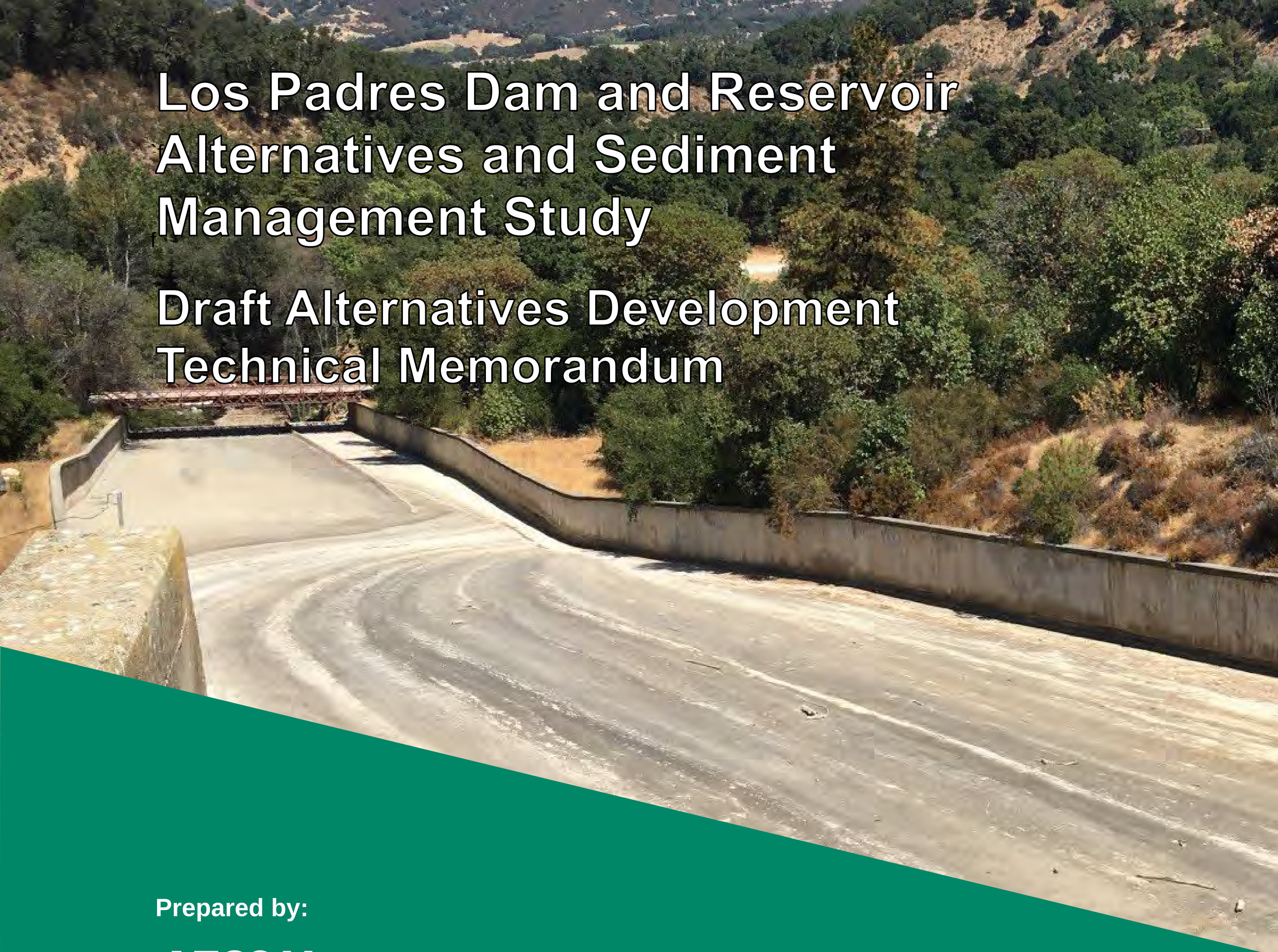
Los Padres Dam and Reservoir Alternatives and Sediment Management Study

Draft Alternatives Development Technical Memorandum



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Prepared for:

Monterey Peninsula Water Management District
In cooperation with
California American Water

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List of Acronyms and Abbreviations

AF	acre-feet
AFY	acre-feet per year
BESMo	University of British Columbia's one-dimensional morphodynamic sediment transport model
BGS	behavioral guidance system
Cal-Am	California American Water
cfs	cubic feet per second
CRBHM	Carmel River Basin Hydrologic Model
CSUMB	California State University, Monterey Bay
CY	cubic yards
DSOD	Division of Safety of Dams
FEMA	Federal Emergency Management Agency
FSC	floating surface collector
FWC	floating weir collector
GIS	geographic information system
HDR	HDR Engineering, Inc.
HEC-HMS	Hydraulic Engineering Center Hydrologic Modeling System
HMR	hydrometeorological report
IFIM	Instream Flow Incremental Methodology
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
mm	millimeters
MOA	memorandum of agreement
MOU	memorandum of understanding
MPWMD	Monterey Peninsula Water Management District
NAVD88	North American Vertical Datum of 1988
NGVD29	National Geodetic Vertical Datum of 1929
NMFS	National Marine Fisheries Service
NMWS	normal maximum water surface
NOAA	National Oceanic and Atmospheric Administration
O&M	operations and maintenance
OPCC	Opinion of Probable Construction Costs
PMF	probable maximum flood
PMP	probable maximum precipitation
SCS	Soil Conservation Service
SWRCB	State Water Resources Control Board
TIFF	tagged image file format
TIN	triangular irregular network
TM	Technical Memorandum
TRC	Technical Review Committee

UAS	unmanned aerial system
UBC	University of British Columbia Geography
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey

1. Introduction

This is one in a series of Technical Memoranda (TMs) developed as part of the Los Padres Dam and Reservoir Alternatives and Sediment Management Study (LP Alternatives Study). It has been developed in consideration of preceding TMs listed below, as well as the related Draft Fish Passage Feasibility Report (HDR et al. 2021) from the Los Padres Dam Fish Passage Study.

- Study Preparation TM (AECOM 2017a)
- Draft Alternatives Descriptions TM (AECOM 2017b)
- Sediment Characterization TM (AECOM 2018)
- Sediment Effects TM (Balance Hydrologics and UBC 2019)
- Effects to Steelhead TM (AECOM and Stillwater Sciences 2022)

1.1 Project Background

A team of engineering and science consultants led by AECOM, and including Balance Hydrologics, Stillwater Sciences, and HDR Engineering Inc. (HDR), has been retained by the Monterey Peninsula Water Management District (MPWMD) to investigate the technical, biological, and economic feasibility of a broad suite of alternatives for Los Padres Dam and Reservoir (LPD and LPR) that includes dam removal, retention of the existing reservoir with the addition of fish passage and sediment management, and reservoir expansion. The study is partially funded by California American Water (Cal-Am), the owner and operator of the dam, and has been conducted in close coordination with the Technical Review Committee (TRC), which consists of technical experts and representatives from the MPWMD, Cal-Am, the National Marine Fisheries Service (NMFS), the California Department of Fish and Wildlife, and the United States Fish and Wildlife Service. Additional project background information is provided in the Study Preparation TM (AECOM 2017a).

1.2 Purpose and Scope

This TM is the deliverable for Task 4-2 of the LP Alternatives Study. It is provided in draft form prior to TRC Meeting No. 2b, and prior to MPWMD and Cal-Am review. Following the meeting, the content of this TM will be updated based on feedback received at the meeting and written comments provided by the TRC. The updated content, as well as summary content from previous TMs, will be included in a Draft Final Report for additional TRC review.

The scope of this TM is to further develop the alternatives presented in the Alternatives Descriptions TM, in consideration of input from the TRC received during and after TRC Meeting No. 2a and previous LP Alternatives Study TMs, with focus on resolving uncertainties associated with short-listed alternatives concerning impacts, benefits, costs, environmental compliance, and permitting of the alternatives. If specific uncertainties remain for what is an otherwise feasible and favorable alternative, the uncertainty, and a potential approach to resolving the uncertainty, is identified. Alternatives that are not feasible are noted to be dropped from consideration, and reasons for them being dropped are described. Alternatives development involves the following activities:

- Draw and describe the concepts to communicate the design intent.
- Define operational characteristics of each concept or alternative.
- List advantages and disadvantages for each alternative.

The LP Alternatives Study scope of work includes retention of a dam removal alternative and a reservoir expansion alternative for the duration of the study, through the final set of alternatives, regardless of their perceived feasibility.

1.3 Previous Studies/Analyses

This TM is informed by and builds upon previous TMs prepared by the AECOM Team as part of the LP Alternatives Study as well as related studies conducted by others. The LP Alternatives Study is an iterative process, where concepts presented in one TM are refined based on TRC input and reformulated in the next TM. Additionally, related studies conducted outside of the scope of the LP Alternatives Study have been incorporated to relevant TMs as they have become available. As concepts have evolved and been presented across different reports and by different authors, changes have been made to the alternatives under consideration, even to the point where alternative numbers are not consistent from beginning to end of the LP Alternatives Study. This section highlights two separate but related studies and provides a crosswalks of model scenarios and alternatives from previous works, so that reviewers can see how previous model scenarios and alternatives relate to the alternatives presented in this TM.

There are several separate but related studies conducted by others that are relied upon in this TM. Water availability associated with the alternatives presented in this TM is based on the Carmel River Basin Hydrologic Model (CRBHM). The CRBHM was developed by the MPWMD and collaborators to evaluate hydrologic effects related to changes in water supply, groundwater pumping, and climate change in the Carmel River watershed. Considerable time was spent by MPWMD and their collaborators reviewing and calibrating the CRBHM in coordination with the TRC. The accuracy and limitations of the CRBHM are described in the Effects to Steelhead TM (AECOM and Stillwater Sciences 2022), and a summary presentation prepared by MPWMD is provided as an attachment to that TM. The Effects to Steelhead TM also summarizes the results of Normandeau's (2019) instream flow incremental methodology study for the Carmel River, which uses output from the CRBHM to evaluate steelhead habitat in relation to instream flow for scenarios relevant to the LP Alternatives Study.

Fish passage is not specifically evaluated in this TM because a separate study of fish passage has been completed for LPD. As part of identifying feasible fish passage facilities at LPD, the Draft Fish Passage Feasibility Report (HDR et al. 2021) evaluated fish passage alternatives to inform management decisions regarding the future operations of LPD. HDR et al. (2021) identified two upstream passage alternatives at LPD for further consideration: Alternative U1 (technical fish ladder) and Alternative U8 (trap and transport – replace). The report also identified two downstream passage alternatives at LPD for further consideration: Alternative D1 (floating surface collector [FSC] – new) and Alternative D8 (spillway modification and floating weir collector (FWC) with 30 cubic feet per second (cfs) attraction flow). For dam and reservoir alternatives that retain LPD, during a future phase of work, one of the upstream and downstream fish passage alternatives from HDR et al. 2021 will be adapted to one of, or a combination of, the selected LPD and LPR alternatives and sediment management options identified in this TM.

Table 1 provides a crosswalk of model scenarios and alternatives from previous works. The alternatives currently under consideration and presented in this TM are listed on the left, and the corresponding alternatives, scenarios, or combination thereof from each previous work that are most relevant to the current alternatives are listed in the subsequent columns to the right. The columns are organized, left to right, from most recent to oldest report or TM, so that the reader can trace the history of alternatives and model scenarios back through the history of the LP Alternatives Study. A more detailed version of this table, with short descriptions of each of the alternatives or scenarios listed in the table, is provided in Appendix A.

1.4 Document Organization

This TM is organized into the following sections:

- **Section 1: Introduction** provides an overview of the project background, TM purpose, organization of the TM, and limitations.
- **Section 2: Existing Conditions** provides a summary of existing conditions associated with structures, disciplines, or data that are pertinent to the development of the alternatives presented herein.
- **Sections 3 through 0: Alternatives** provide overviews of each of the five remaining alternatives, describing key components, construction estimates, operations and maintenance (O&M) considerations, advantages and disadvantages, and uncertainties.
- **Section 0: Conclusions** provides a summary of costs and advantages and disadvantages associated with the alternatives.
- **Section 0: References** provides a list of references from the main body of the TM.

Table 1 Summary of Alternatives and Model Scenarios from Past Work, as Relevant to Current Alternatives

Alternatives Development TM (this TM)	Effects to Steelhead TM (AECOM and Stillwater Sciences 2022)	Fish Passage Feasibility Report (HDR et al. 2021)	IFIM Time Series (Normandeau 2019)	Basin Model Scenario (AECOM and Stillwater Sciences 2022)	BESMo (Balance Hydrologics and UBC 2019)	Alternatives Descriptions TM (AECOM 2017b)
Alternative 1 (No Sediment Action)	Alternative 1	U1 or U8, and D1 or D8	Alternative 1	Current Los Padres	No Action	Alternative 1
Alternative 2 (Dam and Sediment Removal)	Alternative 2	Volitional, no facilities	Alternative 2	Remove LPD	Closest to Historical Supply, but between that and Uncontrolled Supply	Alternative 2a
Alternative 3 (Storage Expansion and Dredging)	Alternative 4	U1 or U8, and D1 or D8	Alternative 4	LPR Expanded Storage	No Action	Alternatives 4b and 3a
Alternative 4 (Recover Storage Capacity with Excavation)	SM1 and SM2	U1 or U8, and D1 or D8	Not specifically addressed – between Current Los Padres and Los Padres Expanded Storage		Not specifically addressed – between No Action and Pulsed Supply	SM1 and SM2
Alternative 5 (Recover Storage Capacity with Sluice Tunnel)	SM3	U1 or U8, and D1 or D8	Not specifically addressed – between Current Los Padres and Los Padres Expanded Storage		Pulsed Flow Simulation	SM3

Notes:

BESMo = University of British Columbia's one-dimensional morphodynamic sediment transport model
IFIM = Instream Flow Incremental Methodology
LPD = Los Padres Dam
LPR = Los Padres Reservoir
TM = Technical Memorandum

1.5 Limitations

This work was performed in a manner consistent with that level of care and skill ordinarily exercised by other members of the engineering profession practicing in the same locality, under similar conditions and at the date the services are provided. The conclusions, opinions, and recommendations in this TM are based on a limited number of observations and data. It is possible that conditions could vary between or beyond the data evaluated. AECOM makes no other representation, guarantee, or warranty, express or implied, regarding the services, communication (oral or written), report, opinion, or instrument of service provided.

Some background information and other data used by AECOM in preparing this TM have been furnished by third parties. AECOM has relied on this information as furnished and is neither responsible for nor has confirmed the accuracy of this information.

Conceptual or planning-level alternatives are uncertain by nature, given the typical lack of sufficient design parameters and analysis available during the planning phase. Although this TM strives to address key uncertainties related to feasibility and cost, additional investigation, analysis, and design are needed to adequately address the uncertainty. Analyses and results presented in this TM are for the current study only and should not be extended or used for any other purposes.

2. Existing Conditions

Existing conditions for the LP Alternatives Study were summarized in the Study Preparation TM (AECOM 2017a). The following subsections summarize existing condition information from that and other documents (as referenced) associated with structures, disciplines, or data that are pertinent to the development of the alternatives presented herein. Where new information was available, it was incorporated into this summary.

2.1 Coordinate System and Datum

All elevations referenced in this report are given in feet, North American Vertical Datum of 1988 (NAVD88), unless otherwise noted. The conversion from National Geodetic Vertical Datum of 1929 (NGVD29) to NAVD88 is +2.9 feet (VERTCON). The horizontal coordinate systems used for geographic information system (GIS) and computer-aided design data, figures, and drawings are referenced to California State Plan, Zone IV, North American Datum of 1983, unless otherwise noted.

2.2 Dam and Spillway

The existing conditions of LPD are summarized in the Los Padres Dam and Reservoir Alternatives and Sediment Management Study Preparation Technical Memorandum (AECOM 2017a). A partial list of key features and data of note is presented below for convenience.

1. **Foundation.** As described by the California Department of Water Resources, Division of Safety of Dams (DSOD) (1980a), the downstream three-quarters of the dam foundation and extreme upstream toe were founded on bedrock. The rock at the right abutment is granitic, with predominantly vertical jointing. One 4-foot-wide bedrock fault on the lower right abutment, containing an approximately 2-inch-wide gouge zone, was treated by excavating a shaft and backfilling with concrete to form a concrete plug. The rock at the left abutment is weathered mica schist and gneiss intruded by granitic rock. The contact between the mica schist and gneiss with the granitic rock is, in part, a 4-foot-wide faulted zone extending both upstream and downstream along the lower left abutment that has been partially healed by intrusive dikes. The rock in the channel section consists largely of extensively sheared and folded gneiss and mica schist. Portions of the rock foundation were grouted during construction. The right abutment foundation of the dam is topographically complex in that it includes an old stream channel separated from the main channel by a ridge with a top elevation of 1,013 feet that was uncovered during construction. The old stream channel drops to the right of the ridge, 50 feet down, to an elevation of 960 feet; and the main channel drops steeply to the left of the ridge, 100 feet down, to an elevation of 910 feet.

2. **Embankment.** The LPD embankment is a 148-foot-high, zoned, earth-fill dam with a crest length of 570 feet, a crest width of 12 feet, and a crest elevation that ranges from 1,060.0 to 1,060.6 feet (HDR et al. 2021). The original design crest elevation was 1,060.9. The upstream face slopes are 1.5H (horizontal):1V (vertical) for the uppermost 10 feet of the embankment, and 2.35H:1V below. The downstream face slopes are 2H:1V for the uppermost 10 feet, and 2.25H:1V below. LPD consists of several zones of fill.

3. **Spillway.** The spillway consists of a 108.7-foot-wide ungated ogee crest section that ranges in elevation at the crest between 1,042.7 and 1,042.9 feet; and a 580-foot-long spillway chute that has upper and lower straight sections, with a transitional curved and super-elevated section between them. The curve in the spillway alignment was required to avoid the old stream channel found during construction at the right abutment described above. The width of the spillway chute

varies from 98 feet where it joins the ogee crest section, to 59 feet at its lower end. The walls on either side of the ogee crest consist of an approximately 28-foot-high gravity wall on the right (eastern) side, and an approximately 45-foot-high gravity wall on the left (western) side. Flows discharge from the end of the spillway chute (elevation 951.67 feet) into a deep erosion hole (approximate bottom elevation of 900 feet) that formed below the end of the chute following construction. The spillway was modified in 1994 or 1995 to provide better fish passage across the ogee crest when flows across the spillway are low. According to DSOD's Memorandum of Design Review (DSOD 1993), the modifications included a 9-inch-deep, 3-foot-wide notch near the right side of the spillway crest, with notches in the sides to allow the placement of stop logs. A vehicle railcar bridge currently spans the concrete spillway toward the downstream end.

4. **Outlet Works.** There is a low-level outlet works and high-level outlet works, as described below. The original outlet works was designed for combined operation of the low- and high-level outlets to allow the reservoir to be drained to 50 percent of the original storage in 7 days (DSOD 1980a).

    a. The low-level outlet works consist of a 30-inch-diameter pipe encased in reinforced concrete that penetrates through the western base of the dam. The upstream invert of the outlet pipe is at an approximate elevation of 960 feet. A three-sided open-top intake structure equipped with a movable grated steel trash rack and a 30-inch hydraulically operated slide gate is situated at the upstream end of the outlet pipe. An array of release valves is present at the downstream end. A large valve exists to evacuate flow from the reservoir in an emergency release situation; smaller valves route flow to the existing adult fish collection facility and the bypass channel that unites downstream with the Carmel River. Water conveyed to the 12-inch supply branch discharges to both the fish trap and to a point about halfway up the Denil ladder to provide attraction flow for migrating adult steelhead. Water conveyed to the bypass channel provides instream flows when the downstream passage facilities and/or the fish ladder are not in operation. The actual flow capacity of the low-level outlet has not been verified. In the past, flow releases have typically been limited to 10 cfs, as measured at the river gage below LPD. Rockslides originating from the left bank of the reservoir occurring in 2018, 2019, and 2020 have covered the existing lower outlet with mud, rock, and debris, and reduced its overall reliability and capacity. Despite several attempts by divers contracted by Cal-Am to investigate and clear debris from the trash rack, the capacity of the lower outlets remains diminished. Throughout the summer of 2021, the lower outlet had only been able to convey between 1 and 3 cfs downstream of the dam (HDR et al. 2021). A new low-level outlet is currently under design and will equal or exceed the designed capacity of the original outlet works. The proposed invert of the new low-level outlet is at an elevation of 981.8 feet.

    b. The high-level outlet works consist of a gated 30-inch-diameter concrete-encased outlet pipe through the left side of the spillway ogee crest. The pipe terminates at the spillway chute floor, where it meets the downstream end of the ogee crest. The slide gate is controlled by an operating shaft connected to a hand wheel at the top of the right abutment gravity wall. The invert of the slide gate is at an elevation of 1,020 feet, approximately 23 feet below the spillway crest. The high-level outlet works is no longer used, having been replaced by the outlet associated with the fish diversion structure described below.

5. **Reservoir Siphon.** The siphon and pertinent infrastructure were installed as a temporary water supply strategy to restore flow to the existing adult fish collection facility and maintain downstream flow in the Carmel River while the capacity of the low-level reservoir outlet is being

restored. The siphon consists of a 16-inch-diameter high-density polyethylene pipe, screened inlet, priming branch, and connection to the existing upstream trap water supply pipe gate valve. The siphon pipe is attached to the western wall of the spillway and supplies surface water from LPR, down the interior of the existing spillway, to the existing low level outlet discharge piping. The siphon inlet is at an elevation of 1,002 feet; a minimum 3 feet of water depth is required above the inlet screen. As the reservoir approaches elevation 1,005 feet, the flow reduces and thus the lower limit of operation is at about elevation 1,010 or 1,011 feet. Although the siphon can produce up to 19 cfs, a throttling valve near the bottom of the siphon can reduce flows down to 2 cfs (HDR et al. 2021).

6. **2015 Fish Diversion Structure.** A fish diversion structure was constructed in the upstream approach to the spillway ogee crest in 2015. The diversion structure is a FWC and consists of a 2-foot-wide overshot ramp gate on a floating barge. After flow passes over the weir, it enters an 18-inch-diameter pipe that discharges at the downstream end of the dam's tailrace pool. The FWC has a capacity of approximately 10 cfs, but can be increased to approximately 15 cfs with the adjustment of ballast.

2.3 Reservoir

The design plans for LPD show that the LPR originally had a storage capacity of 3,030 acre-feet (AF), whereas the dedication plaque on the east abutment states 3,100 AF. The former number is usually cited, which coincides with the water right license for the dam (Cal-Am and MPWMD 2016). A study in 2009 (Smith et al. 2009) estimated the remaining storage at 1,786 AF, with reduced storage due to sedimentation; as shown below in Table 2, AECOM (2018) revised the original storage number to 2,720 AF, based on the latest available information.

Table 2 Reservoir Capacity

Description	As-Built Quantity (acre-feet)	Adjusted[1] End Area Approach Quantity (acre-feet)
Reservoir capacity at NMWS (1947)	3,030	2,720
Reservoir capacity at NMWS (2017)	—	1,601

Notes:

[1] Adjustment = 1,0247 x End Area Approach Quantity

NAVD88 = North American Vertical Datum of 1988
NMWS = normal maximum water surface (at spillway crest maximum elevation of 1,042.9 feet NAVD88)

Source: AECOM 2018

As described in Section 2.5, AECOM used an adjusted end-area method to estimate sediment volumes (AECOM 2018). This method was extended to the reservoir capacity to derive a total reservoir capacity of 1,601 AF (in 2017), as summarized in Table 2. An updated stage-storage curve is summarized in Table 3 and depicted in Figure 1.

Current reservoir storage is small relative to median annual inflow (estimated at about 28,000 acre-feet per year [AFY]), and the reservoir normally fills and spills each winter (Cal-Am and MPWMD 2016). Releases during periods of very low storage can be both warmer than incoming flow and anoxic (with low or no dissolved oxygen) (AECOM 2017a).

Stage data available from an automated stage recorder were used to create a stage-duration analysis of LPR (AECOM 2017a). Reservoir elevations are plotted for water years 2002 through 2016 on Figure 2.

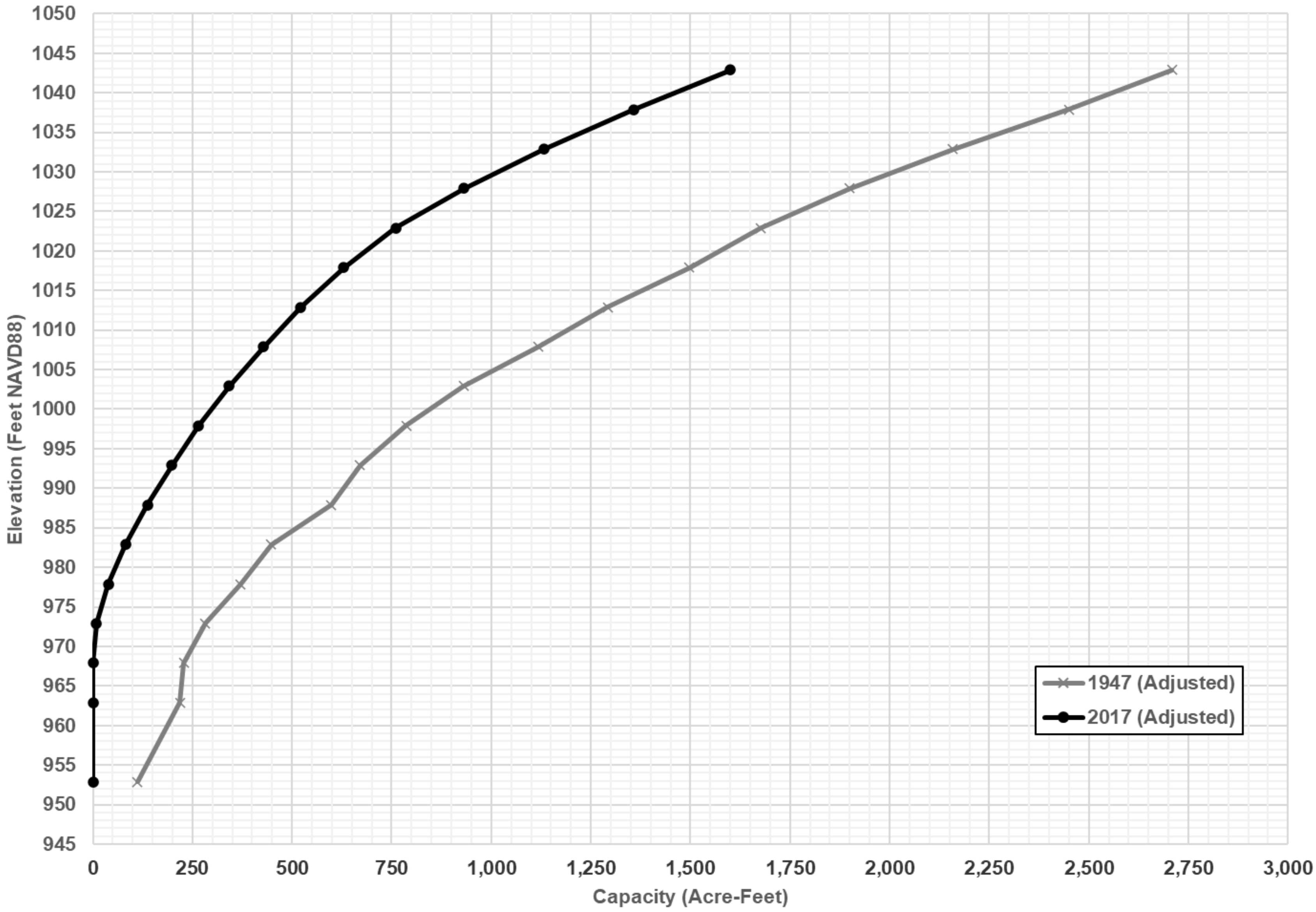
Table 3 Reservoir Capacity Summarized by Water Surface Elevation

Elevation (feet, NAVD88)	Volumetric Capacity (acre-feet)
952.9	0
953.13 (inoperable low-level outlet)	0
962.9	0
967.9	0
972.9	10
977.9	39
981.8 (proposed low-level outlet invert)	72*
982.9	82
987.9	137
992.9	198
997.9	265
1,002.9	342
1,007.9	428
1,012.9	522
1,013.3 (Siphon lowest operating level)	530*
1,017.9	630
1,022.9 (high-level outlet)	761
1,025 (spillway reservoir terrace for offloading)	832*
1,027.9	931
1,032.9	1,132
1,037.9	1,358
1,042.9 (NMWS)	1,601
1,047.9 (optional future)	1,891
1,052.5 (optional future)	2,226

Notes:

* Estimated with linear interpolation

NAVD88 = North American Vertical Datum of 1988
NMWS = normal maximum water surface (at spillway crest maximum elevation of 1,042.9 feet NAVD88)


1050
1045
1040
1035
1030
1025
1020
1015
1010
1005
1000
995
990
985
980
975
970
965
960
955
950
945
Elevation (Feet NAVD88)
0
250
500
750
1,000
1,250
1,500
1,750
2,000
2,250
2,500
2,750
3,000
Capacity (Acre-Feet)
1947 (Adjusted)
2017 (Adjusted)

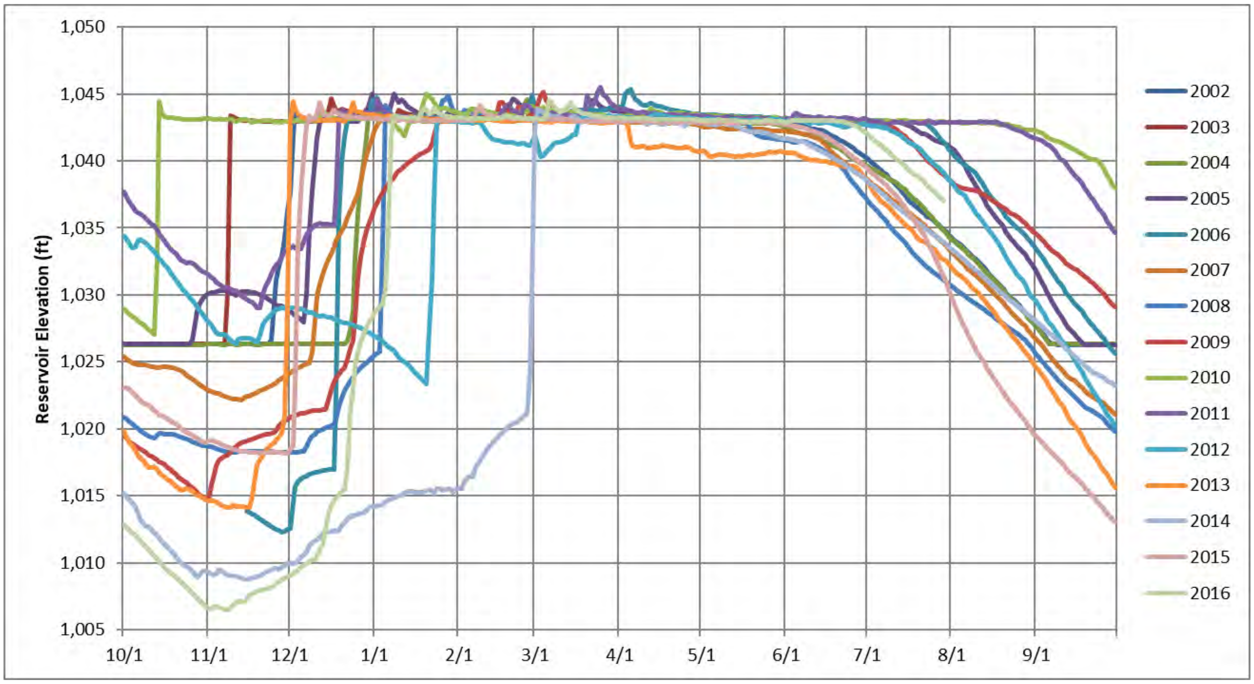


Figure 2 Los Padres Reservoir Elevations for Water Years 2002 through 2016

The following data sets were available as part of this TM:

1. **1947 Topographic Map.** Pre-dam topography was surveyed in 1947 and was available as a scanned as-built drawing sheet depicting 10-foot elevation contours, thalweg lines of Carmel River and Danish Creek, section lines, and a graph of area and capacity curves. The area covered by this survey extends from approximately 500 feet downstream of LPD, with a lower elevation of 900 feet (NGVD29) to approximately 3,600 feet upstream of the original pool extent. This survey extends to an upper elevation of 1,150 feet (NGVD29).

2. **2010 Light Detection and Ranging (LiDAR)) Topography – United States Geological Survey (USGS) Coastal California LiDAR.** The minimum contour interval, based on the vertical accuracy of the survey, is approximately 1 foot in areas not obscured by vegetation.

3. **2016 Bathymetric/Topographic Survey – HDR.** The 2016 bathymetric survey was not used for this TM due to inaccuracies in the data. The 2016 HDR topographic survey used the publicly available 2010 USGS LiDAR, reprocessed by HDR from the reservoir level up to elevation 1,092.9 feet, to address extensive classification errors (HDR 2016).

4. **2017 Bathymetric Survey – California State University, Monterey Bay.** These data were obtained June 3, 2017.

5. **2017 Unmanned Aerial System (UAS) Survey – USGS Pacific Coastal and Marine Science Center.** These data were obtained November 1, 2017, by UAS structure-from-motion photogrammetry. This survey captures the segment of the shallow upper reservoir, above elevation 1,040 feet, that the 2017 bathymetric survey vessel could not reach at the time of data collection. The UAS survey also captures an additional 2,100-foot segment of upland topography

along the Carmel River before terminating roughly 500 feet downstream of the confluence with Danish Creek.

6. **2020 Bathymetric Survey – HDR.** This bathymetric survey was conducted by Bay Marine Services 2020 in support of HDR's design of the LPD outlet modifications drawings. The survey was concentrated around the proposed location of the new low-level outlet near the dam.

2.5 Sediment Characterization and Volume

The sediment stored in LPR is divided into three zones, based on stratigraphy and depositional environment:

- Zone 1 – the downstream pro-delta basin
- Zone 2 – the main delta body
- Zone 3 – upstream alluvial deposits

These zones are depicted in plan and profile view in Figure 3 and Figure 4. The alignment of the profile view (longitudinal section) follows the adjusted 1947 thalweg from the dam to Station 55+00, and the 2010/2016 thalweg upstream of Station 55+00.

AECOM performed a sediment volume calculation documented in AECOM 2018, using the available surveys listed in Section 2.4 (excluding the 2020 bathymetric survey). AECOM found significant, nonsystematic errors in the 1947 pre-dam topography, indicating that the original reservoir capacity may be somewhat less than previously understood. (The 1947 survey appears to depict a valley wider than ever existed.) AECOM cut sections approximately every 200 feet from the 1947 contours, and a merged terrain of the 2016 LiDAR, 2017 bathymetry and the 2017 UAS survey. Volumes were calculated using end area methods, including an adjustment to account for the reduced accuracy of the end area method due to the spacing of the 200-foot sections. The calculated sediment volume is summarized in Table 4.

Table 4 Sediment Volume by Zone

Area	Quantity (AF)	Quantity (CY)	Characterization
Zone 1	340	550,000	Organics, silt, clay, fine sand
Zone 2	701	1,130,000	Predominately silt and sand
Zone 3 below NMWS	79	127,000	Sand and coarser materials
Zone 3 above NMWS	138	223,000	
Total Sediment Volume	**1,258**	**2,030,000**	

Notes:

AF = acre-feet
CY = cubic yards
NAVD88 = North American Vertical Datum of 1988
NMWS = normal maximum water surface (at spillway crest maximum elevation of 1,042.9 feet NAVD88)

Sources: AECOM 2018

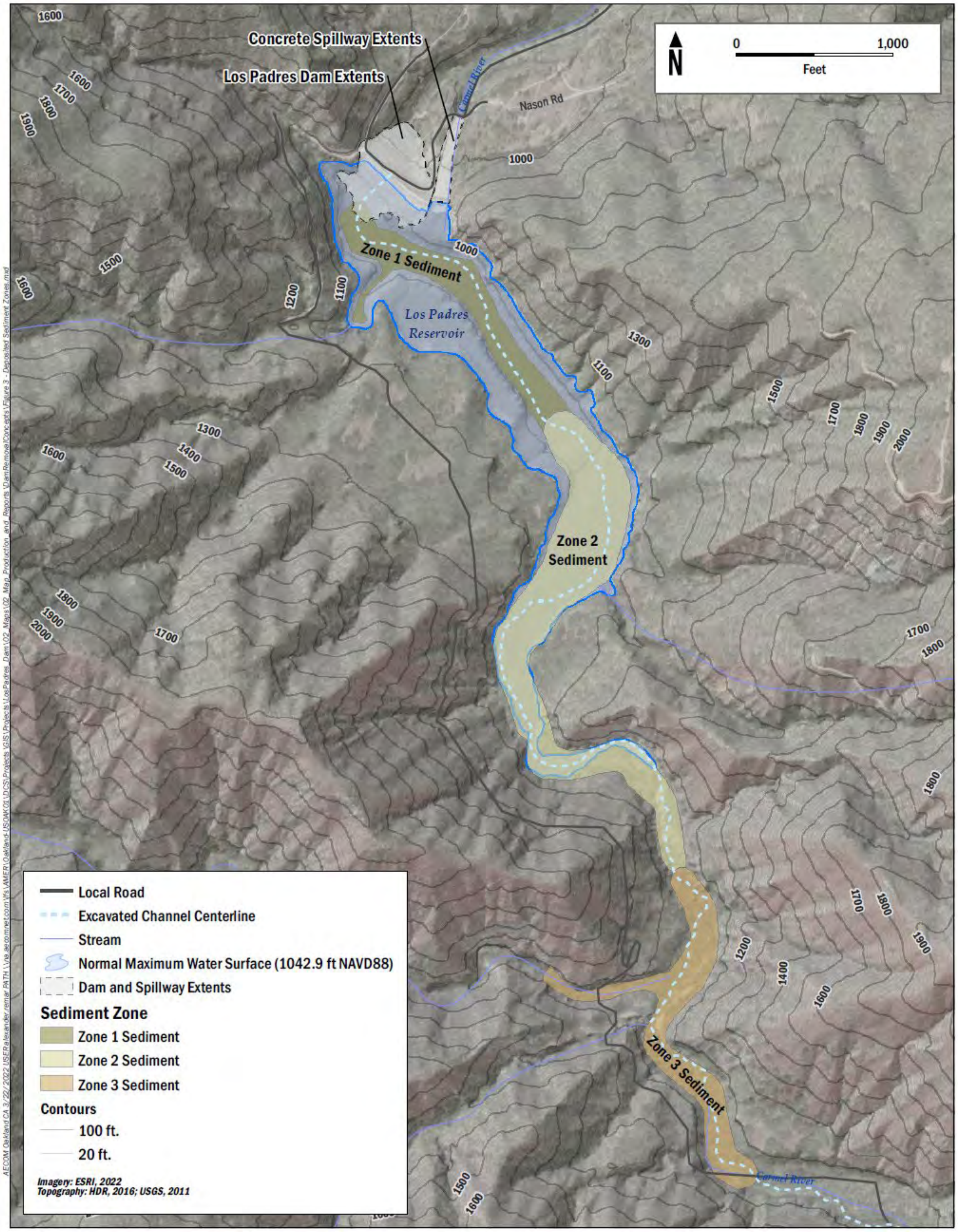


Figure 3 Plan View of Accumulated Sediment Zones

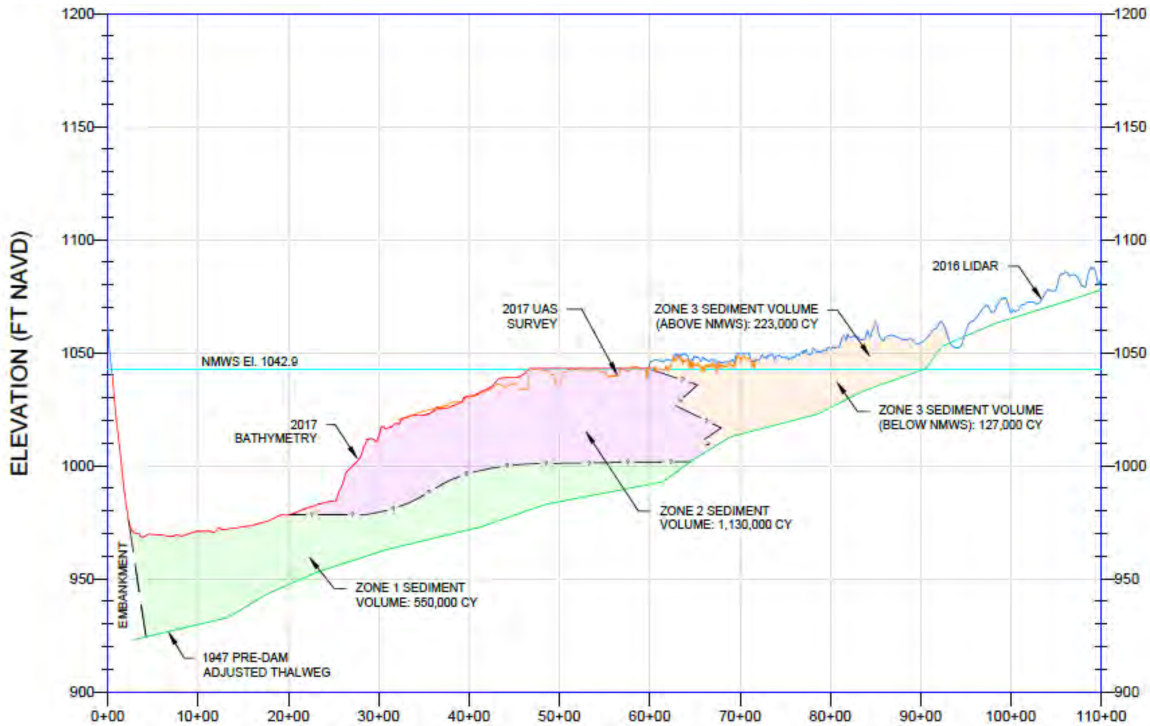


Figure 4 Profile View of Accumulated Sediment Zones

Estimated sediment size-class amounts for the three zones are summarized in Table 5. AECOM estimated the proportion of different grain-size classes composing the sediments in Zone 1 and Zone 2, based on sediment borings, Unified Soil Classification System sediment distribution data, laboratory gradation results, and engineering judgment, as summarized in AECOM 2018.

Table 5 Estimated Sediment Size-Class Amounts

Area	Cobble/Gravel (4.75 to 300 mm)	Sand (0.075 to 4.75 mm)	Silt (<0.075 mm)	Clay (<0.075 mm)	Organics (n/a)
Zone 1	2 to 5%	25 to 35%	50 to 60%	8 to 15%	5 to 10%
Zone 2	5 to 10%	65 to 75%	15 to 25%	2 to 5%	<2%
Zone 3 below NMWS	25 to 35%	60 to 70%	5 to 15%	0 to 5%	<2%
Zone 3 above NMWS	35 to 45%	55 to 65%	0 to 10%	0 to 5%	<2%

Notes:

Estimates for Zone 3 were approximated, based on a correlation to the coarsening upstream Zone 2 deposits and surficial observations, not on subsurface data or quantitative surface data.

mm= millimeters
NAVD88 = North American Vertical Datum of 1988
NMWS = normal maximum water surface (at spillway crest maximum elevation of 1,042.9 feet NAVD88)

Sources: AECOM 2018

2.6 Sediment Deposition Rate

The adjusted sediment volumes documented in AECOM 2018 and the revised reservoir capacity described in Section 2.3 are summarized in Table 6. These values were used to calculate an average sediment deposition rate in and directly upstream of the reservoir, and an average reservoir storage loss rate. The volumes in Table 6 incorporate sediment input resulting from the 1977 Marble Cone Fire and subsequent storm events.

Table 6 Estimated Sediment Volume Summary

Description	Quantity (AF)
Original 1947 reservoir capacity at NMWS	2,720
2017 reservoir capacity at NMWS	1,601
Sediment volume below NMWS	1,120
Sediment volume above NMWS	138
Total sediment volume	**1,258**

Notes:

AF – acre-feet
NAVD88 = North American Vertical Datum of 1988
NMWS = normal maximum water surface (at spillway crest maximum elevation of 1,042.9 feet NAVD88

Sources: AECOM 2018

The calculation of the average sedimentation rate considers accumulated sediment volumes both above and below the normal maximum water surface (NMWS) of 1,042.9 feet. This rate is used in Alternative 4 (Recover Storage Capacity with Excavation) to determine the Alternative 4 goal for periodic removal of sediment, to maintain the existing reservoir capacity.

Dividing the total accumulated sediment volume by the number of years since the dam was constructed to the 2017 data point (70 years) yields an average sediment deposition rate of approximately 18 AFY. Subtracting the 2017 reservoir capacity from the original 1947 reservoir capacity, and then dividing by the number of years between the data points, yields an average reservoir storage loss rate of approximately 16 AFY.

2.7 PMF Analysis

This section summarizes the steps taken to calculate the probable maximum flood (PMF), using methods prescribed in hydrometeorological report (HMR) Numbers 58 and 59 (NOAA 1998, 1999b). The HMR 58/59 PMF will be a key driver for improvements proposed under Alternative 3 (Storage Expansion and Dredging) because DSOD will likely require as part of their approval that the spillway and dam facility be improved to accommodate the revised PMF.

The probable maximum precipitation (PMP) is "theoretically, the greatest depth of precipitation for a given duration that is physically possible over a given storm area at a particular geographical location at a certain time of the year" (NOAA 1998). The PMP can be estimated for two different types of storms: a General Storm and a Local Storm. For relatively small watersheds (< 500 square miles), the PMP for both types of storms are calculated and the largest value is used.

The PMP for the drainage area upstream of LPD (44.8 square miles) was determined using the calculation procedures from HMR 58 (NOAA 1998) and HMR 59 (NOAA 1999b). Using ArcGIS, the isolines of the all-season 24-hour PMP digital shapefiles (NOAA 1999a) were interpolated by converting them to a TIN [triangular irregular network], and then to a 100-foot resolution TIFF [tagged image file format]. Using the Zonal Statics tool, the areal average all-season 24-hour PMP upstream of LPD was determined to be 27.9 inches. Figure 5 shows the drainage area upstream of the LPD as a thick black line; the subbasins for the San Clemente dam, including the 10 subbasins upstream of the LPD, as thin black lines; and the isolines and the interpolated surface of the all-season 24-hour PMP.

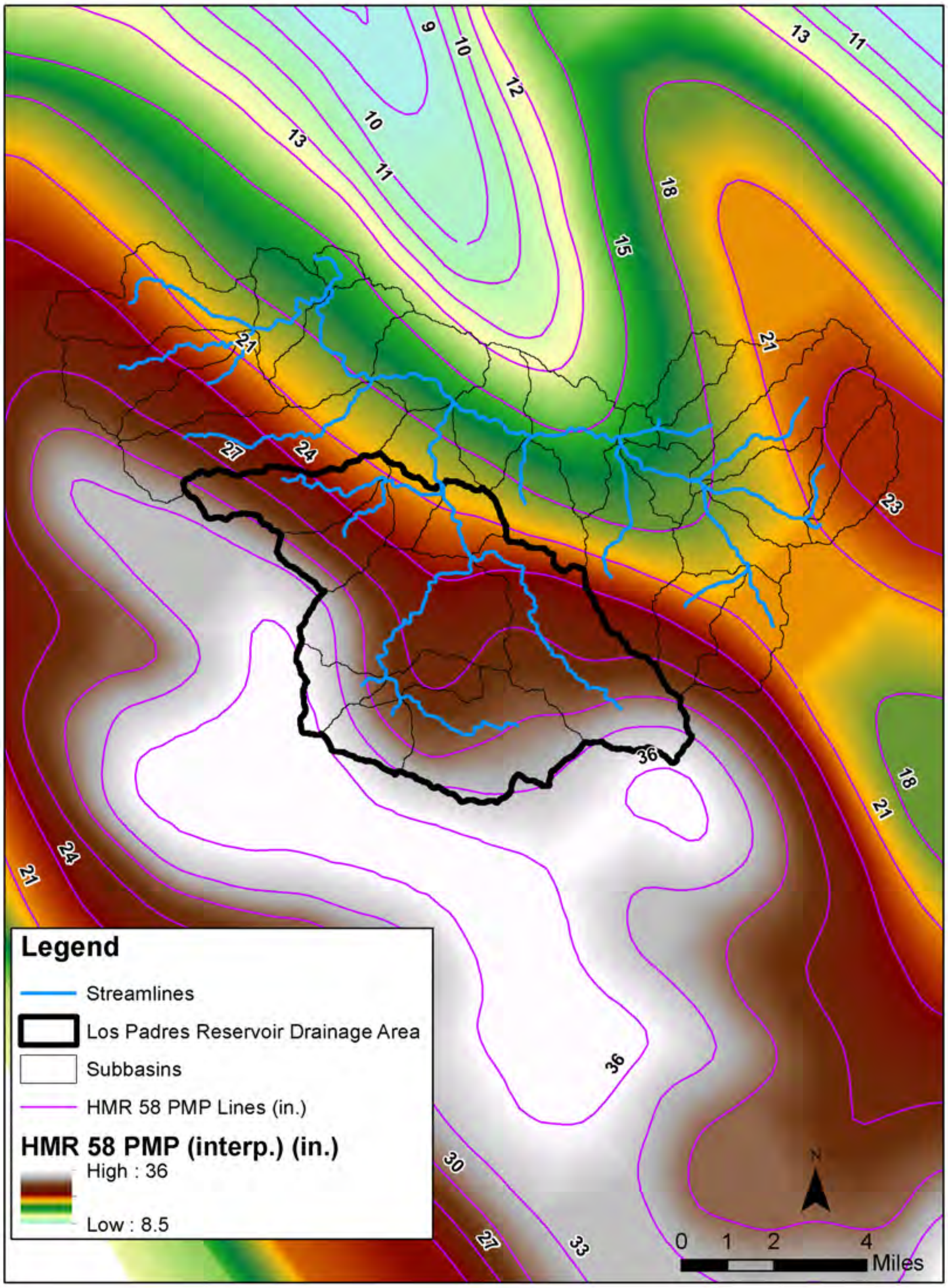


Figure 5 Isolines and Interpolated Surface of All-Season 24-Hour PMP Upstream of LPR

To determine the cumulative 6-hour time step, all-season, 72-hour General Storm, the areal reduction factor for the watershed size was applied to the PMP, along with the all-season depth-duration curve. Because the lag times for the 10 subbasins upstream of LPD range from 24 to 81 minutes (United States Army Corps of Engineers Hydraulic Engineering Center Hydrologic Modeling System [HEC-HMS] model development discussed below), and the time step for the hyetograph needs to be shorter than the lag time to ensure that the peak is properly captured, the cumulative General Storm was interpolated into 15-minute time steps. An incremental 15-minute time step, all-season, 72-hour General Storm was then determined.

Using the procedure from Step 8 of HMR 58, the incremental precipitation was rearranged into the backloaded shape of Figure 6.

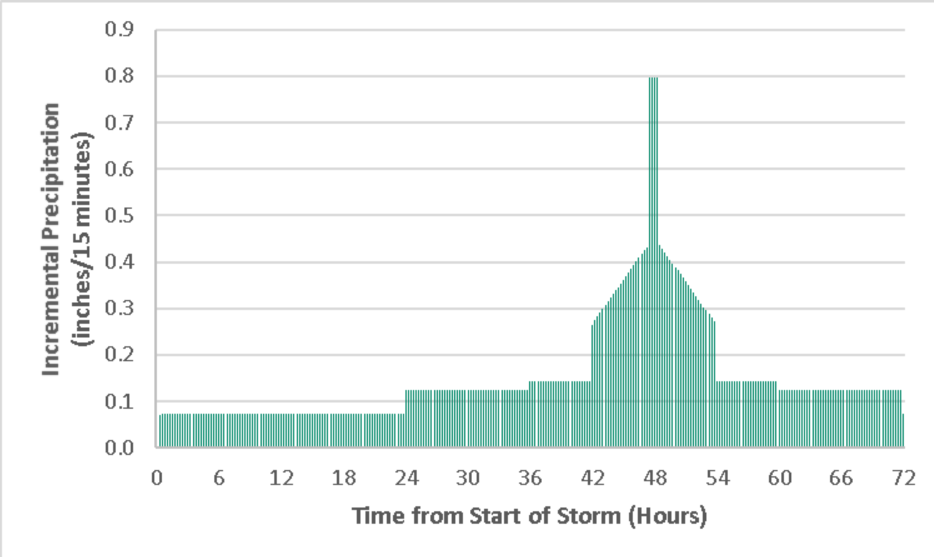


Figure 6 Rearranged Incremental Precipitation for General Storm

USGS topographic maps indicate that there are no 6,000-foot contour lines in the drainage area upstream of the LPD, which also means that the average elevation of the drainage area is less than 6,000 feet; therefore, no elevation adjustment for precipitation was needed. Using standard HMR 58 procedures, the local storm was determined, as shown in Figure 7.

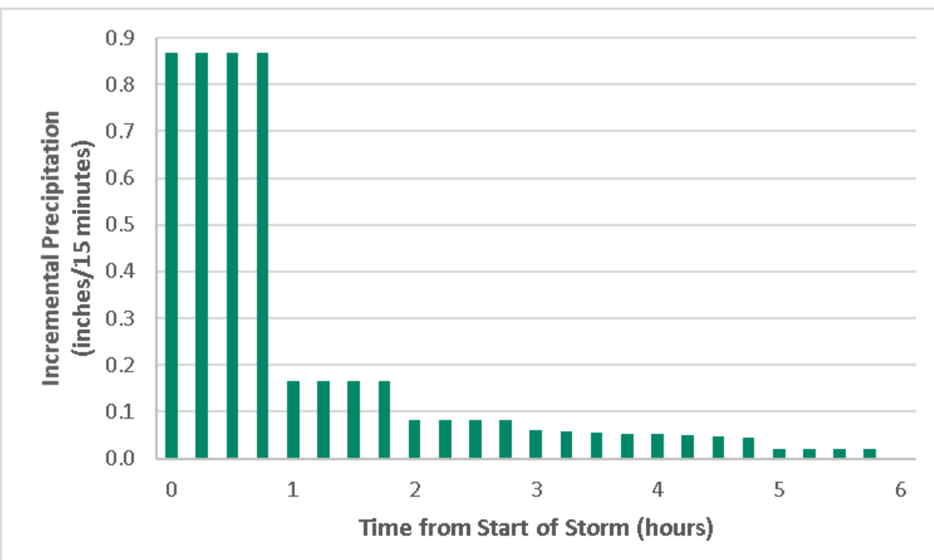


Figure 7 Rearranged Incremental Precipitation for Local Storm

The PMF is the flood that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in a drainage area (FEMA 2003). The PMP for the drainage area upstream of LPD was routed through the United States Army Corps of Engineers' HEC-HMS hydrologic model (USACE 2021) that was developed for the San Clemente Dam Removal

Project to determine the PMF (URS 2012). HEC-HMS was used because it is an industry standard for watershed hydrology.

The basins were delineated using HEC-GeoHMS. The model uses the Soil Conservation Service (SCS) curve number loss method. The transform method used is the SCS unit hydrograph, with lag time determined by HEC-GeoHMS using the curve number lag method, which is based on basin curve number and basin slope. Baseflow was assumed to be zero. The same PMP was applied to all subbasins upstream of LPD, similar to the approach for the San Clemente Dam Removal Project. For further description of the HEC-HMS model set-up and assumptions, refer to URS (2012).

The robustness of the HEC-HMS model for the San Clemente PMF was checked by performing sensitivity analysis on channel geometry, channel routing method, and Manning's n value; varying these values had little effect on the magnitude of the PMF. To be conservative, no channel routing was assumed for the LPD PMF model, similar to the approach taken for the San Clemente PMF.

The HEC-HMS schematic, showing the addition of the LPR, is shown in Figure 8. The model was adjusted to incorporate the LPD and spillway (see Figure 9) and to incorporate the incremental precipitation for the General Storm and Local Storm for the drainage area upstream of LPD.

To account for the attenuation of the flood wave due to the presence of the reservoir, the stage-storage curve was included in the HEC-HMS model (see Section 2.3). The spillway rating curve was obtained from the California DSOD (DSOD 1980b). The Los Padres spillway is at elevation 1,042.9 feet. The current top of dam is at elevation 1,060.9 feet. The stage-storage curve was extrapolated beyond the top of the dam and was associated with the rating (stage-discharge) curve, to develop a storage-discharge curve that could be used in HEC-HMS (Figure 9). Dam overtopping was excluded for this analysis, because the peak water surface elevation without overtopping was used to help determine how high the dam should be raised, and the corresponding spillway modifications to pass the PMF.

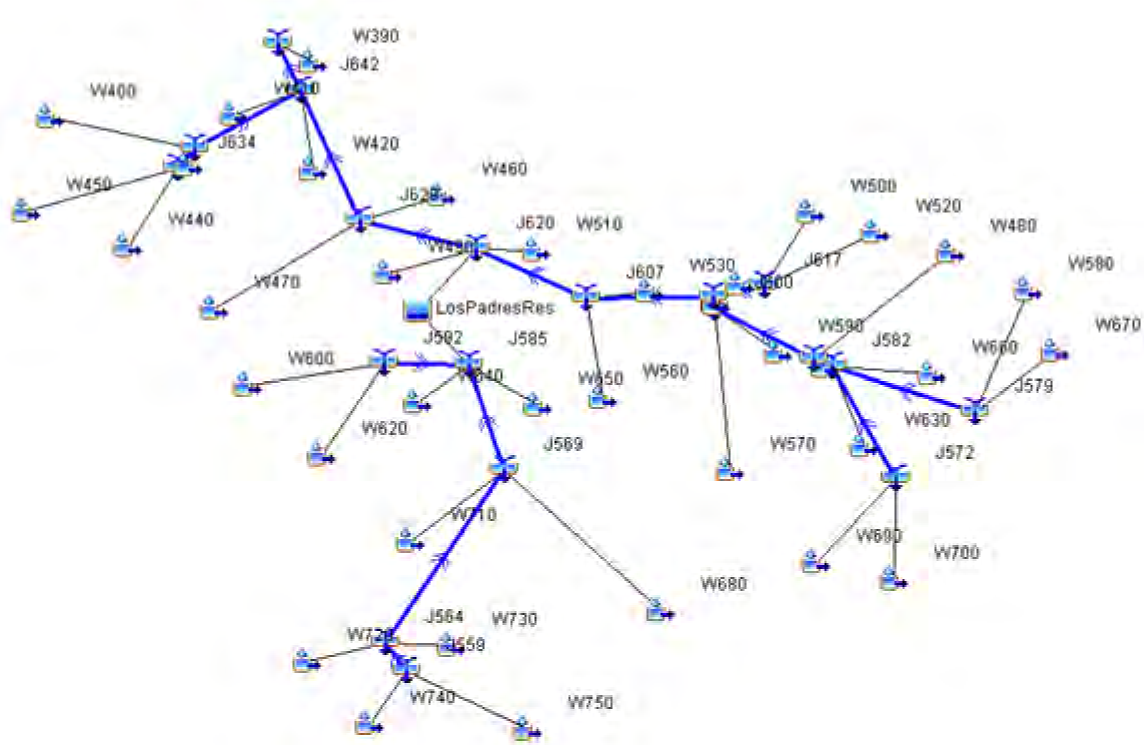


Figure 8 HEC-HMS Model for San Clemente Dam, Including LPR

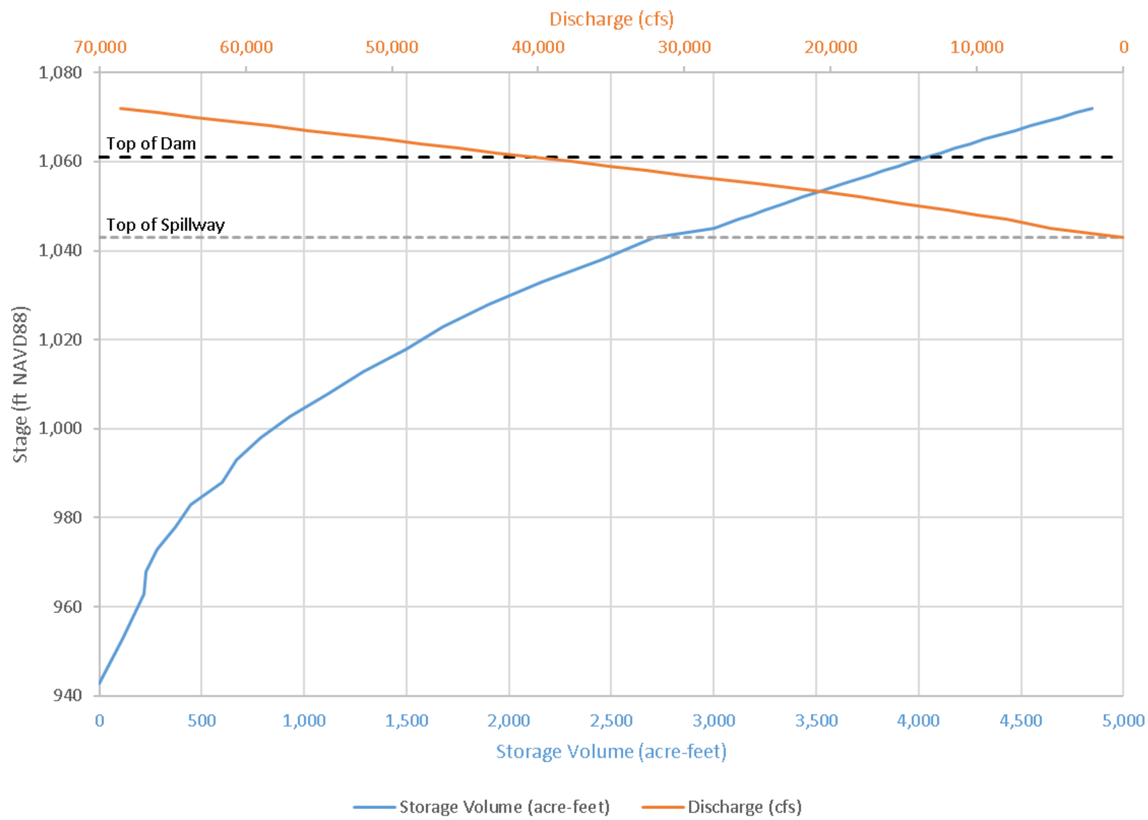


Figure 9 LPR Stage-Storage Curve and Spillway Stage-Discharge Curve

The HEC-HMS results indicate that the General Storm produces the maximum PMF of 66,443 cfs, compared to the HMR 36 PMF of 31,579 cfs (DSOD 1980b).

The HEC-HMS results for the inflow and outflow of LPR for the General Storm and Local Storm is shown in Table 7, as well as on Figure 10 and Figure 11. Based on the results, the revised PMF would result in overtopping of the existing dam embankment during the PMF event.

Table 7 HEC-HMS Results

Description	General Storm	Local Storm
Duration (hours)	72	6
Precipitation depth (inches)	44.34	4.97
Peak Stage (feet NAVD88)	1,071.2	1050.6
Peak inflow to LPR (cfs)	66,305	16,720
Peak outflow over LPD (cfs)	66,443	15,257

Notes:

The calculation of stage assumes no overtopping of the dam and flow is contained in the spillway.

cfs = cubic feet per second
LPD = Los Padres Dam
LPR = Los Padres Reservoir
NAVD88 = North American Vertical Datum of 1988

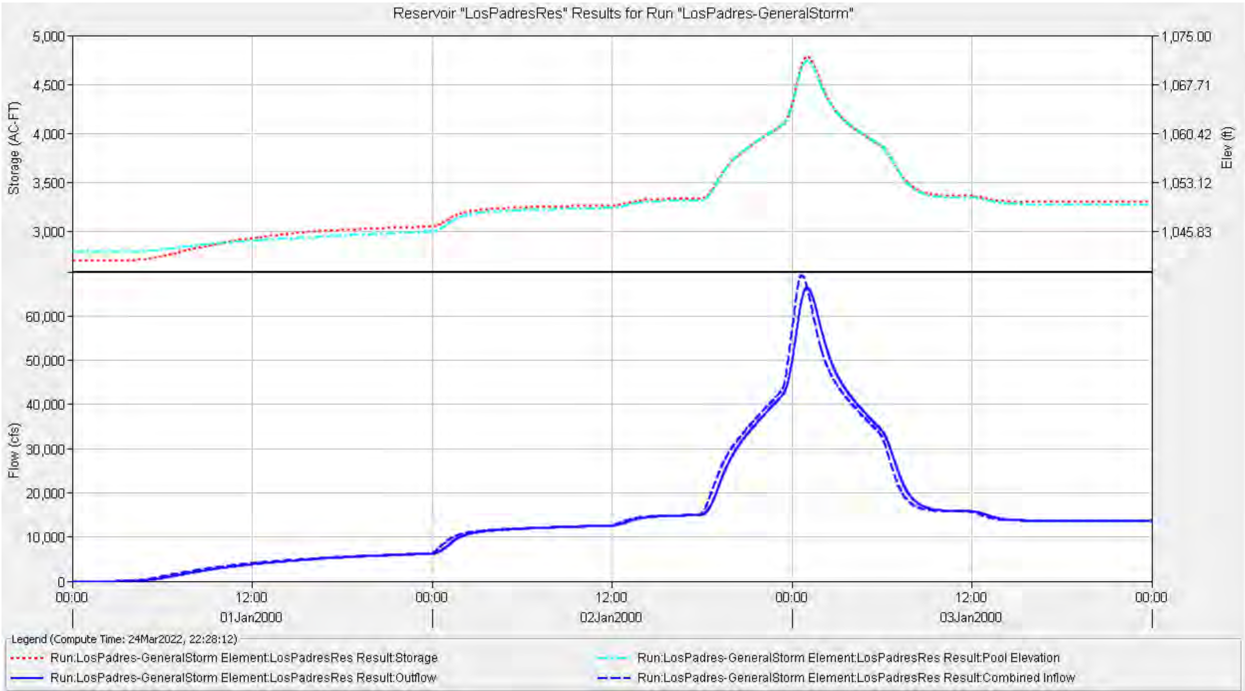


Figure 10 HEC-HMS Results for Inflow and Outflow of LPR for General Storm

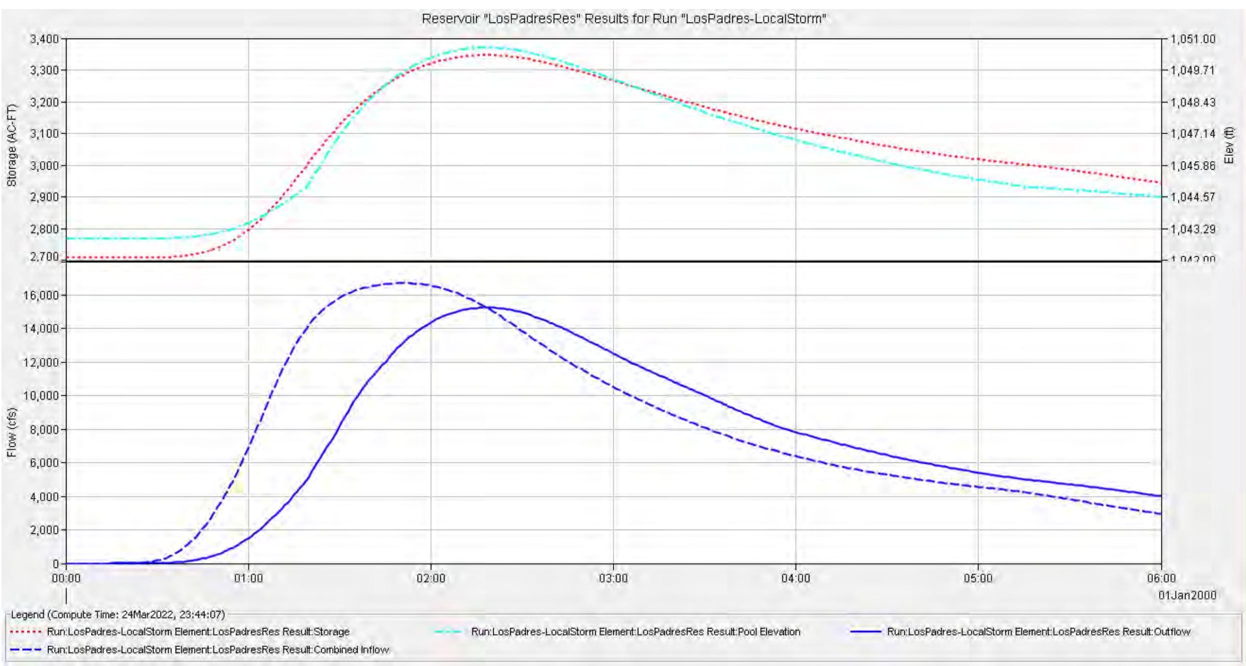


Figure 11 HEC-HMS Results for Inflow and Outflow of LPR for Local Storm

2.8 Geologic Considerations

The rock at the right (east) abutment is granitic rock with predominantly vertical jointing (DSOD 1980a). The rock at the left (west) abutment is weathered mica schist and gneiss intruded by granitic rock. The contact between the mica schist and gneiss with the granitic rock is, in part, a 4-foot-wide faulted zone extending both upstream and downstream along the lower left abutment that has been partially healed by intrusive dikes. Much of the rock in the channel section is extensively sheared and folded gneiss and mica schist. The bedrock on the left (west) and right (east) banks above and downstream of the dam are surface masked by colluvium and debris slides of varying thickness.

Bedrock in the spillway approach and upstream of the spillway crest is very hard, fractured gneiss and/or schist, based on logging of 15 piers installed up to 15.5 feet into bedrock for the Downstream Fish Passage Project in 2015. Where the bedrock could be observed, joints and fractures were described as having a spacing of 4 inches to 2 feet, with tight to extremely narrow apertures and without healing (HDR et al. 2021).

Any spillway reconstruction and/or extension into the reservoir to accommodate the spillway gates in Alternative 3 (Storage Expansion and Dredging) will need to be founded on bedrock either directly or by piers. Excavations for spillway modifications placed directly on bedrock are likely to encounter areas of colluvium or debris slide material at the fishway foundation grade that would need to be over excavated to bedrock and built back up with concrete. Debris slides that would be impacted by excavation will need to be removed or stabilized for construction safety and to mitigate the potential risk of damage to proposed modifications. The slopes of required excavations in colluvium or bedrock, and any required stabilization, will need to be determined through a geotechnical investigation along the alignment of the proposed structures and analysis, using the data from the investigation. Any tunneling activities associated with the sluice tunnel in Alternative 5 (Recover Storage Capacity with Sluice Tunnel) will also require a geotechnical investigation along the alignment of the proposed tunnel.

3. Alternative 1 (No Sediment Action)

Alternative 1 (No Sediment Action) is based on a scenario in which LPD remains in place as under current conditions; no action is taken to manage the existing sediment accumulation in the reservoir, or future sediment inputs.

3.1 Overview

Under Alternative 1 (No Sediment Action), no action is taken to manage the accumulated reservoir sediments or the incoming sediment. In addition, no action is taken to maintain or increase reservoir storage in any way. Given the average reservoir storage loss rate of 16 AFY and the remaining storage volume in 2017 of 1,601 AF (see Section 2.6), it is estimated that the reservoir will be substantially filled with sediment by 2115 (although there is considerable uncertainty associated with this estimate; see Section 3.5). Similar to other large reservoirs that have lost their storage capacity due to watershed sediment load, it is anticipated that some relatively insubstantial reservoir pool will remain directly upstream of the spillway due to hydraulic action occurring during storm events.

As the reservoir continues to lose storage capacity over time, the flexibility to store and then release flows from the reservoir during the summer will decrease. Eventually, there will be little to no capability to augment summer flows with reservoir water.

Figure 12 shows the dam and reservoir, with the approximate zones of current sediment deposition.

3.2 Construction Cost

Alternative 1 (No Sediment Action) does not include any direct construction activities or associated construction costs. However, in accordance with the existing memorandum of agreement (MOA) between Cal-Am, NMFS, and the Conservancy (NMFS 2017), Cal-Am would be required to implement upstream and downstream fish passage improvements if LPD were to remain in place. Construction costs associated with these improvements could total up to $82.1 million, which is the highest combination of passage alternatives proposed (HDR et al. 2021).

Preferred alternatives developed in HDR et al. (2021) to provide upstream and downstream fish passage include the following:

- Upstream Fish Passage
  - U1: Technical Fish Ladder ($49.1 million Capital Cost) consists of a concrete fish ladder traversing the right riverbank, adjacent to the spillway. The fish ladder would be cut into hard rock to avoid potential geotechnical issues associated with the left bank or modification of the earthen dam. Given the elevation difference between the reservoir and tailrace, the fish ladder would likely run parallel to the Carmel River and may require several directional changes to traverse the potential rise, while minimizing the footprint. The fish ladder would likely be a pool-and-weir type, with a central v-notch to operate at low flows (i.e., 3 through 30 cfs), if needed to conserve water releases from the reservoir and to accommodate targeted biological objectives and site-specific characteristics. A vertical slot baffled section of fish ladder would be present at the exit to accommodate the anticipated range of reservoir fluctuations that may be experienced during the period of adult migration (HDR et al. 2021).
  - U8: Track and Transport ($12.0 million Capital Cost) replaces the existing trap-and-transport facility with a newer facility designed to contemporary standards, sized to accommodate the future recovery levels of steelhead in the Carmel River, and formulated using state-of-the-science project elements. In general, fish would be attracted to a fish ladder entrance; they would enter a short section of fish ladder that leads to a small transition pool; they may pass into or be lifted into a large holding gallery; they would pass over a false weir into a transport flume; and, ultimately, they would be conveyed into a holding tank or tanks until transferred into a transport vehicle and driven upstream to the reservoir (HDR et al. 2021).

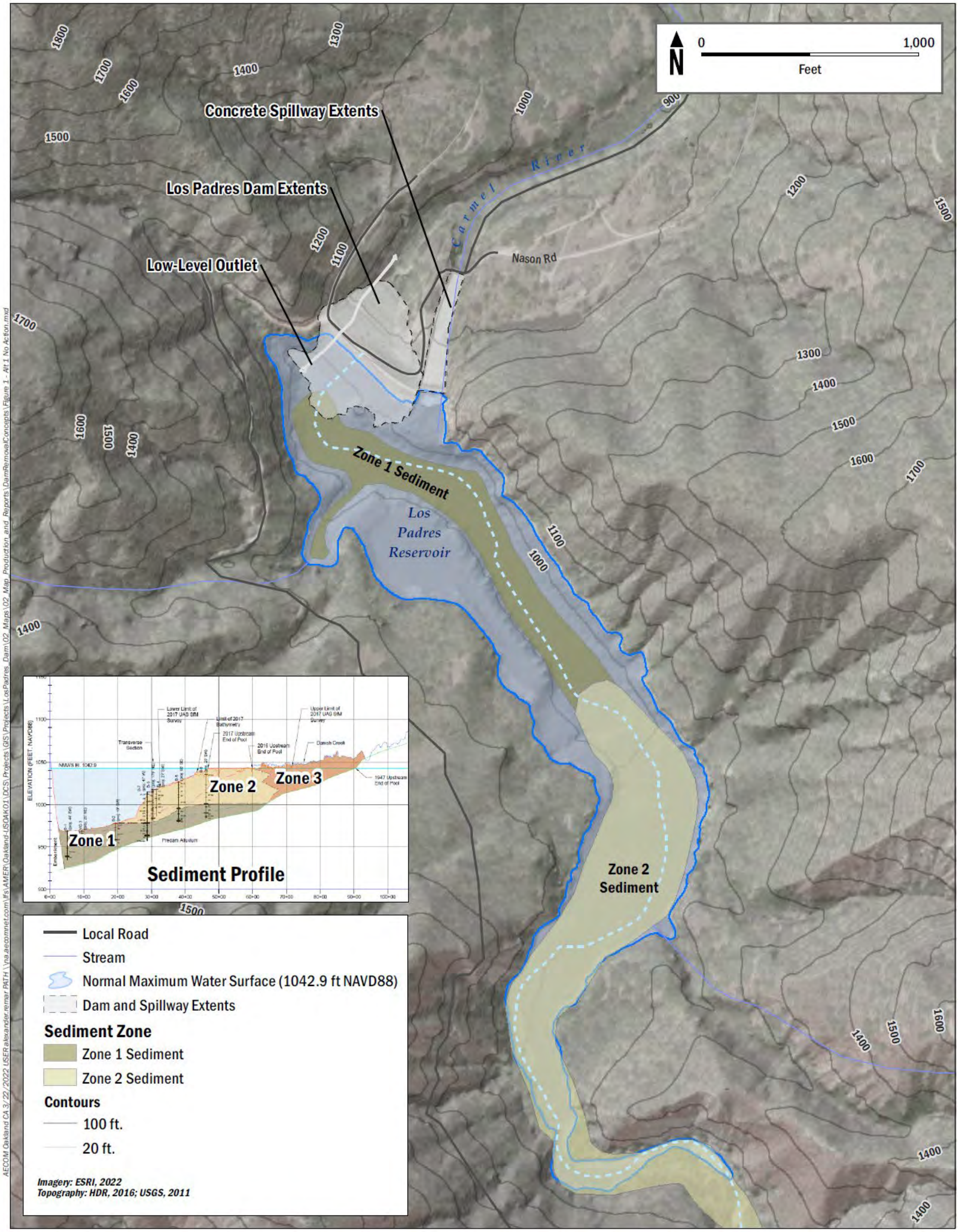


Figure 12 Alternative 1 (No Sediment Action)

- Downstream Passage
  - D1: FSC ($33.0 million Capital Cost) includes implementation of a full-scale FSC with pumped attraction flow, a screened collection inlet, and the ability to collect out migrating smolt throughout a wider range of reservoir water surface elevations. The new FSC would float in the main body of the reservoir just upstream of the spillway forebay to take advantage of better orientation and depth in the reservoir. Full-depth guide nets would narrow the effective collection area in front of the FSC and guide fish to the collection inlet. The floating barge of the FSC would fluctuate vertically with changes in reservoir stage for an approximate range of 45 feet (HDR et al. 2021).
  - D8: Spillway Modification and Existing FWC with 30 cfs Attraction ($12.7 million Capital Cost) includes a passage slot that would be cut at the spillway crest to provide a larger opening for safe entrance and passage, with the implementation of an adjustable crest gate to control depth and flow through this slot. A passage channel would be constructed along the right wall of the spillway, providing safe passage to the existing tailwater pool. Modifications would also be made to the tailwater pool to improve safety during transition from the passage channel. In addition, the existing FWC would be modified to improve attraction to the entrance of the collector inlet. Improvements include additional floatation and modifications to the transition pool, with screens and a pumped flow array that could accommodate a pump-back rate up to 20 cfs. This would provide a total attraction flow of up to 30 cfs, and a targeted gravity bypass flow of 10 cfs (HDR et al. 2021).

3.3 Operation and Maintenance

Current annual operation and maintenance costs associated with the operation of LPD are estimated by AECOM at approximately $440,000 (Cal-Am 2022), and these costs would continue in the future. Annual operation and maintenance activities include the following:

- Daily oversight for dam facility monitoring and reporting (4 hours per day, 7 days per week)
- Fish passage related oversight (5 months per year, 4 hours per day, 7 days per week)
- Behavior guidance system monitoring
- Staff fuel costs
- Road maintenance
- DSOD reporting
- Miscellaneous facility repairs

In addition, in accordance with the existing MOA between Cal-Am, NMFS and the Conservancy (NMFS 2017), Cal-Am would be required to implement upstream and downstream fish passage improvements if LPD were to remain in place. Annual operation and maintenance costs associated with these improvements could range from $389,000 to $782,000 (HDR et al. 2021).

Preferred alternatives developed in HDR et al. 2021 are described above in Section 3.2, with the following operation and maintenance costs:

- Upstream Fish Passage
  - U1: Technical Fish Ladder ($208,000 Annual Operation and Maintenance Cost; HDR et al. 2021)
  - U8: Track and Transport ($392,000 Annual Operation and Maintenance Cost; HDR et al. 2021)

- Downstream Passage
  - D1: FSC ($390,000 Annual Operation and Maintenance Cost; HDR et al. 2021)
  - D8: Spillway Modification and Existing FWC with 30 cfs Attraction ($181,000 Annual Operation and Maintenance Cost; HDR et al. 2021)

3.4 Advantages and Disadvantages

Advantages and disadvantages associated with Alternative 1 (No Sediment Action) are discussed in the following paragraphs and summarized in Table 8. Both Table 8 and the bulleted advantages and disadvantages are organized by the following categories: Cost, Local Impacts, Water Supply, Flooding, Geomorphology, Biological, Water Rights, and Regulatory.

Cost

- **Advantage:** Alternative 1 (No Sediment Action) would trigger commitment, under the 2017 MOA, for Cal-Am to provide fish passage improvements at LPD. This could total more than $82 million of construction cost and up to $783,000 of annual operation and maintenance costs (HDR et al. 2021). The fish passage construction cost total is the lowest of the alternatives presented in this TM, although Alternative 2 (Dam and Sediment Removal) is relatively close in construction cost and lacks annual operation and maintenance costs.

Local Impacts (Traffic and Noise)

- **Advantage:** Impacts to local traffic and noise for Alternative 2 (Dam and Sediment Removal) would be the lowest of the alternatives presented in the TM. However, there would be some level of traffic disruption from equipment mobilization, material on-haul, and construction worker commuting associated with fish passage improvement construction. Similar to all of the other alternatives, small improvements may be required along public roads (see Section 4.2) to accommodate construction traffic, which would cause additional disruption.

Water Supply

- **Disadvantage:** As LPR fills with sediment over time, reduced reservoir storage will limit Cal-Am's ability to store water for any purpose in the future, including in support of surface flow and pumping in the lower river.

Flooding

- **Advantage:** Until LPR is full of accumulated sediment and transport of coarse sediment begins, LPD would continue to prevent the transport of coarse sediment downstream of LPD through the Carmel River. This would limit deposition in the lowermost 30,00 feet of the mainstem, which otherwise could increase flooding (Balance Hydrologics and UBC 2019).

Geomorphology

- **Disadvantage:** Until LPR is full of accumulated sediment and transport of coarse sediment begins, LPD would continue to prevent the transport of coarse sediment downstream of LPD through the Carmel River, especially in the upstream section of Reach 1, 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 and limit other potential morphological benefits associated with large wood and instream and overbank habitat (Balance Hydrologics and UBC 2019; AECOM and Stillwater Sciences 2022).

Biological

- **Advantage:** Until the reservoir is filled with sediment, Alternative 1 (No Sediment Action) would provide flows capable of providing rearing habitat for both fry and juvenile steelhead downstream of LPD during the dry season in normal water years (AECOM and Stillwater Sciences 2022).

Table 8 Alternative 1 (No Sediment Action) Advantage/Disadvantage Summary

Alternative No.	Alternative Name	Advantages/Disadvantages							
		Cost	Local Impacts	Water Supply	Flooding	Geomorphology	Biological	Water Rights	Regulatory
1	No Sediment Action	+ • Up to $82 million of passage improvements; lowest cost	+ • Least impact of alternatives	- • Limits Cal-Am's ability to store water into the future	+ • Limits deposition and associated flooding impacts in the lower river channel until the reservoir is filled	- • Prevents the transport of coarse sediment and associated benefits until the reservoir is filled	- • Adult passage improvements less beneficial than Alternative 2 (Dam and Sediment Removal) volitional passage • Continues to block upstream juvenile passage and provides suboptimal downstream juvenile passage • Provides suboptimal water temperature regime in summer months • As LPR fills long-term, reduces ability to enhance summer rearing habitat and downstream passage for steelhead + • Until the reservoir is filled with sediment, Alternative 1 (No Sediment Action) would provide summer flows capable of providing rearing habitat downstream of LPD	- • Potential reduction in Cal-Am's water rights	- • Sediment accumulation may limit the ability to meet requirement of SWRCB water rights permit for summer releases, and DSOD for reservoir drawdown (through outlet works)

Notes:

+ Advantage
- Disadvantage
Cal-Am = California American Water
DSOD = Division of Safety of Dams
LPD = Los Padres Dam
LPR = Los Padres Reservoir
SWRCB = State Water Resources Control Board

- **Disadvantage:** As LPR fills with sediment over time, the ability to enhance summer rearing habitat and passage for steelhead in the Carmel River downstream of LPD through flow releases from LPR would be incrementally reduced. Based on the current reservoir storage, average releases of 3.2 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.

- **Disadvantage:** Implementation of fish passage improvements (HDR et al. 2021) would improve adult steelhead passage over existing conditions, but would be less beneficial to fish than the volitional passage provided in Alternative 2 (Dam and Sediment Removal).

- **Disadvantage:** Under Alternative 1 (No Sediment Action), upstream movement of juveniles would continue to be blocked, thus continuing to prevent access to thermal refugia in the watershed upstream of LPR (AECOM and Stillwater Sciences 2022).

- **Disadvantage:** Alternative 1 (No Sediment Action) has the potential to continue causing stress and migration delay for migrating steelhead (AECOM and Stillwater Sciences 2022).

- **Disadvantage:** Alternative 1 (No Sediment Action) provides suboptimal downstream juvenile passage through and mortality in LPR (AECOM and Stillwater Sciences 2022).

- **Disadvantage:** Alternative 1 (No Sediment Action) provides a suboptimal water temperature regime in the summer months (AECOM and Stillwater Sciences 2022).

Water Rights

- **Disadvantage:** Alternative 1 (No Sediment Action) may result in a potential 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, and this water right was reduced to 2,179 AFY in 1995 (State Water Resources Control Board [SWRCB] Order WR 95-10), due to siltation in LPR. Therefore, it is possible that, as LPR continues to fill with sediment, the California SWRCB could reduce Cal-Am's current water right.

Regulatory

- **Disadvantage:** As LPR fills with sediment over time, the reduction in reservoir storage capacity would further limit Cal-Am's ability to release at least 5 cfs directly below LPD, as required by the SWRCB water rights permit. License 11866 requires release of 5 cfs at all times when water stored in the reservoir is adequate to maintain the release. 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.

- **Disadvantage:** As LPR fills with sediment over time, the reduction in reservoir storage capacity would eventually limit Cal-Am's ability to meet DSOD drawdown requirements via the low-level outlet works during an emergency. In addition, encroachment of sediment into the upper reservoir would also continue to reduce the capacity of the reservoir above the spillway crest, which may increase the water surface during the 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.

3.5 Uncertainties

The biggest uncertainty associated with Alternative 1 (No Sediment Action) is how quickly the remaining reservoir may fill with sediment, thereby impacting existing infrastructure, storage capacity, and potential summer releases. Although significant thought has been applied to understanding the change in reservoir capacity over time (AECOM 2018; CSUMB 2018) and developing average rates for sedimentation and storage loss, trends in hydrology and wildfire risk make it very difficult to accurately estimate when another large influx of sediment could significantly alter the remaining reservoir storage capacity.

Additional uncertainties associated with Alternative 1 (No Sediment Action) include the following:

- As part of their approval of the proposed fish passage improvements (HDR et al. 2021), DSOD may require that the PMF be updated to HMR 58/59 (see Section 2.7), which would require significant improvements at the dam and spillway.
- The compatibility of the proposed fish passage improvements (HDR et al. 2021) with ongoing sediment deposition should be confirmed.
- Once the reservoir fills and coarse sediment begins to pass over the spillway, it may result in additional deposition and increased flood risk downstream. Although it would be far into the future, mitigating flood risk in the lower Carmel River may eventually be a consideration, even without specific action to introduce bedload downstream of LPD.
- As discussed above, it is uncertain whether Cal-Am might lose a portion or all of their current water right at LPD as sediment continues to fill the reservoir. There is evidence that this has occurred in the past, but we are not aware of any recent discussions with the SWRCB on this topic.

4. Alternative 2 (Dam and Sediment Removal)

4.1 Overview

Alternative 2 (Dam and Sediment Removal) involves the removal of LPD, after excavation of sediments (Zones 1 and 2) that would cause degraded water quality impacts downstream if not removed prior to dam removal. To facilitate the demolition work, an upstream diversion structure and pipeline would be installed to allow for dewatering of the reservoir in the permitted in-water work window (approximately May 15 to October 15). A total of approximately 1,680,000 cubic yards (CY) of sediment from Zones 1 and 2 would be excavated, in the dry, for permanent placement in onsite Disposal Sites A, B, and C. Zone 3 sediment (approximately 350,000 CY) would be left in place for future transport downstream. After Zone 1 and 2 sediment removal, the full dam would be removed down to the original river channel elevation. Excavated material from the dam would be disposed of in onsite Disposal Sites A, B, and C.

Figure 13 shows an overview of Alternative 2 (Dam and Sediment Removal) activities for dam and sediment removal.

A similar concept presented in AECOM 2017b that is not included in the TM is a partial dam removal, which would have left a portion of the existing embankment and concrete spillway (outside of the river channel) in place. This concept did not move forward due to limited cost savings in comparison to a full dam removal and the disadvantage of leaving the concrete spillway in the river canyon. In addition, offsite disposal locations were considered for accumulated sediment disposal, but removed from further consideration given a lack of reasonable locations.

4.2 Access Improvements

Construction equipment access to the project from Carmel Valley Road would be via Tassajara Road to Cachagua Road to Nason Road, as shown on Figure 14. Based on local input, our understanding is that tractor-trailers pulling lowboys have mobilized D8 bulldozers along this route using the existing roads and bridges. Based on an initial assessment, the following improvements would potentially be required for large-scale equipment mobilization and construction material delivery to the project:

- Widen Tassajara Road and improve the shoulder just east of the intersection with Cachagua Road to accommodate construction traffic. The one-lane bridge on Tassajara Road also near the intersection of Cachagua Road would not require strength improvement.
- Widen Cachagua Road just west of the intersection with Tassajara Road to accommodate construction traffic.
- Strengthen Bridge #529 (a one-lane, load-restricted bridge on Cachagua Road) to handle construction equipment loads. Widen the curve west of Bridge #529 to 24 feet.
- Prune trees on Cachagua Road at Carmel Valley Road to improve sight distance.
- Erect a reduced speed limit sign north of Nason Road.

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).

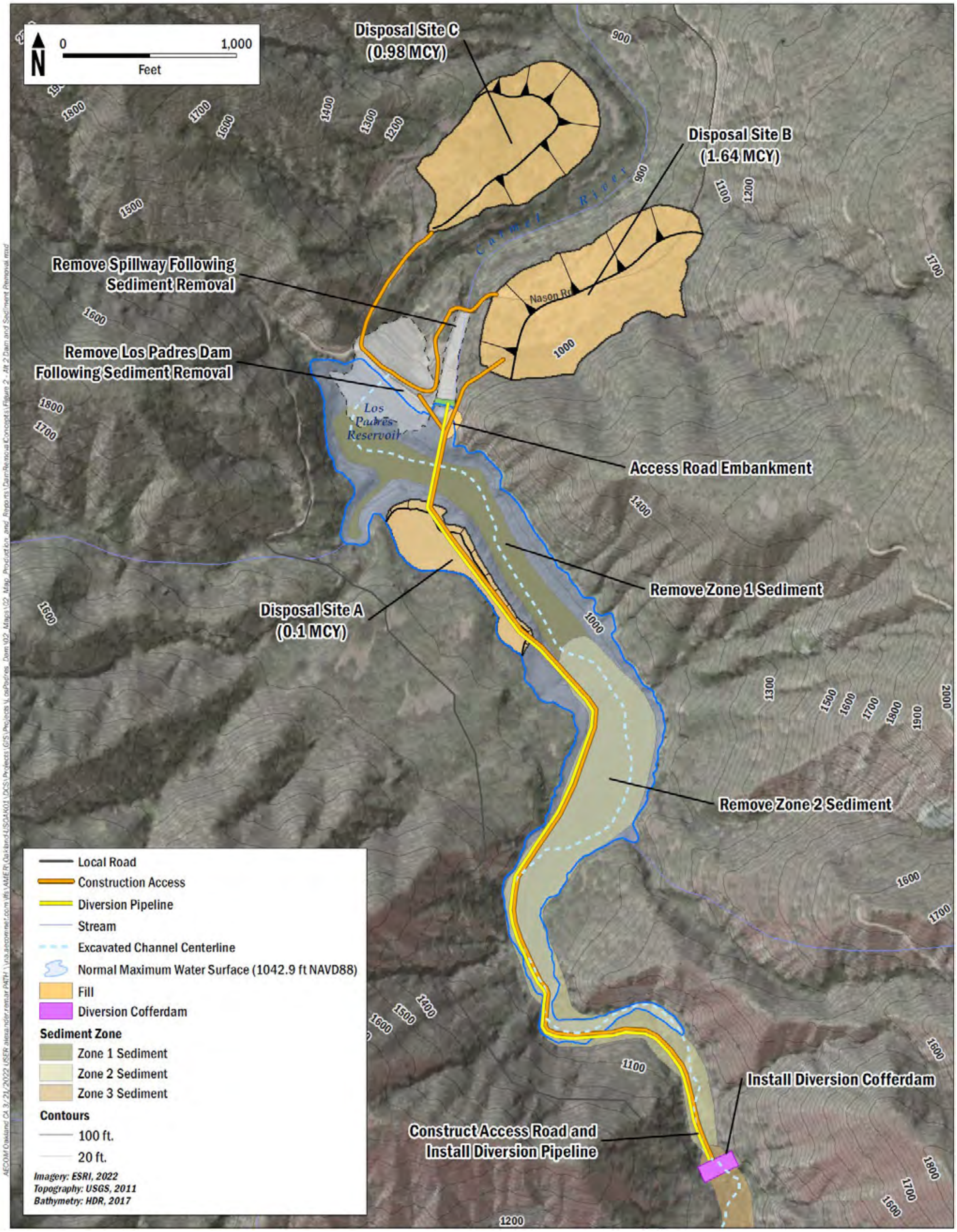


Figure 13 Alternative 2 (Dam and Sediment Removal)

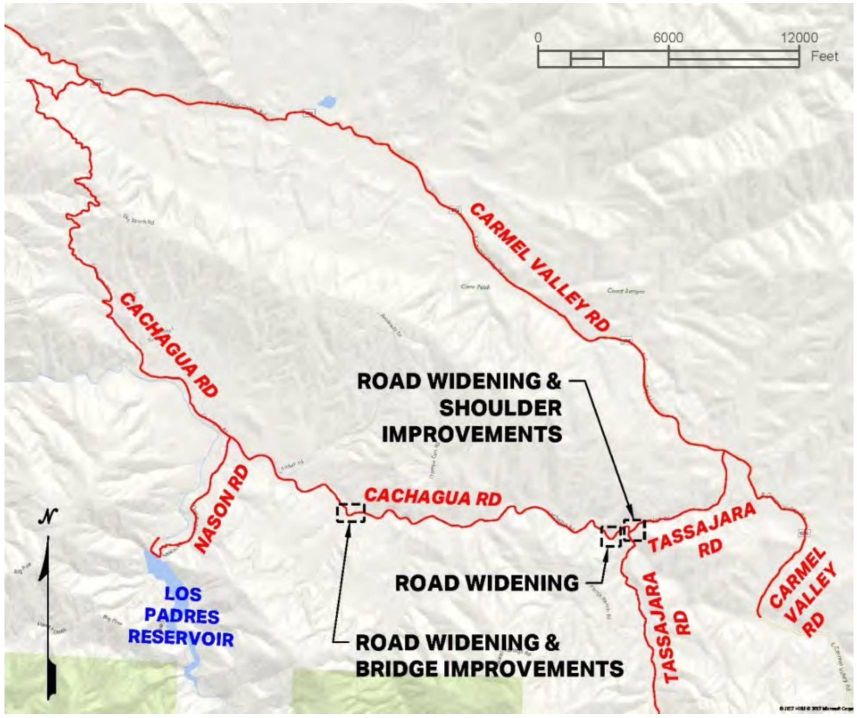


Figure 14 Location of Potential Public Road Improvements for Construction

Construction equipment access near the project site would require the following improvements, as depicted on Figure 13:

- **Disposal Site B Access:** Construct a new quarter-mile access road from the offloading area along the eastern dam embankment (east of the spillway) to Disposal Site B.
- **Reservoir Access:** Improve and widen the existing ramp between the dam crest and the reservoir.
- **Disposal Site C Access:** Widen the existing access road from the dam crest and extend it to Disposal Site C.
- **Spillway Bridge Access:** Replace the existing spillway bridge for construction vehicles.
- **Upstream Access** At the beginning of each season of construction and after dewatering, construct an approximately 1.25-mile, 24-foot access route to the upstream extent of the project area over accumulated reservoir sediments and terraces. See Appendix B, Sheet 10, for the proposed road alignment.

4.3 Sediment Removal

To avoid degraded water quality impacts downstream associated with the release of fine sediments (clay and silt), Alternative 2 (Dam and Sediment Removal) would require, at a minimum, removal of Zone 1 and 2 sediment prior to dam removal. The estimated 350,000 CY of sand and coarser materials in Zone 3 would be left in place to be transported through the reservoir area and downstream naturally following dam removal. The transition zone from sediment removal to remaining Zone 3 sediments may require some manipulation to provide adequate passage to the upstream river channel. In addition, it is likely that an adaptive management plan may be required to address temporary passage impediments that develop during the regulatory monitoring period in this area.

Sediment zone volumes for removal, disposal locations, and characterization for Alternative 2 (Dam and Sediment Removal) are summarized in Table 9.

Table 9 Alternative 2 (Dam and Sediment Removal) Estimated Sediment Removal and Placement

Area	Volume (AF)	Volume (CY)	Disposal Location	Characterization
Zone 1	340	550,000	Sites B and C	Clay/silt/fine sand
Zone 2	701	1,130,000	Sites B and C	Predominately silt and sand
Total Volume Removed	**1,041**	**1,680,000**		

Notes:

AF = acre-feet
CY = cubic yards

Characterization Source: AECOM 2018

Sediment removal upstream of LPD is severely constrained by access. Steep mountainous terrain with 2H:1V topographic slopes encompass the reservoir nearest the dam. Recent rockfall events in 2019 and 2020 eliminated the only vehicle access (“Jeep Trail”), which begins on the western dam abutment and travels southeast to the upstream reservoir reaches. Continued rockfall events are anticipated (Zinn Geology 2021); cutting a wide road across the lower slope could be expected to further destabilize upslope materials, possibly leading to more failures. For these reasons, access roads must be constructed if conventional excavation equipment (tracked or wheeled equipment) is to be used to remove accumulated sediments in the reservoir.

Because the production rate of conventional excavation equipment is nearly double that of a clamshell dredge on a barge, and 10 percent faster than a conventional excavator floating on a barge, Alternative 2 (Dam and Sediment Removal) assumes dry excavation (with Carmel River diversion and dewatering of the reservoir). Dry excavation is most appropriate for Alternative 2 (Dam and Sediment Removal) because the subsequent removal of the dam after sediment removal requires reservoir dewatering and temporary diversion as well. For comparison, Alternative 3 (Storage Expansion and Dredging) (Section 5.6) includes sediment removal with dredging equipment, so both reservoir sediment removal methods (dry and wet) are evaluated in this TM.

The following timeline summarizes the anticipated actions for Alternative 2 (Dam and Sediment Removal) during each construction year, with in-water construction work occurring from May 15 to October 15 of each year. Site mobilization and demobilization would occur just before and after the in-water work window to maximize sediment removal each construction season.

Construction Year 1

Prior to May 15:

- Begin drawdown of the reservoir using the restored low-level outlet with an inlet elevation of 981.8 feet (in accordance with the 60 percent design drawings [HDR 2022]), and the existing siphon. A discharge rating curve was not yet available for the low-level outlet, but it is assumed to controllably pass 30 to 70 cfs (AECOM 2017b). Using the lower discharge of 30 cfs and an average siphon discharge of 12 cfs (down to elevation 1,013 feet), the reservoir could be dewatered to elevation 981.8 feet in 3 weeks.
- Conduct fish capture and relocation (to be conducted during every dewatering event).
- Improve access roads as described in Section 4.2, with the exception of in-water access on the reservoir sediments.
- Clear and grub permanent sediment Disposal Sites B and C. Prepare the sites to receive material.
- Construct a temporary dewatering treatment system to process turbid water in the last stages of reservoir dewatering (see Figure 15). The treated water will need to meet discharge criteria prior to release into the Carmel River. The dewatering treatment system would be between Disposal Site B and the downstream end of the spillway. The system would consist of a lined treatment basin; turbine pump; pressurized sand filtration units with automatic backflush systems; flocculent injection pumps (to reduce turbidity); in-line influent and effluent flow and water quality meters; and a control unit.

Figure 15 Dewatering Treatment System and Basin, San Clemente Dam Removal, August 2015

Beginning May 15:

- Once the reservoir water level approaches elevation 980 feet, construct a displacement fill access road across the approximate 400 linear feet of soft reservoir sediments between the (pre-dam) natural terraces (approximate elevation 1,025 feet). The access road would cross from near the location of the pickup truck in Figure 16 to the opposite terrace (Appendix B, Sheet 10). For access road construction, use locally excavated material sourced from the treatment basin construction or Disposal Site B grading. Install culverts by trenching to encourage continued sediment draining to the reservoir bottom, or use the divided basins to enhance dewatering. Continue access road construction along the western reservoir terrace to the upstream extent (Station 62+00) of sediment removal, using fill and crane mats where necessary.
- Construct a temporary diversion system for the Carmel River around the construction site (see Figure 17).

Figure 16 Los Padres Dam Reservoir, Looking Southeast; Approximate Reservoir Elevation 1,014 feet NAVD88, November 5, 2013

Figure 17 San Clemente Dam Removal Upstream Diversion Structure and Diversion Pipe; Bottom Two Installation Photographs, October 2013; Top Operating Photograph, August 2015

- Install a temporary diversion structure near the upstream extent of work (Station 62+00), similar to that constructed during the San Clemente Dam Removal. The temporary structure would consist of a small earthen berm, driven steel sheet piles resting at grade, and a gated intake. If existing alluvial material prevents the use of sheetpiles, over-excavation or alternative cofferdam approaches will need to be considered. Every winter, the earthen berm would be excavated and stockpiled, and the gated intake removed. The sheet piles would remain in place, allowing winter flows to pass over the piles. The pre-dam alluvium is believed to reside approximately 20 to 30 feet below ground surface at this location, based on comparison of the adjusted 1947 pre-dam surface and 2017 UAS survey, and would be confirmed with geotechnical borings. The ground surface is approximately at elevation 1,050 feet, allowing for a potential 10-foot-tall dam crest to reside at an approximate elevation of 1,060 feet.

- Install a diversion pipe from the diversion structure (crest elevation 1,060 feet) to the LPD spillway (elevation 1,043 feet), approximately 6,200 feet long (1.2 miles). The available elevation difference is likely sufficient to pass a 97 percent flow exceedance level of mean daily discharges, similar to the downstream San Clemente Dam Removal Project, which installed a 66-inch corrugated metal pipe to accommodate a 230 cfs flow for a May 15 construction start. An average daily flow frequency analysis is recommended for LPD.

- The diversion pipe may be concrete-encased for rock fall protection; covered to limit water temperature increases if exposed to sunlight; and covered with sediment and secured with anchors to prevent floatation when inundated during winter months. The flow would be discharged to the spillway or into the downstream discharge pool with adequate erosion protection for summer diversions.

Construction Year 2

- Dewater the reservoir (1 month) and reroute river flows for the duration of in-water work.
  - As necessary in this year and the following construction years, install a system of wells, sumps, and trenches to support dewatering of the sediments. Dewatering the Zone 1 sediments will be difficult due to their low hydraulic conductivity and high moisture retention properties. A series of trenches will encourage water accumulation around dewatering sumps, allowing water to be pumped through the dewatering conveyance system. The dewatered fine-grained sediments will be moved and worked for moisture conditioning (discing or windrowing multiple times a day) at the disposal sites.
- Remove Zone 1 and 2 sediments (954,000 CY) (4 months).

Construction Year 3

- Dewater the reservoir (1 month) and reroute river flows for the duration of in-water work.
- Complete removal of Zone 1 and 2 sediments (726,000 CY) (3 months) (Figure 18).

Figure 18 Sediment Excavation of Lower Reservoir Sediments, San Clemente Dam Removal, July 2014

Construction Year 4

- Dewater the reservoir (1 month) and reroute river flows for the duration of in-water work.
- Remove the LPD embankment (460,000 CY) (1.5 months) and associated features such as the spillway and low-level outlet (a portion of which is to be protected in place). See Section 0 for a description of dam removal.
- Construct channel grade-control and habitat restoration features.
- Remove the diversion structure, diversion pipe, and dewatering and treatment system components.

Each year, site mobilization would include equipment and material delivery. Site demobilization each year would include diversion structure winterizing, disposal site hydroseeding, and best management practices. All heavy equipment will be moved off site at demobilization.

Although not included in Alternative 2 (Dam and Sediment Removal), Zone 3 sediments could be included in the sediment removal volume, assuming the upstream diversion structure is installed near Station 69+00 instead of Station 62+00 to allow for removal of the sediments up to this station. Moving the cofferdam upstream could increase the difficulty in using a sheetpile cofferdam, given the likely coarser substrate. There is a total of 350,000 CY of Zone 3 sediments, of which it is estimated that 200,000 CY could be removed during Construction Year 3 without impacting the schedule. The remaining 150,000 CY of Zone 3 sediments could be removed in Construction Year 4 while the LPD is removed.

The preceding sediment removal timeline is based on the following assumptions:

- Two 10-hour shifts per day, 7 days per week; production rates assume 1 day per week of downtime (e.g. maintenance, weather delays, or inefficiencies)
- 5-month construction season from May 15 to October 15
- 1-month dewatering each season from May 15 to June 15
- 4,500 CY/day per excavator; two excavators used
- An adequate number of trucks used to not cause delay time in loading and transporting
- An adequate number of dozers used at disposal sites to not cause delay time in grading or spreading material

4.4 Hauling and Sediment Disposal

Excavated material would be disposed of at the following three permanent disposal sites: Sites A, B, and C, as shown on Figure 13 and summarized in Table 10. Appendix B, Sheets 5 through 8, contain plan and cross section views of each proposed site. Prior to material placements, Disposal Sites B and C would be cleared of trees and vegetation and the topsoil stripped and stockpiled for reuse during site restoration. Site A resides on a terrace below the NMWS (where limited sediments have deposited), and therefore does not require clearing, grubbing, or significant sediment removal prior to use.

Table 10 Alternative 2 (Dam and Sediment Removal) Disposal Sites A, B, and C

Location	Storage Capacity Cumulative Volume (CY)	Acreage (acres)	Maximum Fill Height (feet)	Proposed Finished Elevation (feet NAVD88)
Site A	107,000	5.1	30	1,042.9
Site B	1,640,000	16.8	120	1,100
Site C	980,000	14.1	120	1,080

Notes:

CY = cubic yards
NAVD88 = North American Vertical Datum of 1988

Because Alternative 2 (Dam and Sediment Removal) includes reservoir dewatering, the excavated material will be relatively dry, with the exception of the fine-grained sediments. Zone 1 sediments will be moved and worked for moisture condition (discing or windrowing multiple times a day) at the disposal sites, but they will not delay the material acceptance rate of the disposal sites (the opposite is true in Alternative 3 [Storage Expansion and Dredging], where the disposal site capacity limits the rate of dredging).

Site A is a 5.1-acre site on a terrace on the western side of the reservoir (Figure 13, Appendix B, Sheet 6). Site A has a storage capacity of approximately 107,000 CY if filled to the NMWS elevation of 1,042.9 feet. The fill thickness in Site A would be about 30 feet. Because it would be inundated during the winter months, when the reservoir fills between construction seasons, Site A is only anticipated to be used for sediments from the dam embankment removal. Access to Site A would be along the dewatered reservoir sediments.

Sites B and C are downstream of the dam (Figure 13). Site B is a 16.8-acre site on a terrace on the eastern side of the canyon, and Site C is a 14.1-acre site on a terrace on the western side of the canyon (Appendix B, Sheet 7).

Access to Site B would be along a new access road constructed from the spillway terrace (at an approximate elevation of 1,025 feet), adjacent to the eastern abutment of LPD and the spillway, and down to Disposal Site B at a grade similar to that of the existing road on the embankment dam. This road is necessary because the existing narrow road on the dam crest has a sharp turn, insufficient for the 25- to 30-foot radius required for turning of articulated trucks (Figure 19). The new eastern access road would eliminate the need for significant modifications to the dam embankment to allow for a sufficient turning radius, or a longer truck route requiring additional trucking times compounded over numerous years of construction.

Figure 19 Articulated Dump Truck, CAT 730

Access to Site C would be from the dam along an access road on the downstream west abutment. The access road would be widened and improved.

The slopes of the permanent disposal sites are anticipated to be between 2H:1V and 3H:1V and would be protected from erosion by hydroseeding (Appendix B, Sheets 6 and 7). The steeper slopes might require zoning of the disposal sites, with the coarser materials from Zone 2 being placed on the outside of the disposal site and finer materials from Zone 1 and 2 on the inside of the disposal site. Intermediate benches may also be needed, depending on slope heights.

4.5 Dam Removal

Dam removal would be completed in a single 5-month construction period (between May 15 and October 15). Phased removal of the embankment dam over multiple years is not feasible because it is not possible to safely convey flood flows past the dam without an active spillway.

Removal of the 148-foot-high LPD would require excavation of about 460,000 CY of zoned embankment (DSOD 2015) for full removal, as shown conceptually in profile on Figure 20 and in plan and section on Sheets 1 and 2 in Appendix B. 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 were 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 B and C. The remaining embankment materials are sand, gravel, cobbles, and boulders that could be placed in Site A. The spillway would be removed in its entirety so as not to pose a health and safety risk to the public. Concrete debris generated during spillway demolition could be buried in the excavated materials at Sites B and C. The intake and outlet structures for the low-level outlet would be demolished, and the 30-inch-diameter outlet conduit would be 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.

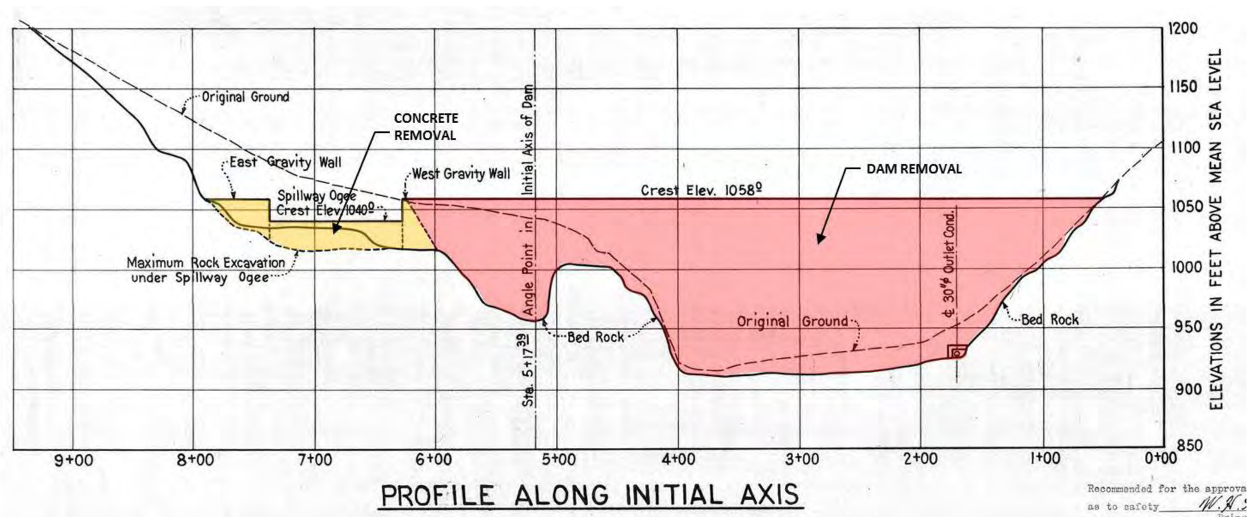


Figure 20 Alternative 2 (Dam and Sediment Removal) Full Dam Removal Profile (NGVD29)

4.6 Construction Cost

Costs associated with construction include the procurement of materials and the time, labor, and equipment required to install, erect, and construct each of the alternative components to the intended initial operational condition. Anticipated construction costs are included herein as Opinions of Probable Construction Costs (OPCCs); OPCCs express an opinion of costs, generated by the study engineers, based on information available at the time the TM was prepared.

The following assumptions were used as a common framework during OPCC development for each alternative:

- OPCCs are developed in conformance with AACE International Recommended Practice No. 18R-97, Class 5 Cost Opinions, with a range of accuracy based on 0- to 10-percent project definition and a +50 percent to -25 percent Range of Accuracy.

- Mobilization and general requirements are expressed as a percentage of the OPCC subtotal (10 percent each).
- Contractor general conditions, bonds, and overhead and profit are expressed as a percentage of the OPCC subtotal (10 percent, 3 percent, and 15 percent, respectively).
- State taxes are assumed to be 7.25 percent, as applied to material and equipment.
- Each OPCC includes a 50 percent contingency to account for undefined design and construction items.
- All OPCCs are presented in 2022 US dollars and are not escalated (unless otherwise noted for longer-term recurring activities).
- Individual cost items, details, and quantities for each concept alternative are developed using concept-level illustrations, details from OPCCs prepared for other like projects, RSMeans cost databases, and parametric comparison to other like facilities already constructed and in operation.

Table 11 summarizes the OPCC for Alternative 2 (Dam and Sediment Removal); a detailed breakdown is provided in Appendix C.

Table 11 Alternative 2 (Dam and Sediment Removal) OPCC Summary

Line Item #	Line Item	Description	Estimate
1	Mobilization/demobilization	Percentage of construction activities (10%)	$4,490,000
2	Site preparation	Clearing and grubbing, work pads, access improvements, new access through reservoir, dewatering and diversion	$5,820,000
3	Dam removal	Demolition of dam, spillway, and outlet works; hauling and placement of concrete and embankment materials in disposal	$9.660,000
4	Reservoir restoration	Restoration of former reservoir area with native vegetation	$7,270,000
5	Sediment removal	Sediment removal (1.7 million CY) in the dry, hauling and placement at disposal sites	$22,070,000
		Subtotal	**$49,310,000**
		General Conditions (10%)	$4,931,000
		Bond (3%)	$1,480,000
		General Contractor’s Overhead and Profit (15%)	$7,400,000
		Total Construction Cost	**$63,121,000**
		Contingency (50%)	$31,570,000
		Total with Contingency	**$94,700,000**
		Low Side of Class 5 Estimate Range (-30%)	$66,290,000
		High Side of Class 5 Estimate Range (+50%)	$142,050,000

Notes:

Line item totals are rounded up to the nearest thousand, and subsequent calculations are rounded to the nearest thousand.

CY = cubic yards

Approximately 58 percent of the cost for Alternative 2 (Dam and Sediment Removal) involves the removal and disposal of more than 1.68 million CY of accumulated reservoir sediment (including reservoir dewatering and diversion in the site preparation line item); the remaining 42 percent of costs are associated with dam removal and reservoir restoration. This calculation considers applicable portions of mobilization/demobilization and site preparation.

4.7 Operation and Maintenance

Although there would be some level of post-construction monitoring and reporting associated with regulatory permits (likely lasting up to 10 years), there would be no long-term operation and maintenance at the site. Post-construction activities associated with regulatory permits could involve maintenance activities related to fish passage, sediment stabilization, and habitat establishment.

4.8 Advantages and Disadvantages

Advantages and disadvantages associated with Alternative 2 (Dam and Sediment Removal) are discussed in the following paragraphs and summarized in Table 12. Both Table 12 and the bulleted advantages and disadvantages are organized by the following categories: Cost, Local Impacts, Water Supply, Flooding, Geomorphology, Biological, Water Rights, and Regulatory.

Cost

- **Advantage:** Alternative 2 (Dam and Sediment Removal) construction costs (approximately $95 million) are the second-lowest among the alternatives presented in this TM. Alternative 2 (Dam and Sediment Removal)'s relatively low construction cost is mostly attributed to the dam removal, which will eliminate the need for engineered fish passage (HDR et al. 2021). Alternative 2 (Dam and Sediment Removal) is the only alternative without long-term O&M costs.

Local Impacts (Traffic and Noise)

- **Disadvantage:** Equipment mobilization, material on-haul, and construction worker commuting traffic would be more disruptive to local traffic than under Alternatives 1 (No Sediment Action), 4 (Recover Storage Capacity with Excavation), and 5 (Recover Storage Capacity with Sluice Tunnel), due to the number of construction seasons, but less disruptive to local traffic than under Alternative 3 (Storage Expansion and Dredging) (which has significantly more material being brought on site). Sediment removal would operate 24 hours per day, 6 days per week onsite for three construction seasons (plus one preparation season of 12-hour days). Similar to all of the other alternatives, small improvements may be required along public roads (see Section 4.2) to accommodate construction traffic, which would cause additional disruption.

- **Advantage:** If Cal-Am prefers not to continue with ownership of the property surrounding LPD and LPR following dam removal, the adjacency of public land managed by the United States Forest Service and the Monterey Peninsula Regional Park District may favor conversion of the property 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.

Water Supply

- **Disadvantage:** Due to the loss of storage associated with LPR, Cal-Am would lose the ability to store water at this facility for any purpose, including in support of surface flow and pumping in the lower river.

Table 12 Alternative 2 (Dam and Sediment Removal) Advantage/Disadvantage Summary

Alternative No.	Alternative Name	Advantages/Disadvantages							
		Cost	Local Impacts	Water Supply	Flooding	Geomorphology	Biological	Water Rights	Regulatory
2	Dam and Sediment Removal	+ • $95 million is the second-lowest among alternatives; only alternative without long-term O&M costs	- • Second-highest impact, due to four construction seasons	- • Reservoir storage lost	- • Restores downstream deposition and increased flood risk	+ • Increase in suitable spawning gravel, channel complexity, and overbank habitat connectivity	+ • Fully volitional upstream and downstream passage for all life stages of steelhead • Increased steelhead habitat in former reservoir area • Restored natural thermal regime and access to temperature refugia - • No ability to release summer flows	- • May lead to loss of water rights	+ • Limited long-term regulatory involvement and oversight

Notes:

+ Advantage
- Disadvantage
O&M = operations and maintenance

Flooding

- **Disadvantage:** The return of the historic sediment load would increase deposition, and associated flood risk, throughout the downstream river relative to Alternatives 1 (No Sediment Action), 3 (Storage Expansion and Dredging), and 4 (Recover Storage Capacity with Excavation). However, deposition would be slightly less pronounced than under Alternative 5 (Recover Storage Capacity with Sluice Tunnel) because Alternative 2 (Dam and Sediment Removal) includes removal of sediment in Zones 1 and 2 prior to dam removal, while Alternative 5 (Recover Storage Capacity with Sluice Tunnel) flushes material from Zones 1 and 2 downstream (Balance Hydrologics and UBC 2019).

Geomorphology

- **Advantage:** Restoring natural sediment transport under Alternative 2 (Dam and Sediment Removal) would result in an overall increase in the amount of suitable spawning gravel downstream of LPD when compared with Alternatives 1 (No Sediment Action), 3 (Storage Expansion and Dredging), 4 (Recover Storage Capacity with Excavation), and 5 (Recover Storage Capacity with Sluice Tunnel). Although increases of spawning gravel have not been seen as a result of the removal of San Clemente Dam, Smith et al. (2021) suggested that this was likely due to the trapping capacity of LPD. Alternative 2 (Dam and Sediment Removal) would also have impacts to steelhead habitat, resulting from increased bedload movement from upstream of LPD in the short term, including the loss of pool habitat due to bedload deposition. However, this effect would be short-lived; in the long term, Alternative 2 (Dam and Sediment Removal) would increase channel complexity and limited overbank habitat connectivity, resulting in an increase in stream habitats that support steelhead fry and juvenile rearing (AECOM and Stillwater Sciences 2022).

Biological

- **Advantage:** Alternative 2 (Dam and Sediment Removal) provides for the safest and most efficient steelhead upstream and downstream passage, providing fully volitional upstream and downstream passage for all life stages of steelhead. Adult upstream migration would be unimpeded by LPD and could result in the passage of more adult fish to the upper watershed when compared to Alternatives 1 (No Sediment Action), 3 (Storage Expansion and Dredging), 4 (Recover Storage Capacity with Excavation), and 5 (Recover Storage Capacity with Sluice Tunnel). Additionally, juvenile steelhead mortality currently presumed to occur under existing conditions in LPR would be significantly reduced after the removal of LPD. Juvenile downstream migrants would experience less predation and mortality than under the other project alternatives, resulting in a potential increase in smolt production in the Carmel River, which would better support an anadromous life history (AECOM and Stillwater Sciences 2022).

- **Advantage:** Alternative 2 (Dam and Sediment Removal) would increase the amount of habitat for juvenile steelhead and resident *O. mykiss* rearing in the Carmel River through the restoration of approximately 1 mile of stream habitat in the former LPR reach. Additionally, juvenile steelhead and resident *O. mykiss* rearing downstream of LPD would be provided year-round access to the upper watershed, which currently provides suitable rearing habitat and optimal temperatures for rearing steelhead throughout the year (AECOM and Stillwater Sciences 2022).

- **Advantage:** Alternative 2 (Dam and Sediment Removal) would restore a natural thermal regime to the Carmel River downstream of LPD (AECOM and Stillwater Sciences 2022).

- **Disadvantage:** Due to the loss of storage associated with LPR, Cal-Am would lose the ability to store water at this facility for any purpose, including summer releases to enhance rearing habitat and passage. This would result in a substantial decrease in flows capable of providing adequate rearing habitat for steelhead—and a substantial reduction in wetted stream, especially during dry years (AECOM and Stillwater Sciences 2022).

Water Rights

- **Disadvantage:** Alternative 2 (Dam and Sediment Removal) may 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 current 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—could also be terminated. Discussions with the SWRCB should be conducted to investigate the possibility of modifying the referenced agreements to maintain some level of the current water rights.

Regulatory

- **Advantage:** Current regulatory requirements associated with the dam would be renegotiated during the permitting process. Long-term regulatory involvement and oversight would be limited to post-construction monitoring and reporting, likely extending up to 10 years following construction.

4.9 Uncertainties

Key uncertainties associated with Alternative 2 (Dam and Sediment Removal) include the following:

- It is uncertain whether regulatory agencies may consider allowing accumulated sediment flushing to the downstream river channel (and associated impact to downstream aquatic resources [AECOM and Stillwater Sciences 2022]). If it is determined to be acceptable by the regulatory agencies that some portion of the accumulated sediment can be flushed downstream during one or more storm events, the sediment removal effort and cost could potentially be decreased, thereby reducing the relative cost of this alternative.

- Based on ongoing planning and design processes for other dam removal projects in California, mitigation for the potentially increased flood risk due to increased transport of bedload to the lower Carmel River could be required as part of the environmental compliance or regulatory approval process for dam removal.

- It is uncertain whether current water rights agreements can be renegotiated as part of dam removal. Discussion with SWRCB is necessary to address this uncertainty and understand the process and timing of negotiations.

- Currently, Cal-Am is required by SWRCB Order 95-10 to divert flow under all of its Carmel River water rights at the wells farthest downstream. When Order 95-10 is lifted, it is unknown how SWRCB will interpret Cal-Am's future water rights, what conditions might be placed on future rediversions of releases from storage, and what effect this will have on the water supply for the Monterey Peninsula.

- Conceptual or planning-level alternatives are uncertain by nature, given the typical lack of sufficient design parameters and analysis available during the planning phase. Although this TM strives to address key uncertainties related to feasibility and cost, additional investigation, analysis, and design are needed to adequately address the uncertainty. Design and construction uncertainties are addressed to some extent in the OPCC estimates provided herein, through the use of design and construction contingencies (see Section 4.6). Key assessments or investigations to help address uncertainties related to design and construction of this alternative are listed below:

  – To confirm the approach provided herein, a detailed assessment must be completed of the public road improvements that may be required to accommodate construction traffic.

  – An assessment of potential passage issues at the transition zone between the proposed sediment removal and the remaining Zone 3 sediments is needed to reduce uncertainties associated with passage to the upstream river channel. An adaptive management plan will likely be needed to address temporary passage impediments that may develop during the regulatory monitoring period in this area.

- Additional onsite geologic assessment and geotechnical investigation may be required during detailed design to confirm the extent of improvements required for the temporary onsite access roads proposed for sediment access and hauling.
- Additional onsite geotechnical investigation will be required during detailed design to confirm the feasibility of using a sheetpile cofferdam for river diversion.
- Additional assessment of likely dewatering requirements, given the local geology and groundwater, should be completed during detailed design.
- This TM assumes a fairly proactive restoration, involving hydroseeding and planting for a variety of habitat types, along with associated irrigation. This approach should be discussed with appropriate regulatory agencies to see if a less proactive approach may be permittable.

5. Alternative 3 (Storage Expansion and Dredging)

5.1 Overview

Under Alternative 3 (Storage Expansion and Dredging), storage capacity of LPR would be increased through a combination of the following:

1. The existing spillway would be modified by installing pneumatically actuated gates (also referred to as rubber bladder gates) on the existing spillway crest.
2. An associated embankment dam raise would be performed to accommodate the updated HMR 58/59 PMF, with gates in the lowered position.
3. Removal of the majority of Zones 1 and 2 sediments, and partial removal of Zone 3 sediments, would be performed through wet dredging methods, allowing water to remain in the reservoir during sediment removal. Dredged clays, silts, and sands would be disposed of at Sites B and C; coarser material would be disposed of at Sites D and E, where it would be eroded over time and reenter the river system.

Once construction is complete, the proposed spillway gates could be raised toward 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.

Figure 21 shows an overview of Alternative 3 (Storage Expansion and Dredging) activities for installing the rubber bladder gates, raising the embankment dam, and removing the accessible sediment. Access to the accumulated sediment for removal would be via barge.

In addition to actions described in this TM, because the dam would remain in place, the fish passage improvements (HDR et al. 2021) discussed for Alternative 1 (No Sediment Action) would also be implemented for Alternative 3 (Storage Expansion and Dredging). However, the fish passage improvements were developed based on existing conditions and infrastructure. The dam, spillway, and infrastructure improvements, in addition to the associated operational changes, outlined in this section for Alternative 3 (Storage Expansion and Dredging) may require changes in the fish passage improvement alternatives and associated costs.

Other concepts to expand the reservoir storage at LPD presented in AECOM 2017b, but not included in this TM, include a dam and spillway raise (without spillway gates), a new dam downstream of the existing dam, and a combination of a new dam with either an existing dam raise or the addition of spillway gates. These concepts were removed from further consideration based on input received during TRC Meeting 2A, and in the TRC's written comments on the Draft Alternatives Descriptions TM, related to high impact and cost compared to other concepts. It was also noted that the stand-alone dam and spillway raise concept lacked flexibility compared to the spillway gate concept.

5.2 Access Improvements

All access improvements described in Section 4.2 for Alternative 2 (Dam and Sediment Removal), apply to Alternative 3 (Storage Expansion and Dredging), with the exception of the access road on the reservoir sediments to the upstream extent of the project area. Alternative 3 (Storage Expansion and Dredging) assumes that the reservoir will retain water during sediment removal, and the sediment will be accessed via barge. Development of an offloading area would use the existing terrace on the reservoir side of the spillway crest. Some grading and added base material may be required.

In addition, temporary access for sediment disposal at Sites D and E is proposed in the existing river floodplain for initial site clearing, grubbing, and grading to increase the flooding frequency and coarse sediment mobilization from these sites. Ideally, this temporary access would stay outside of critical habitat areas and would require limited grading or temporary gravel base. If the habitat impact of the temporary access roads outweighs the benefits of sediment mobilized from Sites D and E, material may alternatively be pushed off Nason road down toward the sites to mimic a natural debris slide, with the understanding that less frequent mobilizations may occur without initial grading.

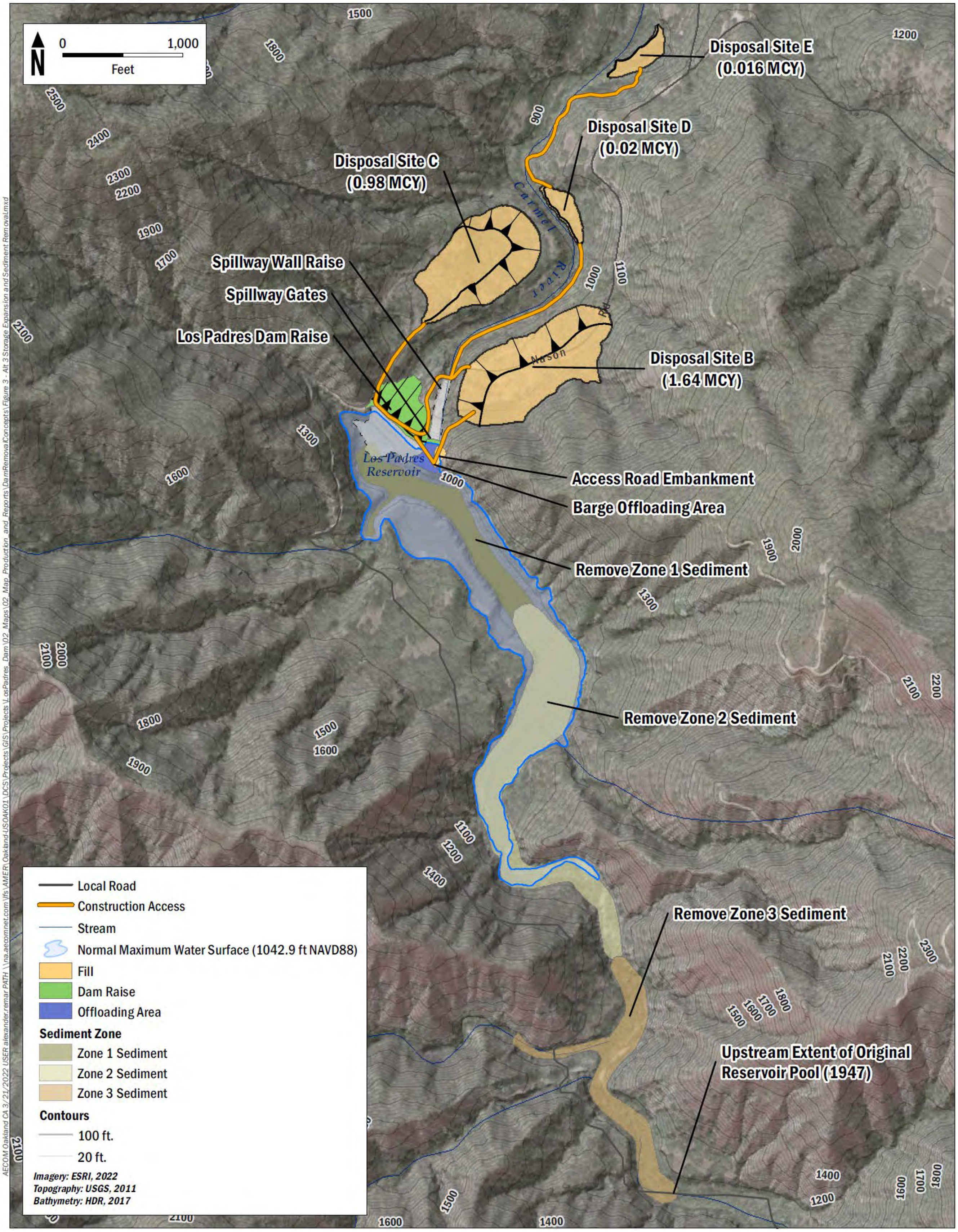


Figure 21 Alternative 3 (Storage Expansion and Dredging)

5.3 Spillway Modifications

Pneumatically actuated spillway gates would be installed on the spillway crest to raise the normal maximum reservoir water surface (NMWS) elevation by 9.6 feet, to elevation 1,052.5 feet. This would increase the maximum storage capacity of the reservoir by 625 AF, from 1,601 AF to 2,226 AF. Additional storage capacity could be provided via sediment removal, as discussed in Section 5.6. The gates would be raised in the spring when the inflow would still be adequate to allow downstream release concurrent with an increase in storage. The gates would be left up throughout the dry season, and lowered prior to any significant storm event. Views of an example pneumatically actuated spillway gate structure installed in the Nacimiento Dam concrete spillway are shown on Figure 22, Figure 23, and Figure 24. Installation of the gate structure would require modification of the existing concrete spillway to provide a flat concrete base on which to install the gates, and to maintain spillway capacity when the gates are lowered.

Figure 22 Pneumatically Actuated Spillway Gate at Nacimiento Dam (Construction – from Upstream Reservoir Side)

Figure 23 Pneumatically Actuated Spillway Gate at Nacimiento Dam (Construction – from Downstream Spillway Side)

Figure 24 Pneumatically Actuated Spillway Gate at Nacimiento Dam (Gates Down – Post-Construction)

To accommodate the proposed 9.6-foot-high spillway gate at LPD, a portion of the concrete ogee spillway crest would be removed and then reconstructed to provide a flat concrete base (see Figure 25 and Sheet 4 in Appendix B). Due to the dimensions of the gate panels, the spillway crest would also be extended approximately 12 feet into the reservoir. Similar to the existing spillway crest, the extended crest would be founded on bedrock. Care must be taken in the next phase of design to ensure that the overall width of the spillway crest does not change the spillway discharge coefficient (e.g., going from an ogee spillway to a broad-crested weir).

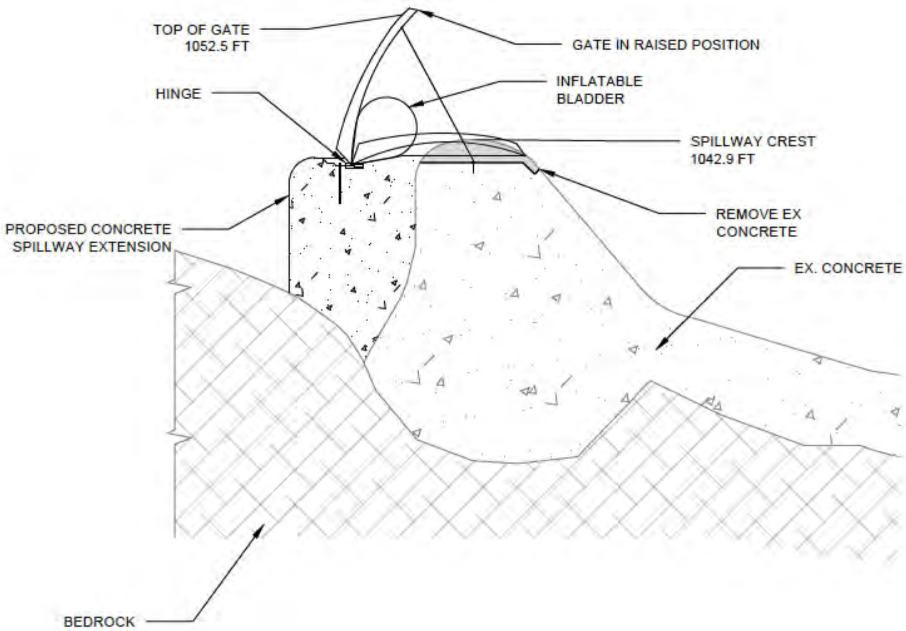


Figure 25 Spillway Modification Schematic

In addition, the spillway walls throughout the length of the spillway chute would be raised to accommodate the higher PMF from HMR 58/59 (Appendix B, Sheet 3).

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 detailed 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 met under those conditions. The seepage analyses, stability analyses, and seismic deformation analyses are discussed in more detail in Section 5.11. It is possible that these 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 and flattening the upstream slope) for Alternative 3 (Storage Expansion and Dredging) to be approved by DSOD.

5.4 Dam Embankment Raise

The spillway modification may be significant enough that DSOD would require the PMF to be reevaluated using HMR 58/59, similar to what is described in Section 2.7. Based on the analyses summarized in Section 2.7, the updated PMF using HMR 58/59 is estimated at 66,443 cfs; the current HMR 36 PMF is 31,579 cfs (DSOD 2015).

Based on an extrapolation of the current spillway rating curve, the HMR 58/59 PMF flood level would be about elevation 1,074.1 feet, 31.2 feet above the current spillway crest maximum elevation of 1,042.9 feet. Therefore, the raised dam crest would need to be elevation 1,042.9 feet plus 31.2 feet plus an assumed 1.5 feet of freeboard for wind-wave runup, which adds up to 1,075.6; a dam raise of approximately 14.7 feet. For the purposes of this TM, it is assumed that the design PMF would be that developed using HMR 58/59, and that the dam raise would be rounded up to 15 feet. 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 spillway rating curve would stay the same as the existing curve.

In the absence of any new geologic and geotechnical data related to dam stability, or any new analyses related to seismicity and related stability, the proposed top width of the raised dam is conceptually shown as widened to 50 feet, to reduce the risk of overall dam failure should the upstream dam face fail under seismic loading. A concept section of the dam raise is shown on Figure 26, and the plan view grading and conceptual cross section are shown on Sheets 1 and 2 in Appendix B.

The spillway walls at the crest would be raised to match the raised embankment crest. In addition, it was determined through HEC-RAS modeling that the spillway chute walls would need to be raised along the entire length of the spillway, as shown on Sheet 3 in Appendix B, to accommodate the higher PMF from HMR 58/59.

For this conceptual design, it is assumed that 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 the Zone 1 embankment material. The top approximately 40 feet of the dam would be removed to facilitate internal zoning of the top of the dam raise, also requiring temporary lowering of the reservoir water surface elevation. The dam raise would include extension of the downstream blanket; a chimney filter between Zone dam 1 (likely silty sand [SM] to sandy silt [ML]) and the material used for the dam raise; and extension of dam Zones 1, 2, and 3 at the top of the dam raise, as shown on Figure 26 and on Sheets 1 and 2 in Appendix B. The chimney provides protection against uncontrolled piping and erosion of Zone 1, which could occur through cracks that could form during seismic deformation.

Dam 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). Potential sources of dam 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.

5.5 Outlet Works

The current outlet works are described in Section 2.2, as is the proposed design to extend the low-level outlet.

The outlet structure for the low-level outlet is far enough downstream that it would not be affected by raising the dam; however, the concrete encasement may need to be extended. The proposed upstream low-level outlet intake, extension, 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, the intake’s ability to temporarily operate under the additional 9.6 feet of head associated with the raised NMWS would need to be confirmed, in addition to the ability to drain the expanded reservoir to meet DSOD standards.

Other outlet works such as the high-level outlet, siphon, and behavioral guidance system (BGS)/FWC will need to be evaluated to confirm their ability to operate under the additional 9.6 feet of head associated with the raised NMWS in the spring and summer months.

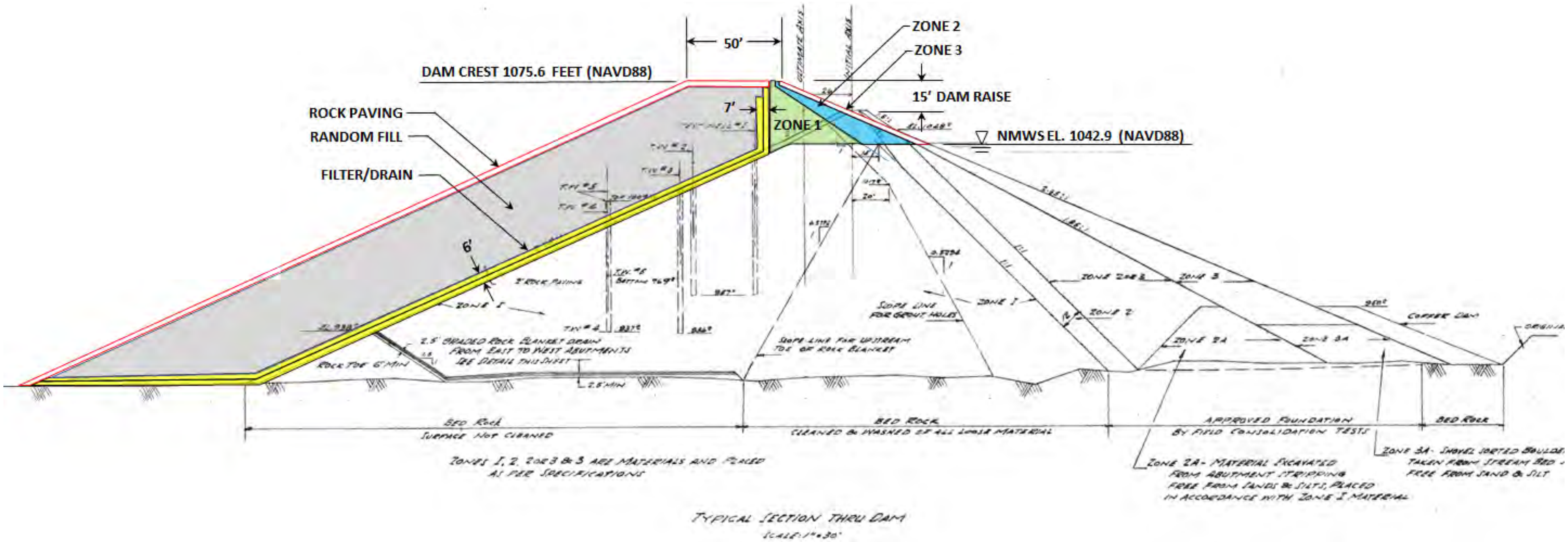


Figure 26 Dam Raise Schematic

5.6 Sediment Removal

This alternative includes the removal of accumulated sediments with dredging methods while the reservoir remains partially full. A barge-mounted hydraulic excavator or clamshell bucket dredge would excavate the material and deposit it into a secondary materials transport barge. The barges would be transported via work boat to the offloading area adjacent to the LPD spillway. There, a secondary land-based excavator would offload the barges onto articulating dump trucks that would haul the finer material to the downstream Disposal Sites B and C for conditioning and drying prior to permanent grading. Coarser-grained material would be hauled directly and placed at Disposal Sites D and E for mobilization downstream during large-flow events.

All access to the sediments and sediment removal would be achieved through the use of floating equipment because road access is infeasible on the adjoining steep mountainous terrain due to recent landslides (see discussion in Section 4.3). Sediment zone volumes, disposal locations, and characterizations for Alternative 3 (Storage Expansion and Dredging) are summarized in Table 13.

Table 13 Alternative 3 (Storage Expansion and Dredging) Estimated Sediment Removal and Placement

Area	Volume (AF)	Volume (CY)	Disposal Location	Characterization
Zone 1	340	550,000	Site B and C	Organics, clay/silt/fine sand
Zone 2	701	1,130,000	Site B and C	Predominately silt and sand
Zone 3 (Below NMWS)	72*	115,700*	Site B, C, D and E	Sand and coarser materials
Zone 3 (Above NMWS)	55**	89,300**	Site B, C, D and E	
Total Volume Removed	**1,168**	**1,885,000**		

Notes:

* Approximately 7 AF (11,400 CY) would not be feasible to excavate due to shallow drafts for floating equipment.
** Approximately 83 AF (133,600 CY) would not be feasible to excavate due to shallow drafts for floating equipment.

AF = acre-feet
CY = cubic yards
NAVD88 = North American Vertical Datum of 1988
NMWS = normal maximum water surface (at spillway crest maximum elevation of 1,042.9 feet NAVD88)

Characterization Source: AECOM 2018

As described in the timelines below, the reservoir water level would be drawn down to elevation 1,025 feet to access the offloading area. Roughly based on historical reservoir levels (Figure 2) (which include prescribed releases, evaporation, and inflows), the water surface is anticipated to drop approximately 5 feet per month, resulting in an elevation of 1,000 feet by October 15.

Figure 27 summarizes which equipment would remove the sediments based on station. Over the course of multiple construction years, it is anticipated that a conventional excavator on a flexi-float barge will be able to excavate all of Zone 2, the majority of Zone 3, and about 30 percent of Zone 1 sediments above elevation 980 feet (because the excavator has a working depth of 20 feet below the lowest water surface elevation of elevation 1,000 feet). Sediments between elevation 980 feet and the original grade of elevation 920 feet would be removed with a barge-mounted clamshell dredge.

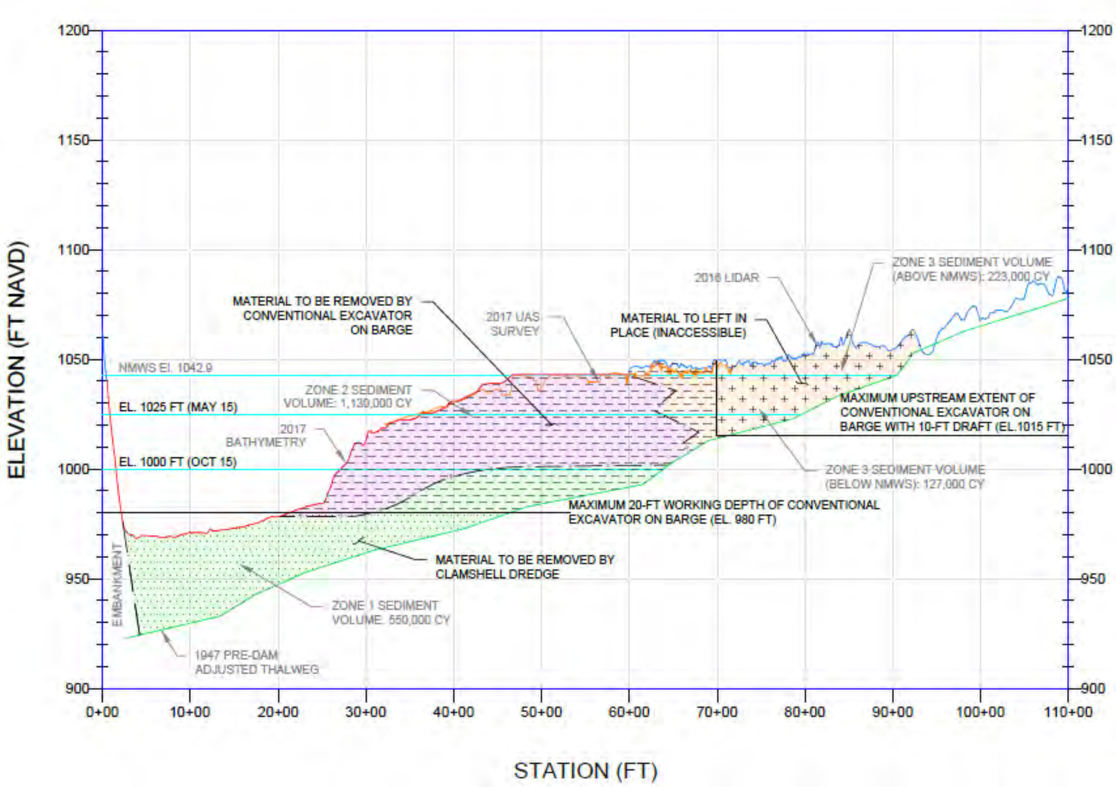


Figure 27 Material Dredging by Equipment Type and Water Level

The barge-mounted excavator would dig its access into the upstream Zone 2 sediments, sequenced over multiple years to safely remove the material that will slough and fall into the working zone of the excavator as it progresses upstream. Near Station 80+00, the maximum water level (elevation 1,025 feet) intersects the original streambed profile. Excavation would cease at that point, leaving approximately 17 percent of the Zone 3 sediments (60,000 CY) upstream of Station 80+00, including all of the sediment accumulated at the mouth of Danish Creek.

The following timeline summarizes the anticipated sediment removal actions for Alternative 3 (Storage Expansion and Dredging) during each construction year, with in-channel construction work occurring from May 15 to October 15 of each year. Site mobilization and demobilization would occur just before and after the permitted in-water work window to allow for maximum sediment removal each construction season.

Construction Year 1:

Prior to May 15:

- Improve access roads as described in Section 5.2.
- Clear and grub permanent sediment Disposal Sites B and C. Prepare the sites to receive material.
- Draw down the reservoir to elevation 1,025 feet to expose the offloading area on the natural terrace. Release of approximately 832 AF would take approximately 10 days, assuming minimum discharges from the restored low-level outlet (30 cfs) and siphon (avg. 12 cfs), as described in Section 4.3.

Beginning May 15:

- Create an approximately 20,000-square-foot offloading area adjacent to the spillway on the natural terrace near elevation 1,025 feet. Maintain the reservoir water level at elevation 1,025 feet, if possible, to offload material most efficiently from barges. Construct a lower shelf from which to offload as continued summer discharges lower the reservoir water surface elevation.

- Assemble the flexi-floats and excavator on the barge to begin sediment removal.
- Remove Zone 2 and 3 sediments (540,000 CY) by barge-mounted excavator (5 months).
- Construct in-channel access routes to floodplain Disposal Sites D and E. Clear and grub and prepare sites to receive material.

Construction Year 2:

- Assemble the flexi-floats and excavator on the barge to begin sediment removal. Lower the reservoir to elevation 1,025 feet and recreate the offloading area as necessary.
- Remove Zone 2 and 3 sediments (540,000 CY) by barge-mounted excavator (5 months).

Construction Year 3:

- Assemble the flexi-floats and excavator on the barge to begin sediment removal. Lower the reservoir to elevation 1,025 feet and recreate the offloading area as necessary.
- Complete removal of Zone 1, 2, and 3 sediments (370,000 CY) by barge-mounted excavator (3 months).
- Disassemble and reconfigure the flexi-floats for the clamshell dredge (0.5 months).
- Remove Zone 1 and 2 sediments (122,000 CY) by clamshell dredge (1.5 months).

Construction Year 4:

- Assemble the flexi-floats and clamshell dredge to begin sediment removal. Lower the reservoir to elevation 1,025 feet and recreate the offloading area as necessary.
- Complete removal of Zone 1 and 2 sediments (313,000 CY) by clamshell dredge (4 months).

The speed of sediment removal depends on the water depth in which the sediments reside and the capacity of the disposal sites to allow sufficient material drying time (discussed in Section 5.7). Table 14 summarizes the working depths and daily production rates for a traditional excavator, such as a CAT 336, mounted on a barge (Figure 28) and clamshell dredge (Figure 29) for use in Alternative 3 (Storage Expansion and Dredging). A clamshell dredge and traditional excavator mounted on a barge could use a bucket larger (3 CY) than that of a long-reach excavator (likely limited to 1 CY). Because the long-reach excavator would therefore have a lower production rate, it was subsequently eliminated from consideration.

Table 14 Equipment Capabilities

Equipment	Daily Production (CY/day)	Working Depth (feet)
Conventional excavator on barge (Alternative 3 [Storage Expansion and Dredging])	4,050	≤ 20
Clamshell dredge (Alternative 3 [Storage Expansion and Dredging])	2,600	> 50
For Comparison:		
Dry excavation (Alternative 2 [Dam and Sediment Removal)])	4,500	N/A
Long-reach excavator on barge (not used)	1,350	≤ 50

Notes:

CY = cubic yards

Figure 28 Conventional Excavator on Flexi-Float Barge

Figure 29 Clamshell Bucket Dredging

The daily production rates listed in Table 14, as well as the overall sediment removal timeline, are based on the following assumptions:

- Two 12-hour shifts per day: 7 days per week (production rates assume 1 day per week of downtime (e.g., maintenance, weather delays, and inefficiencies)body
- 5-month construction season from May 15 to October 15
- Equipment (not used concurrently due to disposal site limitations):
  - 4,050 CY/day per conventional excavator on a barge
  - 2,600 CY/day per clamshell dredge
- Adequate number of material barges, work boats, offloading excavator, and trucks used to not cause delay time in loading and transporting
- Adequate number of dozers used at disposal sites to not cause delay time in grading or spreading material
- Contractor manages excavation around reservoir stage to optimize removal limitations of each dredge in the zoned sediments

5.7 Hauling and Sediment Disposal

Excavated material would be hauled by articulated trucks and disposed of at the permanent Disposal Sites B, C, D, and E, as shown on Figure 21 and summarized in Table 15. Appendix B, Sheets 5 through 8, contain plan and profile views of each proposed site. Refer to Section 4.4 for descriptions of Sites B and C. All of the material excavated for this alternative could be disposed of at Sites B and C, with the option of placing coarser material at Sites D and E for subsequent erosion during large flow events.

Table 15 Alternative 3 (Storage Expansion and Dredging) Disposal Sites A, B, C, D, and E

Location	Storage Capacity Cumulative Volume (CY)	Acreage (acres)	Maximum Fill Height (feet)	Proposed Finished Elevation (feet NAVD88)
Site B	1,640,000	16.8	120	1,100
Site C	980,000	14.1	120	1,080
Site D	20,000	1.8	20	905
Site E	16,000	1.8	15	870

Notes:

CY = cubic yards
NAVD88 = North American Vertical Datum of 1988

5.7.1 Disposal Site B and C Coverage Time Constraints

A land-based excavator will offload the material from the barge onto trucks for hauling to Sites B and C, where the material will require conditioning and drying prior to permanent grading. Zone 1 sediments will require the longest time to dry due to their low hydraulic conductivity and high moisture retention properties. These fine-grained sediments will be moved and worked for moisture conditioning (discing or windrowing multiple times a day) as they dry.

All materials would be dried to a water content no more than 5 to 10 percent above the optimum water content (in accordance with ASTM D1557) prior to placement of the next lift of material. Based on the anticipated material gradations, water content, and weather during construction, drying times could vary from 5 to 7 days for Zone 1 and 2, and from 3 to 5 days for Zone 3. Overall, a drying time of 5 to 7 days is targeted at this stage of design.

Disposal Sites B and C are on hillslopes. When constructed with side slopes between 2H:1V and 3H:1V with fill heights of 120 feet, the effective area (i.e., footprint available to receive material at one time) ranges between 25 percent and 55 percent of the total acreage covered. Table 16 summarizes the effective areas of Sites B and C when broken into three 40-foot incremental fill heights. Dividing the effective area by the anticipated daily fill area for each dredge scenario (conventional excavator, clamshell, or both) results in the number of days the effective area will be covered with a drying 2-foot lift (i.e., coverage time). As described above, a coverage/drying time of at least 5 to 7 days is recommended at this stage of design.

Table 16 Disposal Site B and C Coverage Times

Site	Fill Height (feet)	Incremental Volume (CY)	Effective Area (square feet)	Excavator Coverage Time (days)	Clamshell Coverage Time (days)	Excavator and Clamshell Coverage Time (days)
B	40	460,000	310,500	5.7 + 2.5 = 8.2	8.8 + 3.8 = 12.6	3.5 + 1.5 = 5
C	40	200,000	135,000			
B	80	600,000	405,000	7.4 + 4.4 = 11.8	11.5 + 6.9 = 18.4	4.5 + 2.7 = 7.2
C	80	360,000	243,000			
B	120	580,000	391,500	7.2 + 5.2 = 12.4	11.2 + 8.1 = 19.3	4.4 + 3.2 = 7.6
C	120	420,000	283,500			

Notes:

Excavator Coverage Time assumes an excavator daily fill of 54,675 square feet for a 2-foot lift.
Clamshell Coverage Time assumes a clamshell daily fill of 35,100 square feet for a 2-foot lift.
Excavator and Clamshell Coverage Time assumes a daily fill of 89,775 square feet for a 2-foot lift.
Green = beyond 5 to 7-day design coverage time
Grey = near 5 to 7-day design coverage time
CY = cubic yards

Table 16 shows the time estimated to dry sediment for placement in 2-foot lifts at Disposal Sites B and C, at three potential fill heights and with various equipment. The equations in the time columns represent the sum of the time required to dry one lift of sediment at Site B plus the time required to dry one lift of sediment at Site C, using a single type or both types of equipment. As shown in Table 16, Sites B and C combined have sufficient capacity for one conventional excavator on a barge to work continuously with 8 to 12 days of coverage time, and one clamshell with 13 to 19 days of coverage time. When both these dredges are operated simultaneously, however, the coverage time approaches the limit of 5 to 7 days. An added level of operational complexity and potentially costly shutdowns arise when two dredges are excavating different material types for disposal at two different sites (with constrained access). For these reasons, Alternative 3 (Storage Expansion and Dredging) assumes that only one dredge (conventional excavator or clamshell) would be in operation at any given time.

A drying time test and correlated strength testing should be performed at later stages of design to better define coverage times and reduce the risk of construction delays. Strength testing would also be used in stability analyses of the disposal sites to confirm the proposed slopes and allowable water content of the materials.

5.7.2 Disposal Sites D and E

Disposal Sites D and E are downstream of LPD, at elevations where coarse-grained sediment (Zone 3) could be accessed and mobilized during large-flow events. 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. Preliminary analysis of these disposal sites indicates that

10-year to 20-year flood flows could mobilize sediments placed at Sites D and E (AECOM 2017b), thereby introducing coarser sediment back into the downstream river system. Some grading and removal of the existing armor of boulders would make more of the areas accessible to storm flows, possibly allowing 5-year flood flows to access the area.

Both Disposal Sites D and E would be cleared of trees prior to use. Sites D and E would be accessed on a new road constructed in the river floodplain due to steep slopes between the sites and Nason Road above. Ideally, this temporary access would stay outside of critical habitat areas and would require limited grading or temporary gravel base. See additional discussion in Section 5.11.

5.8 Construction Cost

The approach and assumptions associated with the development of OPCCs for each alternative are summarized in Section 4.6. Table 17 summarizes the OPCC for Alternative 3 (Storage Expansion and Dredging), and a detailed breakdown is provided in Appendix C. Table 17 does not include the upstream and downstream fish passage improvements ($82.1 million per HDR et al. 2021) that would also be required with the dam remaining in place.

Table 17 Alternative 3 (Storage Expansion and Dredging) OPCC Summary

Line Item #	Line Item	Description	Estimate
1	Mobilization/demobilization	Percentage of construction activities (10%)	$4,730,000
2	Site preparation	Clearing and grubbing, work pads, and access improvements	$3,130,000
3	Spillway modifications and gate installation	Spillway crest modification, wall raise, and gate and control system installation	$4,100,000
4	Dam embankment raise	Embankment raise, filter/drain, and surface rock painting	$8,740,000
5	Sediment removal	Sediment removal (1.9 million CY) in the wet, hauling and placement at disposal sites	$31,350,000
		Subtotal	**$52,050,000**
		General Conditions (10%)	$5,205,000
		Bond (3%)	$1,570,000
		General Contractor’s Overhead and Profit (15%)	$7,810,000
		Total Construction Cost	**$66,635,000**
		Contingency (50%)	$33,320,000
		Total with Contingency	**$99,960,000**
		Low Side of Class 5 Estimate Range (-30%)	$69,972,000
		High Side of Class 5 Estimate Range (+50%)	$149,940,000

Notes:

Line item totals are rounded up to the nearest thousand, and subsequent calculations are rounded to the nearest thousand.

CY = cubic yards

Approximately 66 percent of the construction cost for Alternative 3 (Storage Expansion and Dredging) involves the removal and disposal of more than 1.9 million CY of accumulated sediment. This calculation considers applicable portions of mobilization, demobilization, and site preparation.

5.9 Operation and Maintenance

An operations plan would be developed during detailed design to outline the required monitoring and procedures associated with timing of the gate operation and associated flow releases in the summer. Monitoring stations and instrumentation associated with the operations plan would be built into the project design. However, implementation of the plan—which would include data collection and analysis, along with gate and valve operation—would increase the O&M responsibilities and budget at the site. Assuming a half-time employee for up to 4 months could increase the annual O&M budget by as much as $50,000.

Annual operation and maintenance costs associated with the upstream and downstream fish passage improvements could total as much as $782,000 (HDR et al. 2021).

5.10 Advantages and Disadvantages

Advantages and disadvantages associated with Alternative 3 (Storage Expansion and Dredging) are discussed in the following paragraphs and summarized in Table 18. Both Table 18 and the bulleted advantages and disadvantages are organized by the following categories: Cost, Local Impacts, Water Supply, Flooding, Geomorphology, Biological, Water Rights, and Regulatory.

Cost

- **Disadvantage:** The Alternative 3 (Storage Expansion and Dredging) construction costs (approximately $100 million), combined with the potential fish passage improvement costs related to the current MOA ($82 million; HDR et al. 2021), total approximately $182 million. This total combined construction cost is the second-highest of all the alternatives, given the combination of a sediment removal/disposal in the wet, significant dam raise, spillway modification, and fish passage improvements.

Local Impacts

- **Disadvantage:** Alternative 3 (Storage Expansion and Dredging) would have the greatest impact to local traffic associated with material hauling to and from the site. Although all of the accumulated sediment hauling and disposal would occur on site, it may be necessary to import between 2,500 and 3,300 loads of filter and drain material associated with the dam raise, if it is determined that those materials cannot be made on site. Additional material hauling (gates, concrete, rebar, etc.) would add to the local traffic disruption.
- **Disadvantage:** Equipment mobilization and construction worker commuting traffic may be disruptive to local traffic. Sediment removal would operate 24 hours per day, 7 days per week on site for four construction seasons. Similar to all of the other alternatives, small improvements may be required along public roads (see Section 4.2) to accommodate construction traffic, which would cause additional disruption.

Water Supply

- **Advantage (spillway gates):** Raising the maximum storage pool by 9.6 feet with a pneumatically actuated spillway gate would add 625 AF of storage to the current reservoir capacity during the dry season, providing more flexibility for Cal-Am to store water for any purpose, including supplementing summer streamflow to potentially support additional pumping in the lower Carmel River during the dry season. The additional 625 AF of storage would allow additional average releases of 1.7 cfs (3.4 AF per day) over a 6-month period.
- **Advantage (sediment removal):** Removing the majority of the accumulated sediment would add an additional 1,120 AF of storage to the current reservoir capacity, providing more flexibility for Cal-Am to store water for any purpose. When the spillway gates are up during the dry season, sediment removal above the NMWS results in an additional 72 AF of gained capacity, totaling 1,192 AF. The additional 1,192 AF of storage would allow additional average releases of 3.3 cfs (6.5 AF per day) over a 6-month period.

Table 18 Alternative 3 (Storage Expansion and Dredging) Advantage/Disadvantage Summary

Alternative No.	Alternative Name	Advantages/Disadvantages: Cost	Local Impacts	Water Supply	Flooding	Geomorphology	Biological	Water Rights	Regulatory
3	Storage Expansion and Dredging	- • $182 million ($100 million plus $82 million of passage improvements) is the second-highest of the alternatives	- • Highest impact due to filter/ drain material on-hauling	+ • Highest increase in storage and summer flow releases	+ • No significant increase in sediment released downstream over current conditions	- • Prevents long-term transport of coarse sediment and associated benefits	- • Adult passage improvements are less beneficial than Alternative 2 (Dam and Sediment Removal)'s volitional passage, and spillway gates may negatively affect fish passage • Continues to block upstream passage and provide suboptimal downstream passage for juveniles • Continued stress and migration delay for migrating steelhead • Provides a suboptimal water temperature regime in summer months + • Provides increased summer flows capable of providing rearing habitat downstream of LPD	+ • Increases capacity of LPR • Cal-Am could petition SWRCB to increase water right	+ • Increases ability to meet requirements of SWRCB water rights permit for summer releases

Notes:
\+ Advantage
\- Disadvantage
Cal-Am = California American Water
LPD = Los Padres Dam
LPR = Los Padres Reservoir
SWRCB = State Water Resources Control Board

- **Advantage:** Assuming the sedimentation rates described in Section 2.6, following project implementation, an estimated 101 years would be required for the reservoir capacity to be reduced to its current capacity of 1,601 AF.

Flooding

- **Advantage:** Other than the coarse sediment placed in Disposal Sites D and E, LPD would continue to prevent the transport of future coarse sediment downstream of LPD through the Carmel River, thereby limiting deposition compared to other alternatives that either release accumulated sediment more or less uncontrolled (Alternative 5 [Recover Storage Capacity with Sluice Tunnel]) or immediately return the system to the historic sediment load (Alternative 2 – [Dam and Sediment Removal]). There is still a long-term trend toward sediment deposition; it is just less pronounced for those alternatives that keep the dam in place and do not release additional sediments above the current load (Balance Hydrologics and UBC 2019).

Geomorphology

- **Disadvantage:** Alternative 3 (Storage Expansion and Dredging) would result in the continued incision of the channel downstream of LPD, resulting in decreased habitat complexity and a continued lack of access to overbank habitat. The lack of continued upstream gravel recruitment would continue to limit the quantity and quality of spawning habitat downstream of LPD. This in turn would continue to have a negative effect on downstream spawning habitat, and limit other potential morphological benefits associated with large wood and instream and overbank habitat (Balance Hydrologics and UBC 2019; AECOM and Stillwater Sciences 2022). This impact may be reduced by the introduction of coarse sediments into the system through placement in Disposal Sites D and E.

Biological

- **Advantage:** Storage expansion through gate installation and sediment removal would not result in any changes to the downstream channel geometry from the current condition. It would, however, allow for a greater quantity of water for dry season release. This would increase the amount of fry and juvenile rearing habitat in the lower Carmel River, and would reduce the amount of dry back that occurs under existing conditions relative to other alternatives (AECOM and Stillwater Sciences 2022). As noted above under Water Supply, average flow releases over a 6-month period could increase by 1.7 cfs due to the additional storage related to gate installation, and another 3.3 cfs due to the additional storage related to the sediment removal.
- **Disadvantage:** Through implementation of fish passage improvements (HDR et al. 2021), adult steelhead passage would be improved over existing conditions, but would be less beneficial to fish than the volitional passage provided in Alternative 2 (Dam and Sediment Removal).
- **Disadvantage:** Downstream passage 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 interfere with the existing BGS and/or proposed fish passage improvements in HDR et al. (2021).
- **Disadvantage:** If the river dries up during the dry season, filling of a larger reservoir in the rainy season could lengthen the time it takes for the river to fully connect to the lagoon. This impact could be offset somewhat by the ability to release flow during the dry season, which would contribute to aquifer recharge.
- **Disadvantage:** Alternative 3 (Storage Expansion and Dredging) would continue to block upstream movement of juveniles, thus continuing to prevent access to thermal refugia in the watershed upstream of LPR (AECOM and Stillwater Sciences 2022).
- **Disadvantage:** Alternative 3 (Storage Expansion and Dredging) has the potential to continue causing stress and migration delay for migrating steelhead (AECOM and Stillwater Sciences 2022).

- **Disadvantage:** Alternative 3 (Storage Expansion and Dredging) provides suboptimal downstream juvenile passage through and mortality in LPR (AECOM and Stillwater Sciences 2022).
- **Disadvantage:** Alternative 3 (Storage Expansion and Dredging) provides a suboptimal water temperature regime in the summer months (AECOM and Stillwater Sciences 2022).

Water Rights

- **Advantage:** Because the gates would only be raised in the spring and summer months, Alternative 3 (Storage Expansion and Dredging) 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.
- **Advantage:** Alternative 3 (Storage Expansion and Dredging) would increase the capacity of LPR, and Cal-Am could petition the SWRCB to increase their water right associated with LPR.

Regulatory

- **Advantage:** The increase in reservoir storage capacity would further Cal-Am's ability to release at least 5 cfs directly below LPD, as required by the SWRCB water rights permit. Release of 5 cfs at all times during which water is being stored in the reservoir is a requirement of License 11866.

5.11 Uncertainties

The primary uncertainty associated with Alternative 3 (Storage Expansion and Dredging) pertains to the lack of adequate geologic and geotechnical baseline information, and the associated seismic assessment and stability analyses to support a detailed dam embankment raise design. In addition, all modifications would need to be designed using current standards and would require DSOD approval prior to their construction.

Because the reservoir would be operated temporarily at a level greater than the current NMWS, seepage and stability analyses would be required to demonstrate that minimum factors of safety are met. 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 1980a). Based on the seismic hazard evaluation, the San Gregario-Hosgri fault was determined to be the controlling fault, with a Maximum Credible Earthquake of M7.5 and a peak ground acceleration of 0.4g. Based on the current understanding of the seismic hazards around 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 than were assumed in the 1981 analysis.

Ground motions developed based on the revised seismic hazard analysis should be used for liquefaction triggering analyses of the granular dam 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 dam Zone 1 (impervious embankment) and dam Zone 2 (free-draining upstream zone). Obtaining these properties would require drilling multiple 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. It is also possible that the analyses may indicate a similar finding for the downstream slope.

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 and flattening the upstream slope) for Alternative 3 (Storage Expansion and Dredging) to be approved by DSOD.

As described in Section 4.9, conceptual or planning-level alternatives are uncertain by nature. Key assessments or investigations to help address uncertainties related to design and construction of this alternative are listed below:

- A detailed assessment of temporary access that would be required within the river floodplain for equipment to reach Disposal Sites D and E is needed to assess potential impact to habitat in this area.
- A detailed assessment of the public road improvements that may be required to accommodate construction traffic needs to be completed to confirm the approach provided herein.
- Additional onsite geologic assessment and geotechnical investigation may be necessary during detailed design to confirm the extent of improvements required for the onsite temporary access roads proposed for sediment access and hauling.
- Additional assessment of likely dewatering requirements, given the local geology and groundwater, should be completed during detailed design.
- Additional analyses of historical Carmel River flows should be conducted to determine how frequently river flows at the end of the precipitation season are sufficient to close the spillway gates and use the additional storage capacity.
- A drying time test and correlated strength testing should be performed at later stages of design to better define sediment disposal site coverage times and reduce the risk of construction delays. Strength testing would also be used in stability analyses of the disposal sites to confirm slopes of the proposed disposal site and the allowable water content of the materials.
- Fish passage improvement alternatives (HDR et al. 2021) were developed based on existing conditions and infrastructure. The dam, spillway, and infrastructure improvements, in addition to the associated operations, outlined in this section for Alternative 3 (Storage Expansion and Dredging) may require changes in the fish passage improvement alternatives and associated costs.

6. Alternative 4 (Recover Storage Capacity with Excavation)

6.1 Overview

Under Alternative 4 (Recover Storage Capacity with Excavation), accumulated sediments would be periodically removed to maintain or recover reservoir storage capacity.

Alternative 4 (Recover Storage Capacity with Excavation) is broken into two options: Alternative 4a, which assumes removal every 5 years on average; and Alternative 4b, which assumes removal every 10 years on average. Both options have the same removal approach (dredging, like Alternative 3 [Storage Expansion and Dredging]) but differ in their volumes. Both options assume material placement at Disposal Sites B and C, with future dredging episodes potentially reaching far enough upstream to capture Zone 3 sediments for placement at Disposal Sites D and E.

Figure 30 shows an overview of Alternative 4 (Recover Storage Capacity with Excavation) activities for periodic sediment removal to maintain or recover reservoir storage capacity.

In addition to actions described in this TM, because the dam will remain in place, the fish passage improvements (HDR et al. 2021) discussed for Alternative 1 (No Sediment Action) would also be implemented for Alternative 4 (Recover Storage Capacity with Excavation).

6.2 Access Improvements

All access improvements described in Section 5.2 also apply to Alternative 4 (Recover Storage Capacity with Excavation).

6.3 Sediment Removal

Sediment removal upstream of LPD is severely constrained by suitable access capable of supporting thousands of truck trips. As described in Section 4.3, access via the “Jeep Trail” is no longer possible due to recent landslides and the high potential for future landslides along the steep, mountainous terrain. The steep slopes continue down to the accumulated sediments in the reservoir basin, preventing partial dewatering of the reservoir and construction of an access road around the lowest elevations of the reservoir basin.

Access to the upstream sediments must be gained either over water, or via an upstream access road and diversion system, as discussed in Alternative 2 (Dam and Sediment Removal) (refer back to Figure 16). Dewatering to this elevation may require a treatment system to meet discharge criteria. Also, building a road crossing on the approximately 400-foot-wide reservoir basin would require material sourced possibly near Disposal Site B, and would delay the time available for sediment removal. Neither of these complications align with a low-effort periodic removal of sediments from the reservoir. For these reasons, for this alternative, dredging of sediments using a barge-mounted excavator is preferred over dewatering and conventional excavation.

As noted in Section 2.6, an estimated 18 AF (29,000 CY) of sediment is accumulated each year, reducing the reservoir storage by an estimated 16 AF each year. Alternative 4 (Recover Storage Capacity with Excavation) assumes the removal of, on average, 90 AF (145,000 CY) every 5 years (Alternative 4a) or 180 AF (290,000 CY) every 10 years (Alternative 4b), by means of dredging to maintain reservoir storage capacity near the current level. Sediment zone volumes, disposal locations, and characterization for Alternative 4 (Recover Storage Capacity with Excavation) are summarized in Table 19.

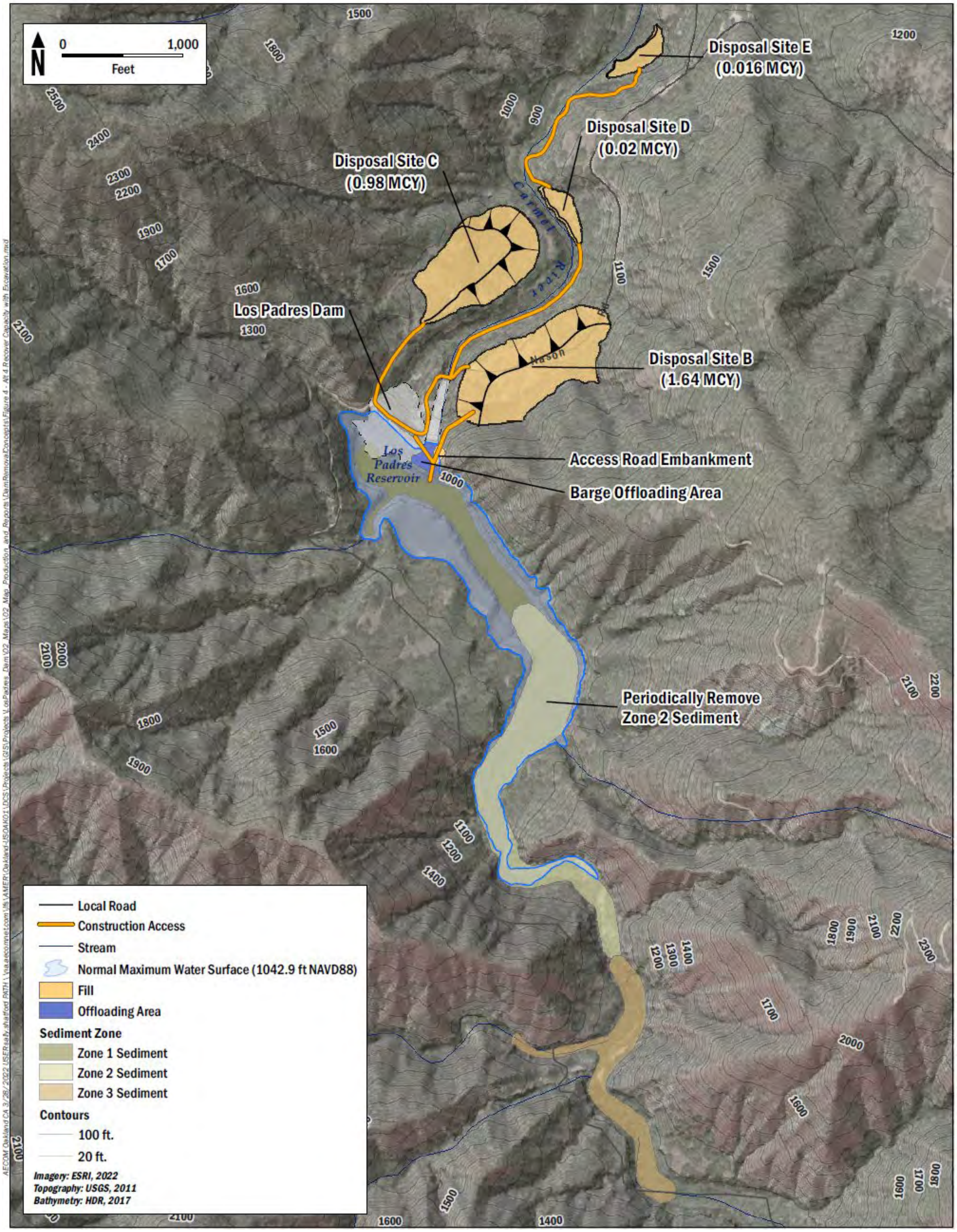


Figure 30 Alternative 4 (Recover Storage Capacity with Excavation)

Table 19 Alternatives 4a and 4b Estimated Sediment Removal and Placement

Alternative	Area	Volume (AF)	Volume (CY)	Disposal Location	Characterization
Alternative 4a (5 years)	Zone 2	90	145,000	Site B and C	Predominantly silt and sand
Alternative 4b (10 years)	Zone 2	180	290,000	Site B and C	Predominantly silt and sand

Notes:

AF = acre-feet
CY = cubic yards

Source: AECOM 2018

The following timeline summarizes the anticipated sediment removal actions for Alternative 4 (Recover Storage Capacity with Excavation) during a single construction year, with in-water construction work occurring from May 15 to October 15. Because the sediment removal work is not anticipated to take more than 1.5 to 3 months, there is available float in the 5-month in-water work window, unlike the other alternatives. Site mobilization and demobilization would occur before and after the sediment removal activities.

Construction Year 1:

Prior to May 15 (or later as schedule allows):

- Improve access roads as described in Section 4.2, with the exception of the access road on the reservoir sediments to the upstream extent of the project area because this alternative assumes that the reservoir will retain water during sediment removal.
- Clear and grub permanent sediment Disposal Sites B and C. Prepare the sites to receive material.
- Draw down the reservoir to elevation 1,025 feet to expose the offloading area on the natural terrace. Release of approximately 832 AF would take approximately 10 days, assuming minimum discharges from the restored low-level outlet (30 cfs) and siphon (average 12 cfs), as described in Section 4.3.

Beginning May 15 (or later as schedule allows):

- Create an approximately 20,000-square-foot offloading area adjacent to the spillway on the natural terrace near elevation 1,025 feet. Maintain the reservoir water level at elevation 1,025 feet, if possible, to offload material most efficiently from barges. Construct a lower shelf from which to offload as continued summer discharges lower the reservoir water surface elevation.
- Assemble the flexi-floats and excavator on the barge to begin sediment removal.
- Construct in-water access routes to floodplain Disposal Sites D and E. Clear, grub, and prepare sites to receive material.
- Remove sediments using barge mounted excavator:
  - Alternative 4a: 145,000 CY (1.5 months)
  - Alternative 4b: 290,000 CY (3 months)

Alternative 4 (Recover Storage Capacity with Excavation) would include periodic removal of the most accessible accumulated sediments in the reservoir, which are the Zone 2 sediments near the upstream extent of the reservoir. The reservoir water surface elevation would be lowered to approximately elevation 1,025 feet NAVD88 to allow for the offloading area to be positioned on the existing spillway terrace. A barge-mounted hydraulic excavator would excavate Zone 2 sandy sediments and deposit the materials in a secondary transport barge. The barges would be transported via work boat to the offloading area adjacent to the LPD spillway. There, a secondary land-based excavator would offload the barges onto articulating dump trucks that would haul the material to the downstream Disposal Sites B and C for conditioning and drying prior to permanent grading.

Figure 31 depicts the sediments to be removed from the reservoir. Substantial Zone 3 sediments begin appearing in the reservoir profile near Station 60+00, and the material excavated for Alternatives 4a and 4b extend no higher than approximately Station 50+00. Because the excavator must dig its access (including 10 feet of draft for full material barges), Zone 3 sediments are likely unreachable in the preliminary dredging episodes. Subsequent episodes may have more access to Zone 3 sediments, although sediment is anticipated to continue to deposit in the reservoir at the same rate of removal. If, however the newly accumulated material allows for more access to Zone 3 sediments, they may be excavated and placed at Disposal Sites D and E for mobilization downstream during large-flow events.

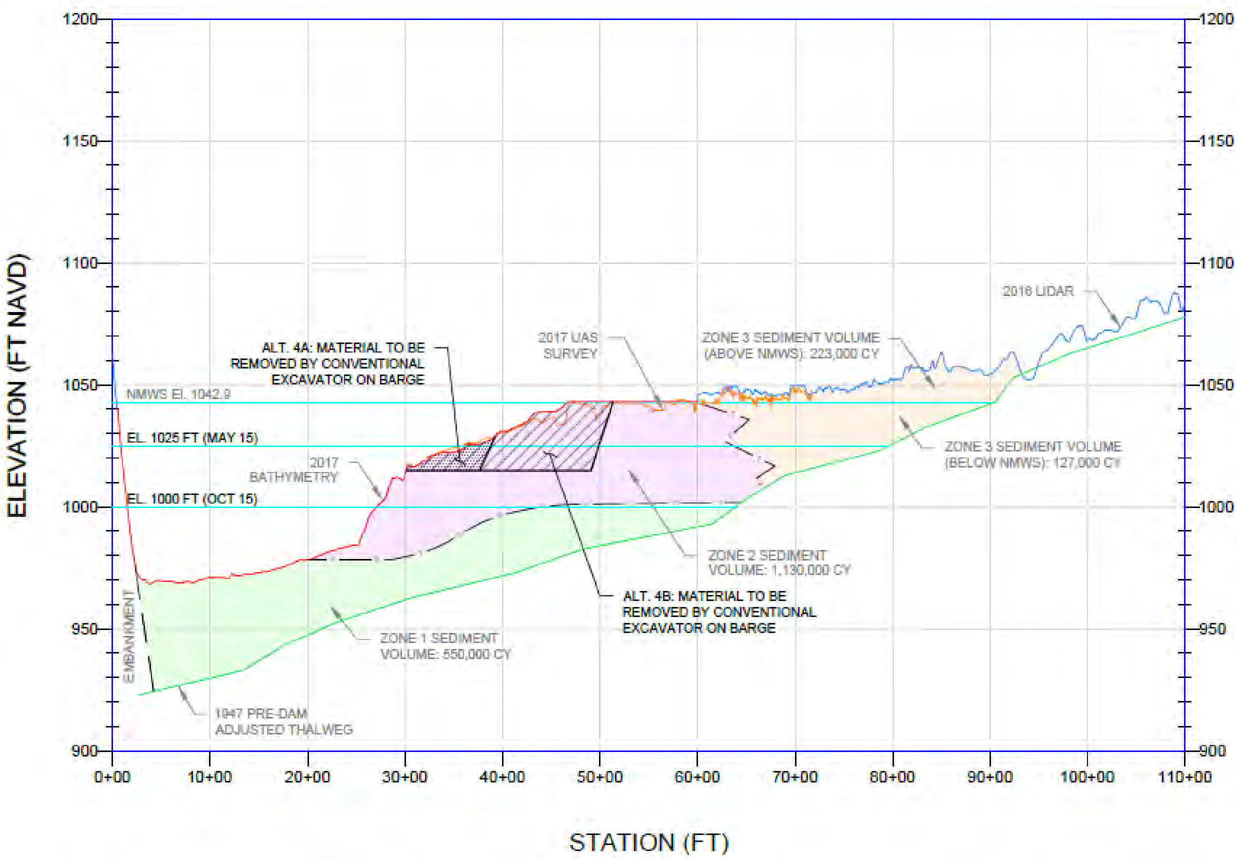


Figure 31 Material Dredging by Equipment Type and Water Level

6.4 Hauling and Sediment Disposal

Excavated material would be hauled by articulated trucks and disposed of at Sites B and C. Appendix B, Sheets 5 through 8, contain plan and profile views of each proposed site. Refer to Section 4.4 for descriptions of Sites B and C. Subsequent episodes may allow for Zone 3 sediment to be placed at Sites D and E (described in Section 0) to support steelhead spawning areas and instream habitat downstream of the dam.

6.5 Construction Cost

The approach and assumptions associated with the development of OPCCs for each alternative are summarized in Section 4.6. Higher unit costs associated with smaller volumes of sediment removal make

Alternative 4a less cost effective over time compared to Alternative 4b. For that reason, this TM presents an OPCC for Alternative 4b only.

Table 20 summarizes the OPCC for a single bout of sediment removal, consistent with Alternative 4b (Recover Storage Capacity with Excavation – 10-year recurrence interval), where 290,000 CY of sediment are removed during each bout, and sediment removal bouts are repeated every 10 years. A detailed cost breakdown is provided in Appendix C.

A 50-year planning horizon for sediment removal was selected to calculate a total OPCC cost for sediment removal to compare with other alternative OPCCs. Assuming an annual escalation rate of 3 percent, the 50-year total (consisting of six separate sediment removal events) would be $195,700,000.

Table 20 does not include the upstream and downstream fish passage improvements ($82.1 million per HDR et al. 2021) that would also be required with the dam remaining in place.

Table 20 Alternative 4 (Recover Storage Capacity with Excavation – 4b) OPCC Summary

Line Item #	Line Item	Description	Estimate
1	Mobilization/demobilization	Percentage of construction activities (10%)	$650,000
2	Site preparation	Clearing and grubbing, work pads, and access improvements	$1,050,000
3	Sediment removal and disposal	Sediment removal (145,000 CY) in the wet, hauling and placement at disposal sites	$5,450,000
		Subtotal	**$7,150,000**
		General Conditions (10%)	$720,000
		Bond (3%)	$220,000
		General Contractor's Overhead and Profit (15%)	$1,080,000
		Total Construction Cost	**$9,170,000**
		Contingency (50%)	$4,590,000
		Total with Contingency	**$13,760,000**
		Low Side of Class 5 Estimate Range (-30%)	$9,632,000
		High Side of Class 5 Estimate Range (+50%)	$20,640,000

Notes:

Line item totals are rounded up to the nearest thousand, and subsequent calculations are rounded to the nearest thousand.

CY = cubic yards

6.6 Operation and Maintenance

An operations plan would be developed during detailed design to outline required monitoring and procedures associated with timing of the recurring sediment removal events. Any monitoring stations and/or instrumentation associated with the operations plan would be built into the project design. However, implementation of the plan—which would include data collection and analysis, along with contracting/procurement and construction oversight—would increase the O&M responsibilities and budget at the site. Assuming a half-time employee for up to 2 months could increase the annual O&M budget by as much as $25,000, and construction oversight costs for each recurring sediment removal project (assuming every 10 years) could add as much as $80,000 per 3-month sediment removal project.

Annual operation and maintenance costs associated with the upstream and downstream fish passage improvements could total as much as $782,000 (HDR et al. 2021).

6.7 Advantages and Disadvantages

Advantages and disadvantages associated with Alternative 4 (Recover Storage Capacity with Excavation) are discussed in the following paragraphs and summarized in Table 21. Both Table 21 and the bulleted advantages and disadvantages are organized by the following categories: Cost, Local Impacts, Water Supply, Flooding, Geomorphology, Biological, Water Rights, and Regulatory.

Cost

- **Disadvantage:** The Alternative 4b (10-year recurrence) recurring construction cost is approximately $13.8 million (present day cost of one removal event). Assuming this would occur every 10 years for 50 years, the resulting total (with 3 percent annual escalation) would be approximately $196 million. In addition, a one-time project cost of as much as $82 million would be required for fish passage improvements related to the current MOA (HDR et al. 2021). The combined total of $278 million would be the highest total of all the alternatives presented in this TM.

Local Impacts

- **Advantage:** The amount of materials to be brought on site, and associated hauling loads, would be significantly less than Alternative 3 (Storage Expansion and Dredging) (filter/drain materials from off site). In addition, because there are minimal materials that will be brought on site for Alternative 4 (Recover Storage Capacity with Excavation), there would also be less impact than under Alternatives 2 (Dam and Sediment Removal) and 5 (Recover Storage Capacity with Sluice Tunnel), both of which require some level of construction materials to be brought on site. Similar to all of the other alternatives, small improvements may be required along public roads (see Section 4.2) to accommodate construction traffic, which would cause additional disruption.

Water Supply

- **Advantage:** Alternative 4 (Recover Storage Capacity with Excavation) would allow for Cal-Am to maintain the status quo related to current available storage and ability to store water for any purpose, including in support of surface flow and pumping in the lower river.
- **Advantage:** Alternative 4 (Recover Storage Capacity with Excavation) would not 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.

Flooding

- **Advantage:** LPD would continue to prevent the transport of coarse sediment downstream of LPD through the Carmel River, with the exception of material that may eventually be excavated and placed in Disposal Sites D and E, thereby limiting deposition compared to other alternatives that either release accumulated sediment more or less uncontrolled (Alternative 5 [Recover Storage Capacity with Sluice Tunnel]) or immediately return the system to the historic sediment load (Alternative 2 [Dam and Sediment Removal]). There is still a long-term trend toward sediment deposition, it is just less pronounced for those alternatives that keep the dam in place and do not release additional sediments above the current load (Balance Hydrologics and UBC 2019).

Geomorphology

- **Disadvantage:** Alternative 4 (Recover Storage Capacity with Excavation) would result in the continued incision of the channel downstream of LPD, resulting in decreased habitat complexity and a continued lack of access to overbank habitat. The lack of upstream gravel recruitment would continue to limit the quantity and quality of spawning habitat downstream of LPD, which would continue to have a negative effect on downstream spawning habitat and limit other potential morphological benefits associated with large wood and instream and overbank habitat (Balance Hydrologics and UBC 2019; AECOM and Stillwater Sciences 2022). This impact would be somewhat mitigated by the introduction of coarse sediments into the system through placement in Disposal Sites D and E, though the volume and timing of that placement is less than that proposed in Alternative 3 (Storage Expansion and Dredging).

Table 21 Alternative 4 (Recover Storage Capacity with Excavation) Advantage/Disadvantage Summary

Alternative No.	Alternative Name	Advantages/Disadvantages							
		Cost	Local Impacts	Water Supply	Flooding	Geomorphology	Biological	Water Rights	Regulatory
4	Recover Storage Capacity with Excavation	- • $278 million ($196 million plus $82 million of passage improvements) is the highest of the alternatives	+ • Second-lowest impact of alternatives due to minimal offsite hauling	+ • Maintains Cal-Am's ability to store water over time	+ • No additional sediment released downstream over current conditions, unless Zone 3 sediments are accessed and moved to Sites D and E during later bouts of sediment removal	- • Prevents the transport of coarse sediment and associated benefits, unless Zone 3 sediments are accessed and moved to Sites D and E during later bouts of sediment removal	- • Adult passage improvements less beneficial than Alternative 2 (Dam and Sediment Removal)'s volitional passage • Continues to block upstream juvenile passage and provide suboptimal downstream passage for juveniles • Provides a suboptimal water temperature regime in summer months • Recurring access to floodplain disposal sites could affect steelhead critical habitat + • Provides summer flows capable of providing rearing habitat downstream of LPD	+ • Maintains existing water rights agreements	+ • Maintains status quo in meeting existing regulatory requirements

Notes:
+ Advantage
- Disadvantage
Cal-Am = California American Water
LPD = Los Padres Dam

Biological

- **Advantage:** Alternative 4 (Recover Storage Capacity with Excavation) would allow for continued storage and associated water releases during the dry season to maintain the amount of fry and juvenile rearing habitat in the lower Carmel River.
- **Disadvantage:** Through implementation of fish passage improvements (HDR et al. 2021), adult steelhead passage would be improved over existing conditions, but would be less beneficial to fish than the volitional passage provided in Alternative 2 (Dam and Sediment Removal).
- **Disadvantage:** Alternative 4 (Recover Storage Capacity with Excavation) would continue to block upstream movement of juveniles, thus continuing to prevent access to thermal refugia in the watershed upstream of LPR (AECOM and Stillwater Sciences 2022).
- **Disadvantage:** Alternative 4 (Recover Storage Capacity with Excavation) provides suboptimal downstream juvenile passage through and mortality in LPR (AECOM and Stillwater Sciences 2022).
- **Disadvantage:** Alternative 4 (Recover Storage Capacity with Excavation) provides a suboptimal water temperature regime in the summer months (AECOM and Stillwater Sciences 2022).
- **Disadvantage:** If coarse sediment would be disposed of at Sites D and E, reliable placement of sediment for future mobilization would require recurring development and removal of road access along the Carmel River, potentially affecting steelhead critical habitat.

Water Rights

- **Advantage:** Alternative 4 (Recover Storage Capacity with Excavation) would maintain the existing water rights agreements.
- **Advantage:** Alternative 4 (Recover Storage Capacity with Excavation) would not 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.

Regulatory

- **Advantage:** Alternative 4 (Recover Storage Capacity with Excavation) would maintain the status quo in meeting existing regulatory requirements from SWRCB and DSOD.

6.8 Uncertainties

Key uncertainties associated with Alternative 4 (Recover Storage Capacity with Excavation) include the following:

- Because this alternative extends into the future (relative to other alternatives, which include a single project and construction duration), a key uncertainty involves the rate of escalation, which can have a significant effect on future recurring sediment removal costs.
- Another key uncertainty involves potential effects of the dredging operation on adult and juvenile steelhead migration through the reservoir and into the upstream river channel. An assessment and adaptive management plan is needed to coordinate the various activities and address associated uncertainties.
- As described in Section 4.9, conceptual or planning-level alternatives are uncertain by nature. Key assessments or investigations to help address uncertainties related to design and construction of this alternative are listed below:
  - A detailed assessment of temporary access that would be required within the river floodplain for equipment to clear, grub, and grade Disposal Sites D and E is needed to understand potential impacts to habitat in this area.

- Additional onsite geologic assessment and geotechnical investigation may be required during detailed design to confirm the extent of improvements required for the other temporary access roads proposed for sediment access and hauling.

- A drying time test and correlated strength testing should be performed at later stages of design to better define sediment disposal site coverage times and reduce the risk of construction delays. Strength testing would also be used in stability analyses of the disposal sites to confirm the proposed disposal site slopes and allowable water content of the materials.

7. Alternative 5 (Recover Storage Capacity with Sluice Tunnel)

7.1 Overview

Under Alternative 5 (Recover Storage Capacity with Sluice Tunnel), a sluice tunnel would be installed through the eastern abutment; it would be used to sluice and/or flush sediment from the reservoir during wet water years (see Figure 32). A typical sluicing operation can be managed either to flush accumulated reservoir sediment (flushing); or to simply pass high sediment-concentrated flow through the reservoir (sluicing), which is typically used to prevent sediment accumulation. A sluicing condition would typically release sediment concentrations similar to those entering the reservoir from the upstream watershed; a flushing condition would release the background concentration as well as additional accumulated sediment, resulting in significantly higher sediment concentrations.

Flushing flows would be timed to coincide with high flows that already carry significant sediment loads, limiting the potential incremental impact to aquatic resources associated with high suspended sediment loads. 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.

In addition to actions described in this TM, because the dam will remain in place, the fish passage improvements (HDR et al. 2021) discussed for Alternative 1 (No Sediment Action) would also be implemented for Alternative 5 (Recover Storage Capacity with Sluice Tunnel). However, it should be noted that those alternatives were developed based on existing conditions and infrastructure. The sluice tunnel improvements, in addition to the associated operations, outlined in this section for Alternative 5 (Recover Storage Capacity with Sluice Tunnel) may require changes in the fish passage improvement alternatives and associated costs.

A similar concept that is not included in this TM is a bypass tunnel that would transport incoming sediment around the dam and reservoir. This concept was removed from further consideration in response to input received at TRC Meeting 2A regarding the high impacts and costs compared to other concepts.

7.2 Access Improvements

All public road improvements described in Section 4.2 will also be required for Alternative 5 (Recover Storage Capacity with Sluice Tunnel), to facilitate material and equipment mobilization. In addition, local temporary access from the reservoir to Disposal Site B would be required to facilitate the hauling of tunnel debris for permanent disposal.

7.3 Sluice Tunnel

A sluice tunnel would be constructed to allow for river flow during storm events to mobilize accumulated reservoir sediments (while tunnel gates are open). Sediment mobilization could be maximized if reservoir drawdown was timed appropriately prior to a large storm event. Sluice tunnels have been used successfully to manage sediment accumulation at other dams (Kondolf et al. 2014), and a sluice tunnel is considered a feasible approach to managing sediment at LPD. However, as described in Section 7.8, additional analysis may be needed to support discussions with stakeholders to determine the specific goals for this alternative (sluicing versus flushing, and the extent of either), how long and how often the tunnel gates would be left open to facilitate sediment mobilization, and the resulting effects to steelhead in the Carmel River.

A straight tunnel alignment was selected along the eastern dam abutment, directly adjacent to the existing concrete spillway (see Sheet 9 in Appendix B). A straight alignment is preferred to a curved alignment (which would be required along the western abutment) due to the complexities and risks associated with drilling along a curve. In addition, although a geologic assessment along the tunnel alignment has not been completed at this time, previous geologic assessments by DSOD (1980a) and HDR et al. (2021) suggest that there is competent rock in this area.

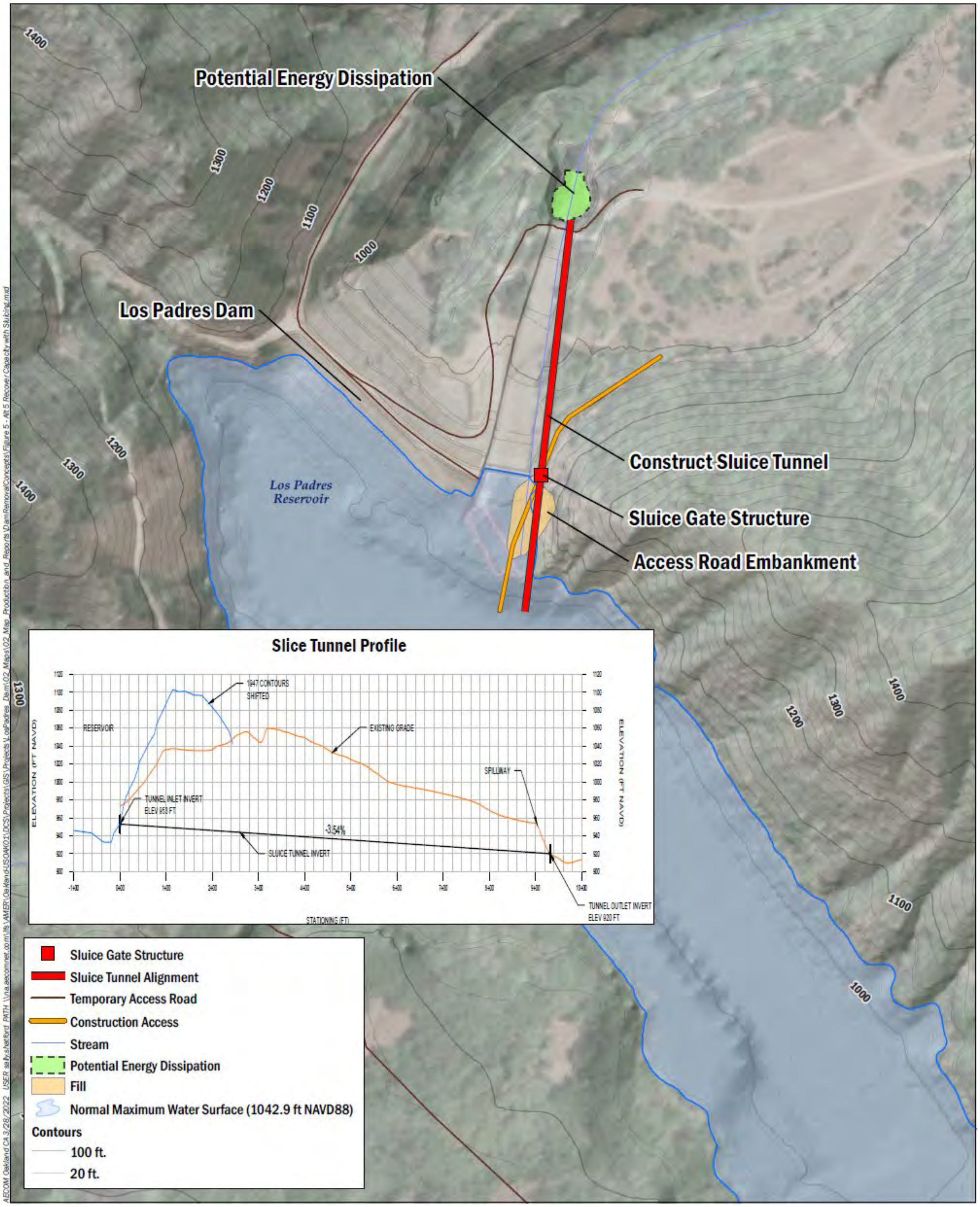


Figure 32 Alternative 5 (Recover Storage Capacity with Sluice Tunnel)

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, respectively. Table 22 shows peak discharge estimates at LPD (AECOM 2017b). The size of the sluice tunnel would ultimately be based on sediment transport analyses completed as part of detailed design, but is assumed at 15 feet for this TM.

Table 22 Annual Instantaneous Carmel River Peak Flows at LPD

Recurrence Interval (years)	Annual Exceedance Probability (%)	Peak Discharge (cfs) Bulletin 17b
2	50	1,500
5	20	3,200
10	10	4,500
25	5	5,800
50	2	7,600
100	1	8,900

Notes:

cfs = cubic feet per second
LPD = Los Padres Dam

Source: AECOM 2017b

The sluice tunnel would require a gate, which could be closed after the flushing duration is complete, allowing the reservoir to refill for the dry season. Minimum stream flow requirements could be met during refilling by using a new secondary pipe and valve to allow bypass flows around the sluice gate and tunnel. Once the reservoir water surface is above the invert of the low-level outlet, it could also be used to facilitate bypass flow releases.

A vertical gate shaft/structure would be constructed at the location shown on Figure 32 to house the sluice gate, provide access for gate installation, and provide access for future gate maintenance.

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 33, 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.

If the majority of Zone 1 and Zone 2 sediment could be flushed over one or several large storm events (possibly over several years), the resulting reservoir capacity could reach up to 2,600 AF. At this storage capacity, refilling of the reservoir would require about 6.5 days, assuming average flows of 200 cfs. Once the volume of sediment in the reservoir has been depleted, less frequent or shorter sluicing events might maintain reservoir capacity, but additional analysis would be needed to refine expectations regarding sediment transport capacity of the sluice tunnel, its ability to reach sediment throughout the reservoir, and the frequency and duration of sluicing needed to initially deplete the accumulated sediment and then maintain capacity.

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. The reservoir would need to be completely lowered and a workpad constructed at the upstream end to accommodate the drilling equipment access. Drilling and blasting involves drilling the blast holes (see Figure 34), loading them with explosives, detonating the blast, ventilating to remove blast fumes, removing the blasted rock (mucking), scaling to remove loosened pieces of rock, and then lining the tunnel. Significant care would need to be taken to ensure that the blasts do not affect the existing spillway structure. This tunnel would likely be lined with reinforced concrete (see Figure 35).

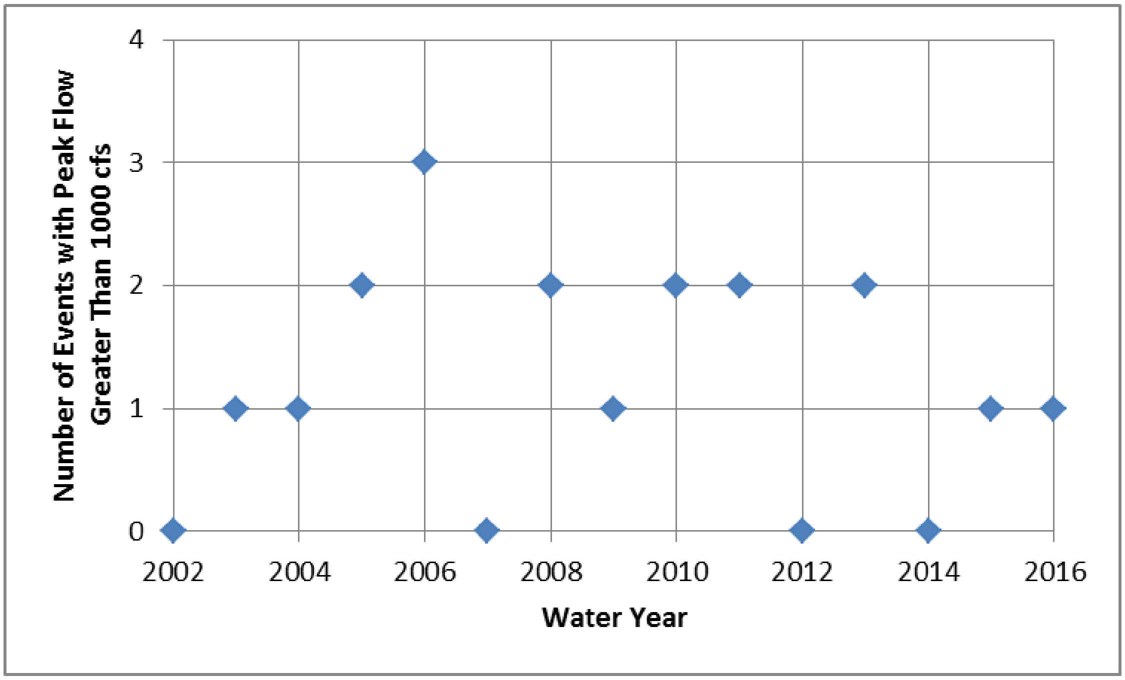


Figure 33 Flow Events Greater than 1,000 cfs at MPWMD Gauge below Los Padres Dam

Figure 34 Self-Drilling Multiple Boom Jumbo

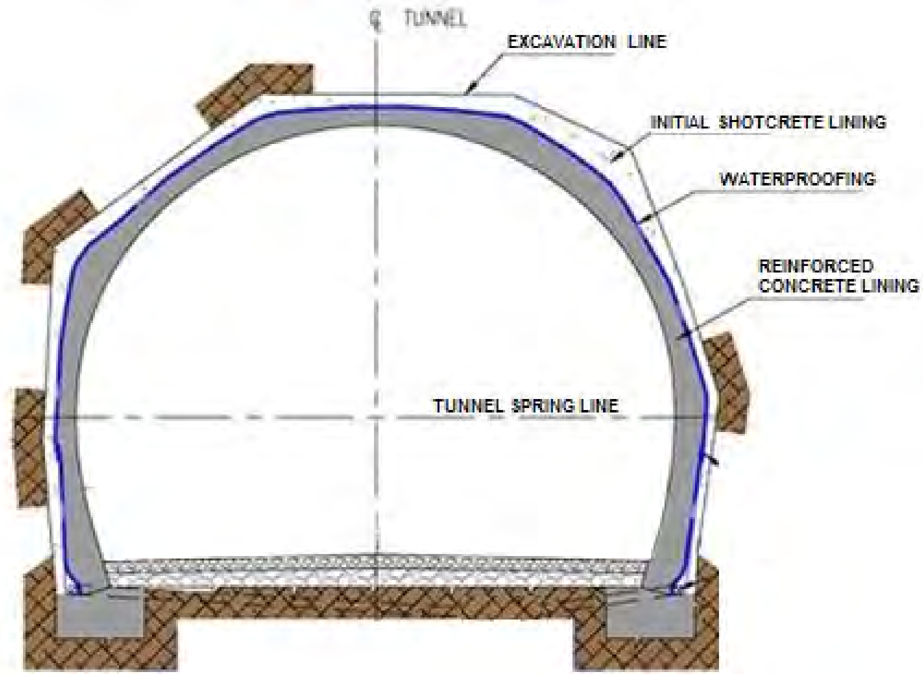


Figure 35 Concrete Tunnel Lining Schematic

Rock excavated from the tunnel and shaft would be hauled and placed in one of the permanent disposal sites (Site B or Site C).

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. Although the diversion, dewatering, and treatment systems would function similarly to those described in Section 4.3, the diversion pipe and treatment system would be designed specifically for needs associated with the tunneling project.

7.4 Outfall

Based on AECOM field reconnaissance, it was determined that the plunge pool below the end of the spillway chute has exposed bedrock that has been sufficiently resistant to erosion (see Figure 36). However, an analysis should be completed in detailed design to confirm the need for any energy dissipation at this location, based on the sluice tunnel discharge and associated scour.

7.5 Construction Cost

The approach and assumptions associated with the development of OPCCs for each alternative are summarized in Section 4.6. Table 23 summarizes the OPCC for Alternative 5 (Recover Storage Capacity with Sluice Tunnel), and a detailed breakdown is provided in Appendix C. Table 23 does not include the upstream and downstream fish passage improvements ($82.1 million per HDR et al. 2021) that would also be required with the dam remaining in place.

Figure 36 Proposed Sluice Tunnel Outfall Area

Table 23 Alternative 5 (Recover Storage Capacity with Sluice Tunnel) OPCC Summary

Line Item #	Line Item	Description	Estimate
1	Mobilization/demobilization	Percentage of construction activities (10%)	$2,860,000
2	Site preparation	Clearing and grubbing, work pads, and access improvements	$880,000
3	Construct sluice tunnel	Tunneling, material disposal, tunnel lining, gate structure, and intake/outfall portals	$27,580,000
4	Site restoration	Removal of temporary access and hydroseed disposal area	$110,000
		Subtotal	**$31,430,000**
		General Conditions (10%)	$3,150,000
		Bond (3%)	$950,000
		General Contractor's Overhead and Profit (15%)	$4,720,000
		Total Construction Cost	**$40,250,000**
		Contingency (50%)	$20,130,000
		Total with Contingency	**$60,380,000**
		Low Side of Class 5 Estimate Range (-30%)	$42,266,000
		High Side of Class 5 Estimate Range (+50%)	$90,570,000

Notes:

Line item totals are rounded up to the nearest thousand, and subsequent calculations are rounded to the nearest thousand.

CY = cubic yards

7.6 Operation and Maintenance

An operations plan would be developed during detailed design to outline required monitoring and procedures associated with timing of sluicing operations. Any monitoring stations or instrumentation associated with the operations plan would be built into the project design. However, implementation of the plan—which would include data collection and analysis, along with gate operation (and likely monitoring of total suspended solids and/or turbidity of releases)—would increase the O&M responsibilities and budget at the site. Assuming a half-time employee for up to 4 months could increase the annual O&M budget by as much as $50,000.

Annual operation and maintenance costs associated with the upstream and downstream fish passage improvements could total as much as $782,000 (HDR et al. 2021).

7.7 Advantages and Disadvantages

Advantages and disadvantages associated with Alternative 5 (Recover Storage Capacity with Sluice Tunnel) are discussed in the following paragraphs and summarized in Table 24. Both Table 24 and the bulleted advantages and disadvantages are organized by the following categories: Cost, Local Impacts, Water Supply, Flooding, Geomorphology, Biological, Water Rights, and Regulatory.

Cost

- **Disadvantage:** The Alternative 5 (Recover Storage Capacity with Sluice Tunnel) construction costs (approximately $60 million), combined with the potential fish passage improvement costs related to the current MOA ($82 million; HDR et al. 2021), total approximately $142 million. This total combined construction cost is the third-highest of all the alternatives, given the combination of a significant tunnel project and fish passage improvements.

Local Impacts (Traffic and Noise)

- **Advantage:** Alternative 5 (Recover Storage Capacity with Sluice Tunnel) would involve more impact to local traffic and noise than Alternatives 1 (No Sediment Action) and 4 (Recover Storage Capacity with Excavation), but less than Alternatives 2 (Dam and Sediment Removal) and 3 (Storage Expansion and Dredging). The amount of materials to be brought on site, and associated hauling loads, would be significantly less under than Alternative 3 (Storage Expansion and Dredging) (filter/drain materials from offsite). The majority of material hauling to the site for Alternative 5 (Recover Storage Capacity with Sluice Tunnel) would be limited to concrete, shotcrete, and gates associated with the sluice tunnel and gate structure. Similar to all of the other alternatives, small improvements may be required along public roads (see Section 4.2) to accommodate construction traffic, which would cause additional disruption.

Water Supply

- **Advantage (sediment removal):** Removing a significant volume of the accumulated sediment through sluicing would increase storage above the current reservoir capacity, providing more flexibility for Cal-Am to store water for any purpose, including summer releases to enhance rearing habitat and passage.

- **Advantage:** Because sluicing could occur at any frequency, and indefinitely into the future, this alternative provides increased flexibility to provide reliable storage into the future; and to deal with significant watershed events, such as fires or landslides, that could introduce a large sediment pulse into the river upstream of LPD.

Flooding

- **Disadvantage:** The release of accumulated reservoir sediment and subsequent return of the historic sediment load would increase deposition, and associated flood risk, throughout the downstream river relative to all other alternatives (Balance Hydrologics and UBC 2019). However, the sluicing objective and frequency could be adaptively managed to minimize or control the potential impact.

Table 24 Alternative 5 (Recover Storage Capacity with Sluice Tunnel) Advantage/Disadvantage Summary

Alternative No.	Alternative Name	Advantages/Disadvantages							
		Cost	Local Impacts	Water Supply	Flooding	Geomorphology	Biological	Water Rights	Regulatory
5	Recover Storage Capacity with Sluice Tunnel	- • $142 million ($60 million + $82 million of passage improvements) is the third-highest of alternatives	+ • More impact than Alternatives 1 and 4, but less than Alternatives 2 and 3	+ • Maintains Cal-Am's ability to store water over time	- • Depending on how sluicing is managed, could release accumulated coarse sediments downstream, increasing deposition and flood risk	+ • Potential benefit is dependent on how sluicing is managed	- • Steelhead in the Carmel River downstream of LPD could experience significant levels of mortality resulting from increased suspended sediment concentrations • Adult passage improvements are less beneficial than Alternative 2, volitional passage, and sluice tunnel operation could conflict with fish passage operation • Continues to block upstream passage for juveniles and provide suboptimal downstream juvenile passage • Provides a suboptimal water temperature regime in summer months + • Provides summer flows capable of providing rearing habitat downstream of LPD • Depending on how sluicing is managed, has potential to improve spawning habitat through transport of coarse sediment	+ • Maintains or increases water rights	- • May be difficult to permit, given potential impact to steelhead and uncertainty of benefits

Notes:

+ Advantage
- Disadvantage
Cal-Am = California American Water
LPD = Los Padres Dam

Geomorphology

- **Advantage:** Depending on how sluicing and flushing are managed, the amount of coarse sediment moving downstream would vary. If the intent is to restore reservoir capacity, the sluicing could be managed to mobilize mostly fine sediments, thus limiting the amount of coarse sediment that would move into the reservoir and displace reservoir capacity. Although the Effects to Steelhead TM (AECOM and Stillwater Sciences 2022) suggests that coarse sediments will not be transported downstream and therefore not improve downstream aquatic habitat, management strategies may allow for some coarse sediment transport downstream. Analysis in the Sediment Effects TM for the Pulsed Flow Simulation, which was intended to represent operation of a sluice gate, assumes that the annual load of coarse sediment is transferred downstream (Balance Hydrologics and UBC 2019).

Biological

- **Disadvantage:** Depending on how the flushing operation is managed, steelhead in the Carmel River downstream of LPD could experience significant levels of mortality resulting from increased suspended sediment concentrations (AECOM and Stillwater Sciences 2022). Generally, under the predicted range of durations and concentrations, all life stages of steelhead would experience paralethal and lethal effects as a result of increased suspended sediment concentrations. This level of effect is expected to have a substantial effect on the steelhead population in the Carmel River, and flushing operations would need to be managed to reduce the risks.
- **Advantage:** Would provide higher summer flows than Alternative 2 (Dam and Sediment Removal), flows capable of providing rearing habitat for both fry and juvenile steelhead downstream of LPD during the dry season in normal water years.
- **Advantage:** Depending on how sluicing is managed, Alternative 5 (Recover Storage Capacity with Sluice Tunnel) has the potential to increase spawning gravel availability downstream of LPD through transport of coarse sediment.
- **Disadvantage:** Through implementation of fish passage improvements (HDR et al. 2021), adult steelhead passage would be improved over existing conditions, but would be less beneficial to fish than the volitional passage provided in Alternative 2 (Dam and Sediment Removal). Additionally, operation of the sluice tunnel could conflict with, or at least would need to be closely coordinated with, fish passage operations.
- **Disadvantage:** Alternative 5 (Recover Storage Capacity with Sluice Tunnel) would continue to block upstream movement of juveniles, thus continuing to prevent access to thermal refugia in the watershed upstream of LPR (AECOM and Stillwater Sciences 2022).
- **Disadvantage:** Alternative 5 (Recover Storage Capacity with Sluice Tunnel) has the potential to continue causing stress and migration delay for migrating steelhead (AECOM and Stillwater Sciences 2022).
- **Disadvantage:** Alternative 5 (Recover Storage Capacity with Sluice Tunnel) provides suboptimal downstream juvenile passage through and mortality in LPR (AECOM and Stillwater Sciences 2022).
- **Disadvantage:** Alternative 5 (Recover Storage Capacity with Sluice Tunnel) provides a suboptimal water temperature regime in the summer months (AECOM and Stillwater Sciences 2022).

Water Rights

- **Advantage:** Depending on how the flushing operation is managed, Alternative 5 (Recover Storage Capacity with Sluice Tunnel) would either maintain the existing water rights agreements or could increase storage capacity, allowing Cal-Am to petition the SWRCB to increase their water right associated with LPR.

Regulatory

- **Disadvantage:** Alternative 5 (Recover Storage Capacity with Sluice Tunnel) could be difficult to permit, given the potential effects to all life stages of steelhead during episodes of elevated suspended sediment concentrations.
- **Disadvantage:** Although the sluice tunnel would not have a direct impact on the safety of LPD, the project may be considered a modification of the existing LPD, thereby requiring DSOD design review and approval for construction.

7.8 Uncertainties

Key uncertainties associated with Alternative 5 (Recover Storage Capacity with Sluice Tunnel) included the following:

- A significant uncertainty associated with Alternative 5 (Recover Storage Capacity with Sluice Tunnel) is the ability to permit the project, given the potential effect to all life stages of steelhead. Sluice tunnels are used effectively to manage sediment behind dams around the world (Kondolf et al. 2014) and in central California (e.g., the Alameda Creek Diversion Dam), but the effectiveness of a sluice tunnel depends on site-specific conditions that limit the ability to extrapolate the effectiveness at one site from observations at another. The BESMo model developed for the LP Alternatives Study predicts bedload movement from LPD to downstream but does not predict fine sediment transport or reservoir evacuation (Balance Hydrologics and UBC 2019). Additional sediment evacuation and fine sediment transport analysis, beyond the scope of the LP Alternatives Study, would help guide expectations regarding the ability of the sluice tunnel conceptualized for LPD to access accumulated sediment away from its inlet; the frequency and duration of operation to move a given quantity of fine and coarse sediment; the resulting suspended sediment concentrations; and, therefore, impacts and benefits to steelhead. If some level of sluicing and/or flushing is acceptable to regulatory agencies, this information may be needed to confirm reasonable goals for sluice tunnel operation, as well as operational constraints, impacts, benefits, and design.
- Another significant uncertainty is whether DSOD would require the dam to accommodate the new HMR 58/59 PMF as part of their approval to construct the sluice tunnel. If so, that would likely require a dam embankment and spillway wall raise project similar to that outlined in Alternative 3 (Storage Expansion and Dredging), which could increase the construction cost by more than $30 million.
- Based on ongoing planning and design processes for several dam removal projects in California, depending on the amount of coarse sediment that would be transported to downstream of LPD, mitigation for the potentially increased flood risk could be required as part of the environmental compliance or regulatory approval process associated with installing and operating a sluice gate.
- As described in Section 4.9, conceptual or planning-level alternatives are uncertain by nature. Key assessments or investigations to help address uncertainties related to design and construction of this alternative are listed below:
  - An onsite geologic assessment and potentially a geotechnical investigation would be necessary to confirm construction and engineering details associated with the proposed tunnel, and the effects its construction might have on the existing spillway structure.
  - An assessment of the potential effects of steelhead entrainment in the sluice tunnel would be needed to address this uncertainty in detailed design.
  - Further study is needed to understand the frequency and duration required to flush varying volumes of accumulated sediment from the reservoir through operation of the sluice tunnel, and the resulting extent of mobilized sediments.

- An onsite geologic assessment and geotechnical investigation may be required during detailed design to confirm the extent of improvements required for the temporary access roads proposed for sediment access and hauling.

- Fish passage improvement alternatives (HDR et al. 2021) were developed based on existing conditions and infrastructure. The dam, spillway, and infrastructure improvements, in addition to the associated operational changes, outlined in this section for Alternative 5 (Recover Storage Capacity with Sluice Tunnel) may require changes in the fish passage improvement alternatives and associated costs.

8. Conclusions

Table 25 summarizes the estimates of OPCC for each alternative, breaking down the cost into “non-sediment removal,” “sediment removal,” and “fish passage” categories, to show what is driving the total cost for each alternative. As mentioned previously, this TM assumes the highest possible OPCC for fish passage improvements, as presented in HDR et al. (2021).

Table 25 Alternatives OPCC Summary

		Alternative OPCC			
Alternative No.	Alternative Name	Non-sediment OPCC	Sediment Removal OPCC	Fish Passage OPCC	Total
1	No Sediment Action	—	—	$82,100,000	$82,100,000
2	Dam and Sediment Removal	$41,910,000	$52,760,000	—	$94,670,000
3	Storage Expansion and Dredging	$30,430,000	$69,520,000	$82,100,000	$182,050,000
4	Recover Storage Capacity with Excavation (50-year total)	—	$195,720,000	$82,100,000	$277,820,000
5	Recover Storage Capacity with Sluice Tunnel	—	$60,380,000	$82,100,000	$142,480,000

Notes:

Totals are rounded up to the nearest thousand.

OPCC = Opinion of Probable Construction Costs

Table 26 summarizes the various advantages and disadvantages associated with the alternatives presented in the TM.

Alternative 1 (No Sediment Action) has the lowest construction cost of the five alternatives, while maintaining limited storage and summer releases in the near future until the reservoir fills with sediment. Although adult passage is provided via engineered fish passage improvement projects (HDR et al. 2021), existing issues associated with juvenile passage, reservoir predation, and temperature regime persist.

Alternative 2 (Dam and Sediment Removal) has the next lowest cost. This alternative provides great benefit to fish passage, restores habitat through the reservoir, provides improved downstream thermal regime and access to upstream temperature refugia, and eliminates all future O&M costs (the only alternative to do so). These benefits come at the price of lost storage, lost ability to release summer rearing flows from the reservoir, and the potential for lost water rights.

Alternative 5 (Recover Storage Capacity with Sluice Tunnel) has the potential to provide significant long-term benefits (at mid-level cost) associated with water storage and summer flow releases, while also providing improved engineered fish passage similar to other alternatives where the dam remains in place. However, as described in Section 7.8 and below, this alternative requires more analysis, planning, and agency coordination to finalize sluicing objectives and assess potential impacts of associated sediment releases.

The costs of Alternative 3 (Storage Expansion and Dredging) are high relative to the other alternatives discussed above, but significantly lower than Alternative 4 (Recover Storage Capacity with Excavation). This alternative provides increased storage and summer releases and improved adult passage at a high cost, but fails to address existing issues associated with juvenile passage, reservoir predation, and temperature regime. The cost of Alternative 3 could come down significantly with a reduction in the accumulated sediment removal volume.

Table 26 Alternatives Advantage/Disadvantage Comparison

No.	Alternative Name	Advantage/Disadvantage Cost	Local Impacts	Water Supply	Flooding	Geomorphology	Biological	Water Rights	Regulatory
1	No Sediment Action	+ • Up to $82 million of passage improvements; lowest cost	+ • Least impact of alternatives	- • Limits Cal-Am's ability to store water into the future	+ • Limits deposition and associated flooding impacts in the lower river channel until the reservoir is filled	- • Prevents the transport of coarse sediment and associated benefits until the reservoir is filled	- • Adult passage improvements less beneficial than Alternative 2 (Dam and Sediment Removal) volitional passage • Continues to block upstream passage for juveniles and provide suboptimal downstream juvenile passage • Provides suboptimal water temperature regime in summer months • As LPR fills long-term, reduces ability to enhance summer rearing habitat and downstream passage for steelhead + • Until the reservoir is filled with sediment, Alternative 1 (No Sediment Action) would provide summer flows capable of providing rearing habitat downstream of LPD	- • Potential reduction in Cal-Am's water rights	- • Sediment accumulation may limit the ability to meet requirement of SWRCB water rights permit for summer releases, and DSOD for reservoir drawdown (through outlet works)
2	Dam and Sediment Removal	+ • $95 million is the second-lowest among alternatives; only alternative without long-term O&M costs	- • Second-highest impact, due to four construction seasons	- • Reservoir storage lost	- • Restores downstream deposition and increased flood risk	+ • Increase in suitable spawning gravel, channel complexity, and overbank habitat connectivity	+ • Fully volitional upstream and downstream passage for all life stages of steelhead • Increased steelhead habitat in former reservoir area • Restored natural thermal regime and access to temperature refugia - • No ability to release summer flows	- • May lead to loss of water rights	+ • Limited long-term regulatory involvement and oversight
3	Storage Expansion and Dredging	- • $182 million ($100 million + $82 million of passage improvements) is the second-highest of alternatives	- • Highest impact due to filter/drain material on-hauling	+ • Highest increase in storage and summer flow releases	+ • No significant increase in sediment released downstream over current conditions	- • Prevents the transport of coarse sediment and associated benefits	- • Adult passage improvements are less beneficial than Alternative 2 (Dam and Sediment Removal)'s volitional passage • Spillway gates may negatively affect fish passage • Continues to block upstream juvenile passage and provide suboptimal downstream juvenile passage • Continued stress and migration delay for migrating steelhead • Provides a suboptimal water temperature regime in summer months + • Provides increased summer flows capable of providing rearing habitat downstream of LPD	+ • Increases capacity of LPR • Cal-Am could petition SWRCB to increase water right	+ • Increases ability to meet requirements of SWRCB water rights permit for summer releases
4	Recover Storage Capacity with Excavation	- • $278 million ($196 million + $82 million of passage improvements) is highest of the alternatives	+ • Second-lowest impact of alternatives due to minimal offsite hauling	+ • Maintains Cal-Am's ability to store water over time	+ • No additional sediment released downstream over current conditions, unless Zone 3 sediments are accessed and moved to Sites D and E during later bouts of sediment removal	- • Prevents the transport of coarse sediment and associated benefits, unless Zone 3 sediments are accessed and moved to Sites D and E during later bouts of sediment removal	- • Adult passage improvements less beneficial than Alternative 2 (Dam and Sediment Removal)'s volitional passage • Continues to block upstream juvenile passage and provide suboptimal downstream juvenile passage • Provides a suboptimal water temperature regime in summer months • Recurring access to floodplain disposal sites could affect steelhead critical habitat + • Provides summer flows capable of providing rearing habitat downstream of LPD	+ • Maintains existing water rights agreements	+ • Maintains status quo in meeting existing regulatory requirements

No.	Alternative Name	Cost	Local Impacts	Water Supply	Flooding	Geomorphology	Biological	Water Rights	Regulatory
		Advantage/Disadvantage							
5	Recover Storage Capacity with Sluice Tunnel	- • $142 million ($60 million + $82 million of passage improvements) is the third-highest of alternatives	+ • More impact than alternatives 1 and 4, but less than Alternatives 2 and 3	+ • Maintains Cal-Am's ability to store water over time	- • Depending on how sluicing is managed, could release accumulated coarse sediments downstream, increasing deposition and flood risk	+ • Potential benefit is dependent on how sluicing is managed	- • Steelhead in the Carmel River downstream of LPD could experience significant levels of mortality resulting from increased suspended sediment concentrations • Adult passage improvements are less beneficial than Alternative 2, volitional passage, and sluice tunnel operation could conflict with fish passage operation • Continues to block upstream juvenile passage and provide suboptimal downstream juvenile passage • Provides a suboptimal water temperature regime in summer months + • Provides summer flows capable of providing rearing habitat downstream of LPD • Depending on how sluicing is managed, has potential to improve spawning habitat through transport of coarse sediment	+ • Maintains or increases water rights	- • May be difficult to permit, given potential impact to steelhead and uncertainty of benefits

Notes:

+ Advantage
- Disadvantage
BGS = behavioral guidance system
Cal-Am = California American Water
DSOD = Division of Safety of Dams
LPD = Los Padres Dam
LPR = Los Padres Reservoir
MOU = memorandum of understanding
O&M = operations and maintenance
SWRCB = State Water Resources Control Board

Alternative 4 (Recover Storage Capacity with Excavation) has the highest cost of all the alternatives by a good margin through 50 years. Thereafter, costs would continue to accumulate, due to repeated bouts of sediment removal, and rise, due to cost escalation, into the future. This alternative does not appear to be a cost-effective solution to long-term sediment management, relative to the other alternatives presented in this TM.

Like Alternative 4 (Recover Storage Capacity with Excavation), Alternatives 3 (Storage Expansion and Dredging) and 5 (Recover Storage Capacity with Excavation) would retain LPD and include sediment management, thereby maintaining the ability to store and release water beyond when sediment accumulation would render Alternative 1 (No Sediment Action) incapable of significant storage. However, these two alternatives are in other ways quite different from each other.

Alternative 3 (Storage Expansion and Dredging) has more certainty regarding outcome than Alternative 5 (Recover Storage Capacity with Sluice Tunnel). The results of manual sediment removal are predictable relative to the sluice tunnel. As described in Section 7.8, substantial analysis may be needed to improve understanding of the sluice tunnel's effectiveness and effects. Although both alternatives have design uncertainties that would be addressed during detailed design, uncertainty regarding effectiveness and outcome differentiates Alternative 5 from other alternatives, including Alternative 3. Another major difference between Alternative 3 and Alternative 5 is that Alternative 5 provides a long-term solution to sediment management, but Alternative 3 is a one-time action that would reset the clock on sediment accumulation. Although Alternative 3 would be more expensive to construct than Alternative 5, the cost of Alternative 3 could be reduced by reducing the amount of sediment that would be removed, eliminating the spillway gates (which would also eliminate potential conflicts with proposed fish passage improvements), or both.

If a dam-in solution is preferred, rejection of the risk and uncertainty associated with Alternative 5 (Recover Storage Capacity with Sluice Tunnel) and focus on actions associated with Alternative 3 (Storage Expansion and Dredging) would allow for a more focused comparison and could lead to quicker identification of the preferred action. On the other hand, if Alternative 5 is retained, evaluation beyond the current scope of the LP Alternatives Study may be required before stakeholders and regulators can determine whether it is permittable or preferred.

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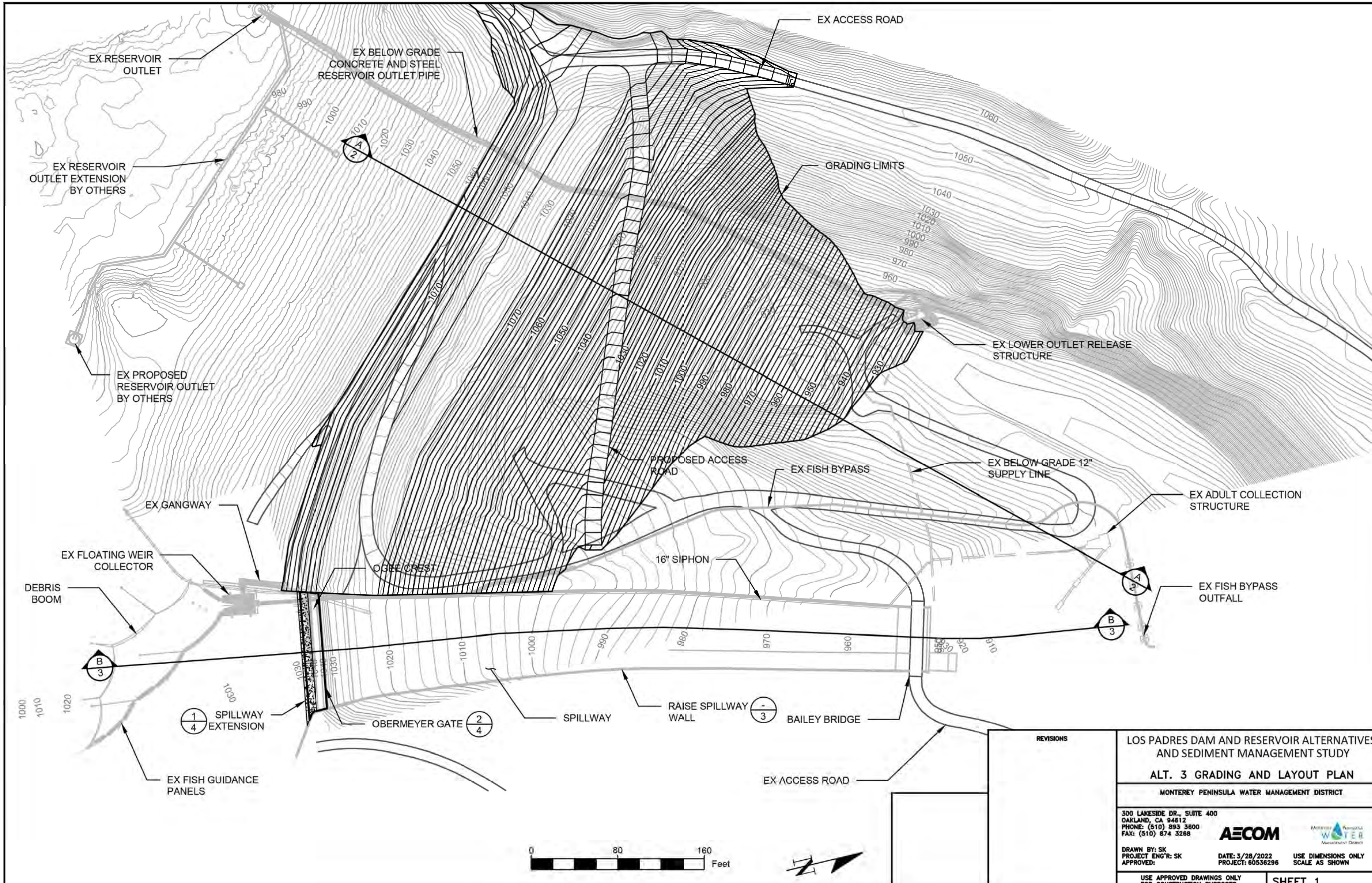
Appendix A
Alternatives Crosswalk

Table A-1 Summary of Scenarios and Alternatives Across Previous Documents that Are Most Relevant to the Current Alternatives

Alternatives Development TM (this document)	Effects to Steelhead TM (AECOM and Stillwater 2022)	Draft Fish Passage Feasibility Report (HDR et al. 2021)	IFIM Time Series Scenario (Normandeau 2019)	Basin Model Scenario (CRBHM) (see AECOM and Stillwater 2022)	Sediment Transport Scenario (BESMo) (Balance Hydrologics and UBC 2019)	Alternatives Descriptions TM (AECOM 2017)
Alternative 1 (No Sediment Action): No action is taken to manage existing or future sediment in the reservoir.	Alternative 1 (No Sediment Action): No action is taken to manage existing or future sediment in the reservoir.	U1, Technical Fish Ladder – Adult, or U8, Trap and Transport – Replace; and D1, Floating Surface Collector or D8, Spillway Modification (D5) and Existing FWC with 30 cfs Attraction Flow (D7).	Current Los Padres (CDO and ASR): incorporates CRBHM model for Alternative 1.	Current Los Padres: Model configured to represent CDO pumping (3,376 AFY) and ASR diversions, with the LPR in place with its current storage and operation.	No Action Simulation: No action is taken at LPD or LPR. Coarse sediment continues to accumulate in reservoir. Only bedload supply is from tributaries.	Alternative 1 (No Sediment Action): No action is taken to manage existing or future sediment in the reservoir.
Alternative 2 (Dam and Sediment Removal): Removal of Los Padres Dam, after removal (in the dry) of fine sediments (Zones 1 and 2).	Alternative 2 (Dam and Sediment Removal): Full dam removal down to original riverbed; includes removal of Zone 1 and 2 sediment via sluicing or dredging.	Volitional, no facilities.	Remove LPD: Incorporates CRBHM model for Alternative 2 (Dam and Sediment Removal).	Remove LPD: Model configured to simulate removal of LPD, with a water right of 3,376 AFY, which reflects the CDO pumping. In addition to pumping that complies with the CDO, ASR diversions are accounted for.	The Historical Supply Simulation represents a dam-out condition but does not account for Zone 3 sediment that would be left in place to transport downstream; therefore, Alternative 2 (Dam and Sediment Removal) may fall somewhere close to Historical Supply but between that and Uncontrolled Supply, which assumed all accumulated sediment is transported downstream.	Alternative 2 (Dam and Sediment Removal): Full (2a) (2b) dam removal down to original riverbed; includes removal of Zone 1 and 2 sediment via sluicing or dredging.
Alternative 3 (Storage Expansion and Dredging): Increase storage capacity through a combination of spillway gates and dredging (in the wet) Zones 1, 2, and part of Zone 3 sediments.	Alternative 4 (Recover Storage Capacity with Excavation): Rubber dam in spillway for late season operation to increase storage for summer months and dredging to remove sediment from reservoir.	U1, Technical Fish Ladder – Adult, or U8, Trap and Transport – Replace; and D1, Floating Surface Collector or D8, Spillway Modification (D5) and Existing FWC with 30 cfs Attraction Flow (D7).	Los Padres Expanded Storage - Rubber Dam: Incorporates CRBHM model for Alternative 4.	Los Padres Expanded Storage: Simulates a spillway gates and dredging, with a water right of 4,492 AFY, which reflects additional storage capacity at LPR (3,295 acre-feet) and pre-1914 and riparian rights (1,197 acre-feet). Assumes a new water right and pumping above the 3,376 AFY CDO limit.	No Action Simulation: No action is taken at LPD or LPR. Coarse sediment continues to accumulate in reservoir. Only bedload supply is from tributaries.	Combination of Alternative 4 (Recover Storage Capacity with Excavation): Rubber dam in spillway for late season operation to increase storage for summer months (4b) and Alternative 3a, Restore Capacity by Dredging.
Alternative 4 (Recover Storage Capacity with Excavation): Periodically (every 5 years [Alternative 4a] or every 10 years [Alternative 4b]) excavate deposited sediments to maintain or recover reservoir storage capacity.	Combination of Sediment Management Option (SM) 1, excavate Zones 2 and 3 and place in disposal sites, and SM 2, excavate Zone 3 and place in floodplain.	U1, Technical Fish Ladder – Adult, or U8, Trap and Transport – Replace; and D1, Floating Surface Collector or D8, Spillway Modification (D5) and Existing FWC with 30 cfs Attraction Flow (D7).	Not specifically addressed in IFIM but outcome would be somewhere between "Current Los Padres" scenario and "Los Padres Expanded Storage - Dredging" scenarios.	Not specifically addressed in CRBHM but outcome would be somewhere between "Current Los Padres" and "Los Padres Expanded Storage" scenarios.	Not specifically addressed in BESMo. Depending on amount of course sediment introduced to the floodplain, outcome would be somewhere between No Action and Pulsed Supply simulations.	Combination of Sediment Management Option (SM) 1, excavate Zones 2 and 3 and place in disposal sites, and SM 2, excavate Zone 3 and place in floodplain.
Alternative 5 (Recover Storage Capacity with Sluice Tunnel): Install a sluice tunnel through the east abutment that would be used to flush sediment from the reservoir during wet water years.	Sediment Management Option 3, Sluicing Tunnel: Tunnel through dam abutment to sluice reservoir sediment during storm events.	U1, Technical Fish Ladder – Adult, or U8, Trap and Transport – Replace; and D1, Floating Surface Collector or D8, Spillway Modification (D5) and Existing FWC with 30 cfs Attraction Flow (D7).	Not specifically addressed in IFIM but outcome would be somewhere between "Current Los Padres" scenario and "Los Padres Expanded Storage - Dredging" scenarios.	Not specifically addressed in CRBHM but outcome would be somewhere between "Current Los Padres" and "Los Padres Expanded Storage" scenarios.	Pulsed Supply Simulation: Pulses of bedload from LPR deposits are introduced into the river. Assumes a sluice tunnel with 5,000 cfs capacity and a minimum sluice flow of 500 to 1,500 cfs.	Sediment Management Option 3, Sluicing Tunnel: Tunnel through dam abutment to sluice reservoir sediment during storm events.

Appendix B
Drawings



REVISIONS	LOS PADRES DAM AND RESERVOIR ALTERNATIVES AND SEDIMENT MANAGEMENT STUDY
	ALT. 3 GRADING AND LAYOUT PLAN
	MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

300 LAKESIDE DR., SUITE 400
OAKLAND, CA 94612
PHONE: (510) 893 3600
FAX: (510) 874 3268

AECOM

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PROJECT ENG'R: SK
APPROVED:

DATE: 3/28/2022
PROJECT: 60536296

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SHEET 1

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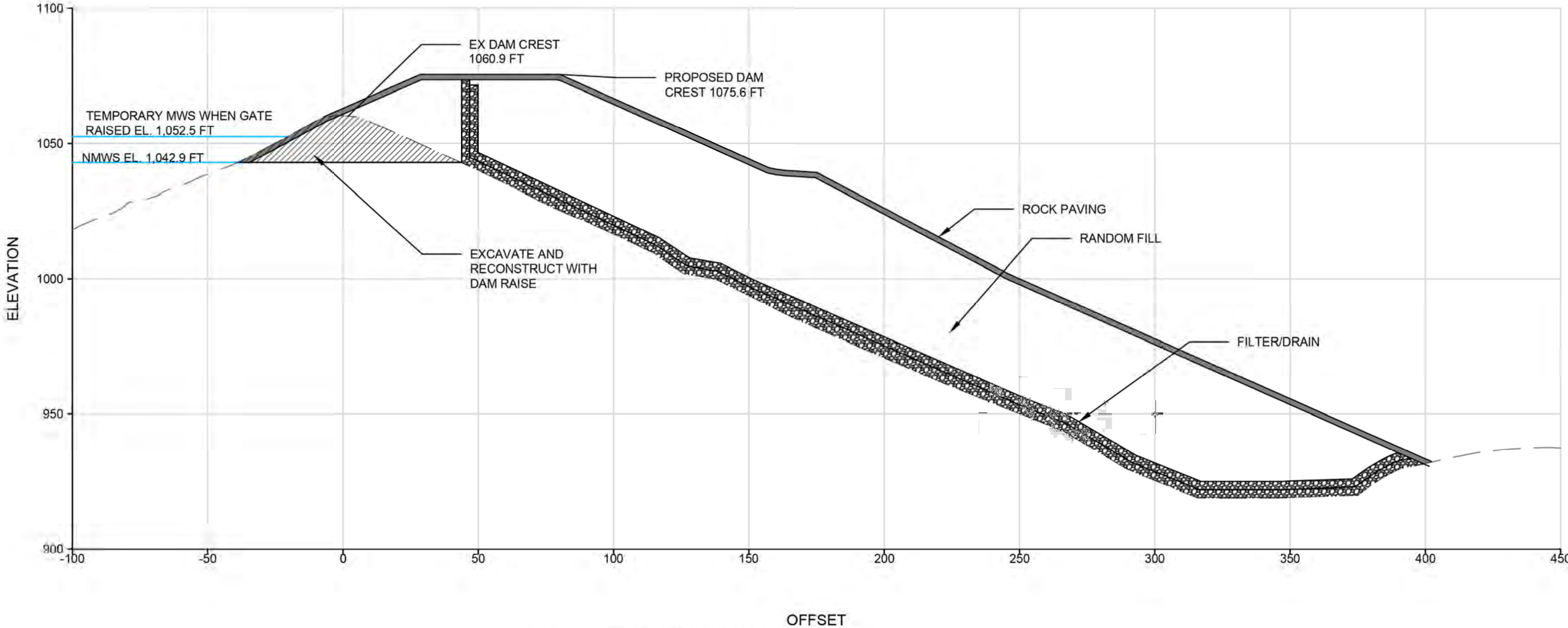
NOTES:
1. BASE CONTOURS GENERATED USING ASSISTED PHOTOGRAMMETRIC METHODS BY HJW GEOSPACIAL, INC., OAKLAND, CA. DATED NOVEMBER 24, 2010
2. ACCURACY OF CONTOURS MAY DEVIATED FROM ACCEPTED STAMDARDS IN AREAS OF DENSE VEGETATION
3. HORIZONTAL COORDINATES ARE IN REFERENCE TO CALIFORNIA STATE PLANE, ZONE IV, NAD 1983
4. VERTICAL ELEVATIONS ARE IN REFERENCE TO NAVD88



A
1
TYPICAL DAM SECTION

0 40 80
Feet

REVISIONS

LOS PADRES DAM AND RESERVOIR ALTERNATIVES AND SEDIMENT MANAGEMENT STUDY

ALT. 3 TYPICAL DAM RAISE SECTION

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SHEET 2

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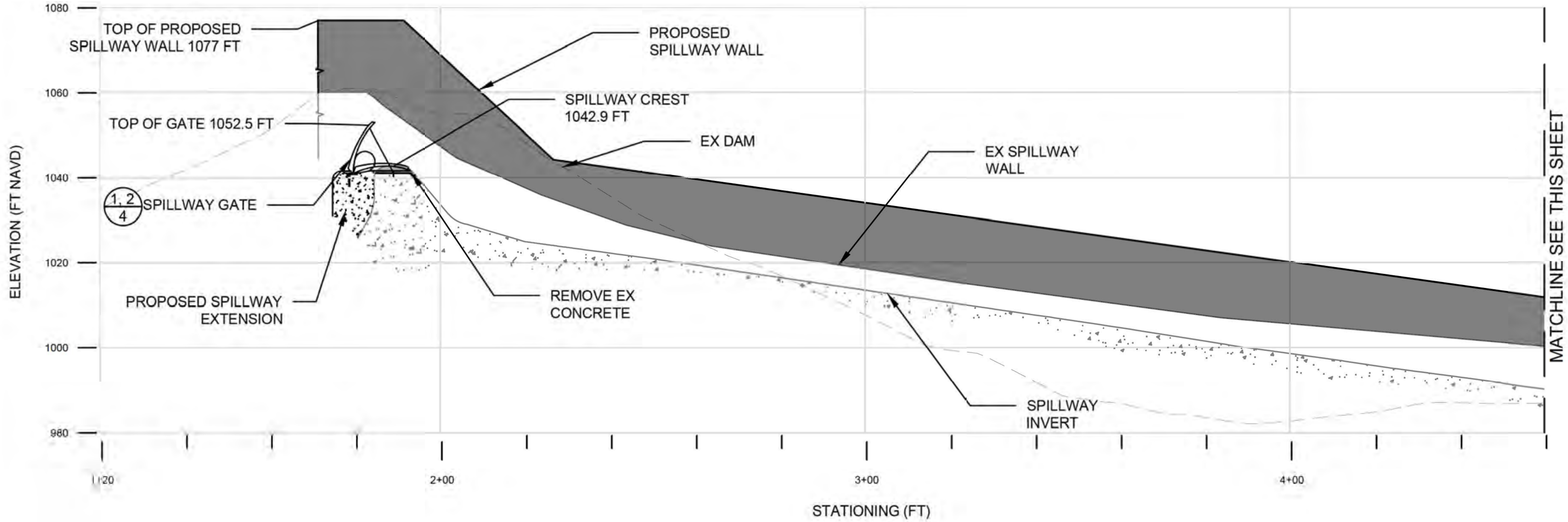

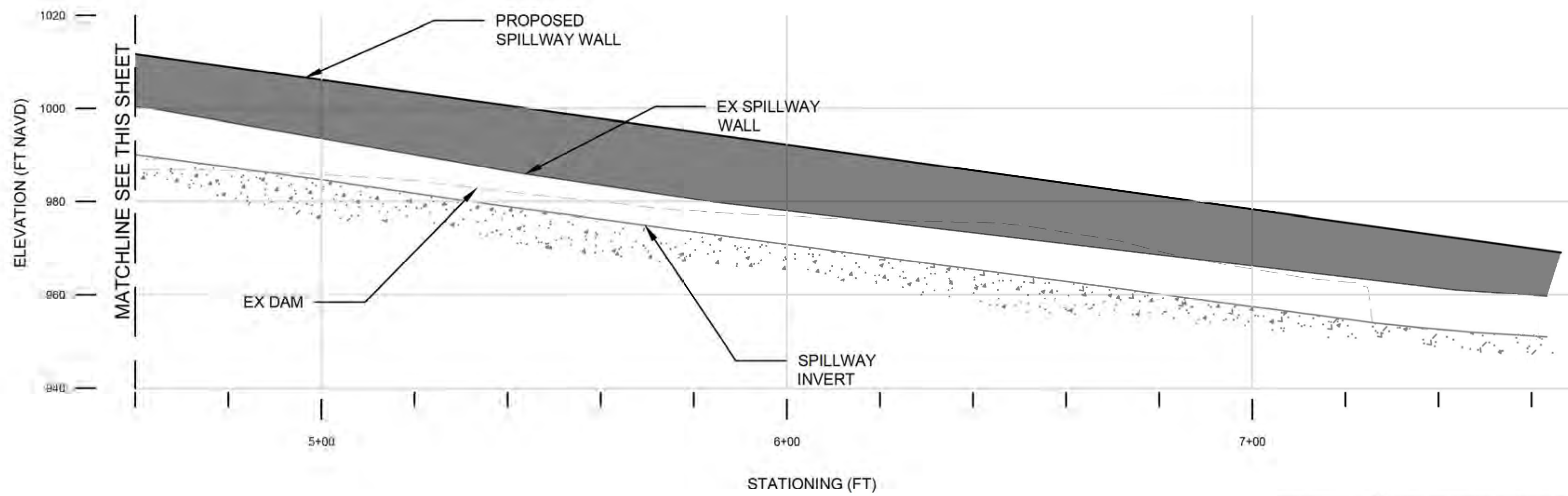

B/1 SPILLWAY PROFILE

0 30 60 Feet

REVISIONS	LOS PADRES DAM AND RESERVOIR ALTERNATIVES AND SEDIMENT MANAGEMENT STUDY
	ALT. 3 CONCRETE SPILLWAY PROFILE
	MONTEREY PENINSULA WATER MANAGEMENT DISTRICT
	300 LAKESIDE DR., SUITE 400 OAKLAND, CA 94612 PHONE: (510) 893 3600 FAX: (510) 874 3268 AECOM
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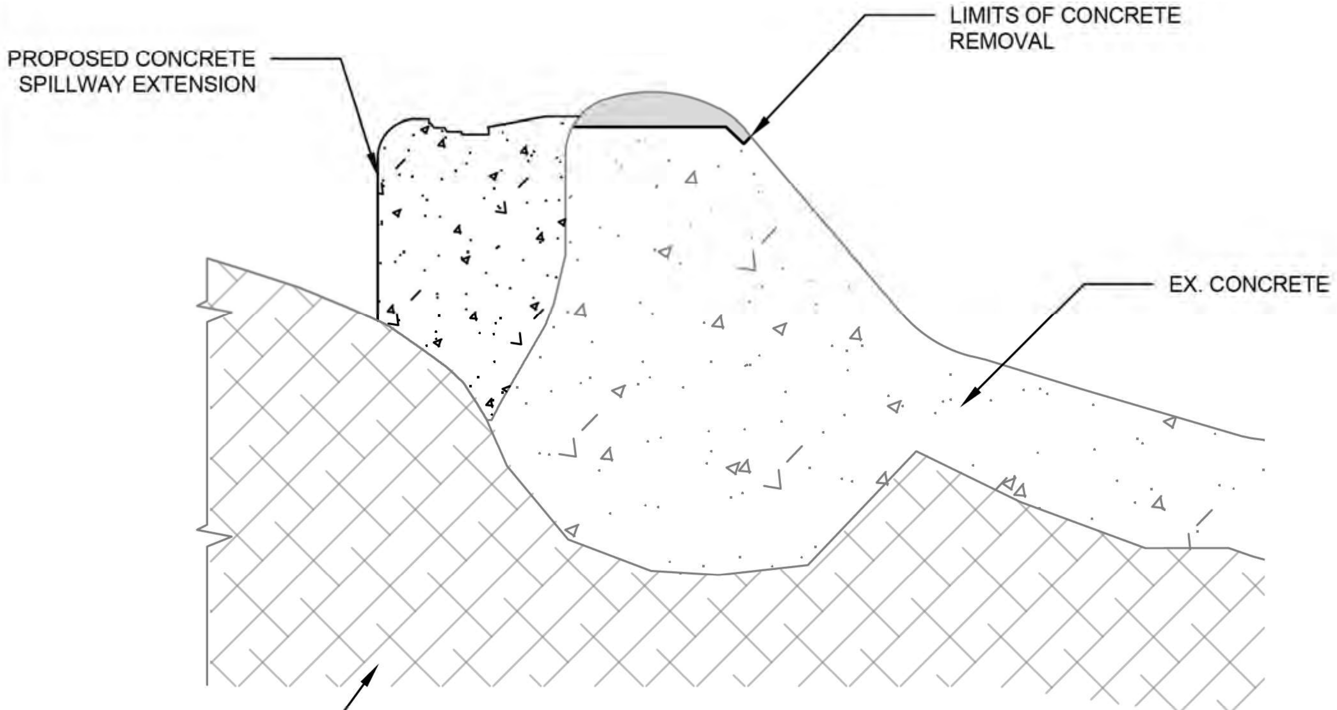
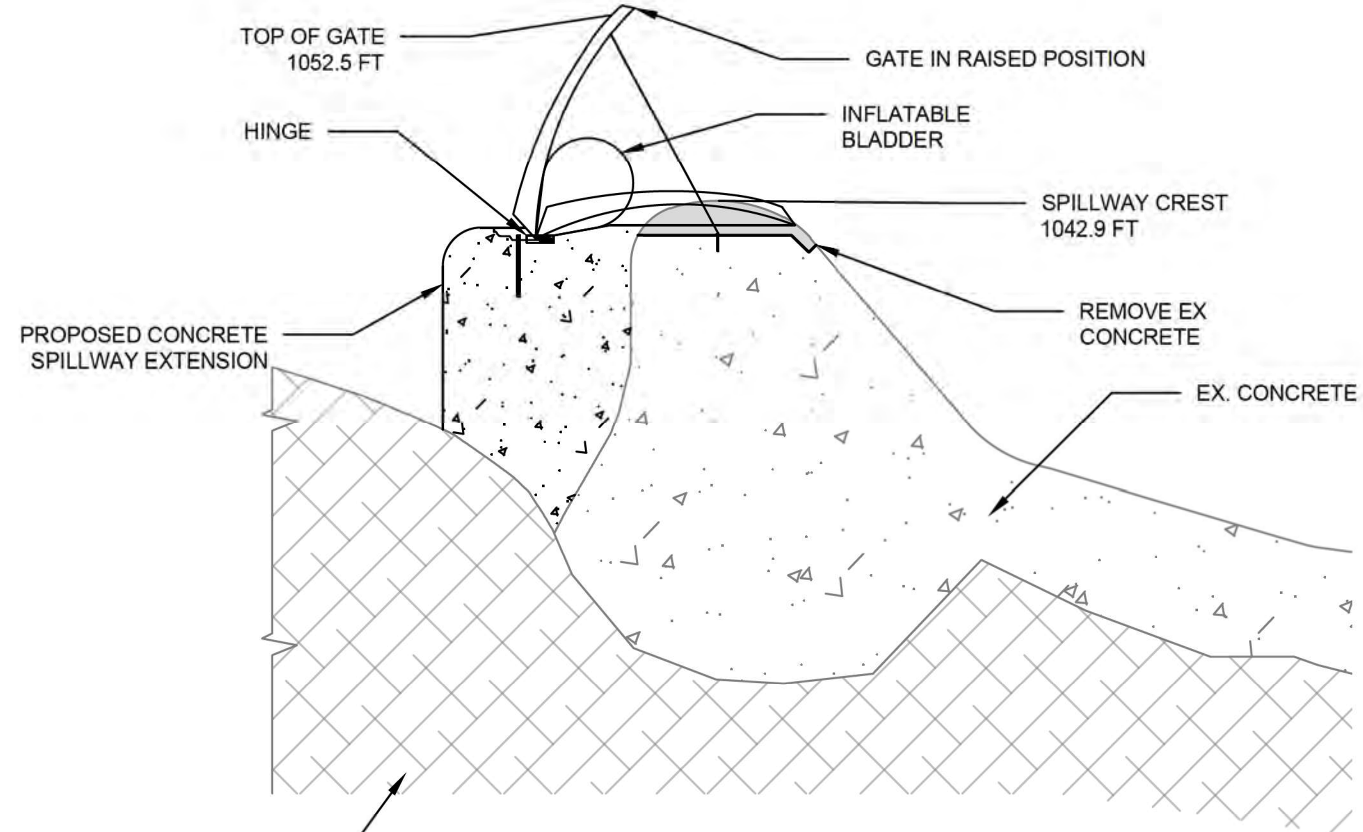
PRELIMINARY – NOT FOR CONSTRUCTION



1
1, 3
SPILLWAY MODIFICATION SECTION



2
1, 3
SPILLWAY GATE

0 10 20 Feet

REVISIONS

LOS PADRES DAM AND RESERVOIR ALTERNATIVES AND SEDIMENT MANAGEMENT STUDY

ALT. 3 SPILLWAY DETAILS

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SHEET 4

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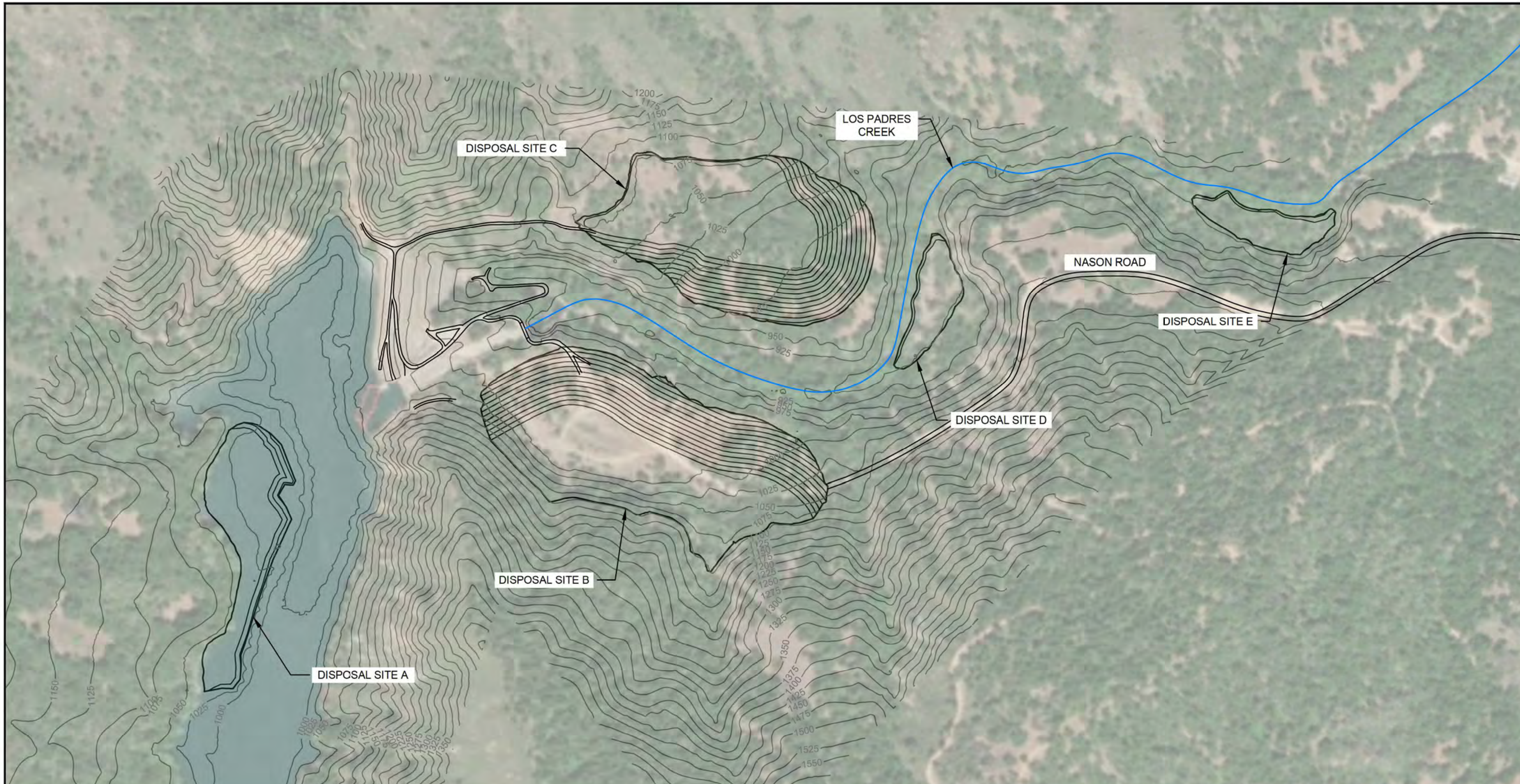

NOTES:

1. ALTERNATIVE 2 ASSUMES USE OF DISPOSAL SITES A, B, AND C
2. ALTERNATIVE 3 ASSUMES USE OF DISPOSAL SITES B, C, D, AND E
3. ALTERNATIVE 4 ASSUMES USE OF DISPOSAL SITES B, C, D, AND/OR E

0 400 800 Feet

REVISIONS

LOS PADRES DAM AND RESERVOIR ALTERNATIVES AND SEDIMENT MANAGEMENT STUDY

DISPOSAL SITES OVERVIEW

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

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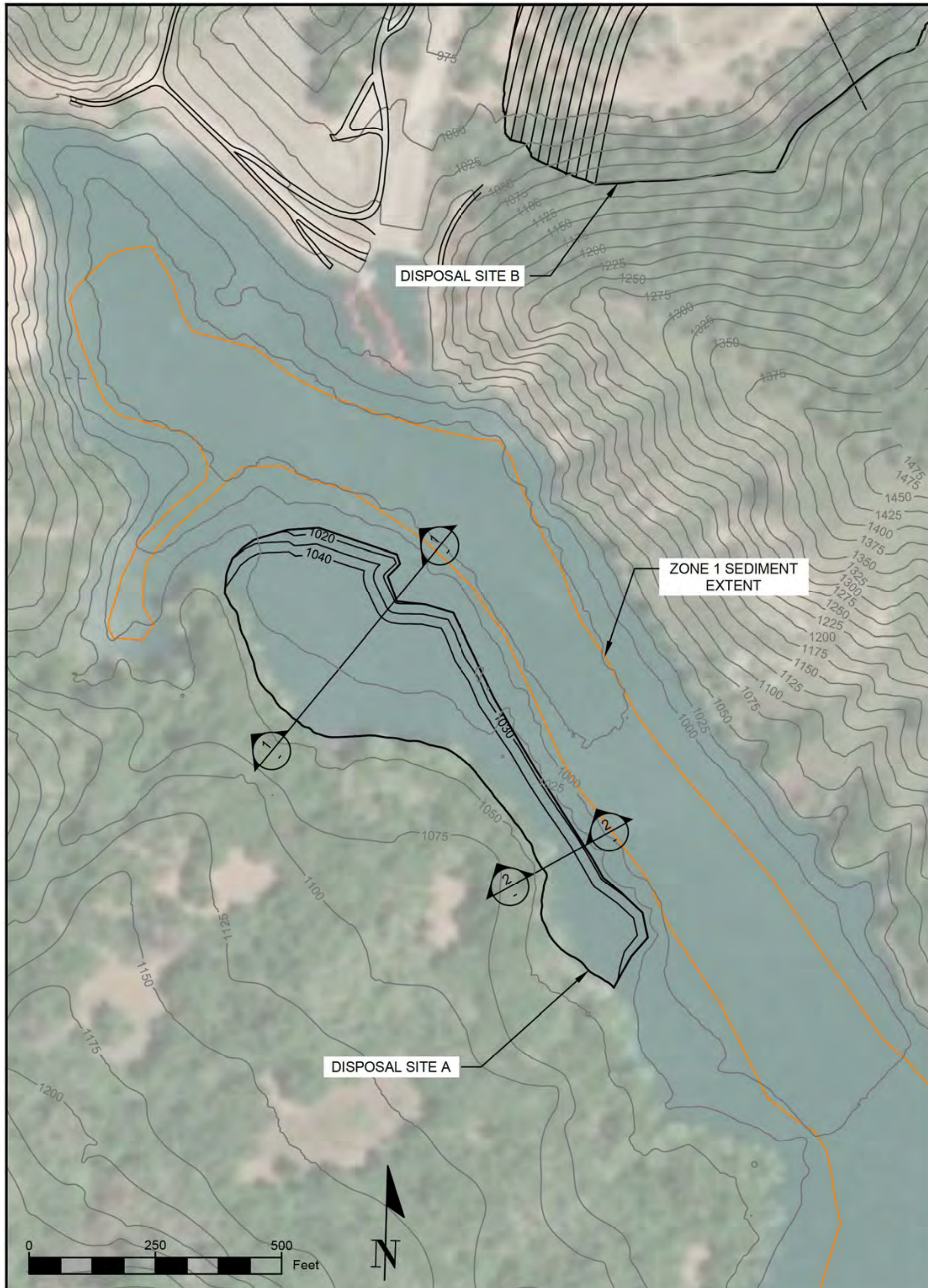
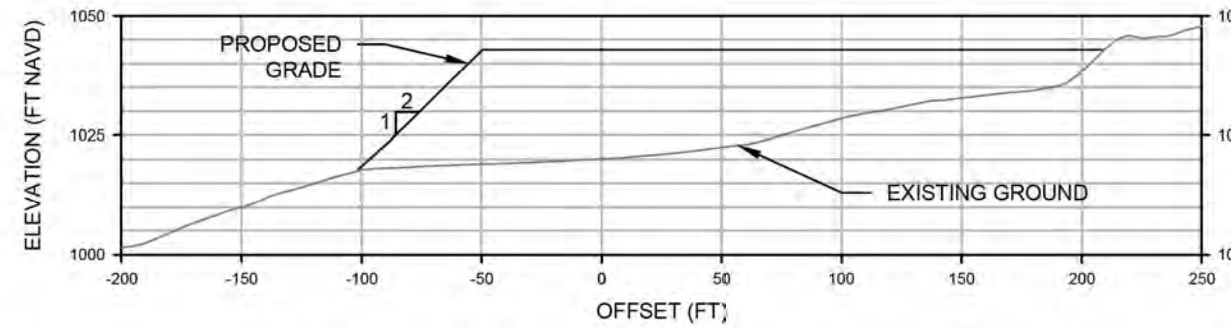
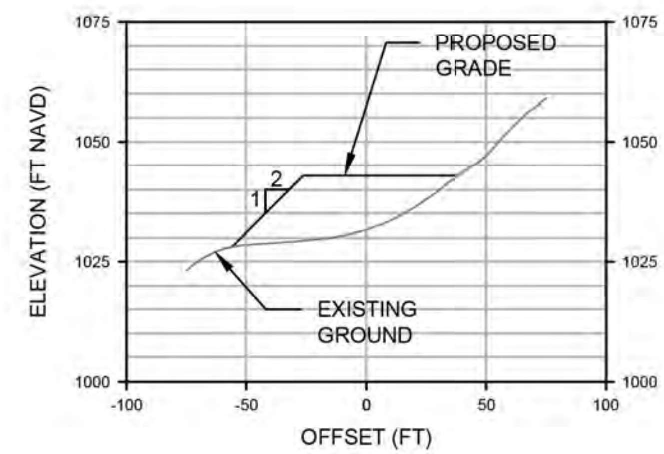
SHEET 5

PRELIMINARY – NOT FOR CONSTRUCTION





1 SITE A SECTION



2 SITE A SECTION

NOTES:

1. ALTERNATIVE 2 ASSUMES USE OF DISPOSAL SITES A, B, AND C

REVISIONS

LOS PADRES DAM AND RESERVOIR ALTERNATIVES AND SEDIMENT MANAGEMENT STUDY

DISPOSAL SITE A

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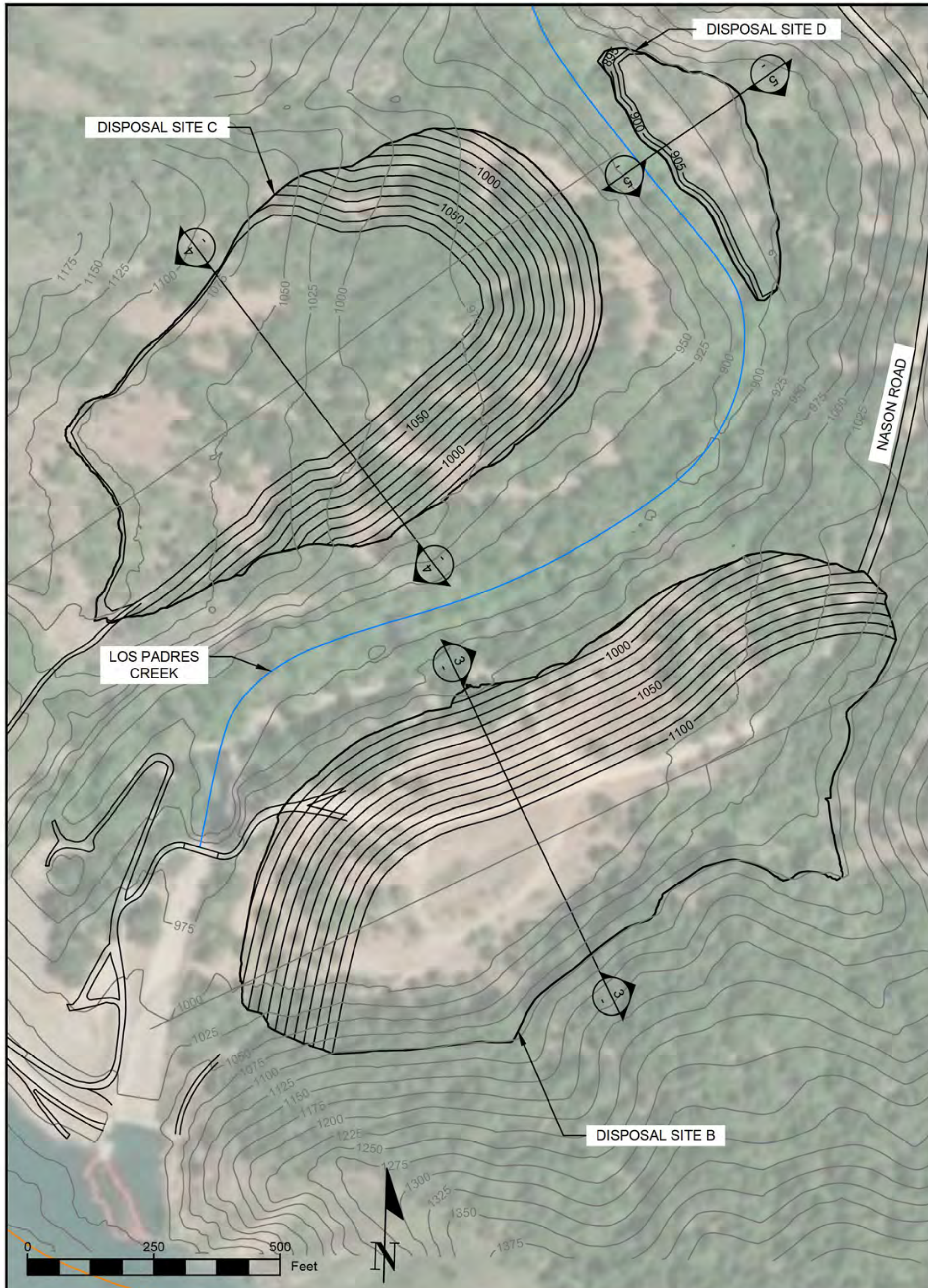
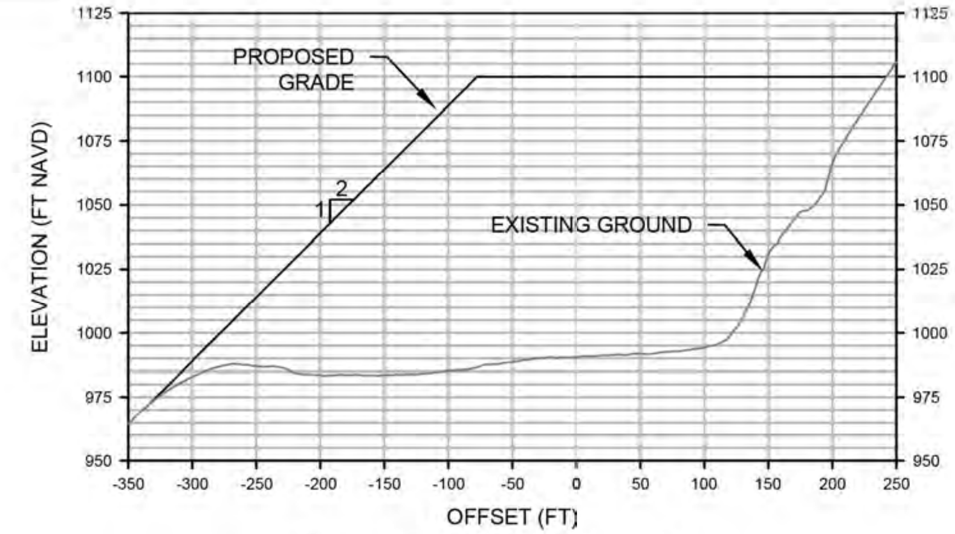
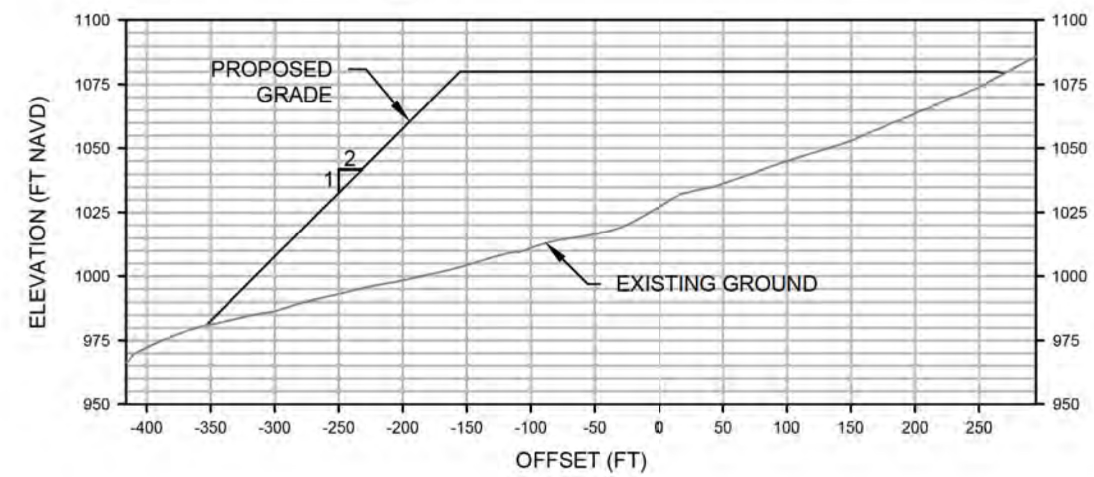
SHEET 6

PRELIMINARY – NOT FOR CONSTRUCTION

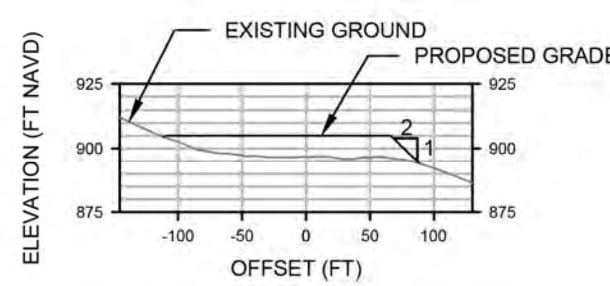




3 - SITE B SECTION



4 - SITE C SECTION



5 - SITE D SECTION

NOTES:

1. ALTERNATIVE 2 ASSUMES USE OF DISPOSAL SITES A, B, AND C
2. ALTERNATIVE 3 ASSUMES USE OF DISPOSAL SITES B, C, D, AND E
3. ALTERNATIVE 4 ASSUMES USE OF DISPOSAL SITES B, C, D, AND/OR E
4. SIDE SLOPES ARE APPROXIMATE AND MAY BE REDUCES TO 3H:1V AS DESIGN PROGRESSES. INTERMEDIATE BENCHES MAY ALSO BE REQUIRE DEPENDING ON SLOPE HEIGHT

REVISIONS

LOS PADRES DAM AND RESERVOIR ALTERNATIVES AND SEDIMENT MANAGEMENT STUDY

DISPOSAL SITE B, C & D

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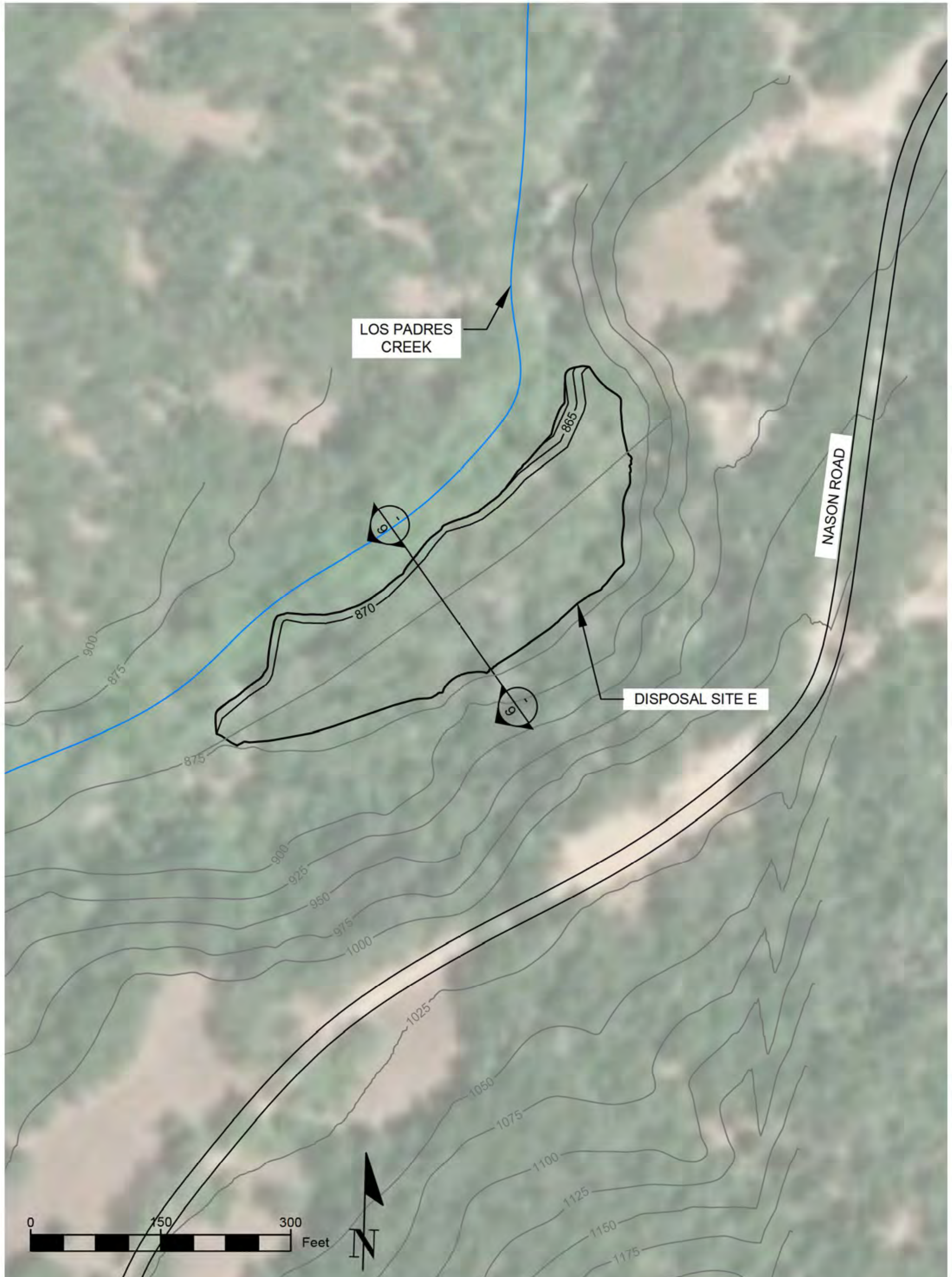
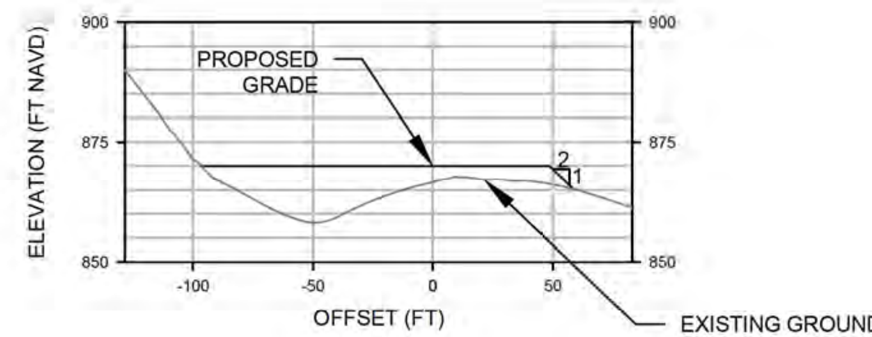
SHEET 7

PRELIMINARY – NOT FOR CONSTRUCTION





6
-
SITE E SECTION

NOTES:

1. ALTERNATIVE 3 ASSUMES USE OF DISPOSAL SITES B, C, D, AND E
2. ALTERNATIVE 4 ASSUMES USE OF DISPOSAL SITES B, C, D, AND/OR E
3. SIDE SLOPES ARE APPROXIMATE AND MAY BE REDUCES TO 3H:1V AS DESIGN PROGRESSES. INTERMEDIATE BENCHES MAY ALSO BE REQUIRE DEPENDING ON SLOPE HEIGHT

REVISIONS

LOS PADRES DAM AND RESERVOIR ALTERNATIVES AND SEDIMENT MANAGEMENT STUDY

DISPOSAL SITE E

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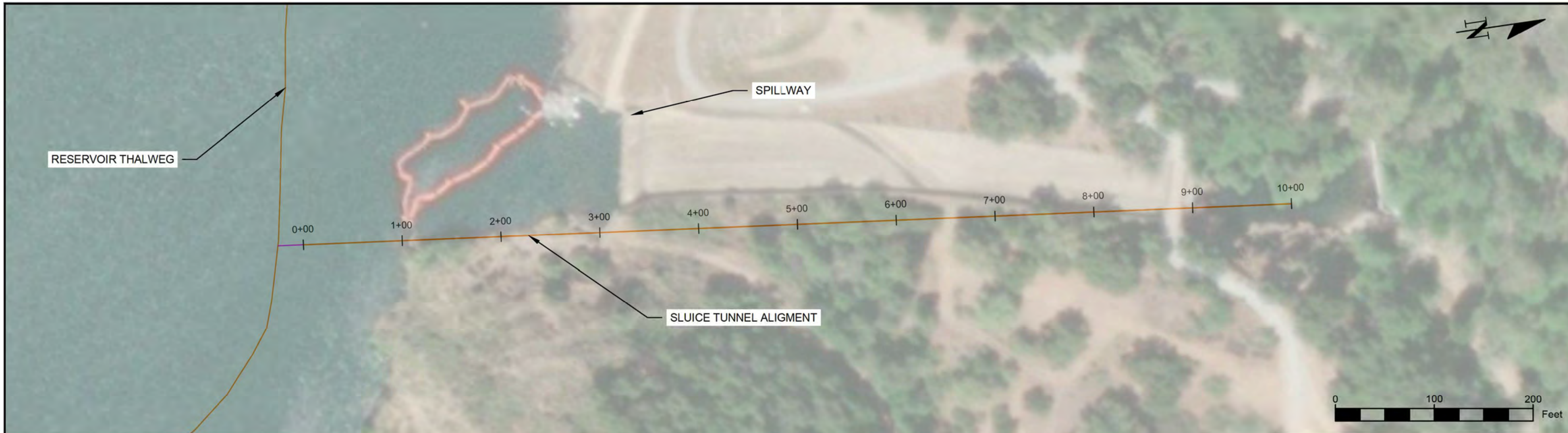
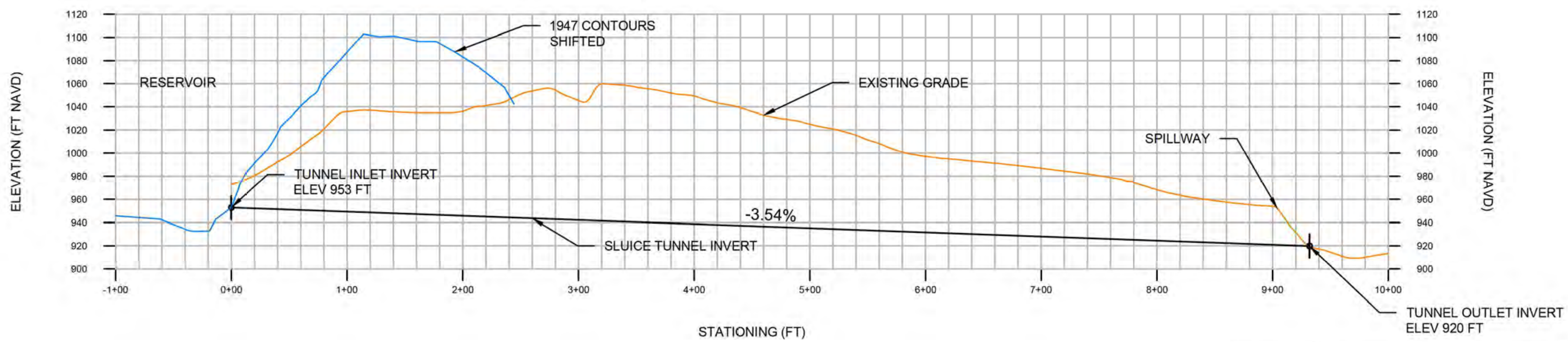
SHEET 8

PRELIMINARY – NOT FOR CONSTRUCTION



SLUICE TUNNEL PROFILE



REVISIONS

LOS PADRES DAM AND RESERVOIR ALTERNATIVES AND SEDIMENT MANAGEMENT STUDY

SLUICE TUNNEL PLAN & PROFILE

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

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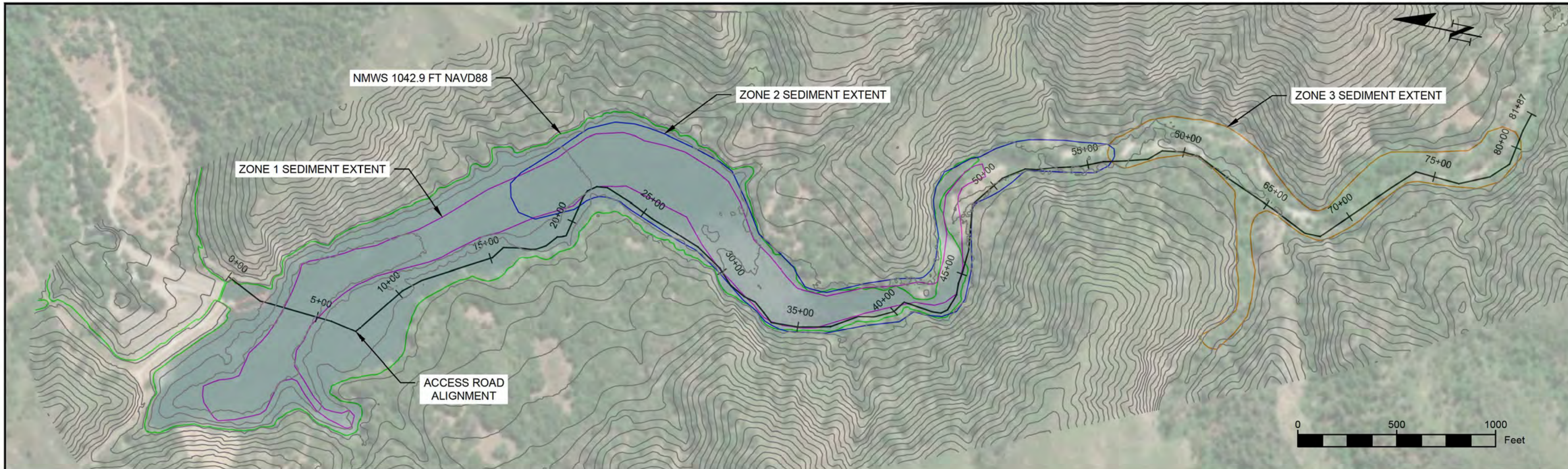
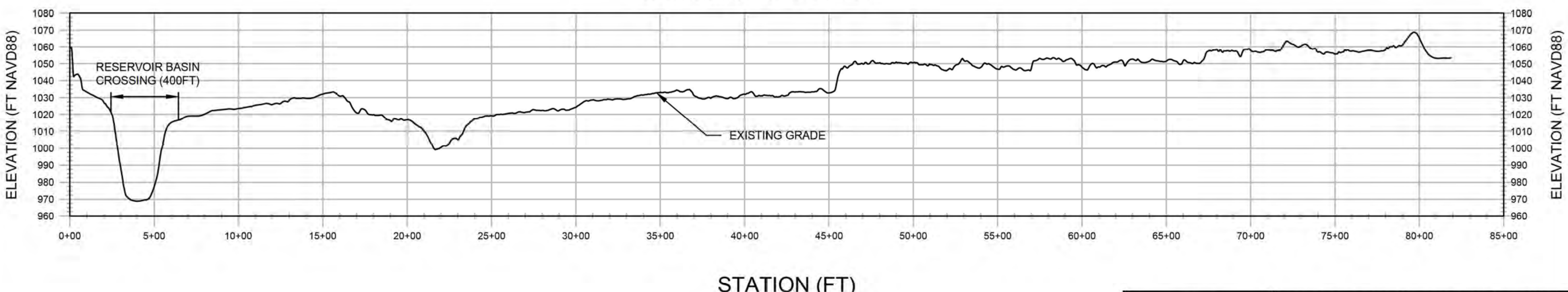
SHEET 9

PRELIMINARY – NOT FOR CONSTRUCTION



ACCESS ROAD PROFILE



REVISIONS

LOS PADRES DAM AND RESERVOIR ALTERNATIVES AND SEDIMENT MANAGEMENT STUDY

ALT 2. ACCESS ROAD PLAN & PROFILE

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

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SHEET 10

PRELIMINARY — NOT FOR CONSTRUCTION

Appendix C
OPCC Details

Date: 3/29/22

OPCC Breakdown: Alt. 2 - Dam and Sediment Removal (Z1/2)

LINE ITEM #	LINE ITEM	QUANTITY	UNIT	UNIT COST	AMOUNT
1	**Mobilization/Demobilization**				**$ 4,480,427**
	Mobilization/demobilization (10%)	1	LS	$ 4,480,427	$ 4,480,427
2	**Site Preparation**				**$ 5,814,109**
	Clear and grub staging/Disposal Sites B and C	30.9	ACRE	$ 4,156	$ 128,420
	Water Diversion/Controls				
	Install temp. diversion structure (sheetpiles and earthen berm)	6,000	SF	$ 70	$ 420,000
	Install temporary diversion gate	1	LS	$ 10,000	$ 10,000
	Seasonal removal of earthern berm	3	EA	$ 10,000	$ 30,000
	Seasonal re-build of earthern berm	3	EA	$ 15,000	$ 45,000
	Remove diversion structure	1	LS	$ 10,000	$ 10,000
	Install temporary diversion pipeline (<66" CMP)	6,200	LF	$ 150	$ 930,000
	Repair pipeline	1,860	LF	$ 150	$ 279,000
	Remove pipeline	6,200	LF	$ 18	$ 111,600
	Dewatering treatment system - rent package	24	mo	$ 25,000	$ 600,000
	Dewatering treatment system - staffing	12	mo	$ 14,400	$ 172,800
	Dewatering treatment system - O&M	1	LS	$ 60,000	$ 60,000
	Dewatering trenching/pumping system (post-drawdown)	1	LS	$ 500,000	$ 500,000
	Access				
	Improve existing dam crest road	550	LF	$ 100	$ 55,000
	Spillway bridge improvements (for construction loads)	1	LS	$ 250,000	$ 250,000
	Improve and widen existing access ramp from dam crest to reservoir	200	LF	$ 100	$ 20,000
	Access ramp to new Site B access road	2,000	CY	$ 26	$ 52,000
	New Disposal Site B access road grading	778	CY	$ 8	$ 6,222
	New Disposal Site B access road aggregate base	294	TON	$ 35	$ 10,283
	Improve and widen existing Disposal Site C access road	650	LF	$ 100	$ 65,000
	Place fill to cross reservoir to terrace	10,667	CY	$ 26	$ 277,333
	Install temporary culverts under crossing	100	LF	$ 300	$ 30,000
	New access road into upper reservoir (1.25 miles)	6,200	LF	$ 35	$ 217,000
	Repair access roads	2,790	LF	$ 35	$ 97,650
	Traffic control (haul road flaggers/truck safety)	18	mo	$ 57,600	$ 1,036,800
	Lighting for night work	1	LS	$ 200,000	$ 200,000
	Offsite access improvements	1	LS	$ 200,000	$ 200,000
3	**Dam Removal**				**$ 9,660,000**
	Demolish FWC and control house	1	LS	$ 50,000	$ 50,000
	Demolish outlet works (low level, high level and siphon)	1	LS	$ 25,000	$ 25,000
	Demolish electrical	1	LS	$ 25,000	$ 25,000
	Demolish spillway	6,000	CY	$ 50.00	$ 300,000
	Process concrete for disposal	6,000	CY	$ 10.00	$ 60,000
	Excavate dam embankment, haul and place at disposal site	460,000	CY	$ 20.00	$ 9,200,000
4	**Reservoir Restoration**				**$ 7,270,000**
	Channed and floodplain fine grading	200,000	CY	$ 8	$ 1,600,000
	Riparian restoration (incl. irrigation)	10	ACRE	$ 51,000	$ 510,000
	Grassland restoration (incl. irrigation)	20	ACRE	$ 48,000	$ 960,000
	Scrub (incl. irrigation)	5	ACRE	$ 45,000	$ 225,000
	Oak woodland (incl. irrigation)	15	ACRE	$ 45,000	$ 675,000
	Channel engineered improvements	6,000	LF	$ 550	$ 3,300,000
5	**Sediment Removal**				**$ 22,060,163**
	Zone 1 and 2 sediment removal (dry), hauling and placement	1,680,000	CY	$ 7.5	$ 12,600,000
	Disposal Site Management	1,680,000	CY	$ 5.5	$ 9,240,000
	Hydroseeding of disposal areas	38.6	ACRE	$ 5,700	$ 220,163
	Subtotal				**$ 49,284,699**
	General Conditions (10%)				$ 4,928,470
	Bond (3%)				$ 1,478,541
	General Contractor's OH and Profit (15%)				$ 7,392,705
	Total Construction Cost				**$ 63,084,414**
	Contingency (50%)				$ 31,542,207
	Total Construction Cost w/ Contingency				**$ 94,626,621**
	Low Side of Class 5 Estimate Range (-30%)				**$ 66,238,635**
	High Side of Class 5 Estimate Range (+50%)				**$ 141,939,932**

Date: 3/29/22

OPCC Breakdown: Alt 3. - Storage Expansion and Dredging (Z1/2/3)

LINE ITEM #	LINE ITEM	QUANTITY	UNIT	UNIT COST	AMOUNT
1	**Mobilization/Demobilization**				**$ 4,729,640**
	Mobilization/Demobilization (10%)	1	LS	$ 4,729,640	$ 4,729,640
2	**Site Preparation**				**$ 3,121,171**
	Clear and grub staging/Disposal Sites B, C, D and E	34.5	ACRE	$ 4,156	$ 143,382
	Cofferdam for spillway modifications	4,000	SY	$ 110	$ 440,000
	Workpad for spillway modifications	5,186	CY	$ 26	$ 134,834
	Dewatering for spillway modifications	1	LS	$ 100,000	$ 100,000
	Offloading area (per season)	4	LS	$ 10,000	$ 40,000
	Access				
	Improve existing dam crest road	550	LF	$ 100	$ 55,000
	Spillway bridge improvements (for construction loads)	1	LS	$ 250,000	$ 250,000
	Improve and widen existing access ramp from crest to reservoir	200	LF	$ 100	$ 20,000
	Access ramp to new Disposal Site B access road	2,000	CY	$ 26	$ 52,000
	New Disposal Site B access road grading	778	CY	$ 8	$ 6,222
	NewDisposal Site B access road aggregate base	294	TON	$ 35	$ 10,283
	Improve and widen existing Disposal Site C access road	650	LF	$ 100	$ 65,000
	Repair access roads	630	LF	$ 35	$ 22,050
	Traffic control (haul road flaggers/truck safety)	24	mo	$ 57,600	$ 1,382,400
	Lighting for night work	1	LS	$ 200,000	$ 200,000
	Offsite access improvements	1	LS	$ 200,000	$ 200,000
3	**Spillway Modifications and Gate Installation**				**$ 4,093,622**
	Drill & break out concrete	244	CY	$ 150	$ 36,667
	Haul and place concrete in disposal area	281	CY	$ 20	$ 5,622
	Foundation treatment	3,300	SF	$ 100	$ 330,000
	Reconstruct reinforced concrete spillway crest	587	CY	$ 800	$ 469,333
	Raise spillway walls	1,200	LF	$ 660	$ 792,000
	Gate material and installation	1	LS	$ 2,000,000	$ 2,000,000
	PLC system for gate	1	LS	$ 160,000	$ 160,000
	Outlet works contingency	1	LS	$ 250,000	$ 250,000
	Control system start-up	1	LS	$ 50,000	$ 50,000
4	**Dam Embankment Raise**				**$ 8,733,292**
	Excavate rock paving on dam face	10,530	CY	$ 26	$ 273,780
	Haul rock paving debris to disposal site	12,121	CY	$ 5	$ 60,603
	Place debris at disposal site	12,121	CY	$ 15	$ 181,809
	Excavate top of dam & stockpile	19,350	CY	$ 26	$ 503,100
	Import filter/drain material and place	41,000	CY	$ 78	$ 3,198,000
	Place embankment fill (from onsite stockpile)	150,000	CY	$ 26	$ 3,900,000
	Place new rock paving	15,400	CY	$ 40	$ 616,000
5	**Sediment Removal**				**$ 31,348,313**
	Zone 1, 2, 3 sediment removal and aquatic transport	1,885,000	CY	$ 5.5	$ 10,367,500
	Hauling and disposal site management	1,885,000	CY	$ 11	$ 20,735,000
	Hydroseeding of disposal areas	43.1	ACRE	$ 5,700	$ 245,813
	Subtotal				**$ 52,026,038**
	General Conditions (10%)				$ 5,202,604
	Bond (3%)				$ 1,560,781
	General Contractor's OH and Profit (15%)				$ 7,803,906
	Total Construction Cost				**$ 66,593,328**
	Contingency (50%)				$ 33,296,664
	Total Construction Cost w/ Contingency				**$ 99,889,992**
	Low Side of Class 5 Estimate Range (-30%)				**$ 69,922,994**
	High Side of Class 5 Estimate Range (+50%)				**$ 149,834,988**

Date: 3/29/22
OPCC Breakdown: Alt. 4b - Recover Storage Capacity with Excavation (Periodic - every 10 years)

LINE ITEM #	LINE ITEM	QUANTITY	UNIT	UNIT COST	AMOUNT
1	**Mobilization/Demobilization**				**$ 648,194**
	Mobilization/Demobilization (10%)	1	LS	$ 648,194	$ 648,194
2	**Site Preparation**				**$ 1,041,776**
	Clear and grub staging/Disposal Sites B and C	30.9	ACRE	$ 4,156	$ 128,420
	Offloading area (per season)	1	LS	$ 10,000	$ 10,000
	Access				
	Improve ex. dam crest road	550	LF	$ 100	$ 55,000
	Spillway bridge improvements (for construction loads)	1	LS	$ 250,000	$ 250,000
	Improve and widen existing access ramp from crest to reservoir	200	LF	$ 100	$ 20,000
	Access ramp to new Disposal Site B access road	2,000	CY	$ 26	$ 52,000
	New Disposal Site B access road grading	778	CY	$ 8	$ 6,222
	New Disposal Site B access road aggregate base	294	TON	$ 35	$ 10,283
	Improve and widen existing Disposal Site C access road	650	LF	$ 100	$ 65,000
	Repair access roads	630	LF	$ 35	$ 22,050
	Traffic control (haul road flaggers/truck safety)	3	mo	$ 57,600	$ 172,800
	Lighting for night work	1	LS	$ 50,000	$ 50,000
	Offsite access improvements	1	LS	$ 200,000	$ 200,000
3	**Sediment Removal**				**$ 5,440,163**
	Zone 2 sediment removal and aquatic transport	290,000	CY	$ 9	$ 2,610,000
	Hauling and disposal site management	290,000	CY	$ 9	$ 2,610,000
	Hydroseeding of disposal areas	38.6	ACRE	$ 5,700	$ 220,163
	Subtotal				**$ 7,130,132**
	General Conditions (10%)				$ 713,013
	Bond (3%)				$ 213,904
	General Contractor's OH and Profit (15%)				$ 1,069,520
	Total Construction Cost				**$ 9,126,569**
	Contingency (50%)				$ 4,563,284
	Total Construction Cost w/ Contingency				**$ 13,689,853**
	Low Side of Class 5 Estimate Range (-30%)				**$ 9,582,897**
	High Side of Class 5 Estimate Range (+50%)				**$ 20,534,780**

Date: 3/29/22

OPCC Breakdown: Alt. 5 - Recover Storage Capacity with Sluice Tunnel

Line Item #	Line Item	Quantity	Unit	Unit cost	Amount
1	**Mobilization/Demobilization**				**$ 2,855,184**
	Mobilization/Demobilization (10%)	1	LS	$ 2,855,184	$ 2,855,184
2	**Site Preparation**				**$ 871,537**
	Clear and grub staging/disposal areas	22	ACRE	$ 4,156	$ 91,432
	Install temp. diversion structure (sheetpiles and earthen berm)	2,000	SF	$ 70	$ 140,000
	Install temporary diversion gate	1	LS	$ 4,000	$ 4,000
	Install temporary diversion pipeline	200	LF	$ 150	$ 30,000
	Dewatering treatment system - rent package	4	mo	$ 25,000	$ 100,000
	Dewatering treatment system - staffing	4	mo	$ 14,400	$ 57,600
	Dewatering treatment system - O&M	1	LS	$ 10,000	$ 10,000
	Dewatering trenching/pumping system (post-drawdown)	1	LS	$ 20,000	$ 20,000
	Improve and widen ex. access ramp from crest to reservoir	200	LF	$ 100	$ 20,000
	Access ramp to new Disposal Site B access road	2,000	CY	$ 26	$ 52,000
	New Disposal Site B access road grading	778	CY	$ 8	$ 6,222
	NewDisposal Site B access road aggregate base	294	TON	$ 35	$ 10,283
	Construct upstream work platform	5,000	CY	$ 26	$ 130,000
	Offsite access improvements	1	LS	$ 200,000	$ 200,000
3	**Construct Sluice Tunnel**				**$ 27,578,906**
	Upstream portal	1	EA	$ 200,000	$ 200,000
	Downstream portal	1	EA	$ 200,000	$ 200,000
	Tunneling	930	LF	$ 17,578	$ 16,347,656
	Tunnel water proofing	930	LF	$ 2,734	$ 2,542,969
	Reinforced concrete liner in tunnel	930	LF	$ 5,391	$ 5,013,281
	Sluice gate and shaft/structure	1	EA	$ 3,125,000	$ 3,125,000
	Outfall energy dissipation	1	LS	$ 150,000	$ 150,000
8	**Site Restoration**				**$ 101,400**
	Remove temporary workpads and access	7,000	CY	$ 6.00	$ 42,000
	Hydroseed disposal and staging areas	22	LS	$ 2,700	$ 59,400
	Subtotal				**$ 31,407,028**
	General Conditions (10%)				$ 3,140,703
	Bond (3%)				$ 942,211
	General Contractor's OH and Profit (15%)				$ 4,711,054
	Total Construction Cost				**$ 40,200,996**
	Contingency (50%)				$ 20,100,498
	Total Construction Cost w/ Contingency				**$ 60,301,493**
	Low Side of Class 5 Estimate Range (-30%)				**$ 42,211,045**
	High Side of Class 5 Estimate Range (+50%)				**$ 90,452,240**