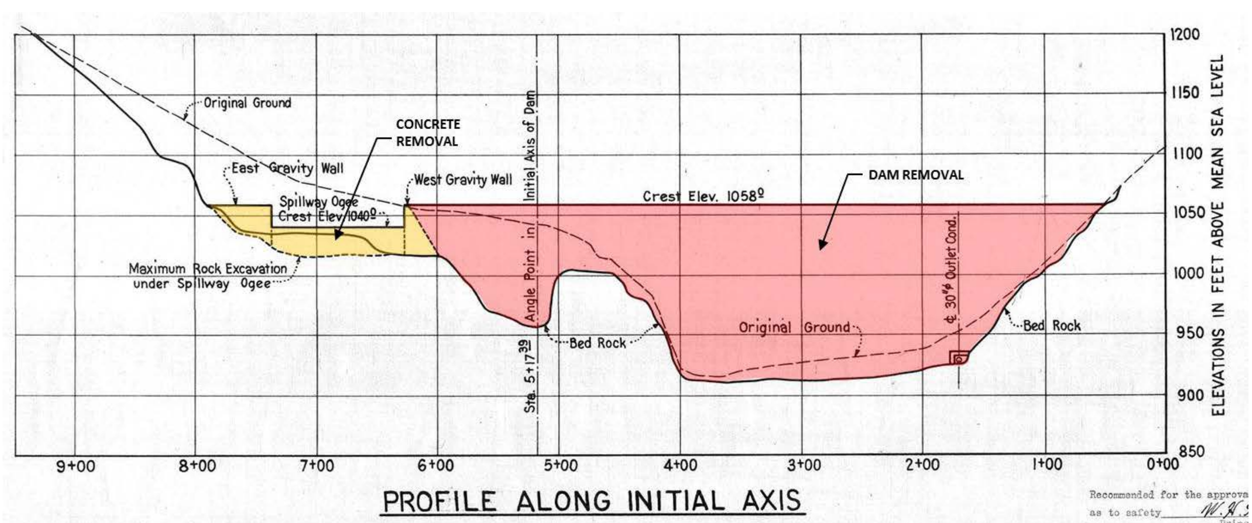

Figure 2-1 Alternative 2a Full Dam Removal Profile

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Three permanent disposal sites have been identified that could be used for disposal of the excavated embankment materials: Sites A, B, and C, as shown on Figure 2-2. Site A is a 5.1-acre site on a terrace on the left side of the reservoir. Site A has a storage capacity of about 107,000 CY at the NMWS El. 1042.9 feet. The fill thickness in Site A would be about 30 feet. Access to Site A would be along the reservoir bottom after sediment has been removed prior to dam removal. Sites B and C are downstream of the dam, as shown in plan on Figure 2-2. Site B is a 16.8-acre site on a terrace on the right side of the canyon and Site C is a 14.1-acre site on a terrace on the left side of the canyon. The storage capacities of Sites B and C are shown by elevation in Table 2-1. Access to Site B would be from the dam and across the spillway along Nason Road. Access to Site C would be from the dam along an access road on the downstream left abutment. The access road would need to be widened and improved.

Table 2-1 Storage Capacity of Disposal Sites B and C

Fill Height (feet)	Site B			Site C		
	Elevation (feet)	Incremental Volume (CY)	Cumulative Volume (CY)	Elevation (feet)	Incremental Volume (CY)	Cumulative Volume (CY)
40	1,020	460,000	460,000	1,000	200,000	200,000
80	1,060	600,000	1,060,000	1,040	360,000	560,000
120	1,100	580,000	1,640,000	1,080	420,000	980,000

Note:

CY = cubic yards

The slopes of the permanent disposal sites would be between 2H:1V and 3H:1V and would be protected from erosion by hydroseeding. The steeper slopes might require zoning the disposal sites, with coarser materials from Zone 3 being placed on the outside of the disposal site and finer materials from Zones 1 and 2 on the inside of the disposal site. Stability analyses would be required to design the slopes of the disposal sites based on the materials to be placed in them.

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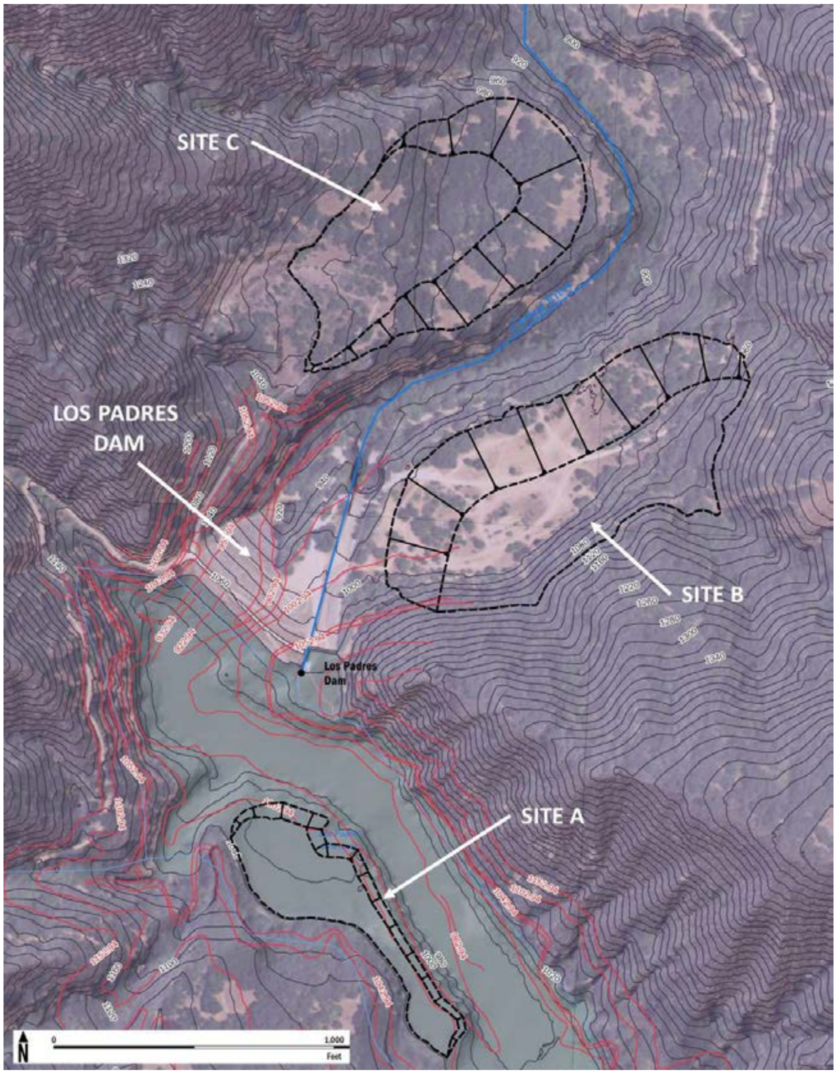

Figure 2-2 Permanent Disposal Sites

The relative cost of Alternative 2a, assuming dredging to remove Zone 1 and Zone 2 sediment, would be high. Dredging and placement of the majority of Zone 1 and Zone 2 materials in Disposal Sites B and C could require 5 years of dredging prior to dam removal, resulting in a 7-year duration for the dam removal project once design and permitting have been completed. Mechanical removal and placement of the majority of Zone 1 and Zone 2 materials in Disposal Sites B and C could require 2 to 3 years of excavation prior to dam removal, resulting in a 4-year to 5-year duration for the dam removal project once design and permitting have been completed.

The relative cost of Alternative 2a, assuming a sluicing tunnel to remove Zone 1 and Zone 2 sediment (described in Section 3.3), would be moderate. The duration for dam removal using a sluicing tunnel to remove the sediment might be on the order of 5 years, considering 2 years to construct the sluicing tunnel, waiting potentially 2 years for a large storm to open the sluicing tunnel and disperse Zone 1 and Zone 2 sediment downstream, and 1 year to remove the dam.

2.2.2 Partial Dam Removal (Alternative 2b)

Partial removal of the embankment would entail removal of the central portion of the embankment in profile, as shown in concept on Figure 2-3. Excavation slopes of 2H:1V are assumed for this study. In concept, the fill remaining on the left abutment (right side of Figure 2-3) would be accessible to Carmel River flood flows and would be entrained into the river when the flows in the river already have a high suspended sediment concentration. The fill remaining on the right abutment would not be accessible to river flow and would be stabilized by hydroseeding. Similar to full removal, partial removal of the embankment would need to be completed in a single 6-month construction season following removal of sediment from the reservoir. Disposal of the excavated embankment materials would be the same as described for full removal. The spillway structure would be left in place, with the higher walls being demolished or trimmed to reduce health and safety risks to the public. The intake and outlet structures for the low-level outlet would be demolished and the 30-inch-diameter outlet conduit would be plugged at each end with concrete.

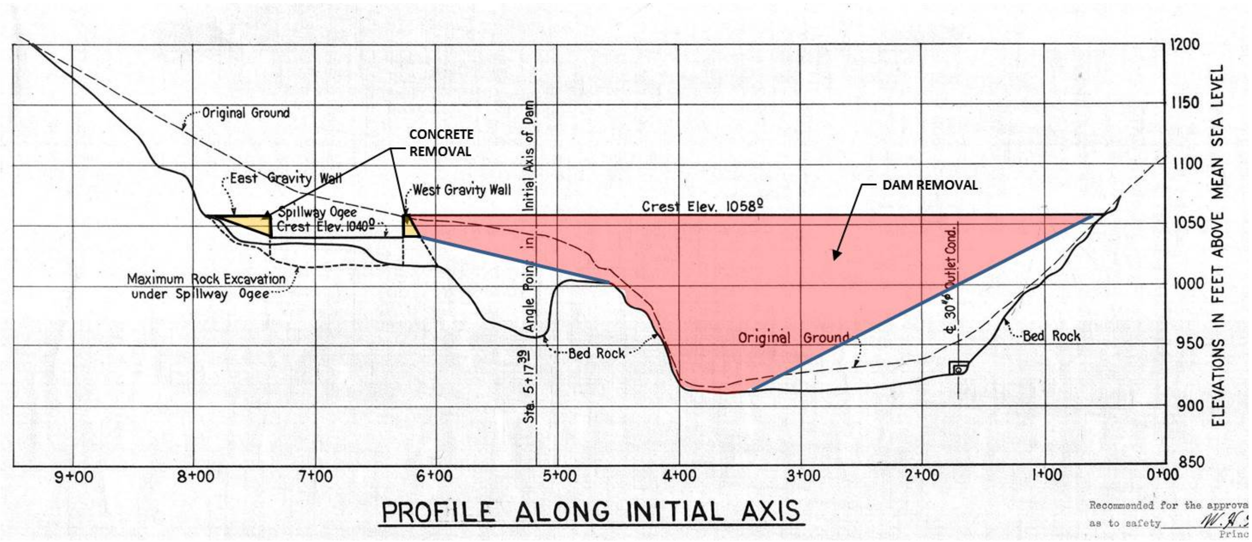

Figure 2-3 Alternative 2b Partial Dam Removal Profile

Construction costs for Alternative 2b would be somewhat less than Alternative 2a, due to a smaller volume of dam to be excavated. However, in terms of relative cost, as described in the introduction to Section 2, Alternative 2b would be the same as Alternative 2a; high assuming dredging to remove Zone 1 and Zone 2 sediment, and moderate assuming a sluicing tunnel to remove Zone 1 and Zone 2 sediment. Alternative 2b would require a duration for implementation similar to that required for Alternative 2a.

2.2.3 Alternative 2 Considerations

Considerations relevant to dam removal include:

1. Disposal, stabilization, or dispersal of existing reservoir sediment;
2. Potential improvements to steelhead passage and restoration of river habitat in the reservoir area;
3. Potential for public ownership of reservoir property;
4. Expected response of the active channel, potential impacts on downstream properties from resumption of the natural sediment load, and the need to develop a riparian management plan;
5. Reduction in dry season flow and the effect on riparian diversions and steelhead habitat below LPD;
6. The effect on water rights and municipal water supply;
7. Impacts on local residents from construction traffic; and
8. For phased removal, dam safety assuming a PMF of 36,000 cfs.

These considerations are described further in the following sections.

Disposal, Stabilization, or Dispersal of Existing Reservoir Sediment

Large, unnatural increases in suspended sediment in the Carmel River that could negatively impact steelhead and other aquatic organisms could occur during or after dam removal, depending on the methods used. Because of the intermittent and unpredictable rainfall patterns and hydrology in the

Carmel River, there would be an unacceptable level of risk associated with any dam removal alternative that would allow accumulated fine sediment to be transported in an uncontrolled manner downstream, where multiple small storm events could create repeated resulting in deleterious water quality conditions over an extended period of time or multiple years. Therefore, as previously discussed, Zone 1 and Zone 2 sediment would need to be removed from the reservoir prior to dam removal. An estimated 340 AF (550,000 CY) of Zone 1 and 692 AF (1,120,000 CY) of Zone 2 sediment are present in the reservoir (AECOM 2017b). The estimated 380,000 CY of coarser Zone 3 sediment in the upstream portion of the reservoir could be left in place to be transported through the reservoir area following dam removal. The timing and magnitude of potential fine sediment releases in the context of effects on steelhead associated with this approach would require further evaluation.

Permanent stabilization of sediment in the reservoir would not be feasible or practicable. Temporary stabilization until there are storm flows large enough to provide adequate dispersal of the sediment would require design of a rock-lined channel over the sediment along the channel thalweg. The rock size would be based on the storm size selected as that under which it would be desirable for the sediment to be transported out of the reservoir area. Risks associated with the temporary stabilization include failure of the temporary stabilization during flows that are less than desired, resulting in high water quality impacts. The rock needed to temporarily line the channel would need to be imported to the site.

Zone 1 and Zone 2 sediment can be removed prior to dam removal by dredging and placement in permanent disposal sites (a subset of Alternative 3a, discussed in Section 2.3), by excavation in the dry and placement in permanent disposal sites (similar to Sediment Management Option 1, discussed in Section 3.1 except that the reservoir would be drained and the Carmel River diverted around the reservoir during the construction season), or by sluicing through a sluicing tunnel (Sediment Management Option 3, discussed in Section 3.3).

Potential Improvements to Steelhead Passage and Restoration of River Habitat in the Reservoir Area

Dam removal would eventually result in fully volitional upstream and downstream passage for all life stages and species of aquatic organisms, including steelhead, to the extent that a natural channel would allow. Passage could at times be disrupted during construction, although careful planning may make that impact avoidable. With either a full or partial dam removal alternative, there would be substantial opportunity for passive or active restoration of habitats inundated by the reservoir. The dam and reservoir currently occupy roughly 1 linear mile of what would otherwise be stream habitat, which would be restored for the benefit of steelhead and many other native aquatic and terrestrial organisms with dam removal. Reservoir restoration to stream habitat may also reduce predation by nonnative species that inhabit the reservoir, and could have an effect on the growth rates of rearing steelhead, assuming some steelhead that would have reared in the reservoir (lacustrine habitat) would rear in riverine habitat instead following dam removal.

Potential for Public Ownership of Reservoir Property

If Cal-Am preferred not to continue with ownership of the property surrounding LPD and LPR following dam removal, its adjacency to public land managed by the United States Forest Service and the Monterey Peninsula Regional Park District may favor conversion of the land to public ownership following dam removal. For example, Cal-Am has agreed to transfer the land at the former San Clemente Reservoir site to the United States Bureau of Land Management at some point in the future.

Expected Response of the Active Channel, Potential Impacts on Downstream Properties from Resumption of the Natural Sediment Load, and the Need to Develop a Riparian Management Plan

With the removal of LPD, bed elevations along channel reaches downstream are expected to increase through sediment transport and deposition of primarily gravels and cobbles (0.5 to 256 millimeters); this is the expected response because downstream reaches have received less coarse sediment per annum than under natural conditions since the dam was constructed. This decrease of coarse sediment supply means that the average bed elevation of downstream reaches has reduced relative to pre-dam levels. The pertinent questions are how fast and over what distance from the dam sediment deposition is expected if the dam is removed. The aggradation of coarse sediment will be greatest in the reaches nearest LPD, and as coarse sediment mobilizes and continues downstream, it may aggrade lower portions of the river channel bed. Aggradation will begin with the first storms that generate runoff capable of mobilizing portions of the coarse sediment wedge in the reservoir, and in general the most rapid rates of aggradation occur with the first several storms following dam removal and taper off into the future years after these events. However, an aggradational signal in reaches most downstream of the dam will be delayed because it takes time for sediment to arrive to these reaches. A sediment transport model study is underway to understand the magnitude and general location of these effects, and to address the two questions raised above; the results of the sediment transport model will be interpreted to develop conclusions about how the river longitudinal profile could respond during many different sequences of future flood events.

Resumption of the natural sediment load may affect steelhead and riparian habitat downstream of the LPD. Redistribution of gravel-sized coarse sediment to reaches downstream of the dam will increase the available steelhead habitat. Depending on the response of the channel to the sediment, some management or riparian vegetation may be required. Monterey Peninsula Water Management District (MPWMD) has an ongoing program to manage riparian vegetation through which riparian vegetation management needs could be addressed.

Streamflow Effects on Steelhead Habitat and Riparian Diversions

As described in detail in Section 2.4.2.2 of the Study Preparation TM (AECOM 2017a) and summarized in Section 2.1.1 of this TM, releases from LPR are used to augment dry season flows in the Carmel River for the benefit of water diversion and steelhead habitat maintenance. If the dam is removed and alternative storage is not developed, there would no longer be stored water available for this purpose. This may decrease the quality of existing steelhead habitat during the dry season. Drying of the channel during summer months, which currently occurs most years in a portion of the Carmel River below RM 8, could be extended across a greater length of stream or for a greater duration. This could affect the extent of suitable steelhead rearing habitat for steelhead and the amount and timing of water available for diversion. Because of the complex interactions among surface flows, flood events, and groundwater, the magnitude of this effect is uncertain. However, the Carmel River Basin Hydrologic Model, when available, will allow for additional insight into the magnitude and extent of this effect.

The Effect on Water Rights and Municipal Water Supply

Alternative 2 would likely lead to the termination of Cal-Am's License 11866 and an amendment to several water rights orders (Orders WR 95-10, WR 2009-060, and WR 2016-0016). Cal-Am's water right—allowing for diversion of 2,179 AFY to LPR and requiring that at least 5 cfs be released directly below LPD at all times during which water is being stored in the reservoir—would also be terminated.

Removal of the dam would result in a loss of storage that has been used for decades to supplement flows in the Carmel River during the summer months. This reduction in summer flows would not affect diversions associated with Cal-Am and MPWMD's appropriative water rights (Permits 21330, 20808A, and 20808B), because these permits only allow for diversion between December 1 and May 31. Cal-Am's riparian and pre-1914 appropriative water rights, as well as diversions made at other private surface diversions and wells, are not subject to diversion windows, and Cal-Am and private diversion and well owners currently divert water during summer months. Reduced summer flows associated with Alternative 2 would likely reduce these summer water diversions. However, as described in Section 2.1.1, the effects of reduced flows on summer water diversions would be somewhat moderated in the lower Carmel River because Cal-Am intends to reduce its dry season diversion from the lower Carmel River to 1 cfs when replacement water supplies are available (Cal-Am and MPWMD 2016).

Impacts on Local Residents from Construction Traffic

Impacts on local residents during construction would include mobilization and demobilization of equipment for construction, delivery of fuel and other supplies during construction, off-hauling of materials that could not be disposed on site (steel reinforcement and building debris), and workers traveling to and from the construction site. Access to the project from Carmel Valley Road would be via Tassajara Road to Cachagua Road to Nason Road, as shown on Figure 2-4.

Cachagua Road is a winding, narrow 1½-lane road with several sharp curves. The section of Cachagua Road to the north of the intersection with Nason Road is generally narrower than the section to the south.

In addition, the northern section includes a couple of curves that would be difficult to improve for the passage of tractor-trailers hauling lowboys for equipment mobilization or construction materials, such as pipe and sheet piling (which require trailers). Based on an initial assessment, the northern section of Cachagua Road could only be used for vehicles bringing construction personnel to the site. To improve sight distance, tree pruning would be necessary on Cachagua Road at Carmel Valley Road, and a reduced speed limit sign north of Nason Road would be erected.

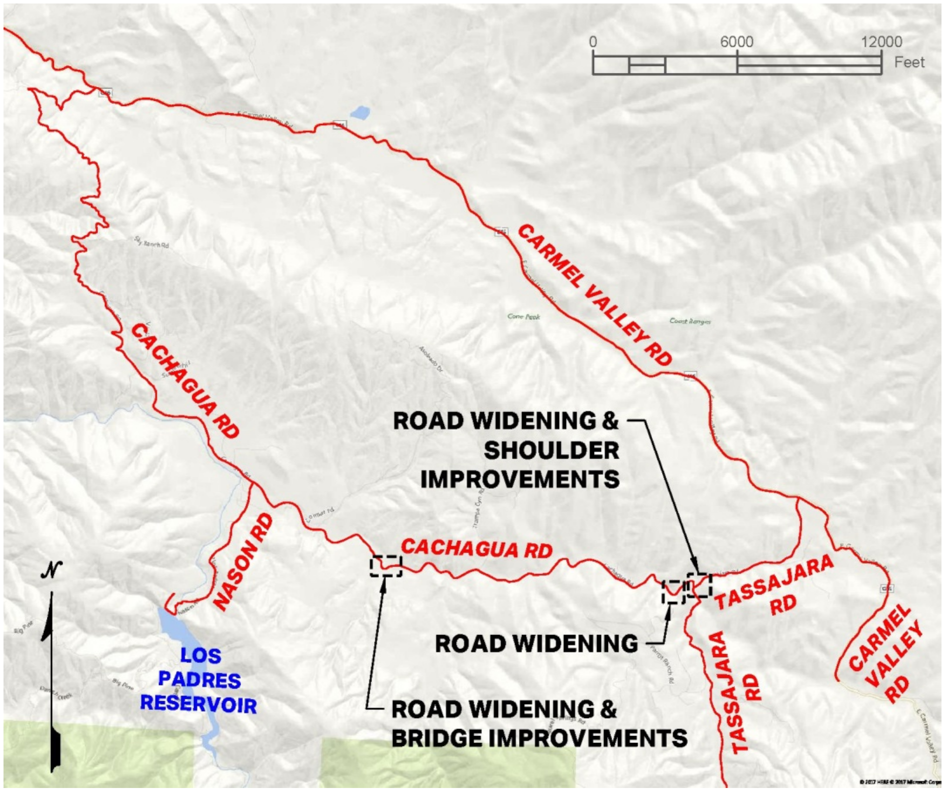

Figure 2-4 Location of Potential Public Road Improvements for Construction

Cachagua Road to the south of the intersection with Nason Road is generally less winding but has three curves that could be difficult for tractor-trailers to negotiate when pulling lowboys. These locations are shown on Figure 2-4. The three curves might require road widening to accommodate construction traffic, depending on the construction equipment that would be mobilized. The southern portion of Cachagua Road also includes two one-lane bridges, one of which is load-restricted. The load-restricted bridge (Bridge #529) would potentially require strengthening to handle construction equipment loads. The road west of Bridge #529 would potentially require widening the curve to 24 feet. The other one-lane bridge, on Tassajara Road near the intersection of Cachagua Road, would not require strength improvement; however, the road west of the intersection would likely require widening to facilitate tractor-trailers to negotiate the turn when pulling lowboys—and, if necessary, to conduct a three-point-turn.

Tassajara Road is wider than Cachagua Road and includes a one-lane bridge, mentioned above. Based on local input, our understanding is that tractor-trailers pulling lowboys have mobilized D8 bulldozers (similar to those recommended for this alternative) up Tassajara Road and the portion of Cachagua Road to Nason Road using the existing roads and bridges. Vehicles hauling construction equipment or materials along this route would require traffic control in the form of pilot cars (and other measures required in the future Contractor-provided, County-approved Traffic Control Plan, and other permits).

2.3 Restore Reservoir Capacity (Alternative 3)

Restore Reservoir Capacity (Alternative 3) includes two sub-alternatives that involve removing sediment from LPR to recover the storage capacity lost since construction. These sub-alternatives differ in the location where sediment is disposed; on Cal-Am Property for Alternative 3a, and off Cal-Am Property for Alternative 3b. These sub-alternatives are described in the following two sections.

2.3.1 Restore Reservoir Capacity by Dredging and Placing on California American Water Property (Alternative 3a)

Restore Reservoir Capacity by Dredging and Placing on Cal-Am Property (Alternative 3a) is the sub-alternative that includes dredging sediment from the existing reservoir and disposing of the sediment by placing it on Cal-Am property downstream of LPD. This sub-alternative builds on the analysis presented in the LPD Sediment Removal Feasibility Study (MWH 2013), and considers whether the downstream sediment disposal site identified in that study can be expanded to accommodate dredging the reservoir to its original capacity.

Based on our review of the disposal sites proposed in MWH (2013) (see Figure 2-5), it has been concluded that the upstream site is not practicable for the following reasons:

- The length of new access road required along the Carmel River channel (about 1 mile);
- The height to the top of the disposal site above the Carmel River channel (390 feet) requiring a very steeply graded, switchback haul road to access;
- The specialized soil-cement containment dike with 1H:1V slope to facilitate construction in the steep drainage; and
- The difficulty in providing for storm drainage across the disposal site following construction.

The downstream disposal site (Site B for this TM) on the right abutment above the spillway is a feasible location and can be expanded to handle a disposal capacity of up to about 1,640,000 CY, as discussed in Section 2.2. An additional downstream disposal site, Disposal Site C (also discussed in Section 2.2), is also considered in this TM.

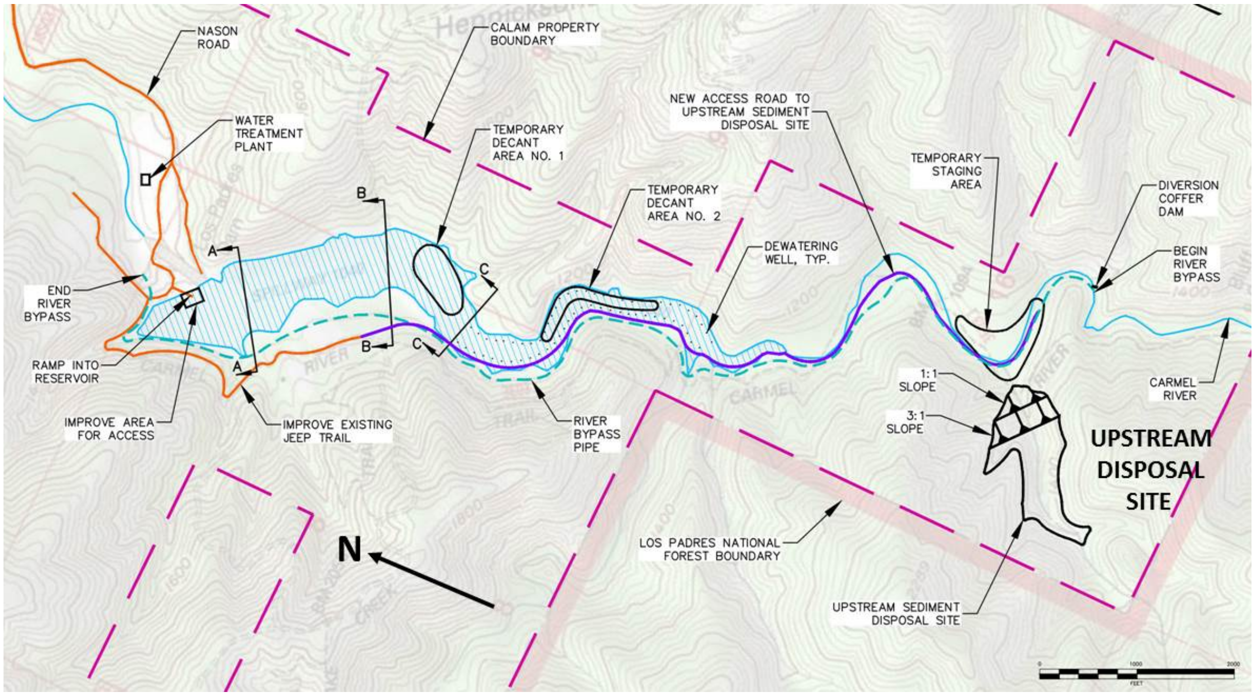

Figure 2-5 Upstream Disposal Site (from Exhibit 2, MWH 2013)

Methods for dredging sediment below the reservoir level, including hydraulic dredging using a suction dredge and barge-mounted clamshell or long-reach excavator, have been previously considered (MWH

2013). The most viable method of dredging Zone 1 and the finer Zone 2 materials would involve mechanical means such as a barge-mounted clamshell or long-reach excavator. The dredged materials would be conveyed to a transport barge that would convey the material to an off-load area where the material would be transferred to trucks and hauled to a decanting area. Following decanting, the sediment would be transported, placed, further moisture-conditioned, and compacted in Disposal Site B or Disposal Site C (Figure 2-2).

Typical operation of LPR during dry years provides the opportunity to excavate Zone 2 and Zone 3 sediment above the reservoir water surface elevation using conventional earth-moving equipment. Based on current sediment conditions (AECOM 2017b) and depending on the water year condition, excavation of sediment could be performed in about the upstream two-thirds of the reservoir. The sediment would be accessed along an existing jeep trail from the dam crest at the left abutment that extends upstream to a terrace that was a source of material for the existing dam. Upstream of the jeep trail, haul trucks would travel on the exposed sediment. Development of access on the exposed sediment would require grading and possibly placement of coarse materials to provide a road base for the access road. Table 2-2 is a summary of the number of days during the years between 2002 and 2016 when the reservoir level was below sediment elevations between El. 1,000 and El. 1,040. Table 2-2 indicates that sediment could have been excavated in the dry down to El. 1,030 in all years, down to El. 1,020 in about 50 percent of the years, and down to El. 1,010 during 2 years of the 15-year record.

Table 2-2 Days of Availability of Sediment for Dry Excavation by Elevation (2002 to 2016)

Days Below El.	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Years of Access
1,042.9	153	39	184	127	95	190	199	175	20	98	183	170	253	161	115	15
1,037.9	124	39	150	110	71	151	179	122	13	59	161	137	221	137	98	15
1,032.9	96	38	125	73	53	117	151	90	12	8	121	111	191	125	96	15
1,027.9	0	0	0	0	34	89	117	82	0	0	24	91	163	113	86	9
1,022.9	0	0	0	0	33	0	69	57	0	0	0	74	141	72	83	7
1,017.9	0	0	0	0	18	0	0	3	0	0	0	19	101	9	79	6
1,012.9	0	0	0	0	0	0	0	0	0	0	0	0	41	0	54	2
1,007.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Days of record	**365**	**126**	**365**	**365**	**321**	**365**	**365**	**365**	**365**	**365**	**365**	**365**	**365**	**365**	**302**	

Notes:

Vertical datum: North American Vertical Datum of 1988

Gray denotes year with incomplete data

In terms of relative cost, Alternative 3a would be high and would likely be similar Alternative 2a using dredging to remove Zone 1 and Zone 2 sediment because the volume of the dam to be removed in Alternative 2a is similar to the volume of Zone 3 sediment that would be removed as part of Alternative 3a. Dredging and placement of Zone 1, Zone 2, and Zone 3 materials in Disposal Sites B and C could require 5 years, meaning the sediment removal project could have a 6-year duration once design and permitting have been completed. Alternative 3a may require implementation of fish passage improvements that have not been included in the relative cost.

2.3.2 Restore Reservoir Capacity by Dredging and Placing Off California American Water Property (Alternative 3b)

Restore Reservoir Capacity by Dredging and Placing Off Cal-Am Property (Alternative 3b) is the sub-alternative that includes dredging the reservoir to original capacity and transporting some or all reservoir sediment to an offsite disposal area (see Figure 2-6 for approximate limits of Cal-Am property). With this sub-alternative, existing public roads in Cachagua Valley would not be used (i.e., Nason Road, Cachagua Road, and Tassajara Road). This concept could be combined with placement of a portion of material on the Cal-Am property and the remainder off site. It is expected that many of the same considerations discussed for Alternative 3a would apply. Based on our review of area surrounding the reservoir using aerial photography, there are no practicable feasible locations for this sub-alternative.

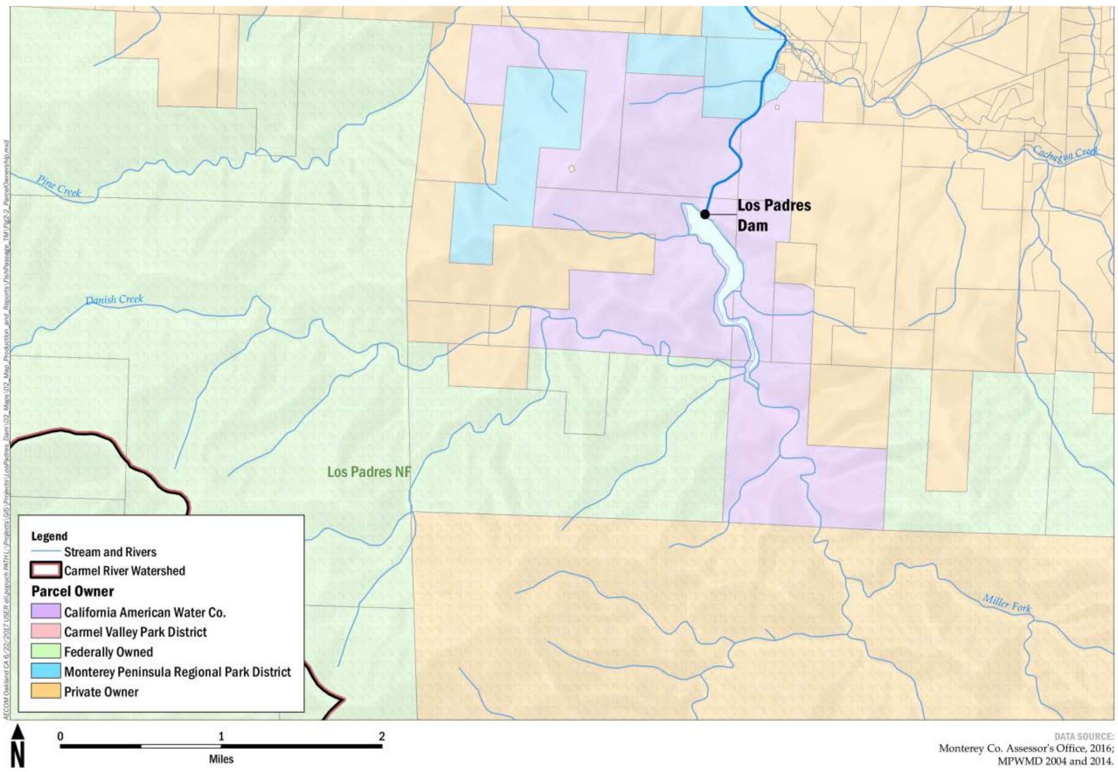

Figure 2-6 Approximate Location of California American Water Property

Source: Cal-Am and MPWMD 2016

2.3.3 Alternative 3 Considerations

Considerations relevant to restoration of reservoir capacity include:

1. Maintaining dam safety;
2. Division of Safety of Dams (DSOD) requirements for disposal containment;
3. Sustainability;
4. Impacts on local residents from construction traffic;
5. Effects on downstream channel geometry and habitat for steelhead;
6. Effects on steelhead passage over LPD and through the reservoir;
7. Environmental and municipal benefits from an increased water supply; and
8. Effects on water rights.

These considerations are described further in the following sections.

Maintaining Dam Safety

This alternative would not impact the dam or its appurtenant structures and would therefore not result in any changes regarding safety of the dam, unless future analyses of the dam found that improvements to the dam were necessary.

Division of Safety of Dams Requirements for Disposal Containment

The disposal areas under consideration do not impact the dam or its appurtenant structures and are not anticipated to be within DSOD's jurisdiction. The possible exception could be Site B, on the terrace above the right side of the spillway structure. DSOD may desire a stability analysis that demonstrates that the disposal site would not pose a stability risk to the slope above the right side of the spillway.

Sustainability

This alternative would recover the 1,108 AF of reservoir capacity lost in the 69 years since construction of LPD was completed in 1948. Assuming the sedimentation rates described in Section 2.1, an estimated 69 to 147 years would be required for the reservoir capacity to be reduced to its current capacity of 1,600 AF.

Impacts on Local Residents from Construction Traffic

Impacts on local residents from construction traffic would be similar to those described for Alternative 2 in Section 2.2.3. The estimated duration of impacts would be six construction seasons.

Effects on Downstream Channel Geometry and Habitat for Steelhead

Effects on downstream channel geometry and habitat for steelhead would be similar to those described in Section 2.1.1 for the No Sediment Management alternative, where LPD and LPR continue to interrupt sediment transport on the mainstem Carmel River until tributaries downstream introduce other sediment sources.

Effects on Steelhead Passage over Los Padres Dam and through the Reservoir

Effects on steelhead passage over LPD and through the reservoir would be similar to those described in Section 2.1.1 for the No Sediment Management alternative, where passage would continue in its current form.

Environmental and Municipal Benefits from an Increased Water Supply

The additional 1,108 AF of storage resulting from removing the accumulated sediment from the reservoir would allow additional average releases of about 3 cfs (6.1 AF) per day during the 6-month dry season period. This increase in summer flow would likely result in opportunities for Cal-Am and private diversion and well owners to divert more water during the dry season, although Cal-Am intends to reduce its dry season diversion when replacement water supplies are available (Cal-Am and MPWMD 2016). An increase in summer instream flow would also increase both the quality and quantity of summer rearing habitat downstream of LPD for steelhead, by increasing flows through existing rearing habitat and by wetting portions of the channel that currently dry during summer months, or by extending the duration of inundation for some reaches.

Effects on Water Rights

Restoration of original reservoir capacity would eliminate the risk of further water rights reductions described in Section 2.1.1 for Alternative 1. With implementation of Alternative 3, Cal-Am could also petition the SWRCB to increase their water right associated with LPR.

2.4 Storage Expansion (Alternative 4)

Storage Expansion (Alternative 4) is the concept of increasing the storage capacity of LPR through modification of the existing dam, a new dam downstream of the existing dam, or a combination of modification of the existing dam and a new downstream dam. The concept includes four sub-alternatives that differ in the type and location of the upgraded dam or dams. The maximum elevation of any storage expansion alternative for this study was set so that the reservoir resulting from a 100-year flood event (8,900 cfs [AECOM 2017a]) would not impinge on the Ventana Wilderness boundary (based on 2010 Light Detection and Ranging [LiDAR] data). The maximum spillway crest elevation for storage expansion alternatives is set at 1,052.5 feet, which is the Ventana Wilderness boundary at Danish Creek of El. 1,060.0 minus 7.5 feet (the depth of water above the spillway crest during the 100-year flood using DSOD's spillway rating curve [MWH 2012]).

The four storage expansion alternatives being considered, and described in this section, include:

1. Expand with Dam Raise (Alternative 4a)
2. Expand with Rubber Dam (Alternative 4b)
3. New Downstream Dam (Alternative 4c)
4. Expand with Combination (Alternative 4d)

2.4.1 Expand with Dam Raise (Alternative 4a)

Expand with Dam Raise (Alternative 4a) is the concept of expanding reservoir surface storage with a small dam raise at the existing dam. The maximum raise for the NMWS would be 9.6 feet, to El. 1,052.5 feet. This would increase the maximum storage capacity of the reservoir by 586 AF, from 1,601 AF to 2,187 AF. Alternative 4a would require raising the dam from the downstream side, modifying the spillway by raising the crest and the walls, and modifying portions of the outlet works. Construction of the dam raise would likely require two construction seasons, with the dam raise occurring during the first 6-month construction season and modifications to the spillway and outlet works being constructed during the following 6-month construction season.

Raised Dam Crest Elevation

Raising the dam would require reevaluation of PMF using Hydrometeorological Report (HMR) 58/59 or, potentially, a probabilistic approach. In either case, the PMF would be greater than the current PMF of 31,579 cfs (DSOD 2015) developed using HMR 36. The water surface elevation during the HMR 36 PMF is 1,060.25 feet, 0.3 foot below the dam crest. Based on a comparison of the HMR 58/59 and HMR 36 PMFs at the former location of San Clemente Dam, 11 miles downstream of LPD, a HMR 58/59 PMF at LPD might be on the order of 42,250 cfs. Based on an extrapolation of the current spillway rating curve, the PMF flood level would be about El. 1,064.44 feet; 21.5 feet above the spillway crest. Thus, the raised dam crest would be El. 1,052.6 feet + 21.5 feet + 2 feet freeboard for wind-wave runup, or El. 1076.1; a dam raise of 15.6 feet. For the purposes of this TM, it is assumed that the design PMF would be that developed using HMR 58/59. The amount of freeboard required to pass the PMF could be reduced if the spillway crest were either widened or modified from its current straight ogee crest to a single-cycle labyrinth spillway crest. For the purposes of this TM, it is assumed that the crest width would stay the same as the existing spillway crest.

Dam Raise

The dam would be raised from the downstream side. The foundation of the dam raise would require excavation at the downstream toe to expose bedrock. The downstream slope of the dam would be prepared by removing vegetation and excavating and stockpiling the existing rock slope protection for reuse, to expose Zone 1 material. The top approximately 40 feet of the dam would be removed to facilitate internal zoning of the top of the dam raise. The dam raise would include extension of the downstream blanket, a chimney filter between Zone 1 (likely silty sand [SM] to sandy silt [ML]) and the material used for the dam raise, and extension of Zones 1, 2, and 3 at the top of the dam raise, as shown on Figure 2-7. The chimney provides protection against uncontrolled piping and erosion of Zone 1 that could occur through cracks that could form during seismic deformation.

EXHIBIT 2-C

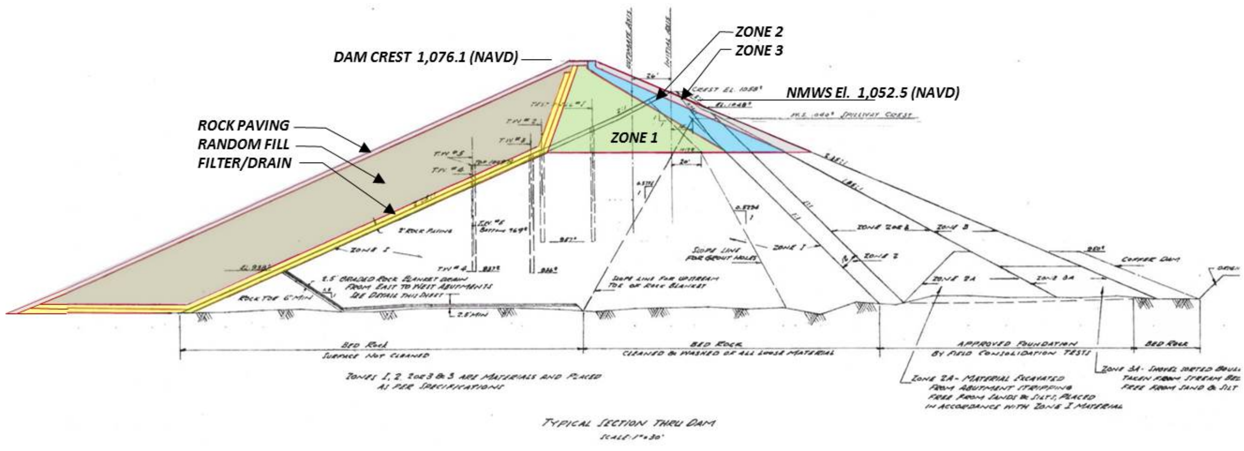

Figure 2-7   Alternative 4a Dam Raise Section Concept

Zone 1 material could come from alluvial fan deposits at the top of the terrace deposits that form the base of permanent disposal Sites A, B, and C (The Mark Group 1995), as shown on Figure 2-2. Potential sources of Zone 2, Zone 3, and random fill materials are the coarse sediment in the upstream portion of the reservoir and terrace gravels underlying the alluvial fan deposits in the terraces that form the base of permanent disposal Sites A, B, and C. Filter and drain materials would likely need to be imported, but could potentially be processed from the coarse sediment in the upper end of the reservoir.

Design for a dam raise would require stability analyses and seismic deformation analyses. The most recent seismic stability analysis was performed for LPD by DSOD in 1981 (DSOD 1981). The 1981 seismic stability analysis was based on a seismic hazard analyses for the dam that considered three major active faults: the San Gregario-Hosgri fault, the San Andreas fault, and the Rinconada fault (DSOD 1980). Based on the seismic hazard evaluation, the San Gregario-Hosgri fault was determined to be the controlling fault, with a Maximum Credible Earthquake (MCE) of M7.5 and a peak ground acceleration of 0.4g. Based on current understanding of the seismic hazards in the area of LPD, the Monterey Bay-Tularcitos Fault Zone should also be considered an earthquake source. The Monterey Bay-Tularcitos Fault Zone, being much closer to the dam than the San Gregario-Hosgri fault, will likely result in higher peak ground accelerations.

Ground motions developed based on the revised seismic hazard analysis would be used for liquefaction triggering analyses of the granular Zones 2 and 3 in the upstream shell; seismic deformation of both the upstream and downstream shells; and analyses for potential for cracking of Zone 1 during seismic shaking where it overlies the foundation ridge at the right abutment, which could lead to seepage and potential piping from the downstream slope of the embankment. Seepage analyses, static stability analyses, and seismic stability analyses would require a better understanding of the static and dynamic properties of the Zone 1 (impervious embankment) and Zone 2 (free-draining upstream zone). Obtaining these properties would require drilling a number of holes in the dam to obtain samples for laboratory analyses, including gradation, Atterberg Limits, and shear strength. In addition, downhole geophysics would likely be needed for dynamic properties of the Zone 1 material. Given the relatively steep upstream slope (2.35H:1V), there is a potential that deformation analyses could indicate the need for the upstream shell to be flattened.

Spillway Modifications

The spillway would require significant modification for the dam raise. The spillway crest would be raised by 9.6 feet, to El. 1,052.5 feet. The left and right gravity walls would be raised 15.6 feet, to the embankment crest elevation of 1,076.1 feet. The left gravity wall could potentially require post-tensioned anchorage, depending on the results of its performance during the MCE. If required, the spillway could be shifted to the right into the abutment to allow additional room for the left abutment gravity wall, or to widen the spillway.

Outlet Works

The current outlet works consists of a low-level outlet and a high-level outlet. The low-level outlet includes an upstream intake structure with a 30-inch hydraulically operated slide gate (invert El. 950.2 feet), an approximately 620-foot long 30-inch-diameter steel conduit encased in reinforced concrete, and a downstream outlet works that divides into four outlet gates: a 30-inch butterfly valve, two 12-inch guard gate valves and regulating butterfly valves, and a 12-inch gate valve for habitat flow.

The high-level outlet works is a slide-gate-controlled, 30-inch-diameter, concrete-encased outlet pipe through the left side of the spillway ogee crest that terminates at the spillway chute floor, where it meets the downstream end of the ogee crest. The slide gate invert is El. 1,020 feet; 20 feet below the spillway crest.

The outlet structure for the low-level outlet is far enough downstream that it would not be affected by raising the dam. The upstream slide gate and hydraulic operating system would also not likely be affected by the dam raise (unless flattening of the upstream slope was determined to be needed); however, its ability to operate under the additional 12.5 feet of head at the raised NMWS would need to be confirmed. The high-level outlet would need to be modified to extend through the raise of the existing spillway crest. The combined outlet works would need to be reevaluated for meeting DSOD drawdown criteria, which includes the following:

- Drain 50 percent of the original reservoir capacity in 7 days; and
- Drain the entire reservoir in 20 days.

In terms of relative cost, Alternative 4a is judged to be moderate. Construction of Alternative 4a is judged to be feasible in two construction seasons once design and permitting have been completed. Alternative 4a would require implementation of fish passage improvements that have not been included in the relative cost.

2.4.2 Expand with Rubber Bladder Gates (Alternative 4b)

Expand with Rubber Bladder Gates (Alternative 4b) is the concept of expanding reservoir surface storage by using a gates controlled using rubber bladders within a gate structure installed on the existing spillway crest. The gates could be raised at the end of the precipitation season, when the risk of large storms has passed but there is sufficient flow in the Carmel River that water could still be captured and stored for release later during the dry portion of the year.

A rubber bladder gate structure could be installed on the spillway crest to raise the maximum normal reservoir water surface elevation by 9.6 feet, to El. 1,052.5 feet. This would increase the maximum storage capacity of the reservoir by 586 AF, from 1,601 AF to 2,187 AF. An example rubber bladder gate structure installed for the Salinas River Diversion Structure is shown on Figure 2-8. Installation of the gate structure would require modification of the existing spillway so that when the gates are lowered the spillway capacity would not be less than the current capacity. Operational rules for the gates (when they can be raised, considering flood control, and what other circumstances would require lowering) and protection against vandalism would need to be addressed during design to obtain DSOD approval.

Because the reservoir would be operated temporarily at a level greater than the NMWS, seepage and stability analyses—and likely seismic deformation analyses—would be required to demonstrate that minimum factors of safety are being met. The seepage analyses, stability analyses, and seismic deformation analyses would be similar to those described in Section 2.4.1. It is possible that the analyses will indicate that other features of the dam will also require improvement (e.g., increasing the thickness of Zone 1 to the top of gate elevation, adding a chimney drain, and flattening the upstream slope) for Alternative 4b to be approved by DSOD.

Figure 2-8 Obermeyer Gate at Salinas River Diversion Facility

The spillway modification may be significant enough that DSOD could require the PMF to be reevaluated using HMR 58/59 or, potentially, a probabilistic approach, as described in Section 2.4.1. The raised dam crest required to safely pass the HMR 58/59 PMF using the existing spillway crest would be El. 1,042.9 feet + 21.5 feet + 2 feet freeboard for wind-wave runup, or El. 1,066.4 feet; a dam raise of about 6 feet. A concept section of the dam raise is shown on Figure 2-9. In addition, the spillway walls at the crest would have to be raised to match the raised embankment crest, and the chute walls would also likely need to be raised.

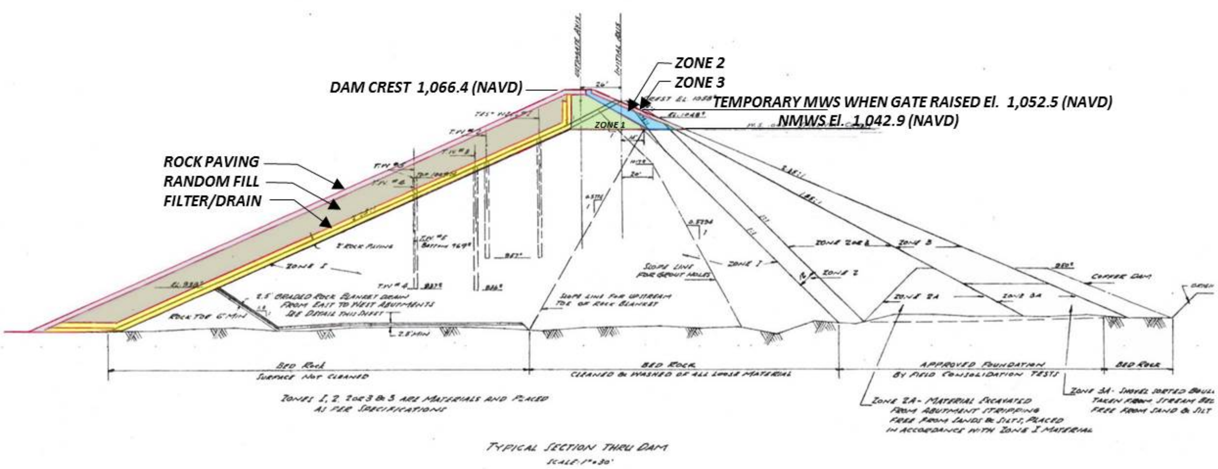

Figure 2-9 Alternative 4b Dam Raise Section Concept to Pass Hydrometeorological Report 58/59 Probable Maximum Flood

Construction of the dam raise to provide sufficient freeboard for the HMR 58/59 PMF would be similar to that described for Alternative 4a in Section 2.4.1, except that about the top 20 feet of the existing dam would be removed to facilitate the dam raise. For the purposes of this TM, it is assumed that the dam would need to be modified as shown on Figure 2-9.

Alternative 4b would cost less and could be implemented in less time than Alternative 4a, due to a smaller volume of dam construction and less spillway modification. In terms of relative cost, Alternative 4b is judged to be low to moderate. Construction of Alternative 4b is judged to be feasible in a single construction season once design and permitting have been completed. Alternative 4b would require implementation of fish passage improvements that have not been included in the relative cost.

EXHIBIT 2-C

2.4.3 New Dam Downstream (Alternative 4c)

New Dam Downstream (Alternative 4c) is the concept of expanding surface storage by constructing a new dam downstream of the existing LPD. The Carmel River canyon downstream of LPD and within Cal-Am property was reviewed for potential locations for the new dam. The location previously selected by The Mark Group (1995) for the New LPD (see Figure 2-10) is the only location that makes sense topographically and geologically. Topographically, this is the narrowest part of the canyon in the area being considered, requiring the least material to construct the new dam.

Geologically, bedrock at the selected location is granitic (The Mark Group 1995), with the right abutment having a somewhat thicker section of weathered rock than the valley or left abutment. All colluvium, alluvial fan deposits, terrace gravels, and weathered rock would need to be excavated for dam construction. Excavation depths for the right abutment, valley, and left abutment were estimated to be 20 to 80 feet, 10 feet, and 20 to 70 feet, respectively. Based on geotechnical investigations made of the New LPD (The Mark Group 1995), the foundation at the site would be suitable for construction of either an embankment dam or a roller-compacted concrete (RCC) dam.

Materials for an embankment dam would be sourced from terraces between the existing dam and new dam, the existing dam, and rock quarried from below the terraces between the two dams. The terraces include alluvial fan deposits overlying terrace gravels. The alluvial fan deposits would be used for the impervious zone, and the terrace gravels would be used for the shells of the dam. The majority of reservoir sediment would be unsuitable for an impervious zone, due to the high organics content and the effort required to dredge the material from the existing reservoir and process the sediment for placement. Filter and drain materials would likely need to be imported, but could potentially be processed from the coarse sediment in the upper end of the reservoir. Aggregate materials for an RCC dam would be developed on site from the terrace gravels and from rock underlying the terrace gravels (The Mark Group 1995). Cement and flyash for the RCC would need to be imported.

Three possible dam sizes were considered at the downstream dam location:

- A dam with a spillway crest elevation that is the same as the existing dam (i.e., El. 1,042.9 NAVD);
- A new dam with a spillway crest elevation of 1,052.5 (9.6 feet above the current NMWS); and
- A new dam with a spillway crest elevation of 1,007 (about 36 feet below the current NMWS).

Freeboard of an additional 20 feet is assumed to be required between the spillway crest and the dam crest to pass the HMR 58/59 PMF. Table 2-3 summarizes the storage capacity, dam height, and estimated volume of material required for dams at the two spillway crest elevations.

Table 2-3 Summary of Potential New Dams Downstream of Los Padres Dam

NMWS (feet)	Storage Capacity (AF)	Dam Height (feet)	Embankment Dam Volume (CY)	RCC Dam Volume (CY)
1,007	3,000	152	1,100,000	230,000
1,042.9	6,311	193	2,100,000	400,000
1,052.5	7,529	203	2,400,000	460,000

Note:

AF = acre-feet
CY = cubic yards
NMWS = normal maximum water surface

As shown in Table 2-3, the volume of materials required for a new embankment dam at maximum NMWS El. 1052.5 is about four to five times greater than for the existing dam, and 2.5 times greater for a new embankment dam having a storage capacity of 3,000 AF. Based on estimated volumes of materials in potential borrows reported in The Mark Group (1995), and including the existing dam, the volume of available material for the core of the largest new embankment dam appears to potentially be present, but may not have the reserves (typically two times the required volume) desired for construction. New RCC and embankment dams with dam crest El. 1,073 feet (NMWS 1,052.5 feet) are assumed for this TM. Concept plans of a new RCC dam and new embankment dam are shown on Figure 2-10.

In terms of relative cost, Alternative 4c with RCC would be high, and Alternative 4c with embankment would be very high. Alternative 4c would require implementation of fish passage improvements that have not been included in the relative cost. Construction of Alternative 4c would require an estimated four construction seasons once design and permitting have been completed. Construction of an RCC dam would require excavation of the foundation, development of a borrow area for aggregate for the RCC, and construction of diversion during the first construction season. The diversion system would be designed to convey winter flows around the new dam site without developing a large pool behind the partially completed dam after the second year of construction. Two construction seasons would be required for dam construction and removal of the existing dam, and a final construction season for project restoration and closeout.

Construction of an earthfill dam would require excavation of the foundation, excavation of a diversion tunnel (that would also be used as the permanent low-level outlet), development of borrow areas, and construction of a cofferdam for diversion of the Carmel River during construction. The diversion system would be designed to safely convey at least a 100-year storm event around the new dam site without overtopping the cofferdam. Construction of the dam, spillway, and outlet works would require three more construction seasons, and a final construction season for project restoration and closeout.

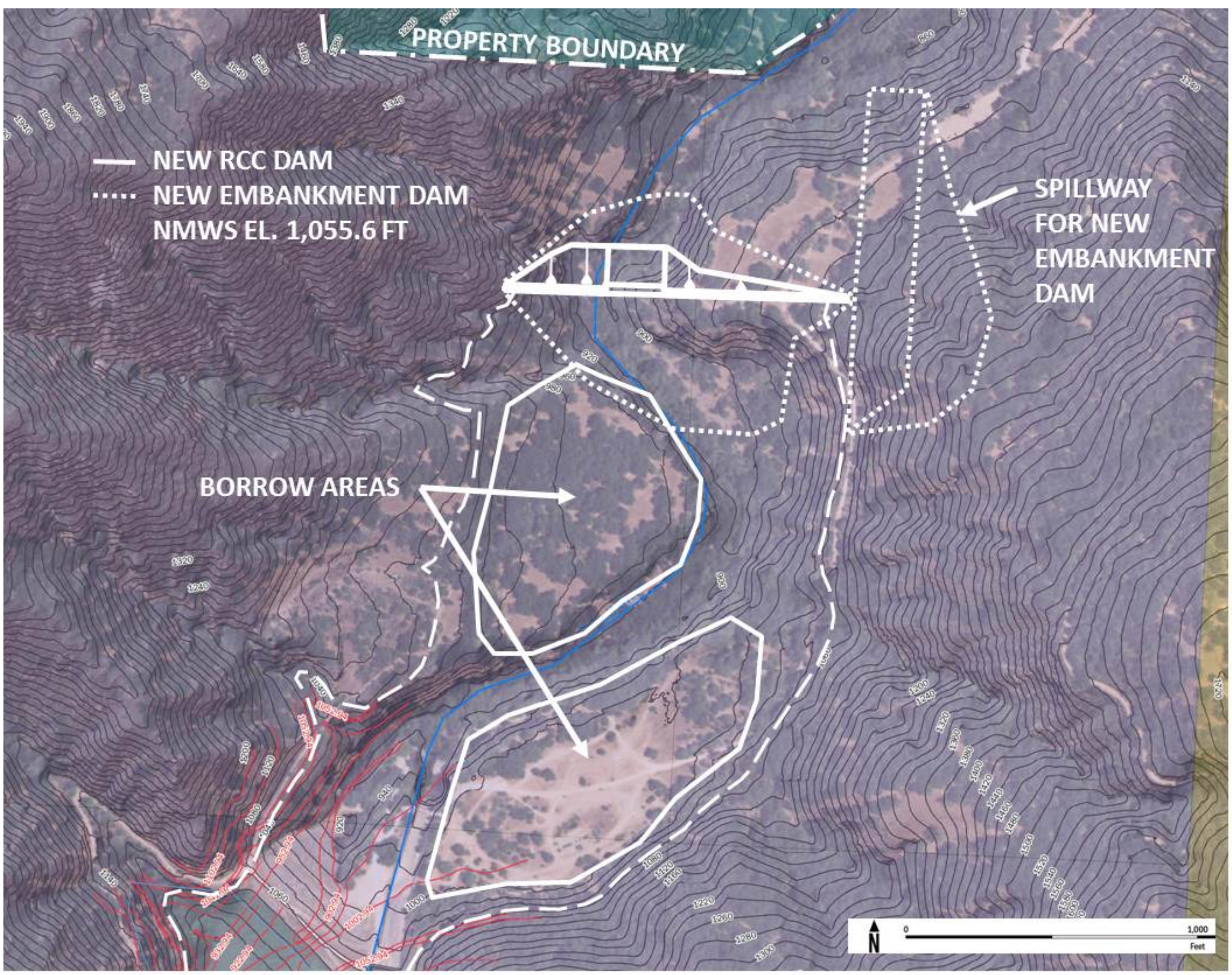

Figure 2-10 Alternative 4c New Downstream Dam Concept Plan

EXHIBIT 2-C

2.4.4 Expand with Combination (Alternative 4d)

Expand with Combination (Alternative 4d) is the concept of expanding surface storage with a combination of two or three methods described above. Alternative 4d could provide an opportunity to use the original reservoir to continue capturing sediment, allowing a lower reservoir to trap less sediment. This alternative would combine a new downstream dam with either a raise of LPD or placement of a rubber dam on the LPD spillway crest (Figure 2-11). The new downstream dam would be restricted to a height that would not cause inundation of the invert of the LPD outlet structure (about El. 927.0 feet) during typical operations. Based on this restriction, the new downstream dam would be on the order of 45 feet high, with a maximum spillway crest elevation of about 920 feet, assuming 2 feet of freeboard between the LPD outlet invert and a reservoir level behind the new dam resulting from a 100-year event. The spillway crest would be at about El. 940 feet, to pass the HMR 58/59 PMF. The new dam would have a reservoir capacity of about 200 AF. The new dam would be constructed with RCC so that the majority of the dam crest could be used as a spillway crest, thereby avoiding construction of a separate spillway structure. The new dam would be at the same location described for Alternative 4c. Construction of the dam would be similar to that described for Alternative 4c.

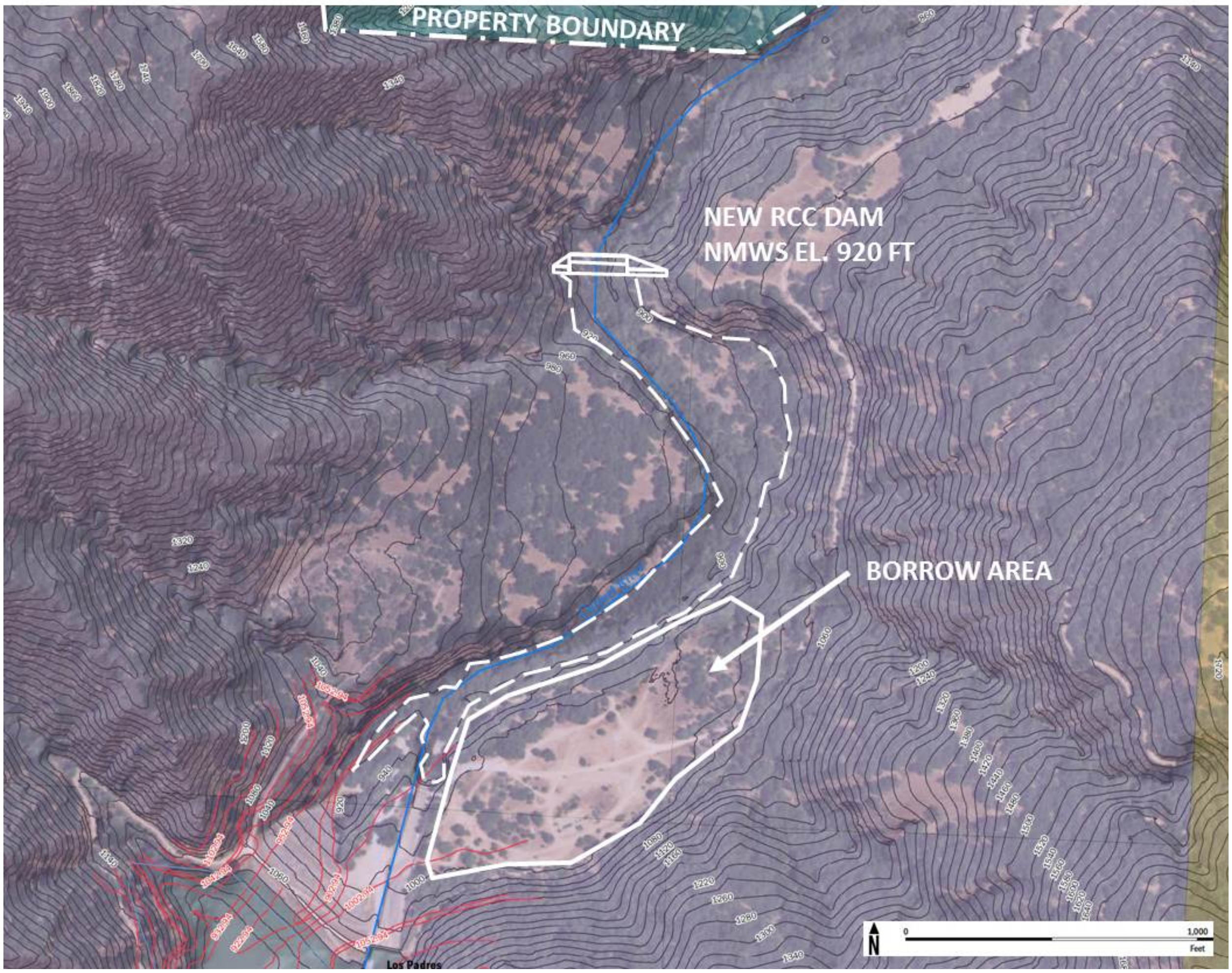

Figure 2-11 Alternative 4d New Downstream Roller-Compacted Concrete Dam Used With Alternatives 4a or 4b

In terms of relative cost, Alternative 4d would be moderate. Construction of Alternative 4d would require an estimated two to three construction seasons once design and permitting have been completed, depending on whether it is combined with Alternative 4a or Alternative 4b. The RCC dam would be constructed during two seasons: the first for excavation of the foundation and development of a borrow area for aggregate for the RCC; and the second for placement of the RCC, project restoration, and closeout. Alternative 4d would require implementation of fish passage improvements at both dams that have not been included in the relative cost.

2.4.5 Alternative 4 Considerations

Considerations relevant to storage expansion include:

1. Maintaining dam safety and passage of the PMF;
2. Sustainability, especially of surface storage;
3. Local impacts from traffic and noise;
4. Effects on downstream channel geometry and habitat for steelhead;
5. Effects on steelhead passage over a dam and through the reservoir;
6. Water availability analysis (i.e., what effects would alternatives have on instream flows);
7. Municipal and environmental benefits from an increased water supply; and
8. Effects on water rights

These considerations are described further in the following sections.

Maintaining Dam Safety and Passage of the Probable Maximum Flood

The raised dam and modifications to the spillway and outlet works (Alternative 4a); the rubber bladder gate structure and modifications to the dam and spillway (Alternative 4b); the new dam, spillway, and outlet works (Alternative 4c); and the new dam, spillway, and outlet works and the improvements made to the existing dam (Alternative 4d) would all be designed using current standards and would require DSOD approval prior to their construction.

Sustainability, Especially of Surface Storage

Raising the dam (Alternative 4a) or adding a 9.6-foot-high rubber bladder gate structure (Alternative 4b) would add 586 AF of storage to the current reservoir capacity. With an additional 586 AF, and assuming the sedimentation rates described in Section 2.1, an estimated 37 to 78 years would be required for the reservoir capacity to be reduced to its current capacity of 1,600 AF.

The largest new dam downstream (Alternative 4c) would add 4,710 to 5,928 AF of storage to the current reservoir capacity. With an additional 5,928 AF, and assuming the sedimentation rates described in Section 2.1, an estimated 374 to 787 years would be required for the reservoir capacity to be reduced to its current capacity of 1,600 AF.

A new dam downstream, designed to function in combination with either a raise of LPD or placement of a rubber dam on the LPD spillway crest (Alternative 4d), would add 786 AF of storage beyond the current reservoir capacity. With an additional 786 AF, and assuming the sedimentation rates described in Section 2.1, an estimated 50 to 104 years would be required for the reservoir capacity to be reduced to its current capacity of 1,600 AF.

Local Impacts from Traffic and Noise

Local impacts from traffic and noise for Alternative 4 would be similar to those described in Section 2.2.3 for Dam Removal (Alternative 2), but with the following differences by sub-alternative:

- Alternative 4a -- Impacts would occur only over a single construction season. Impacts would potentially include between 2,300 to 3,000 loads of filter and drain material if it is determined that those materials cannot be made on site.

- Alternative 4b -- Impacts would occur only over a single construction season, would require less equipment and manpower than Alternative 4a, and would therefore have a reduced relative impact with respect to traffic and noise. Impacts would potentially include between 2,100 to 2,800 loads of filter and drain material.

- Alternative 4c -- Impacts would occur over four construction seasons. For an RCC dam, impacts would include between 1,500 and 2,500 loads of cement and flyash delivered to the site for a 7.5 thousand acre-feet (TAF) reservoir and between 700 and 1,300 loads of cement and flyash delivered to the site for a 3.0 TAF reservoir. For an embankment dam, impacts would potentially include 15,000 to 20,000 loads of filter and drain material for a 7.5 TAF reservoir and 6,300 to 8,300 loads of filter and drain material for a 3.0 TAF reservoir.

- Alternative 4d -- Impacts would occur over one to two construction seasons. Impacts would include between 100 and 200 loads of cement and flyash delivered to the site and potentially 2,100 to 2,800 loads of filter and drain material.

Effects on Downstream Channel Geometry and Habitat for Steelhead

For Alternatives 4a and 4b, raising the dam or expanding storage with a rubber bladder gate would not result in any changes to the downstream channel geometry from the current condition, but could allow for a greater quantity of water for dry-season release to increase the amount of juvenile rearing habitat in the lower Carmel River. For Alternatives 4c and 4d, the new dam downstream would result in loss of 2,600 to 2,700 feet of river channel that is habitat for steelhead, and also would allow for a greater quantity of water for dry-season release to increase the amount of juvenile rearing habitat in the lower Carmel River.

Effects on Steelhead Passage over a Dam and through the Reservoir

For Alternatives 4a and 4b, upstream passage would be unaffected from the current condition. Downstream passage, however, could be affected by increasing the reservoir water surface elevation during the latter portion of the juvenile out-migration season. Increasing the water surface elevation could be incompatible with the existing BGS or render it inoperable during the period of elevated water surface elevation. For Alternative 4c, current passage facilities would be eliminated and new passage facilities would be required. A larger reservoir would increase the risks associated with passage through a reservoir. For Alternative 4d, where there would be two separate dams and reservoirs, and the existing dam would be modified; entirely new passage facilities would likely be required for upstream and downstream passage. The existing downstream passage BGS could be compromised, as described above for Alternatives 4a and 4b; even if its function could be preserved, it would only pass fish downstream into the lower reservoir. Upstream passage would likely favor trap-and-haul from below the downstream dam to upstream of the upper dam, to avoid having two upstream passage facilities (one at each dam). If passage occurred through—as opposed to around—the reservoir(s), reservoir rearing impacts, such as exposure to nonnative predators, would likely increase.

Effects on Instream Flows

Given the small size of the reservoir, the raised dam (Alternative 4a) and temporarily raised reservoir water surface elevation (Alternative 4b) would not have a significant impact on instream flows during the precipitation season. However, during the dry season, the additional 586 AF of storage would allow additional average releases of 1.6 cfs (3.2 AF) per day over a 6-month period.

For Alternative 4c, the larger size of the reservoir could have a significant impact on instream flows during the precipitation season, depending on the reservoir level at the beginning of the season and the type of water year. An operations plan for releases during the wet season of a dry year would need to be developed to facilitate upstream steelhead migration. During the dry season, the additional 4,710 to 5,928 AF of storage would allow additional average releases of up to 13 to 16 cfs (26 to 32 AF) per day over a 6-month period, assuming a full reservoir at the beginning of the dry season.

For Alternative 4d, given the small size of the two reservoirs, the dams would not have a significant impact on instream flows during the precipitation season. However, during the dry season, the additional 786 AF of storage would allow additional average releases of 2.1 cfs (4.3 AF) per day over a 6-month period.

Environmental and Municipal Benefits from an Increased Water Supply

Alternative 4c would have the potential to significantly reduce instream flows downstream of the new dam during the precipitation season. This could result in Cal-Am and MPWMD meeting the minimum mean daily instream flow requirements in Permits 21330, 20808A, and 20808C less frequently; and therefore, potentially, to a restriction of Cal-Am's and MPWMD's ability to divert water from the Carmel River Watershed to various groundwater wells and the Seaside Groundwater Basin. Alternatives 4a, 4b, and 4d would not significantly impact instream flows during the precipitation season and would therefore not affect Cal-Am's and MPWMD's water diversions associated with Permits 21330, 20808A, and 20808C.

All four storage expansion alternatives would have the potential to increase instream flows during summer months through release of additional stored water. Increased summer flows would not allow for increased water diversion associated with Cal-Am and MPWMD Permits 21330, 20808A, and 20808C, because diversions under these permits are only authorized between December 1 and May 31. However, the increase in summer flows would likely result in opportunities for Cal-Am (through riparian and pre-1914 appropriative water rights) and private diversion and well owners to divert more water during the dry season, although Cal-Am intends to reduce its dry season diversion when replacement water supplies are available (Cal-Am and MPWMD 2016).

Increased summer instream flow would also increase both the quality and quantity of summer rearing habitat for steelhead downstream of LPD or a new dam, by increasing flows through existing rearing habitat and by wetting portions of the channel that currently dry out in summer months.

Effects on Water Rights

Alternatives 4a and 4b would increase the capacity of LPR, and Cal-Am could petition the SWRCB to increase their water right associated with LPR. Permit 20808B, held by MPWMD, authorizes 18,674 AFY to be diverted to the New LPD. This permit is set to expire in 2020, so Alternatives 4c and 4d would require MPWMD to petition for an extension of this water right. If Alternative 4c or 4d were implemented, the License 11866 requirement to release at least 5 cfs directly below LPD at all times during which water is being stored in the reservoir would be replaced by the minimum instream flow requirements in Permit 20808B.

3. Sediment Management Options

This section includes a discussion of sediment management options that could be incorporated into the alternatives described in the preceding section. A sediment management program would be relevant to alternatives involving retention, expansion, or relocation of LPD, and would evaluate management activities that could result in either maintaining the existing surface storage capacity, or increasing surface storage over time (up to the original reservoir capacity). In addition to reviewing options previously developed for dredging, this evaluation considers whether there are additional feasible alternatives for removing material from the reservoir and transporting it to a disposal site. The following sediment management options are described in this section:

1. Periodic sediment removal off site (Option 1);
2. Periodic sediment removal and placement downstream of LPD, with the intent to allow the material to be captured and mobilized by the river at high flows (Option 2);
3. Sluicing fine sediment during high flows (Option 3);
4. Construction of a bypass tunnel for incoming sediment (Option 4); and
5. Combinations of sediment management options.

3.1 Periodic Sediment Removal to Offsite Disposal Site (Option 1)

This sediment management option would involve excavation of a portion of the Zone 2 and Zone 3 sediment from the upstream half of the reservoir and hauling for placement in the two permanent upland disposal areas downstream of the dam (see Section 2.2 and Figure 2-2). Depending on the volume of sediments removed, this alternative would maintain reservoir capacity or could recover some lost reservoir capacity. Currently, the majority of sediment trapped by the reservoir is Zone 2 and Zone 3 sediment. An estimated 5 AF (8,100 CY) of Zone 2 sediment and 2.5 AF (4,050 CY) of Zone 3 sediment comes into the reservoir each year, assuming an annual ratio of Zone 2 to Zone 3 sediment of 2:1 and an annual rate of sediment accumulation of 7.5 AFY. Based on these assumptions, an estimated 12,150 CY per year would need to be removed from the reservoir to maintain the current reservoir storage. Excavation of Zone 3 sediment at the upstream end of the reservoir would effectively result in a sediment capture area, where coarse sediment being transported from upstream of the reservoir would collect in subsequent years.

Because LPD is operated to enhance fishery habitats in the lower Carmel River during the dry summer months, the reservoir would not be drawn down at the beginning of the dry season to facilitate mechanical removal in the dry. Rather, the volume of sediment excavated in the dry would be dictated by the water year condition and the level to which the reservoir would be drawn down over the dry season. Excavation of sediment in the dry would be limited by the minimum operating pool level (target El. 1,003; in very dry years, El. 980). The number of years and available days that sediment could be removed in the dry for the years between 2002 and 2016 are shown in Table 2-2 in Section 2.3.1. Table 2-2 indicates that sediment could have been excavated in the dry down to El. 1,030 in all years, down to El. 1,020 in about 50 percent of the years, and down to El. 1,010 during 2 years of the 15-year record. An average excavation volume of 60,750 CY could be removed every 5 years to maintain the current reservoir volume. Access to the upstream end of the reservoir would be the same as described for Alternative 3a in Section 2.3.1.

In terms of relative cost, Option 1 would be moderate. The relative cost assumes removal every 5 years on average, with the access road to the upstream end of the reservoir requiring rebuilding each time removal is performed. It is estimated that each periodic removal would require about 3 months to perform.

3.2 Periodic Sediment Removal and Placement Downstream of Los Padres Dam (Option 2)

Sediment management Option 2 would involve excavation of a portion of the coarser Zone 3 sediment from the upstream half of the reservoir, and hauling for placement in two areas downstream of the dam in the river channel that appear to be accessible by flood flows. This alternative would provide a means by which these coarser sediments (sand, gravel, and cobble), which are currently trapped by the reservoir, could be moved around the dam to maintain steelhead spawning areas and instream habitat downstream of the dam. Currently, the majority of sediment trapped by the reservoir is Zone 2 and Zone 3 sediment. An estimated 2.5 AF (4,050 CY) of Zone 3 sediment comes into the reservoir each year, assuming an annual ratio of Zone 2 to Zone 3 sediment of 2:1 and an annual rate of sediment accumulation of 7.5 AFY.

The two downstream areas (Sites D and E) where placed sediment could be accessed and mobilized during large flow events are shown on Figure 3-1. Site D is a 1.8-acre area that has a capacity of about 20,000 CY at a top elevation of 905 feet. Site E is a 1.8-acre area that has a capacity of about 16,000 CY at a top elevation of 870 feet. Both of these areas would need to be cleared of trees to be used for mechanical placement of sediment. The reliability of these areas to provide the desired function could be improved with some grading to remove the existing armor of boulders and make more of the areas accessible to storm flows.

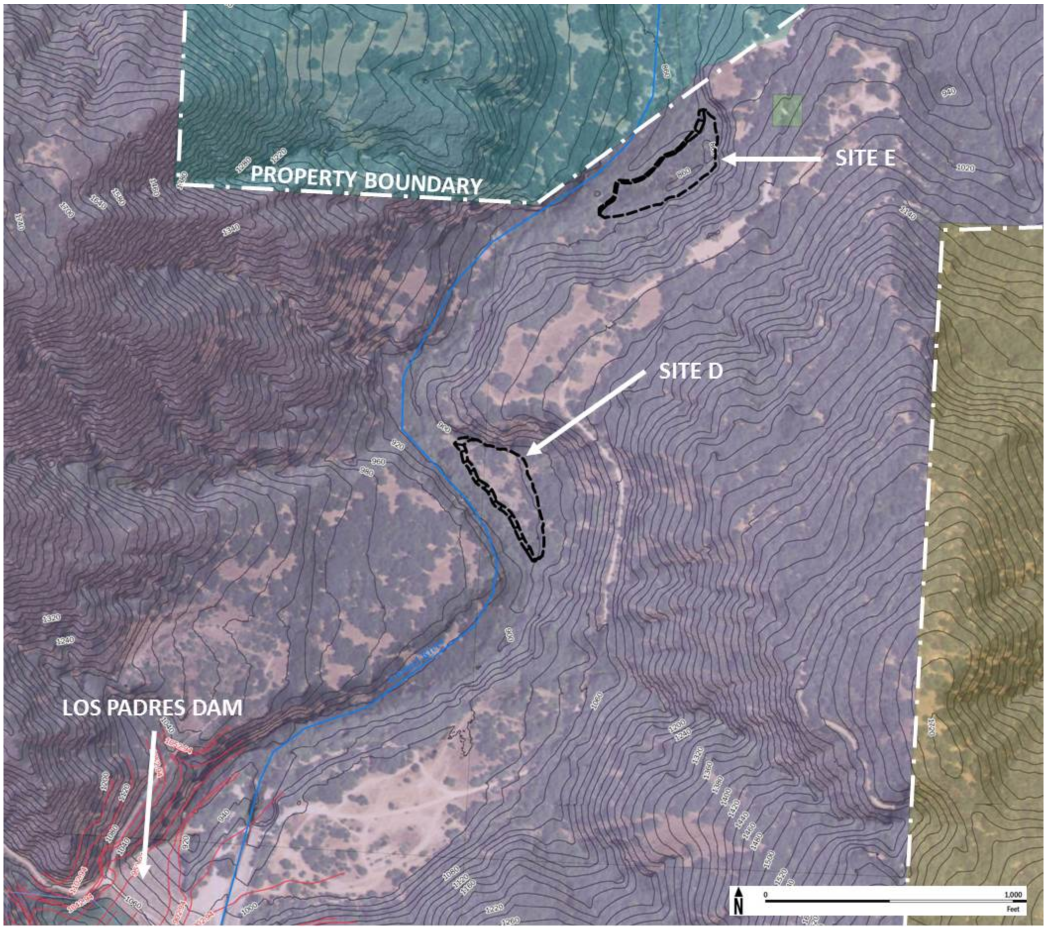

Figure 3-1 Downstream Flood-Accessible Sediment Placement Sites

Peak flood depths and average flow velocities for typical sections at Sites D and E for the estimated 2-year (1,500 cfs), 5-year (3,200 cfs), 10-year (4,500 cfs), 20-year (5,800 cfs), 50-year (7,600 cfs), and 100-year (8,900 cfs) events (as described in the Study Preparation TM, Section 2.6.3, Table 2-6, AECOM 2017a) were approximated using simple Manning's calculations. The slope of the river channel was estimated from the 2010 LiDAR at the two sections. A range of channel roughness values was used in the calculations, as follows:

- 0.045 – Clean, winding, some pools and shoals with some weeds and stones
- 0.07 – Sluggish reaches, weedy, deep pools

- 0.1 – "Floodplain" with heavy stand of timber, few down trees, little undergrowth, flow below branches

The results of the simple Manning's calculations are summarized for Site D in Table 3-1 and for Site E in Table 3-2.

Table 3-1 Peak Flood Depth and Velocity for Various Flood Events at Site D

Manning's n	Event	2-year	5-year	10-year	20-year	50-year	100-year
	Flow (cfs) (AECOM 2017a)	1,500	3,200	4,500	5,800	7,600	8,900
	Channel Depth (feet)	13.5					
0.045	Flow normal depth (feet)	7.24	9.62	10.93	12.02	13.30	**14.11**
0.07		8.54	11.35	12.90	**14.19**	**15.70**	**16.66**
0.1		9.77	12.98	**14.74**	**16.22**	**17.95**	**19.04**
0.045	Average flow velocity in channel (feet/second)	10.30	12.45	13.56	14.44	15.45	16.08
0.07		7.39	8.94	9.73	10.37	11.09	11.54
0.1		5.66	6.84	7.45	7.94	8.49	8.83

Notes:
Gray shading indicates flood flows at which water depth is greater than the existing condition.
cfs = cubic feet per second

Table 3-2 Peak Flood Depth and Velocity for Various Flood Events at Site E

Manning's n	Event	2-year	5-year	10-year	20-year	50-year	100-year
	Flow (cfs) (AECOM 2017a)	1,500	3,200	4,500	5,800	7,600	8,900
	Channel Depth (yes)	8.5					
0.045	Flow normal depth (yes)	4.28	5.96	6.90	7.68	**8.60**	**9.18**
0.07		5.20	7.20	8.31	**9.23**	**10.32**	**11.01**
0.1		6.07	8.36	**9.63**	**10.69**	**11.93**	**12.72**
0.045	Average flow velocity in channel (feet/second)	8.49	10.30	11.23	11.98	12.82	13.34
0.07		6.11	7.41	8.07	8.61	9.21	9.58
0.1		4.68	5.67	6.18	6.59	7.05	7.34

Notes:
Gray shading indicates flood flows at which water depth is greater than the existing condition.
cfs = cubic feet per second

Tables 3-1 and 3-2 indicate that 10-year to 20-year flows are needed to fully access Sites D and E. Tables 3-1 and 3-2 also indicate that Sites D and E could be graded to be more accessible to smaller storms, perhaps as small as 5-year events. An estimated 36,000 CY of Zone 3 materials could be moved to Sites D and E every 10 years, assuming that the sites are regraded and that a 10-year event is able to remove all of the material placed at each site. During those same 10 years, an estimated 40,500 CY of Zone 3 material will have moved into the reservoir, resulting in a net input into the reservoir of about 4,500 CY. This sediment management option would likely be done in combination with Sediment Management Option 1 to at least maintain the current LPD storage. It is not anticipated that impacts due to flooding would be significantly impacted in the areas of Sites D and E if the material placed at each site were not able to be moved during flood events. The degree of flooding could be confirmed during future design phases.

Sediment Management Option 2 would require the same access road to the upstream end of the reservoir as required for Sediment Management Option 1. Access down to Sites D and E would be difficult to develop without construction of an access road in the river channel. One option could be to simply push Zone 3 material over the right bank from Nason Road to form debris slides that could be accessed by high flows.

In terms of relative cost, Option 2 would be low, given the smaller volumes that could be placed in Sites D and E. The relative cost assumes removal every 5 years on average, with the access road to the upstream end of the reservoir requiring rebuilding each time removal is performed. It is estimated that each periodic removal would require about 1 month to complete. Option 2 could be combined with Option 1.

3.3 Sluicing Tunnel (Option 3)

Option 3 would install a sluicing tunnel through either the right or left abutment that would be used to flush sediment from the reservoir during wet water years (Figure 3-2). Ideally, the flushing flows would be timed to coincide with high flows that are already carrying significant sediment loads, and would therefore represent an incremental increase in sediment load. Flushing would involve lowering the reservoir to allow flows to pass through the reservoir area as run-of-the-river flows that would erode and flush a significant amount of the accumulated sediment downstream. Based on simple calculations of uniform flow through a horseshoe-shaped tunnel, tunnel sizes of 12 feet, 13.5 feet, and 15 feet would be required to pass 5-year (3,200 cfs), 10-year (4,500 cfs), and 20-year (5,800 cfs) storm events. The sluicing tunnel gates would be closed after flows begin to decrease, allowing the reservoir to refill for the dry season. The size of sluice tunnel would ultimately be based on sediment transport analyses. Minimum required stream flow requirements could be met during refilling by making releases through the low-level outlet. Assuming that the majority of Zone 1 and Zone 2 sediment could be flushed, the resulting reservoir capacity would be about 2,600 AF. Refilling of the reservoir would require about 6.5 days, assuming average flows of 200 cfs.

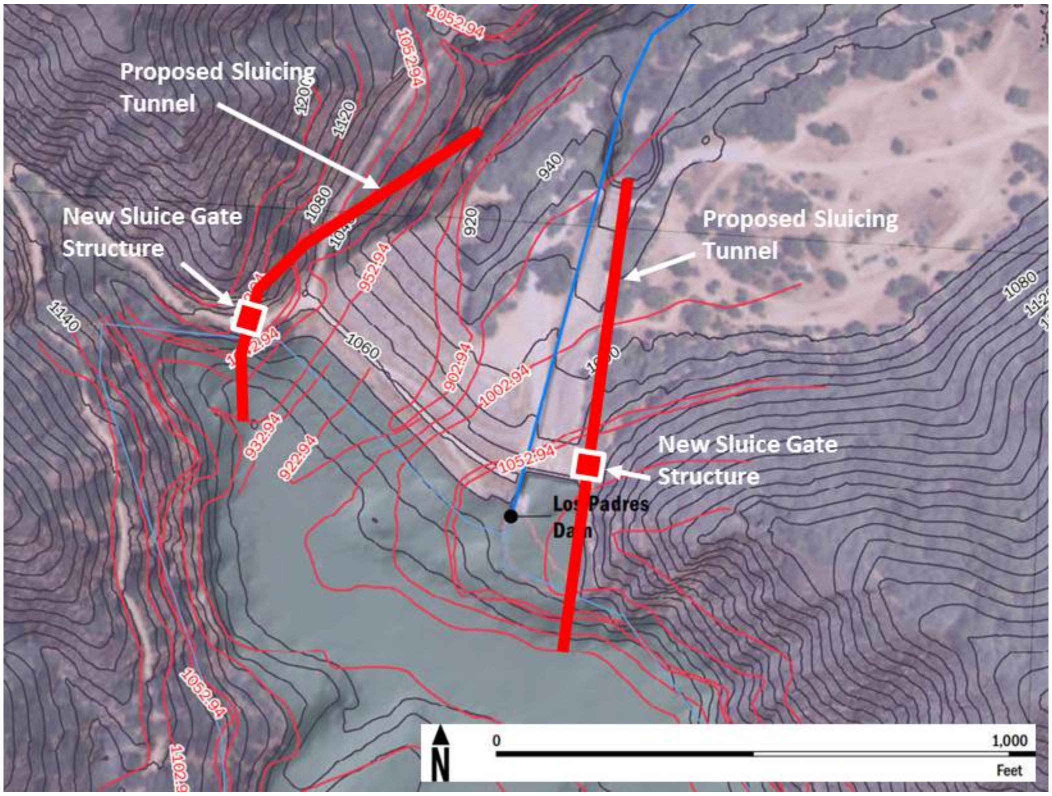

Figure 3-2 Sluicing Tunnel Locations

Assuming a minimum flushing flow of 1,000 cfs, the sluicing tunnel could have been operated 11 of the 15 years from 2002 through 2016, based on data obtained from the MPWMD gauge downstream of the LPD (AECOM 2017a). As shown on Figure 3-3, 6 of the 11 years had two or three events with peaks greater than 1,000 cfs. Operation of the sluicing tunnel would require forecasting of large storm events and protocols for opening the sluice gate, with respect to timing and rate of lowering of the reservoir.

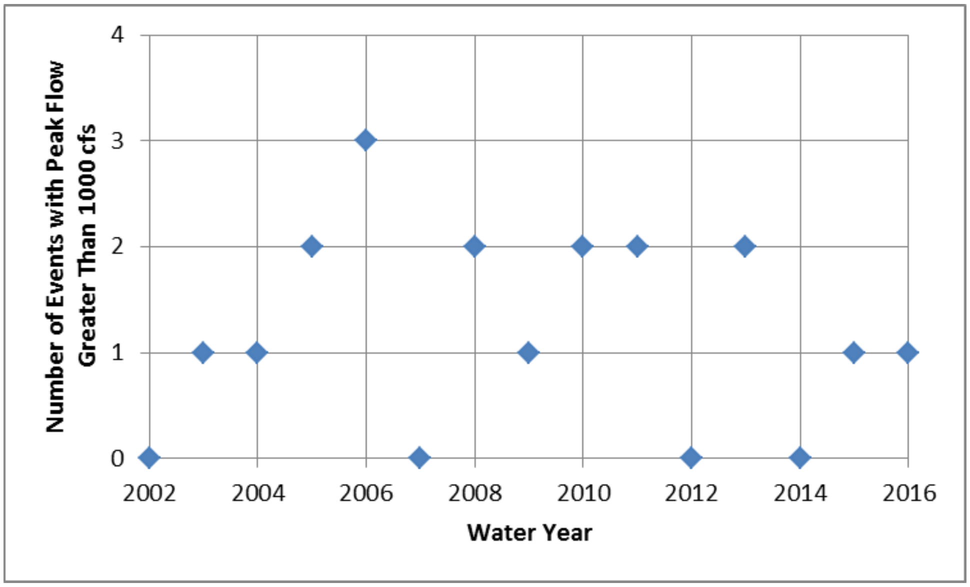

Figure 3-3 Flow Events Greater than 1,000 cfs at MPWMD Gauge below Los Padres Dam

In terms of relative cost, Option 3 would be low. Construction of the approximately 900-foot-long tunnel could occur over a 2-year construction period, with the first construction season being used to construct the sluice gate shaft and downstream portion of the tunnel. Completion of the upstream portion of the tunnel would occur during the dry season, when the reservoir could be emptied and Carmel River flows pumped around the dam. Excavation of the tunnel and shaft through granitic rock would likely use drilling and blast methods, with the excavated tunnel walls being temporarily supported by rock dowels. Rock excavated from the tunnel and shaft would be hauled and placed in one of the permanent disposal sites (Site B or Site C). Following excavation, the tunnel and shaft would be lined with reinforced concrete.

3.4 Bypass Tunnel (Option 4)

Option 4 would construct a bypass tunnel from the upstream end of the reservoir, extending downstream past LPD (Figure 3-4). The intent of the bypass tunnel would be to convey sand and finer sediment past the reservoir during high-flow events, when sediment transport is greatest. A settling basin just upstream of the intake would trap coarser sediment to prevent gravel, cobbles, and boulders from entering the tunnel and potentially being trapped in the tunnel. Access to the intake location would be required for construction and for periodic removal of gravel, cobbles, and boulders from the settling basin. The access road would include improving 3,200 lineal feet of existing unimproved road along the left side of the reservoir, and construction of an additional 6,600 lineal feet of new access road along the left side of the reservoir. The coarse sediment could be hauled to permanent disposal sites (Site B and Site C) or to Sites D and E along the river downstream of LPD, where it could be mobilized back into the river system during high flows.

The size and length of tunnel that would be needed to convey sediment past the dam would be significant and potentially cost-prohibitive. The length of tunnel would be on the order of 7,000 feet and would have a flatter slope (about 1.9 percent) than the sluicing tunnel. Based on simple calculations of uniform flow through a horseshoe-shaped tunnel, tunnel sizes of 13 feet, 15 feet, and 16.5 feet would be required to pass 5-year (3,200 cfs), 10-year (4,500 cfs), and 20-year (5,800 cfs) storm events. Sediment would be transported past the bypass tunnel into the reservoir during larger, less frequent storms. Bypass flows would be timed to coincide with high flows that are already carrying significant sediment loads and would thus represent an incremental increase in sediment load. Assuming that one-third of the sediment might get past the bypass tunnel, 125 AF to 260 AF of reservoir capacity might be lost during the 60-year project life.

Based on characterization of the sediment in the reservoir (AECOM 2017b) an estimated 1,800 to 3,000 CY of gravel and larger-size particles could be trapped annually in the settling basin. Assuming that the settling basin was large enough to accommodate 15,000 CY, periodic cleanout of the settling basin would occur on average every 5 years. Periodic cleanout would require reconditioning the access road and excavation and hauling of the coarse material to either the permanent disposal sites (Sites B and C) or the in-river disposal sites (Sites D and E).

In terms of relative cost, Option 4 would be very high. Construction of Alternative 4d would require an estimated four construction seasons once design and permitting have been completed. Construction of the bypass tunnel and intake structure would likely require three construction seasons. Both the upstream and downstream portals would require cofferdams to separate the work from the active river channel. Construction from the downstream end could be performed year round; construction from the upstream end would be limited to the dry season, when the access road would be less likely to be impacted by higher flows in the river channel. Rock from the tunnel excavation would be hauled and placed in one of the permanent disposal sites (Site B or Site C). Excavation of the tunnel and shaft through primarily granitic rock would likely use drilling and blast methods, with the excavated tunnel walls being temporarily supported by rock dowels in areas of stronger rock, and steel sets in areas of weaker rock. Following excavation, the tunnel would be lined with reinforced concrete.

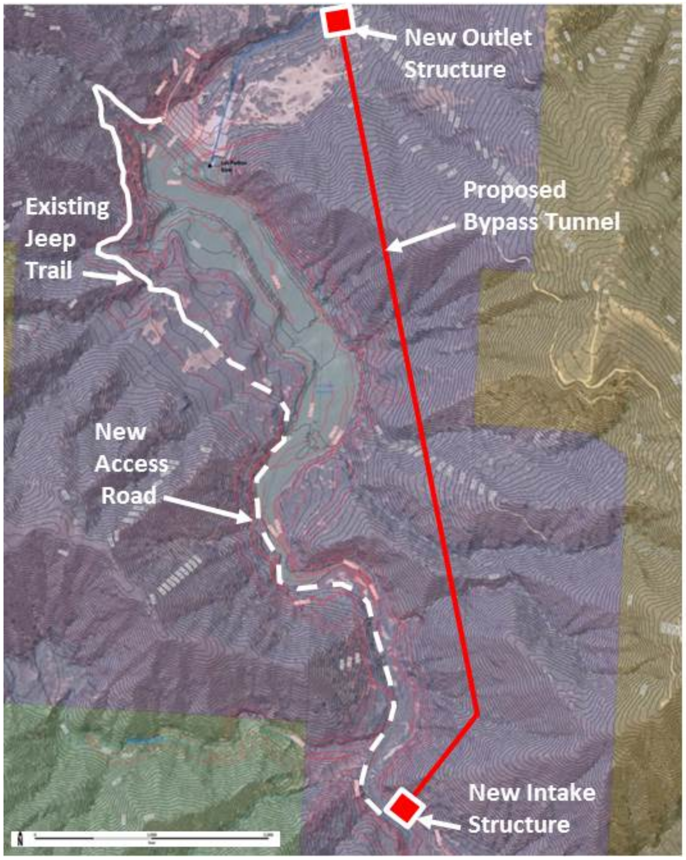

Figure 3-4 Bypass Tunnel Location

3.5 Combinations of Sediment Management Options

Some combination of sediment management options could include combining a sluicing tunnel for removing finer Zone 1 and Zone 2 sediment from the reservoir during flooding events, and mechanical removal of coarser sediment from upstream of the reservoir to downstream sites where those materials could be mobilized during large flow events.

3.6 Sediment Management Considerations

Considerations relevant to sediment management include:

1. Maintaining dam safety;
2. DSOD requirements for placement of sediment downstream of the dam, a sediment capture area, sediment sluicing, and bypass tunnel;
3. Sustainability;
4. Effect of fire/landslides in the watershed;
5. Beneficial effects on downstream aquatic habitat;
6. Harmful effects on steelhead; and
7. Effects on downstream channel geometry and flood elevations.

These considerations are described further in the following sections.

Maintaining Dam Safety

Sediment Management Options 1 and 2 would not impact the safety of LPD. Option 3, construction and operation of a sluicing tunnel, and Option 4, a bypass tunnel, would not have a direct effect on the safety of LPD.

Division of Safety of Dams Requirements

Sediment Management Options 1 and 2 are not likely to require DSOD design review and approval for construction. The sluicing tunnel described in Option 3 would be considered a modification of the existing LPD, and would require DSOD design review and approval for construction. Because the bypass tunnel (Option 4) would bypass the dam, there would not likely be any DSOD requirements for Option 4.

Sustainability

Sustainability in the context of these sediment management options refers to how frequently sediment management would be required. For Option 1, a reasonable estimate would be that sediment removal would occur every 5 years. Every 5 years, an estimated 60,750 CY of Zone 2 and Zone 3 sediment would accumulate in the reservoir. Removal of this volume of sediment would require about 2 to 3 months, assuming a production rate of about 1,500 CY per day. Option 2 would be similar, but a smaller volume of sediment would be removed each time. Based on the water years between 2002 and 2016, Option 3 could potentially be operated on average every 2 years to flush sediment from the reservoir. Option 4 may be less effective, given a lesser capacity to transport sediment and the potential for sediment to pass the bypass tunnel inlet and be transported into the reservoir.

Effect of Fire/Landslides in the Watershed

Option 3, the sluicing tunnel, would provide an effective means of managing sediment resulting from fire or landslides in the watershed. In decreasing order of effectiveness, Options 1, 2, and then 4 would also provide some ability to manage sediment associated with future fires or landslides that may occur in the LPD watershed.

Beneficial Effects on Downstream Aquatic Habitat

Beneficial effects on downstream aquatic habitat could include habitat effects that may occur as a result of restoring a more natural sediment load. Of the sediment management options described above, Option 2 is the only one that specifically describes placement of coarse sediment downstream of LPD at a location where it could be captured by the river and transported downstream to improve habitat conditions. Transport of fine sediment downstream, as is described for Options 3 and 4, is not expected to markedly improve downstream aquatic habitat, and could have short-term deleterious effects on steelhead. Generally, any option that restores the transport of coarse sediment downstream of LPD would be expected to improve habitat conditions.

Harmful Effects on Steelhead

Harmful effects on steelhead, in the context of the sediment management options described above, could include an increase in bedload and suspended sediment beyond what would be expected to occur naturally. This could occur with any sediment management option that moves accumulated sediment (as opposed to the naturally occurring sediment load) downstream of LPD. Effects during operations could include entrainment in bypass or sluice tunnels, reduced ability to encounter prey, injury or mortality during periods of increased suspended sediment, and burial of redds by pulses of sediment.

Effects on Downstream Channel Geometry and Flood Elevations

Option 1 would result in no change to the sediment regime over existing conditions, and the downstream channel geometry would be similar to current conditions.

Option 2 would introduce coarse sediment downstream of the dam during high-flow events. The addition of coarse sediment would return sediment to starved reaches and eventually increase coarse sediment supplies further downstream. Depending on the quantity of excavated sediment that is placed at the disposal sites and then mobilized by high flows, the magnitude of effects would vary. With the largest amounts of sediment reintroduced, the response of the channel is expected to be similar to that experienced under Alternative 2 (dam removal).

Option 3 would sluice sediment from the reservoir. During the initial sluicing events, the majority of sluiced sediment would be fine sediment from the lower reservoir. The increased fine sediment is expected to have little effect on the channel thalweg elevation downstream, because fine sediment tends to stay suspended throughout the river to the ocean. Depending on how the sluicing is managed, the amount of coarse sediment moving downstream would vary. If the intent is to restore reservoir capacity, the sluicing could be managed to only mobilize the fine sediment and maintain the coarse sediment in place, to prevent it from moving further into the reservoir and displacing capacity. This management approach would not increase coarse sediment supply downstream and would have little effect on the active channel geometry. If the intent is to mobilize coarse sediment as well, to restore sediment supplies downstream, then the channel downstream would see an increase in coarse sediment supply and its response would be similar to that experienced under Option 2 and Alternative 2.

Option 4 would bypass mobilized sand and fine sediment around the reservoir during high-flow events and introduce them to the downstream river reaches. The amount of fine sediment from upstream is expected to be similar to the amount of fine sediment currently discharged via the spillway, so there would be no effects on the downstream channel from fine sediment. Sands likely will enter the bypass tunnel at higher concentrations than what currently discharges via the spillway during high-flow events. This would increase the amount of sand entering the reach downstream and would lead to an accumulation of sand in reaches downstream.

4. Summary

Table 4-1 is a summary of the draft LPD and LPR alternatives and sediment management options. The summary includes the relative cost; the estimated reservoir capacity 60 years from the present; and the assumptions made regarding durations for design and permitting, construction, and operation for the 60-year planning period.

EXHIBIT 2-C

Table 4-1 Summary of Draft Los Padres Dam and Reservoir Alternatives and Sediment Management Options

Alternative/ Option	Description	Relative Cost [a, b]	Storage Capacity in 60 Years (AF)		60-Year Implementation [c]		
			Low Sedimentation Rate (7.53 AFY)	High Sedimentation Rate (15.86 AFY)			
1a	No Sediment Management	Very Low	1,150	650	–	–	O 60-year
2a + 3a	Full Dam Removal + Dredge Zone 1 and Zone 2	High	0	0	D&P 5-year	C 7-year	O 48-year
2a + SM-3	Full Dam Removal + Sluicing Tunnel	Moderate	0	0	D&P 5-year	C 5-year	O 50-year
2b + SM-3	Partial Dam Removal + Sluicing Tunnel	Moderate	0	0	D&P 5-year	C 5-year	O 50-year
3a	Dredge and Place on Cal-Am Property	High	2,300	1,900	D&P 3-year	C 6-year	O 51-year
3b	Dredge and Place off Cal-Am Property	not practicable					
4a	Raise LPD	Moderate	1,700	1,400	D&P 5-year	C 2-year	O 53-year
4b	Rubber Dam in LPD Spillway	Low	1,700	1,400	D&P 5-year	C 1-year	O 54-year
4c (RCC)	New 7.5 TAF RCC Dam Downstream of LPD	High	7,100	6,600	D&P 5-year	C 4-year	O 51-year
4c (Emb)	New 7.5 TAF Embankment Dam Downstream of LPD	Very High	7,100	6,600	D&P 5-year	C 5-year	O 50-year
4c (RCC)	New 3.0 TAF RCC Dam Downstream of LPD	Moderate	2,500	2,000	D&P 5-year	C 3-year	O 52-year
4c (Emb)	New 3.0 TAF Embankment Dam Downstream of LPD	High	2,500	2,000	D&P 5-year	C 4-year	O 51-year
4d	Combo 4c + 4a or 4b	Moderate	2,100	1,600	D&P 5-year	C 3-year	O 52-year
SM-1 [d]	Periodic Sediment Removal to Offsite Disposal Site	Moderate	1,600	1,100	D&P 3-year	C 5-year	O 57-year
SM-2 [e]	Periodic Sediment Removal and Placement Downstream	Very Low	1,200	700	D&P 3-year	C 5-year	O 57-year
SM-3 [f]	Sluicing Tunnel	Low	1,800	1,800	D&P 5-year	C 2-year	O 53-year
SM-4 [g]	Bypass Tunnel	Very High	1,400	1,200	D&P 5-year	C 4-year	O 51-year

Notes:

[a] Relative cost does not include implementation of fish passage improvements.
[b] Very Low ($0 to $10M), Low ($10M to $30M), Medium ($30M to $70M), High ($70M to $150M), Very High (>$150M)
[c] D&P (Design and Permitting), C (Construction), O (Operation)
[d] Assumes removal of 7.53 AFY average.
[e] Assumes removal of 1.11 AFY average.
[f] Assumes that stable sediment bed plane through reservoir will occupy one-third of original storage capacity.
[g] Assumes one-third of average annual sediment will pass by intake structure and deposit in reservoir.

AF = acre-feet, TAF = thousand acre-feet, AFY = acre-feet per year
LPD = Los Padres Dam
RCC = roller-compacted concrete
SM = sediment management

5. Limitations

AECOM represents that our services were conducted in a manner consistent with the standard of care ordinarily applied as the state of practice in the profession, within the limits prescribed by our client. No other warranties, either expressed or implied, are included or intended in this technical memorandum.

Background information, design bases, and other data have been furnished to AECOM by MPWMD and/or third parties, which AECOM has used in preparing this technical memorandum. AECOM has relied on this information as furnished, and is neither responsible for nor has confirmed the accuracy of this information.

The analyses and results presented in this report are for the current study only and should not be extended or used for any other purposes.

6. References

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EXHIBIT 2-C